APS physics™

Forum on Education
American Physical Society

Summer 2013 Newsletter

Beth Lindsey, Editor

In this issue:

Paul Cottle

Chair, APS Forum on Education

Dear Forum on Education Colleagues,

The next few years will be pivotal for physics education in the United States.

At the K-12 level, the pressure on school districts to focus resources even more on raising student achievement on math and English – while laudable in itself – will tend to steer resources away from other subjects like science and, in particular, physics and the physical sciences. Meanwhile, the Next Generation Science Standards provide us with a vehicle for trying to keep physics (and science in general) on the instructional agenda.

At colleges and universities around the nation, undergraduate programs in physics are under increasing pressure to raise enrollments and degree production, and some have been terminated. Nevertheless, there are physics departments that are showing spectacular improvement and success in recruiting and educating bachelor's-level physicists. The 2013 winners of the Committee on Education's Award for Improving Undergraduate Physics Education (Colorado School of Mines, Kettering University, Massachusetts Institute of Technology and the University of Wisconsin – La-Crosse) provide a spectacularly diverse range of examples of how success can be found in different institutions. The latest winners of the Excellence in Physics Education award, the smartPhysics group at the University of Illinois – Urbana-Champaign, provided an extraordinary demonstration not only of how to use technology to improve teaching, but also how to get widespread buy-in from faculty in a department at a leading research university.

At the graduate level, the sequester has further eroded our ability to recruit and train Ph.D.-level physicists and increased the pressure on departments to prepare their students for careers outside of academic research. Fortunately, the physics community has been proactive about broadening participation by underrepresented groups and getting its graduate students ready for non-academic careers. The latest APS effort in this regard, the 2013 Graduate Education Conference held January 31 – February 2 and the American Center for Physics, was a rousing success.

What can the Forum on Education and its members do? Plenty. First of all, the forum membership should not underestimate the importance of the unit's primary activities – organizing programming at national meetings and making awards. Our sessions of invited and contributed talks give us the opportunity to muster our efforts for positive change. I have been a witness to the impact our awards have had on the communities in which our winners work and live and on our winners' abilities to expand their efforts.

Quality nominees are critical to maintaining the impact of the Forum's Excellence in Physics Education Award. If you know a group that has shown a sustained commitment to excellence in physics education, make your own commitment to submit an inspired nomination on their behalf. You can find nomination information at http://www.aps.org/programs/honors/awards/education.cfm. The nomination deadline for the 2014 award is August 1.

Come up with an idea for a session of invited talks for the March or April Meetings. And think big – how should the physics community address the major challenges it is facing in the education arena? Let this year's Program Chair (and Forum Chair-Elect), Michael Fauerbach, know about your ideas. He's at mfauerba@fgcu.edu.

Help us identify great candidates for the Forum's Executive Committee. Send your ideas to Randy Knight, who as Vice Chair is responsible for running our nomination and election process. You can reach Randy at rknight@calpoly.edu.

We'll also be trying to identify other opportunities for you to positively affect physics education nationally, at all three levels (K-12, undergrad, grad), and we'll be sharing these with you.

If you have ever thought about getting involved, now is the time to do it.

Sincerely,

Paul Cottle

Chair, APS Forum on Education

Paul Cottle is the Steve Edwards Professor of Physics at Florida State University and the current chair of the Forum on Education. He also serves as the chair of the APS Committee on Education (COE). He was recently elected a Fellow of the APS. Paul conducts research in experimental nuclear physics, and is active in precollege science teacher preparation. He is an advocate for effective standards for STEM education in his home state of Florida and nationally.

Letter from the Editor

Beth Lindsey

"I touch the future. I teach." This quote, commonly attributed to Christa McAuliffe, has always resonated with me as an educator. A desire to improve physics education, to make a difference in students' lives, and thereby to influence the future, is a large part of what drew me to the field of Physics Education Research. Many of you – physicists with a special interest in education – probably feel similarly. In many cases, our interest in improving the world (or at least in improving Physics Education) has led us to be advocates for some cause. We may start within our department or university as advocates for reform-based instruction, but many of our number move beyond this to be active at the local, state, or national level in advocating for improvements to science standards, for science teacher education, or for science funding.

In this edition of the FEd newsletter, I bring you three perspectives from physicists who have become advocates for physics in other ways: Scott Franklin (currently the Secretary/Treasurer of the FEd) describes his experience meeting with Staff Aides on Capitol Hill, Aline McNaull (a policy associate for the American Institute of Physics) describes more broadly how physicists can interact with Capitol Hill staffers, and Jim Borgardt describes some cultural differences between working in academia and working in government that he has encountered in his role as an AIP Science Fellow working in the Executive Branch. If their experiences inspire you to become more active in policy or advocacy yourself, the APS website includes links to tools and other resources to get you started: http://www.aps.org/policy/ An article by Scott Bonham in the Fall issue of this newsletter mentioned another way that physicists can participate in policy or advocacy: by getting involved in the implementation of the Next Generation Science Standards now that they have been finalized.

This newsletter marks the beginning of my three-year term as Editor-in-Chief. I'm interested in hearing ideas for articles or theme issues from you, the readers of the FEd newsletter. Please don't hesitate to get in touch with me by sending me articles or suggestions that you think would be of interest to the APS FEd community.

Beth Lindsey
Penn State Greater Allegheny

Call for nominations for FEd Executive Committee

December seems far away, but the next FEd election will be upon us before you know it. Three executive committee positions will be open: vice chair (who, in subsequent years, becomes chair elect and then chair), secretary-treasurer (3-year term), and an APS-AAPT member at large (3-year term). The latter must be a member of both the FEd and AAPT. The newly elected members will assume their duties in April 2014.

The Forum on Education only exists because of volunteers willing to give a little of their time; it has no paid staff. Please consider running for one of the three positions. It's perfectly OK to nominate yourself! Or nominate a colleague who you think would do a good job. Serving as an officer is an excellent way to learn more about APS and its many educational missions.

Please send suggestions to
Randy Knight (rknight@calpoly.edu)
FEd Vice Chair, and Chair of the Nominating Committee

Opportunities from APS

APS Bridge Program Summer Meeting

Register Now for the APS Bridge Program Summer Meeting, **June 27-29, 2013** in College Park, MD! The meeting will bring together experts to discuss efforts to increase the number of underrepresented minorities who receive PhDs in physics. Faculty, administrators, researchers and students are welcome to attend. Registration fees are $100 for registrants from Bridge Member Institutions and $175 for registrants from non-member institutions.

Registration Deadline: June 21st

Have your institution become a member institution today!

Bridge Program Main Web page: http://www.apsbridgeprogram.org/conferences/summer13/index.cfm

Bridge Program Summer Meeting Registration site: https://www.aps.org/memb-sec/meeting/startpage.cfm?event_id=1087

Member Institution Webpage: http://apps3.aps.org/phystec/apsbridge.cfm

Sign up for the Wavefront Newsletter

Educators, stay informed! APS *Wavefront* is a free electronic newsletter for physics educators. Sign up to stay informed about APS programs, upcoming meetings, recent APS actions, and activities within the physics community.

►**http://www.aps.org/programs/education/wavefront.cfm**

APS Speakers Program features Physics Education Researchers

The APS Speakers Lists contain names, contact information, and talk titles of physicists who are willing to give talks on a variety of subjects. Advanced searches allow one to search specifically for physics education researchers (PER).

►**Learn more at http://www.aps.org/programs/speakers/**

Opportunities for Physicists in the Pre-Health iCollaborative

Juan Burciaga, Mt. Holyoke College and Patricia Allen, Appalacian State University

New Call for Submissions

The AAMC (Association of American Medical Colleges) announces a new call for innovative teaching resources in physics that teach the pre-health competencies. Share your best teaching resources (including case studies, self-learning modules, classroom learning activities and team-based activities) to be considered for a $750 prize for the most innovative resource. Eligible resources will address a pre-health competency that draws from the disciplines of biology, biochemistry, chemistry, physics, psychology and sociology and engage students in further developing their scientific inquiry and reasoning skills. Competency-based learning emphasizes both knowledge and skills. Innovative resources will engage students in activities that mirror the work of social and natural scientists and reflect the interdisciplinary nature of their work.

►Learn more at: www.mededportal.org/icollaborative/prehealthcompetencies.

Here is the winner in physics for our previous call, Computed Tomography, by Elliot Mylott, Ryan Klepetka, Ralf Widenhorn, and Grace Van Ness of Portland State University: https://www.mededportal.org/icollaborative/resource/645

Winning competency-based resources will emphasize real-world problems and interdisciplinary problem-solving activities. Up to six resources will be selected for awards and be published in the Pre-health Collection within MedEdPORTAL's iCollaborative.

►Submissions are due by August 26, 2013.

Submit here: www.mededportal.org/icollaborative/pre-health

Get Involved Now! Political Advocacy for STEM

Scott Franklin, Rochester Institute of Technology

As faculty, we are so occupied with our research and teaching that we rarely have time or energy to engage in the political process. And the current political climate hardly encourages involvement. Nevertheless, discussions on Capitol Hill are happening now that will have a very significant impact on our careers: decisions will be made about what activities to fund (and to what extent) that will shape the next several years of STEM education. It is more important than ever for physics faculty to become involved in grass roots advocacy. Fortunately, APS has many resources to help, from editors for letters and op-ed pieces, handouts to help start discussions, and even staff who will escort you around "the Hill" to facilitate meetings.

A recent conference in D.C. gave me the opportunity to advocate on Capitol Hill. Since the conference activities did not begin until the evening, I contacted Aline McNaull, Policy Associate at AIP, and asked if she could escort me around meetings with Congressional Offices. Aline arranged a series of meetings with staff aides, an important conduit to the Senators and Representatives, and explained to me the issue that would dominate the discussions: the House Science Committee's wrestling with the issues of oversight of NSF. She met me at the offices and sat in on all meetings, introducing me and framing the discussion.

The central focus of the meetings was to explain the peer-review process that functions so well at NSF. I gave my experiences reviewing, including details of how many proposals I would typically review and what a panel discussion was like. We explained the differences between the individual and panel reviews, and how anonymity in the individual reviews is a critical component of the process that should not be threatened by oversight. The aides were extremely intelligent, asked very specific and germane questions (e.g., how peer evaluation at NSF began and evolved into its current form), and discussions were, frankly, a lot of fun. Noticeably absent were ad hominem attacks or other anti-STEM rhetoric or uncomfortable questions about how to resolve the country's fiscal situation. The aides were clearly grappling with a very difficult question – how Congress can exercise appropriate and legitimate oversight without upsetting the peer-review process – and recognizing that there were no easy answers.

This Fall, Congress will consider renewing the "Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science" (COMPETES) Act. This legislation frames the country's approach to STEM and STEM education. In it, decisions are made about allocating funds to basic research and STEM Education, budgets are authorized for NIST and NSF, and broad policies defined. We faculty must be a part of these discussions.

If we don't advocate for the issues we find important, who will? Please consider taking the first step by contacting Aline McNaull (amcnaull@aip.org) or Scott Franklin (svfsps@rit.edu) for more information.

Scott Franklin is a Professor of Physics at RIT. His research interests range from the behavior of granular materials to physics education research. He directs RIT's Science & Mathematics Education Research Collaborative. Scott is the co-author of "Explorations in Physics: An activity-based guide to understanding the world," which won the 2012 Science Magazine Prize for Inquiry-based instruction. He is currently the Secretary/Treasurer of the FEd.

Advocating for Science on Capitol Hill

Aline McNaull, AIP

Science education comes in many forms. There is the traditional formal method in which students sit in a classroom with teacher or lecturer in the front of the room or when students participate in laboratory activities in small groups and the teacher or professor circulate the room to work with students. Informal education can also be effective, whether that be through exhibits at a museum or websites and blogs. Science education can also take the form of science advocacy.

In the case of visiting congressional offices on Capitol Hill, the audience is typically around 25 years old and very bright. Many staff members have backgrounds (often graduate degrees) in political science, economics, and law. Some of them liked science and others were scared of it in their high school and undergraduate years; many may have never taken physics. Staffers are engaged in issues ranging from agriculture, transportation and energy production, to animal rights and Native American tribal policy. Somewhere in that varied list is science – not physics, but the broader topic of "science issues." Though their backgrounds do not often include a PhD in a science field, they are still responsible for understanding issues relating to science.

While they are never expected to understand how radioactive decay produces neutrinos or how to mount thermally conductive material to a focal plane array, they are tasked with discerning whether their boss agrees with the National Ocean Policy Implementation Plan or the Nuclear Energy Research and Development (NERD) Act (yes, a PhD physicist helped decide that acronym). To understand those policies, Hill staffers rely on the science community to answer their questions; they also need the science community to help them determine what questions to consider.

Staffers reach out to science societies to seek advice. They ask science societies to read over legislation text in order to ensure that there are no problems with the bill language, or they ask for suggestions on what would help scientists solve problems. In this context, science policy staff in the societies get a chance to educate Hill staffers.

Advocating and working with the Hill allows physicists to ask, as Scott Franklin did, "what is the topic of the day?" If he had asked me the same question at a different time, I might have said that we are looking at national helium shortages, rare mineral supplies, or weather satellite coverage. Topics change based on crises, shortages, national need, but more frequently the "issue of the day" in policy is driven by how the news media portrays science.

Soon Congress will reauthorize many of the science agencies, including the National Science Foundation, Department of Energy Office of Science, National Institute of Standards and Technology, and National Aeronautics and Atmospheric Administration. Hill staffers, particularly those who work for Members of Congress on the House Science, Space and Technology Committee and the Senate Commerce, Science and Transportation Committee, will be searching for information about the programs and research that is funded by each of these agencies.

It is an opportunity for physicists to educate policymakers and play a role in the policy process – to explain where they get funding, what programs they work under, and how they educate the next generation of scientists. Today's "topic of the day" about National Science Foundation grant evaluation stems, in part, from the lay public having difficulty grasping why public tax dollars go to individual grants. Individual grants, whose titles are misunderstood, are being questioned particularly due to tight federal budgets. Grant titles using very technical terms are not as frequently called out but titles that use words that confuse the underlining merit of the grant are being questioned. In some cases, grant titles that refer to research being done in countries outside the United States have raised eyebrows and the public has questioned why the National Science Foundation is funding research conducted abroad.

While the scientific community can and does stand behind the merit review process and can likely explain the value of many of the grants funded by federal science agencies, this trust in the merit review process is not always understood by non-scientists. The public does not necessarily follow why or how research analyzing one topic can have implications for many fields or scientific disciplines. Educating Hill staff about this process can help them discuss these issues with their constituents.

As professors and researchers think about their work, it is important to consider how to explain the reason for receiving grant money and how federally funded research can have broader societal impact. This helps staffers on the Hill, the lay public who contact their Members of Congress, and the Members themselves to discuss what is the federal role in science research and how the US should continue to support science.

For more information about contacting Congress, please visit:
APS Advocacy Tools: http://www.aps.org/policy/tools/index.cfm
AIP Communicating with Congress: http://www.aip.org/gov/commcong.html

Aline McNaull is a Policy Associate at the American Institute of Physics (AIP).

Culture Clubs: Academia and Government

Jim Borgardt, Juniata College and U.S. Department of State

Each year formal government and professional society programs bring a few hundred academics and professionals into the United States government (USG) allowing individuals with expertise to share their knowledge. Such Fellows represent a broad range in age and career stage, and come from a wide array of sectors including academia, government labs, non-profit enterprises, and private industry. They have existing professional relationships and subject-matter expertise, and these competitive fellowships provide an introduction to government and policy, and function as potential inroads for those exploring longer term service in this capacity.

I have been fortunate to have the opportunity for such an experience as the 2012-2013 American Institute of Physics (AIP) Executive Branch Fellow. While the AIP annually sponsors one Congressional and one Executive Branch Fellowship, the main player in this arena, the American Association for the Advancement of Science (AAAS), places Fellows in a wide spectrum of USG agencies and offices, including, among others, NASA, NIH, NOAA, NSF, USAID, DoA, DoD, DoE, DHHS, DHS, DoS, EPA, USGS, and OSTP, as well as in Congressional offices.

As an individual coming from academia with a desire to better understand the mechanics of government and policy formation, it was important to recognize and acclimate to some fundamental cultural differences in the USG. As there is certainly not a single monolithic government culture, I solicited insights and perspectives from about two dozen current AAAS Fellows in various federal agencies and Congressional offices regarding some of the cultural differences they have noticed to give broader representation beyond my experience. For any academic considering a Fellowship, in many ways it can be likened to a study abroad experience where one is very often immersed into a culture that can be foreign to your own. This contrast in culture between government and academia is not meant to insinuate in any way, shape, or form that one is "better" than the other. Rather, it is intended to highlight some of the differences between the two worlds in the hopes that readers from the academic realm who are considering a transition or foray to the government side might find some of these cultural observations useful.

While the emphasis placed on comments in different thematic areas varied with the agency the Fellow was associated with, some well-defined themes emerged. The most frequently mentioned centered on issues of the nature of time, offering input and receiving feedback, and subject matter expertise.

The Nature of Time

Einstein established that time is relative for observers in reference frames in relative motion. In the reference frame of the government timelines can be very different than in academia. Deadlines can be quite short, with as little as 5-minutes to pen a brief on a bill in a Congressional office. "Short fuse" is a common email subject line or header, and deadlines are stricter. As one Fellow noted, "writer's block is not an option." Whereas academics may dote over a particular word or specific phrasing, in the fast-paced world of government work sometimes "good enough" must do in order to "move the ball forward." However, such frenzied events comingle with longer term endeavors. For example, if one is part of a US team in an international group working to deliver a position paper, there are interagency clearances required domestically to ensure all principles are "on board" and that the paper accurately represents all aspects of the USG position on an issue, in addition to the international negotiations that can take time as foreign counterparts work through a similar process on their end. Discussions can go through many iterations, and as a result such papers can take years to bring to fruition.

Test for Echo – Offering input, getting feedback, writing and speaking

The process by which by input is proffered in the USG is unlike the academic route. In general, input is more hierarchical, an observation noted by many Fellows. In academia, you might feel comfortable making suggestions to your College President, questioning the scientific methodology of a luminary in your field, or directly contacting an author if you want to resolve some confusion on a published paper. However government agencies to varying degrees can be more established, rigid, and restricted. There is a "chain of command" that must be followed in promoting ideas and initiatives. If an offered idea is rejected by your leadership, it can be harder to move it forward. This is not to say that the government has no room for creativity, for there are many inspired ideas that can have a large impact, but rather that one may not be aware of all the implications of an idea, or its consistency with established policy, among other related issues. In government, communication generally occurs more through established channels, and circumventing this process can create problems and introduce challenges. As one Fellow put it, "Intellect is valued and invited to the table, but it does not trump rank."

The process of bureaucratic feedback can be novel to an academic as well. In academics, we are habituated to give and receive criticism – it's expected, and welcomed, and we don't take it personally. We expect students to take a "you are capable of more" comment as a challenge to improve, and not a personal affront. In government you are often part of an assembly line on position papers and briefings where you might write the first draft and pass it up the ladder for revisions and subsequent rewrites which occur

at increasingly higher rungs, and beyond your view. As such, you do not receive structured feedback on your work. It moves up the chain, receiving edits at each successive step as it is passed on and moves through any required interagency reviews. The main formative feedback is indirect – you compare the final product to your early submission and glean how an initial draft might look better in the future.

Due to the writing process not being a solitary or "research group of peers" effort, there is a lot of "group-write" in government where, unlike academics, names are not attached to a product and there are many eyes checking to ensure the paper reflects established policies and positions. This also leads to another cultural difference that can make many academics squeamish. In academics failing to cite a source is viewed as a major professional indiscretion that can cast a permanent pall over a transgressor's career. In government, using text from prior documents is approved and even encouraged. This "cut-and-paste" ethos makes sense in this culture as the work, as noted above, is often a collaborative process where the entire office may make progressive and substantive contributions. Even more importantly, prior documents have been previously cleared, and thus accurately reflect official doctrine and contain very specific language which precisely captures the views of the organization on a particular issue. Using such key sentences or phrases verbatim gives one cover and speeds up the writing process, as it is "preapproved language".

The gravity and impact of speech in a forum is also fundamentally different in the USG. Academics are used to their communication being a reflection of their own ideas. Speech in a federal capacity represents the position of your agency, and hence your government, and as such is more conservative and guarded. It takes a little acclimation to realize the full implications of this, and understand that in speaking openly you must stay within those confines and not imply any stance or promise that is not explicitly sanctioned, as others will view your statement as an official USG position. As in an academic conference, there are numerous side conversations that occur on the margins of meetings where one can speak a little more openly and forward leaning in private, while still reflecting USG points.

Specialist vs. generalist

A final cultural difference noted by a number of Fellows is that in academics we often burrow down the rabbit hole, specializing in a narrow niche or specific subfield. Outside of this realm, we may feel uncomfortable speaking definitively or with authority. In government, a civil employee must be a skilled and knowledgeable generalist, a sort of jack-of-all-trades with broad familiarity with a wide range of subjects, and maintain a vital network of colleagues to call upon to "come up to speed" on a topic. Adept at quickly extracting the essential elements of this new topic, they are comfortable making decisions and recommendations based on this cursory understanding.

Individuals in the academic community represent a great reserve of ability, skills and subject-matter-expertise that can be of immeasurable benefit to the country when paired in an appropriate government agency. I have personally been amazed by not only the talents, but the tenacity and dedication to mission on behalf of our country of the individuals in the office I am contributing to, and many other Fellows have shared similar observations regarding their placements. These partnerships between academics and government facilitate a better understanding of policy formation and implementation for academics, and provide a potential conduit for such individuals to transition to government while providing valuable knowledge to the government office or agency involved. I feel fortunate to be a part of this philosophy of governance that realizes the value of such interactions, and encourage those who believe they have something to offer to explore such an opportunity.

Jim Borgardt is the William W. Woolford Professor of Physics at Juniata College in Huntingdon, Pennsylvania. He has collaborated on research with radiation portal monitors, deployed at border crossings to intercede illicit nuclear material, with Pacific Northwest National Laboratories over the past decade. He has won several teaching awards, and is active in the Central Pennsylvania section of the AAPT. He serves as the 2012-2013 AIP Executive Branch Fellow in the State Department's International Security and Non-proliferation bureau in the Weapons of Mass Destruction Terrorism office.

Physics Teacher Education Coalition

Section on Teacher Preparation

Teacher Preparation Section

John Stewart, University of Arkansas

The teacher preparation section begins with Beth Cunningham and Robert Hilborn of the American Association of Physics Teachers discussing their organization's support of in-service teachers. Prominently featured is the very successful PTRA program. This program was also discussed by Jim Nelson in the Summer 2009 edition of this newsletter.

Steven Case of the University of Kansas (KU) discusses UKanTeach, a UTeach replication site that has been particularly successful in improving the number of highly qualified STEM teachers graduating from KU. While very effective, UTeach still struggles with graduating teachers qualified in the areas of greatest need, physics and chemistry. John Quintanilla and Cindy Woods discussed the UTeach program at the University of North Texas in the Fall 2012 edition of this newsletter. A number of PhysTEC sites also now have UTeach programs. Cody Sandifer and Ronald Hermann discussed UTeach and PhysTEC at Towson University in the Spring 2013 issue and Ron Henderson discussed UTeach and PhysTEC at Middle Tennessee State University in the Fall 2010 issue.

This year's wonderful PhysTEC conference was held in partnership with the American Chemical Society whose Chemistry Teacher Education Coalition (CTEC) proposal is under review. The combination of PhysTEC, CTEC, and UTeach may finally make major inroads into the critical shortage of chemistry and physics teachers.

Reaching out to diverse, underprivileged schools is one of the greatest challenges facing science educators. In our third article, Andrew Elby, Ayush Gupta, Luke Conlin, and Jennifer Richards present an interesting peer-led professional development program targeted at the teachers of students in an economically challenged county in Maryland.

The American Association of Physics Teachers Support for K-12 Teachers

Beth A. Cunningham, Executive Officer, AAPT
Robert Hilborn, Associate Executive Officer, AAPT

The American Association of Physics Teachers (AAPT) provides a number of programs and activities that support pre-service teacher preparation efforts, early career induction and mentoring of teachers of physics, and in-service professional development for teachers of physics. Much has already been written about PhysTEC and AAPT's partnership with the American Physical Society on supporting pre-service physics teacher preparation; therefore, this article will focus on the AAPT programs that support teachers of physics once they are in the classroom.

High School Teacher Professional Development and Physics Teaching Resource Agents

AAPT initiated the Physics Teaching Resource Agents (PTRA) Program in 1985—with support from the National Science Foundation (NSF) —with the mission of improving the teaching and learning of physics and physical science for all teachers and students in the United States. AAPT/PTRA is the leading in-service physics professional development program for middle school and high school teachers. It provides professional development on physics content, teaching techniques based on research in physics education, and integration of technology into the curriculum. The program maintains a nationwide cadre of accomplished high school teacher-leaders who are trained and continually involved in professional development. These teacher-leaders are certified as PTRAs by AAPT to lead workshops throughout the country.

Since 1985, over 150 experienced PTRAs have participated in national leadership institutes in which they have developed their skills on a wide range of topics in order to assist their fellow physics teachers. The program has involved more than 30 university and college physics departments partnering with PTRA's to provide the summer institutes and follow-up sessions. This partnership is an important feature that ensures a high quality and sustainable environment for the PTRA workshops. Physics departments

provide the infrastructure and faculty support for workshops and the PTRAs provide peer mentoring and leadership in conducting the workshops.

The American Physical Society recognized the achievements of the AAPT/PTRA program with its **Excellence in Physics Education Award** in 2011.

In 2012, AAPT announced a new Physics Teaching Resource Agents (PTRA) initiative in response to the proposed Next Generation Science Standards. The AAPT Executive Board has constituted a new committee, the AAPT/PTRA Oversight Committee, to provide advice and guidance to the Executive Board in the planning and use of AAPT funding to support this new initiative as well as continuation of projects associated with the AAPT/PTRA program. The AAPT/PTRA Oversight Committee will work with the Program Director and Executive Officer to develop plans for the use of AAPT funding and recommendations for the long-term governance and plans for the AAPT/PTRA program.

The first set of members of the AAPT/PTRA Oversight Committee are recognized leaders in K-12 physics education. Many have served as PTRAs in the past and others have extensive experience in providing professional development to teachers of physics. Karen Jo Matsler has agreed to serve as Director of AAPT/PTRA for three years of the program. She has taught for over 30 years, served as a K-12 science coordinator, and currently is a Master Teacher in the UTeach program at University of Texas – Arlington. As Co-Principal investigator for the AAPT/PTRA project, Karen Jo was responsible for gathering data to document the impact of PTRA on over 1,000 teachers and 500,000 students. Members of the Oversight Committee include the following individuals:

- Pat Callahan, Delaware Valley Regional High School (PTRA) - 2-year term, Chair of the Committee
- John Roeder, Calhoun School (PTRA) - 1-year term
- Deb Roudebush, Oakton HS, (PTRA) - 1-year term
- Elaine Gwinn, Shenandoah High School (PTRA) - 3-year term
- Lillian McDermott, University of Washington - 3-year term
- Keith Clay, Green River Community College - 2-year term
- Steve Shropshire, Idaho State University (former Advisory Committee Member) - 3-year term

AAPT celebrates the long and proud heritage of AAPT/PTRA and the roles that all current and past PTRAs have played in its success. We plan to continue and extend this work for the next generation of teachers of physics. We also are continuing to serve the needs of the current cadre of AAPT/PTRA's to ensure that those teacher leaders are prepared to lead workshops as new standards are adopted and technology changes. We anticipate exciting developments as the program grows into new areas and state-level PTRA activities continue to receive funding. The following list highlights recent developments in the PTRA program.

PTRA Summer Leadership Institute – Just before the 2013 AAPT Summer Meeting, 30 high school physics teachers and other physics educators will meet for three days in Portland, OR to be trained or update their training as PTRAs. Three topics will be addressed in this training: engineering design and applications, integration of information technology and engineering (iOS devices, etc) to the current PTRA content workshops, and integration of literacy and math with a focus on the upper-elementary and middle-school physical science curriculum. This Institute resumes our training of physics teacher leaders after a one-year hiatus. We anticipate further growth of the Summer Leadership Institute in future years.

PTRA State-Level Summer Programs - We also have a number of state-level PTRA programs that will occur during summer 2013 and beyond. These programs are located in Oklahoma, Alabama as a part of the APEX program (see http://apex.aamu.edu) funded by the NSF Math and Science Partnerships program, Idaho, Maryland, and Georgia.

Expansion of the AAPT/PTRA Effort. The 100Kin10.org STEM education consortium has granted AAPT funding for a meeting of representatives of the AAPT, the American Chemical Society, and the American Modeling Teachers Association to develop plans for professional development activities for physics and chemistry teachers. We will hold this planning meeting in late summer 2013. We hope to initiate joint professional development programs starting in 2014, depending on the availability of funding.

AAPT e-Mentoring Program for First-Time Teachers of Physics
The 2012-13 academic year marks the third year of the e-Mentoring program, a program for mentoring teachers in the US who are teaching high school physics for the first time. The AAPT eMentoring program is designed to connect high school physics educators who desire additional guidance with experienced high school physics educators. Based on the mentees' profiles, the program will connect each of them with a qualified mentor who fits the needs of that mentee. The mentee and mentor can then begin communicating through email, voice chat, telephone, or in some cases face-to-face meetings. All participants will have an opportunity to grow professionally and connect with colleagues at a regional and national level. Mentors have extensive experience teaching high school physics and are often current or past PTRAs.

AAPT continually monitors the eMentoring program to assess its effectiveness. An end-of-year survey was distributed to both mentors and mentees in 2011 and 2012. Overall, the program has been fairly successful as reflected in the result that mentors have increased the likelihood that mentees will remain in teaching (92.9% responding yes or maybe). Many mentees would like to continue to have a mentor (78.6%) and most mentors would like to remain as mentors (96.4%). In response to a question about potential new features, mentees want more resources as do mentors. There is a sense that mentors and mentees would like to interact among their peers and also that an "instant mentor" module should be imple-

mented to respond to short, time sensitive questions from new high school physics teachers not necessarily seeking a long term mentoring relationship. The AAPT e-Mentoring staff team and the e-Mentoring Advisory Committee are reviewing the survey results to improve the program in order to enhance the success of this program and potentially expand it. For more information about the AAPT eMentoring program, see http://ementoring.aapt.org/ementor.cfm?CFID=12967199&CFTOKEN=66440330.

ComPADRE Digital Library

The ComPADRE digital library (www.compadre.org) is a network of free online resource collections supporting faculty, students, and teachers in Physics and Astronomy Education. Each of the collections in ComPADRE contains materials designed for a specific community. A number of collections have been designed to support teachers of physics and physical sciences.

Physics Front - includes teaching resources for K-12 physics and physical science classes seeking to integrate high-quality materials into their lessons. This library contains lesson plans, technology tools, teaching modules, and a featured resource. Teachers can look for materials related to a specific level (Physics First, conceptual physics, algebra-based or calculus-based physics, and K-8 physical sciences). A special section for first-time physics teachers is highlighted in this collection.

Physics To Go – is an online monthly mini-magazine and collection of more than 1,000 websites with physics images, activities, and information. Teachers can learn physics on their own, through games, webcasts, and online exhibits and activities. Also included are physics-on-the-road outreach programs, which bring demonstration shows, and in some cases hands-on activities, to teachers and their students. Teachers can browse the collection and search the database by content topic, resource type, and grade level. Past issues include topics such as "Carbon Dioxide and Global Warming" (May 1, 2013), "Waves and Music" (November 16, 2009), "Resonance" (May 16, 2007), and "Life and Death of Stars" (June 1, 2010). Many of these resources can be used to supplement classroom materials.

Physical Sciences Resources Center (PSRC) - a web-based database that provides K-20 teachers links to a wide range of teaching and learning resources in the physical sciences. All materials are classified by their grade level, topic, and activity type, and have descriptions outlining their content. Information about authors, publishers, costs, and copyright is also provided. Educators can use the PSRC to find curriculum materials for all grade levels, classroom demonstrations, labs, online learning material, evaluation instruments, and articles about approaches to science education. The collection can be searched by keyword and author's name and organization, or browsed by topic, type of resource, or grade level. Users of the PSRC are encouraged to participate actively in the PSRC. They may suggest materials for the editors to include in the collection, share comments, and build personal collections of materials.

Statement on "Critical Need for Support of Professional Development for the Teaching of Physics in K-12 Schools"

A group of AAPT members and teacher professional development experts have prepared a statement on the need for support of professional development for the teaching of physics in K-12 schools. This statement was prepared to describe the professional development needs for beginning and experienced teachers in anticipation of the release of the Next Generation Science Standards as well as to emphasize the need for on-going support for the professional development of all in-service teachers of physics. See www.aapt.org/Resources/policy/upload/130129_Statement_on_PD_for_HS_Physics_Teachers_final.pdf for a copy of the final version of the statement. The AAPT Executive Board endorsed this statement in April 2013. We anticipate that AAPT members as well as others will use this statement in visits to members of Congress or state legislators, federal funding agencies, and with local school districts.

National and Section Meetings.

Several hundred K-12 physics teachers attend AAPT's two national meetings and many regional section meetings each year. These meetings provide a mix of workshops and talk sessions where teachers can share their experiences, learn more physics content and pedagogy, and network with their colleagues. In addition, AAPT and its local sections organize Physics Days at each of the National Science Teachers Association regional meetings.

Beth A. Cunningham, currently Executive Officer of the American Association of Physics Teachers, received her bachelors, masters, and doctorate from Kent State University, taught physics for 17 years at Bucknell University where she also served as the Associate Dean of Faculty, and held the position of Provost, Dean of the Faculty, and Professor of Physics at Illinois Wesleyan University.

Robert Hilborn, currently Associate Executive Officer of the American Association of Physics Teachers, earned his bachelor's in physics from Lehigh University and his master's degree and Ph.D. in physics from Harvard University. He brings to this position extensive experience as a physics faculty member and college administrator at Oberlin College, Amherst College, the University of Nebraska-Lincoln, and the University of Texas at Dallas.

UKanTeach STEM Teacher Preparation: An innovative and experimental program changing STEM teacher preparation.

Steven Case, University of Kansas

In 1998 the State of Kansas was startled into awareness of Science, Technology, Engineering, and Mathematics (STEM) literacy by concerns about evolution in the Kansas K-12 Science Education Standards that were partially the result of poor public understanding of the nature and process of science. Prompted by statewide concerns, the University of Kansas (KU) community quickly began a discussion of the essential skills and knowledge our undergraduates need to be ready to begin university work and upon graduation. In the past, the next generation of scientists, engineers and mathematicians were educated without these individuals actually engaging in doing authentic scientific practice. It was very clear that scientific literacy at all levels must involve much more than learning static facts about the STEM disciplines; it must also involve the understanding and practice of the unifying practices of the scientific community, the scientific method.

In order to move to this kind of STEM literacy, we began to explore college readiness and with it STEM teacher preparation. There are approximately 3.6 million public school K-12 teachers in 90,000 public schools in the United States with teacher preparation programs graduating more than 200,000 new teachers every year. Between 70 and 80 percent of these future teachers are enrolled in traditional programs in postsecondary institutions, while others pursue the teaching profession through approximately 130 "alternative" routes.

The UKanTeach program originated from a partnership between the KU College of Liberal Arts and Sciences, the KU School of Education and Kansas school districts and is coordinated by the Center for STEM Learning. Students complete their BS or BA in mathematics and/or natural science and simultaneously the UKanTeach coursework to obtain a secondary teaching license at the same time as their bachelor's degree. UKanTeach utilizes a blended pedagogy; learning both the content discipline and the pedagogical skills required to teach the specific science and mathematics discipline. This results in and is supported by a secondary teaching field experience informed by a deep and rich content understanding. Launched in spring 2007 with support from the Ewing Marion Kauffman Foundation and subsequent support by the National Math and Science Initiative (NMSI), UKanTeach is now a leader in a national reform effort that has been adopted at 34 universities. The program is dramatically increasing the number of highly prepared mathematics and science teachers graduating from the University of Kansas. Figure 1 shows the total historical enrollment of the UKanTeach program since its inception.

With six years of experience, the UKanTeach program has slightly over 100 program completers with over 80% entering secondary teaching. The first graduate/completer has completed her fourth year of mathematics teaching. To date, all of our graduates who have sought teaching positions are teaching and 100% of our

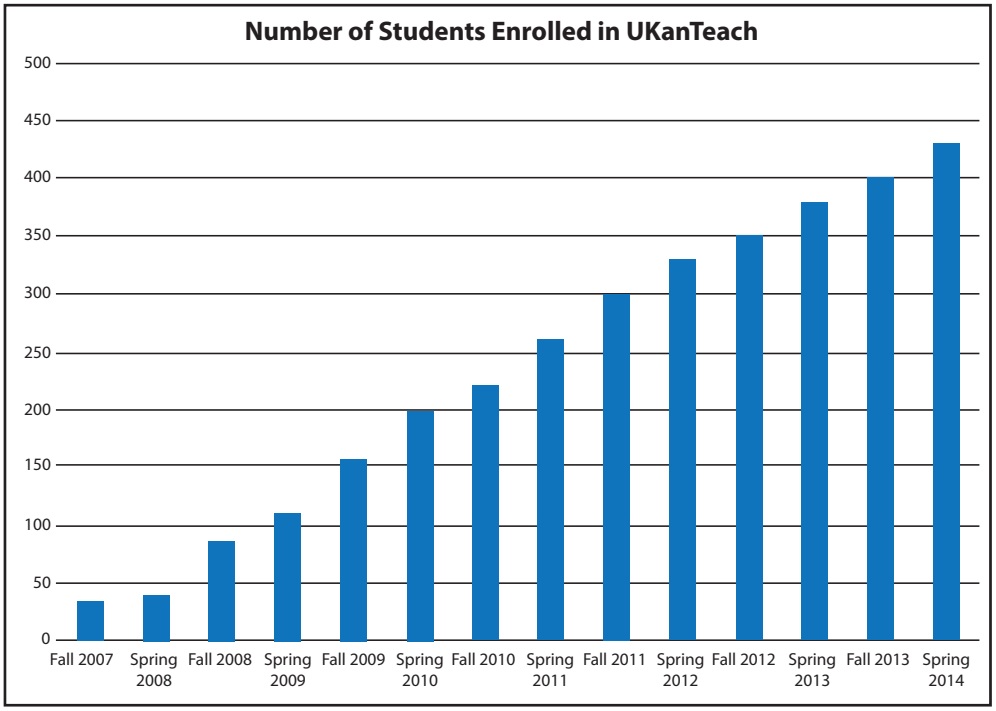

Figure 1: The total historical enrollment of the UKanTeach program since its inception.

UKanTeach program completers who went into teaching are still teaching. With longer experience, the UTeach program at the University of Texas at Austin finds that after seven years of teaching, 82% of the UTeach teachers are still teaching. This university-based innovative and experimental STEM teacher preparation program is now at 34 universities. A recent funding announcement from the Howard Hughes Medical Institute and NMSI will bring 10 more research universities into the UTeach community. It is expected that as this community grows and additional understanding is developed, this robust, transferrable model of STEM teacher recruitment and preparation will continue to evolve and flourish.

The UKanTeach program was founded because of a shortage of highly qualified mathematics and science teachers in Kansas. An aging teacher workforce, early retirement and poor retention of new teachers combined with insufficient production of new secondary science and math teachers to create a perfect storm.

The Kansas economy requires well-prepared citizen STEM workers. Wichita manufactures 70% of the world's general aviation aircraft. The Kansas City metropolitan area is a center of automobile production and printing. Metal fabrication, printing, and mineral products industries predominate in southern Kansas and Kansas continues to lead in agricultural production. Well-prepared workers are innovators in their fields; they fuel innovations in energy, biotechnology, manufacturing, aviation and agriculture that drive the region's economic engine.

The UKanTeach program at the KU is designed to improve the learning and teaching of all STEM undergraduate students. It is not intended as solely a teacher preparation program, but also to offer additional options to all STEM graduates. The program centers on developing critical scientific literacy through specific science education programs, curriculums and research-based teaching. While UKanTeach is an undergraduate program, teacher professional development must continue through all stages of a teacher's career: from recruitment through retirement. Undergraduate STEM teacher preparation must be designed as only one part of an ongoing continuum of teaching and learning. This recognition changed the nature of our teacher preparation program. Students are recruited to UKanTeach with the idea that secondary STEM teaching is a career option for all STEM majors. STEM workers should be able to move back and forth seamlessly between a variety of STEM-related jobs, including teaching. STEM teaching is a hard job; being an effective STEM teacher may be one of the most challenging jobs in STEM.

UKanTeach is an innovative and experimental STEM Teacher Preparation program. Built on the successful practices of the UTeach program at the University of Texas-Austin and combined with innovations established by the UKanTeach faculty and staff, the program has created a unique model that meets the needs of our STEM students and the needs of the regional community. The critical program elements of UKanTeach include:

- A carefully planned set of degree requirements across all disciplines in the program that avoids unwarranted content duplication.
- An intense, hands-on coaching model engaging students from initial recruitment including induction support, in-service professional development, and ongoing support throughout their career.
- A very strong advising, tracking, and academic support program managed by dedicated teaching professionals.
- Early and frequent field experiences that lead to a capstone student teaching experience.
- Clinical faculty, master teachers who are experts in teaching, who work with the students throughout their program.
- An engaged partnership with regional STEM classroom teachers and clearly developed partnerships with regional school districts which provide advice, field placements, and teaching positions for UKanTeach graduates.

The interconnected nature of these program elements is the primary driver of both the innovations and successes of the program. The combination of the UTeach critical program elements and UKanTeach program innovations has been recognized as a Promising Practice by the Association of Public and Land Grant Universities, Science and Math Teacher Imperative.

This integrated program has led to impressive outcomes for our students. The UKanTeach program follows its students very closely. To date, of the UKanTeach students who have taken the Praxis PLT (pedagogy) test, 22% earned a score that ranks them within the top 15% of all test takers who have taken this assessment in previous years; of the UKanTeach students who have taken the Praxis Content test in their disciplines, 35% earned a score that ranks them within the top 15% of all test takers who took this STEM discipline assessment in previous years. In the fall of 2010, the Kansas Department of Education launched the Kansas Performance Teaching Portfolio (KPTP) an extensive teaching performance evaluation completed during student teaching. Of the UKanTeach students who have taken the KPTP, 35% have earned exemplary scores with one student achieving a perfect score. These graduates are superbly prepared for the first day of teaching and recognize the importance of ongoing learning within their discipline.

The heart and soul of the UKanTeach program is two courses: Research Methods and Project-Based Instruction. Research Methods engages students in a scaffolded undergraduate research experience in their discipline. It is our belief that engaging students in the scientific process, with guided reflection on the process, will allow students to learn the process and nature of science while also improving discipline-specific content knowledge. In recent discussions about new workers at a biotechnology company, the most important skill required by the lab director was the ability to think: the central skill developed by undergraduate research. Engaging undergraduates in research provides training that they don't receive in traditional science courses such as practice with deep critical thinking, research ethics, oral and written communication skills and information literacy. For students in the program who

are going on to graduate school or directly to the STEM workforce, these are highly transferable intellectual and communication skills.

The Research Methods course is supported by another UKanTeach course, Perspectives in Science and Mathematics. This unique course is a blend of philosophy and history that gives the students a way to reflect on the nature and process of science while they are engaged in their research. They learn that research is a process of careful inquiry that leads to the discovery of new information.

UKanTeach students who go on to become secondary science teachers are well versed in the Next Generation Science Standards (NGSS) that establish learning expectations for students including interacting disciplinary core ideas and crosscutting concepts. Research Methods provides a learning experience that integrates these important cross-cutting themes.

Project-Based Instruction extends the undergraduate research experience to the secondary teacher's instructional practice; they learn how to be the research director for over one hundred secondary students. Directing research requires very different skills if teachers are to engage adolescent, novice learners in middle school and high school in meaningful authentic research. To examine real-world problems as scientists examine research problems is critical to the STEM literacy that we seek for all citizens.

The changes in STEM teaching and learning supported by the UKanTeach program affect secondary students and their readiness for post-secondary experience. They also bring a major change in the nature of undergraduate STEM education. The grand vision of the UKanTeach program is to respond to our STEM literacy challenges by moving the needle on STEM literacy. The UKanTeach program is a part of a national experiment in STEM teacher preparation in which the early results are very encouraging and indicate that these program innovations are returning very positive results.

Steven B. Case Ph.D. is the Director of the Center for STEM Learning at the University of Kansas. He has worked to establish STEM Literacy at all academic levels, including the establishment of the UKanTeach program at KU.

Inquiry-Based Professional Development for a Diverse Population

Andrew Elby, Ayush Gupta, Luke Conlin, Jennifer Richards
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In this article, we describe a professional development program for fourth through eighth grade teachers in a large county in Maryland. In this county, about 67% of the students are African American and 23% are Hispanic. Approximately 60% of the students are economically disadvantaged, and 27% were born outside the US or speak a language other than English at home. After giving a program overview, we'll briefly present an episode from a professional development session to illustrate some of the unusual but (we hope) promising features of our program.

Program overview

For the past four years, as part of an NSF-funded Math Science Partnership (DUE-08319705), our program has offered a two-week summer workshop followed by continued contact with teachers during the academic year. Our goal is to help teachers (i) refine their conceptions of inquiry and "good scientific thinking" and (ii) engage their students in those practices more deeply and consistently. Fostering deeper conceptual understanding is also a goal; but our top priority is helping teachers develop their sense of what counts as learning and understanding science to the point that they can more effectively learn particular content on their own and in other professional development settings.

Summer workshop. Each summer, the teachers in our program meet six to seven hours a day for ten days. During this time, they engage in three main types of activities: their own extended scientific inquiry, discussions about classroom video of elementary and middle school students engaged in inquiry, and activities directly related to their teaching such as planning lessons and discussing assessment strategies.

Many teachers participate in the program for multiple years, so we split the participants into "oldies" (teachers returning to the program) and "newbies." Each year, newbies work through the same, well-tested inquiry units on forces and motion and on basic circuits, co-facilitated by our team and by oldies. In parallel, oldies work on 1-2 day inquiry units, often suggested by and usually co-facilitated by an oldie.

In discussing classroom video, the newbies and oldies often come together, and much of the classroom video comes from the oldies. One of our goals in the summer workshop is to create and reinforce a non-evaluative atmosphere in which teachers share video and student work from their classes. To promote this aim, we try to keep discussion of the videos centered on the substance of the students' thinking, not the teacher's moves. We also focus on students' thinking because inquiry-oriented teaching involves interpreting students' ideas and making them central to instruction, as several NRC reports have emphasized. We want to give teachers a chance to use and refine their skills of attending to students' thinking and reflecting on how they could alter instruction to respond to those ideas. As often happens in the Colorado Physics for Elementary Teachers curriculum, our teachers regularly relate the inquiry they see students doing in the videos to their own reasoning during their inquiry sessions.

Academic year activities. Science and mathematics education researchers studying K-12 teacher professional development have reached a consensus that substantive changes in teachers' classroom practices usually occur after at least a year of sustained professional development. Intensive summer programs can develop content knowledge and alter some beliefs about teaching and learning, but have not been documented to change teachers' day-to-day practices in the classroom. Our program addresses this issue by offering three types of activities during the school year: (1) visits by individual members of our team to the teachers' classrooms, (2) twice-a-month group meetings after school, and (3) monthly evening workshops run by science instructional coaches employed by the county school system but paid by the MSP grant.

1. The teacher and the team member assigned to that teacher typically arrange classroom visits to occur when an inquiry lesson is planned. The teacher decides what role our team member plays: observer, lesson co-planner, or even co-teacher. Many of the teachers use these visits as opportunities to try out new inquiry lessons and to get feedback We also typically videotape these lessons, though teachers have taken more ownership over taping their own teaching over the past two years, even when we are not there.

2. In the first and second year of the project, we planned the group meetings, at which the group focused on issues teachers were having, discussed video from teachers' classes, and sometimes engaged in inquiry about the topics they were teaching. In later years, the teachers have gradually taken the lead in these meetings, setting the agenda and holding the meetings in their own schools (on a rotating basis). As our funding draws to a close, we plan to research how these "professional learning communities" continue to function with minimal support from us.

3. The instructional coaches, all former science teachers in the county, are experts about the county curricula, county resources, and discussion-leading techniques and strategies for fostering students' inquiry. Their workshops and our team's work complement each other. The coaches have also been grooming several of our "star" teachers as teacher-leaders in their schools. This extends the reach of our program.

Our primary means of assessing the program is our (often video-

taped) observations in the teachers' classrooms. Following highly individualized trajectories, most teachers have made progress in the confidence, frequency, and/or skill with which they make space for students' ideas to surface and attend and respond to those ideas. The MSP project as a whole is also analyzing the Maryland State Assessment scores of students of the teachers in our program.

An episode from our first summer workshop

The following episode, summarized from a paper by Gupta et al. that is under review (available at http://arxiv.org/abs/1305.1225), illustrates the open-endedness of the inquiry in which we engage the teachers. We intend this inquiry *not* as a model of what they can do in their own classrooms, but rather to help them develop a sense of what "real" inquiry is so that they can engage their own students in its closest possible approximation, given the constraints of curricula and standardized testing. (Most of the teachers, however, modify and use our inquiry units.)

For several days in the summer of 2009, the teachers had been investigating offshoots of our opening question, which is the only pre-planned part of our newbie "curriculum": *Suppose you're walking at a steady pace, holding your keys in your hand but keeping your hand still compared to your body. You want to drop the keys into a small, low trash can sitting on the floor. Should you drop the keys before you reach the can, directly over the can, or after you pass the can*? Teachers began with extended small-group and whole-class discussions formulating arguments for the different possibilities. These discussions led to experiments which in turn led to more questions and explanations involving gravity, air resistance, and the object's "inherited" forward motion. Through this process, most teachers came to realize that the discourse surrounding experiments is just as important for inquiry as the experiments themselves.

At one point, the teachers decided to drop both filled and empty water bottles out the window of a moving car, to probe the relative effects of air resistance on each. Watching video of their experiment in slow motion, they noticed, among other things, that both bottles landed at about the same time. This led to a discussion in which the teachers brought up a result most of them knew and many of them had taught: a heavier and lighter object dropped from the same height land at the same time. The teachers decided that they didn't understand why the heavy and light object fall together, and that figuring out why could help them understand what was going on with the water bottles. So, they broke into small groups to discuss it.

One small group's discussion was rife with incorrect reasoning of the type usually labeled "misconceptions." At some moments, they thought of gravity as an agent pulling the objects down, rather than as an interaction between the Earth and the falling object. At other moments they thought of gravity as analogous to gasoline, a "fuel" carried by the object. (Gupta et al.'s paper analyzes their reasoning in more detail.) A team member was listening to this group the whole time, but said nothing; neither she nor a "curriculum" nudged the group toward correct notions of gravitational force and inertia.

Reporting out to the whole "class" a bit later, one of the teachers, "Lynn," summarized her group's argument as she currently understood it:

Lynn: Well we were really struggling with the germ of an idea, and we're not totally sure, but, we sort of have the idea that, like if you take a roll of quarters and one quarter, we know that if you drop them, they're going to land at the same time now. And to try to reconcile that, I was trying, we had a couple of analogies, I was trying to think of gravity as a constant force all over the earth, and in order to pull that one quarter down, it takes like two ounces, or two whatever, units of gravity to pull it down. So, when you just lump them all together, it doesn't change the fact that each one of those quarters in that roll is still going to need its little two whatevers of gravity, so putting them together doesn't make it any harder or any easier for it to come down, if each little part still needs that little bit of gravity, so if you thought about that coin roll, and slowly started separating them, just the fact that you're pushing them together doesn't, shouldn't really affect the fact that each need their own little bit of gravity. And we thought about a car as well, we said maybe it takes fifty gallons to move one of those semi trucks a mile. Well, when you add another semi truck to it, it doesn't make it take less energy, for the new space that's been added on, it needs more gasoline, so we kind of think of gravity as this is something that each little amount of space needs a certain amount of to be pulled down, and it doesn't matter if you lump the space together, you pull them apart, it's all going to work the same, if you think of that roll of quarters as just a mess of little quarters put together.

We'd like to point out a few features of Lynn's explanation. First, it contains the same "misconceptions" present in the small-group discussion, with gravity as agent and gravity as analogous to a substance that can make the coins move. Nonetheless, the explanation elegantly accounts for why heavier and lighter objects fall at the same rate; indeed, it's similar to the one Galileo gives in On Motion (1590). Furthermore, this idea led to a more textbook-style explanation of why the heavy and light objects fall together:

Daniel: Well, the eight quarters also have eight times the inertia, right? So it's going to, if they're heavier, they're going to have more mass, so they have more inertia, um, does that factor in?

Andy (facilitator): So, more inertia. So what is inertia meaning for us, you right now?

Daniel: Um, it's going to have, uh, when you drop it, it wants to stay at rest, but gravity's pulling it down, so it's got to overcome that willingness to stay at rest. The more mas-

sive it is, the more it's going to want to stay, to not move.

Andy: So you're saying things that are just sitting somewhere don't want to move, and you're saying the, uh, the bigger heavier thing has more "not want to moviness" to it then a lighter thing, so.

Daniel: Eight quarters stacked together is eight more times not willing to move than one quarter.

Andy: So the eight quarters is eight times as hard to move.

Dave: But that means there's eight times as much gravity pulling it down.

Daniel: Right. And that's why they fall at the same [inaudible]

This episode was typical of our summer inquiry sessions in several ways. Instead of confronting the teachers' misconceptions, we gave them the extra time needed to work through those misconceptions on their own—or actually build on them to make conceptual progress, as Lynn's group did. This often led to frustration, which several teachers disliked; yet teachers also noted, in retrospect, the important role that confusion and frustration play in pushing learning forward.

By giving the teachers more time and agency over the direction of their inquiry than is typical in summer programs for teachers, we hope that they develop a better understanding of the nature of doing and learning of science. Equally important, we want them to feel the joy of taking charge of their own learning in science. Lynn referred back to the coin roll discussion several times in subsequent years as transformative in helping her think of herself as a "science person."

On a personal level, the first year I did this and we did the, one of the things where you drop book and feather, which hits first? And we had to figure out for ourselves how that occurs? What happens? And I, it was very frustrating working through that, but when I actually figured it out for myself, that was probably one of the most exhilarating intellectual moments I've ever had in my life. It was just really astonishing. And then, that was cool because that happened with me that summer, and then I started using it in classroom, and I can see same kind of epiphany occurring with students, and I know how exhilarating and empowering it is to have that kind of experience. So that's probably been the most amazing part.

Andrew Elby, Associate Professor of Teaching & Learning, Policy & Leadership at the University of Maryland, did his doctoral work in Physics and taught high school physics before turning to science education research.

Ayush Gupta, Research Assistant Professor (Department of Physics) and Instructor (Keystone Program, AJC School of Engineering) at the University of Maryland, did his doctoral work in Electrical Engineering before turning to discipline-based education research in physics and engineering.

Luke Conlin, Postdoctoral Scholar in the Graduate School of Education at Stanford University, received a B.S. in astrophysics and taught high school physics prior to pursuing education research, recently completing his Ph.D. in science education at the University of Maryland.

Jennifer Richards is currently finishing up her doctorate in science education at the University of Maryland and continuing work on the (MSP)^2 project as a research associate next year.

Browsing the Journals

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

- Thomas Bensky and Matthew Moelter outline an introductory-level computer analysis of the kinematics and dynamics of a bead sliding on a frictionless wire on page 165 of the March 2013 issue of the *American Journal of Physics* (http://scitation.aip.org/ajp/). Art Hobson argues that the fundamental constituents of relativistic quantum reality are fields, not particles, on page 211 of the same issue. In a short note on page 313 of the April issue, we are reminded of how important it is to keep track of which variables are being kept constant during partial differentiation; that truth is particularly important in statistical mechanics, but the presented example contrasts the partial derivative of the kinetic energy with respect to a generalized coordinate in Lagrangian and Hamiltonian dynamics. Finally, Alejandro Jenkins tells us the history of a fraudulent perpetual motion machine on page 421 of the June issue that fooled even Leibniz and Bernoulli, while Selmke and Cichos draw an instructive analogy between Rutherford and optical scattering on page 405.

- The February 2013 issue of *The Physics Teacher* (http://scitation.aip.org/tpt/) has various descriptions of useful mechanics experiments: using buoyancy to measure the volume of a helium balloon on page 93 and to consider the change in apparent weight of an immersed object on page 96, and using an Atwood machine to measure dry axle friction in the pulley. On page 155 of the March issue, Frank Wang reminds us that a moving clock may not *appear* slow, owing to the finite signal propagation time from the clock to the observer. Speaking of motion relative to observers, that is what is important for the force on moving charges in a magnetic field, as discussed on page 169 of the same issue. Steve Iona reviews the 50 years of publication of TPT at the beginning of the April issue, and Mikhail Kagan solves the classic fox and rabbit chase problem by an elegant use of nonorthogonal coordinates on page 215.

- A short but accurate calculation of Baumgartner's velocity of fall starting from 39 km above New Mexico is found on page 139 of the March 2013 issue of *Physics Education*. Some class demos about surface tension using soap films are presented on page 142. Mark Harrison compares impedance matching of resistors to perfectly inelastic collisions in mechanics on page 207. Ciocca and Wang discuss why moonlight often appears silvery or bluish on page 360 of the May 2013 issue, even though spectroscopically moonlight is redder than sunlight. Also don't miss the contrast between blowing toward a candle from behind a menu, a wine bottle, or a funnel on pages 414 and 416. David Rowland has written another paper in his series about longitudinal motion for transverse string waves on page 225 of the March 2013 issue of the *European Journal of Physics*. Both journals can be accessed at http://iopscience.iop.org/journals.

- I enjoyed Howard DeVoe's contrast of the local and global formulations of thermodynamics in the May 2013 issue of the *Journal of Chemical Education* at http://pubs.acs.org/toc/jceda8/90/5. Be sure not to overlook the online Supporting Information in which he performs a computer-based Eulerian integration of the equations for a pinned vertical piston subject to wet friction (with vacuum on one side and an ideal gas on the other) that is suddenly released while the cylinder is immersed in a constant-temperature fluid reservoir.

- If you make the effort to correct the large number of typos, there are some interesting comparisons of the times required for objects to move vertically due to gravity along various special paths on page 398 of the September 2012 issue of the *Latin-American Journal of Physics* at http://www.lajpe.org.

- The Fall 2012 Newsletter of the *Society for College Science Teachers* has a Teaching Tip by Paul Dolan in which he discusses the wide range of physics phenomena that can be presented using a ball on a string. Find it online at http://www.scst.org/about/newsletters.

Web Watch

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

- Have you seen IBM's incredible movie "A Boy and his Atom"? Start exploring at http://www.youtube.com/madewithatoms.
- The Center for Science and Engineering Education at Lawrence Berkeley National Lab is online at http://csee.lbl.gov. Also check out the Department of Energy's pages of discovery and innovation at http://science.energy.gov/discovery-and-innovation.
- AT&T Labs has researcher profiles, application overviews, and technical documents on their website at http://www.research.att.com.
- The University of California Museum of Paleontology has built a website called "Understanding Science: How Science Really Works" at http://undsci.berkeley.edu.
- The National Science Foundation hosts "K–12 Resources for STEM Education" based on their funded projects at http://www.nsfresources.org. A related set of materials devoted more particularly to applied physics can be found at http://www.teachengineering.org.
- If you often write your own HTML code, as I do, it's helpful to have lists of codes for special characters. A useful one is http://www.w3schools.com/tags/ref_entities.asp.
- John Denker has started writing a much more careful analysis of how an electrophorus works than the usual oversimplified explanations at http://www.av8n.com/physics/electrophorus.htm.
- GlowScript is a software environment for creating 3D animations such as of a stick-and-ball model of an atomic solid. Start at http://www.glowscript.org. Be sure to see the example programs with code.
- A rich trove of procedures and videos presenting materials science labs, divided into basic, intermediate, and advanced levels, can be found at http://education.mrsec.wisc.edu/Edetc/nanolab/.
- Annenberg always has well-crafted instructional materials. Your students may enjoy Amusement Park Physics in classic or flashed formats at http://www.learner.org/interactives/parkphysics.
- Several different pages discuss the Navy's plans to deploy a solid-state laser weapon aboard a ship next year, such as http://www.photonics.com/Article.aspx?AID=53535&refer=LasersNewsletter& utm_source=LasersNewsletter_2013_04_17&utm_medium=email&utm_campaign=LasersNewsletter and http://navylive.dodlive.mil/2013/04/10/solid-state-laser-gun-to-be-placed-aboard-uss-ponce.
- Scientific American has a site entitled "Sixty-Second Science" with minute-long MP3 podcasts at http://www.scientificamerican.com/podcast/podcasts.cfm?type=60-second-science.
- What happens if a meteorite of specified size and density slams into the Earth (hitting water or rock) with a given impact angle and speed? Try simulating it at http://www.purdue.edu/impactearth.
- Lawrence Livermore has a site devoted to fusion energy education at http://fusedweb.llnl.gov/CPEP.
- Amazon probably paid a fortune to buy this small company. Find and create lists of good books on various topics at http://www.goodreads.com.

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