

Forum on Education

American Physical Society

Fall 2015 Newsletter

Beth Lindsey, Editor

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From the Chair

Randy Knight

FEd and COE

With this issue of the newsletter I would like to welcome what we hope will become a regular new feature: A “From the Chair” column written by the chair of the APS Committee on Education (COE). For 2015-16, the COE chair is Carlos Bertulani from Texas A&M University, Commerce.

You may wonder, and rightly so, how the Committee on Education differs from the Forum on Education. It’s a question I’m often asked. Is there a real difference, or is this just a proliferation of acronyms?

The FEd is one of seven APS forums. Each is a membership-driven group of people – any APS member can join – with a common interest that falls outside the research-oriented focus of the APS divisions. A forum, just as in the original Roman forum, is a place where members can communicate, interact, and exchange ideas. Thus the FEd sponsors invited sessions at meetings, publishes a newsletter, gives the yearly Excellence in Physics Education award, and helps support conferences on physics education. Notably, the FEd does not formulate policy or in any way speak for APS when it comes to matters of policy.

COE, in contrast, is a standing committee of APS with a specific charge to “advise the Society on matters pertaining to physics education at all levels, including K-12, undergraduate, graduate, and beyond.” Thus COE helps APS shape policy statements that relate to education, suggests and promotes various education initiatives

that APS undertakes, and provides some degree of oversight and feedback to the APS Office of Education and Diversity. Carlos, in future columns, will tell you more about specific actions the COE is undertaking.

The Chair, Chair-Elect, and Past Chair of the FEd serve on the COE, so that each hand knows what the other is doing, but other COE members are appointed by the APS President-Elect with the advice of the Committee on Committees. If you have an interest in science education policy and would like to serve on the Committee on Education, please send an email to Ted Hodapp, the APS Director of Education and Diversity, at hodapp@aps.org.

In the meantime, you’re receiving this Fall newsletter just before the election begins for two new members of the FEd Executive Committee and a new Vice Chair. You’ll soon be receiving an email with voting instructions. PLEASE VOTE! It only takes a few minutes to vote online, and the strength of our forum depends on an active and engaged membership. I would like to thank the Nominating Committee (Wendy Adams, Scott Franklin, Ken Heller, Ramon Lopez, Carl Mungan, and chair John Stewart) for putting together an excellent slate of candidates.

Randy Knight is Chair of the Forum on Education. He is Professor Emeritus at California Polytechnic State University, San Luis Obispo, and author of the introductory textbooks Physics for Scientists and Engineers: A Strategic Approach and (with co-authors Brian Jones and Stuart Field) College Physics.

From the Editor

Beth Lindsey, Penn State Greater Allegheny

In June of 2015, 60 members of the Physics Education Research (PER) community gathered at the College of the Atlantic in Bar Harbor, Maine, for the 6th biennial “Foundations and Frontiers in Physics Education Research” (FFPER) conference. First held in 2005, and modeled after the Gordon Conferences, this meeting is a “venue for specialists who are active researchers in the field of physics education.” Talks at the conference are all in a plenary format, typically addressing the speaker’s take on the major accomplishments of the field of PER (Foundations) or describing possibly promising research directions (Frontiers). This year, I was honored to be included among the plenary speakers. Other speakers were: Tim Stelzer (University of Illinois – Urbana-Champaign), Homeyra Sadaghiani (Cal Poly Pomona), Warren Christensen (North Dakota State University), Shulamit Kapon (Technion – Israel Institute of Technology), Chandra Turpen (University of Maryland), and Rosemary Russ (University of Wisconsin – Madison). Valerie Otero provided an overview of the themes of the conference and closing remarks on the final day. The plenary sessions are followed by coffee breaks and discussion sessions in which attendees engage deeply with the speakers and with each other.

Afternoons at the conference are spent in smaller sessions. Conference attendees self-organize into groups that examine particular research interests (Targeted Sessions) or explore current issues in PER. This year, the Working Groups included one that attempted to identify a set of Grand Challenges for the field of PER, one examining how issues of race and ethnicity relate to our roles as educators and education researchers, and one that discussed the role, use and importance of theories in PER. The Targeted Sessions included a group that discussed teaching and research related to the Second Law of Thermodynamics. Each of these groups has provided a short write-up of their discussion for this newsletter.

The FFPER conference continues to exist and flourish in part because of the financial support of the Forum on Education, and I believe that I speak for all of the conference attendees in my gratitude for that support. As a member of the PER community, I value the FFPER as a space in which to immerse myself in current research and to form connections and collaborations with other members of the community.

From the Committee on Education Chair

Carlos Bertulani, Texas A&M University-Commerce

To handle issues related to physics education in the nation, the APS has created committees and forums. The society has also hired personnel to advance best practices in physics education and to provide resources and guidance to students, educators, and institutions. Through these organizations, and also by promoting policies regarding the importance of physics education, APS acts in the best interests of American society. Two of these organizations, the Committee on Education (COE) and the Forum on Education (FEd) possess nearly complementary roles.

The COE implements programs, suggests studies, and provides oversight for APS programs that improve physics learning. COE consists of 12 members: the chair, past chair, and chair elect of the Forum on Education plus nine persons selected by the Committee on Committees and appointed by the president elect to staggered three-year terms. Its members meet twice a year for a face-to-face meeting, usually at the APS headquarters in College Park. COE

also organizes a teleconference with its members twice a year. The meetings and conference calls take into account different opinions and ideas on pending tasks and actions on the COE agenda. Common items on the COE agenda include the development and implementation of education policies and the review of applications for the COE-sponsored Award for Improving Undergraduate Education. The most recent meeting occurred on September 26, 2015, in Phoenix, Arizona. This meeting focused on how to implement best practices in physics education.

COE has three subcommittees: K-12 education, undergraduate education, and graduate education. Each subcommittee works separately on their specific area, reviews applications for awards, and makes an assessment of education statistics and of new federal, state, and local education policies. For more on the COE please check out the link www.aps.org/about/governance/committees/coe/

The Forum on Education Election Process

John Stewart – Vice Chair APS Forum on Education, West Virginia University

The Forum on Education (FEd) Executive Committee is in the process of finalizing a slate of candidates for open positions on the Forum on Education Executive Committee. Three new members will be elected this fall and will begin their terms of office at the FEd annual business meeting during the April 2016 APS meeting in Salt Lake City. The three open posts are Vice Chair and two Members at Large; one of the Members at Large must also be an American Association of Physics Teachers (AAPT) member. Members at Large serve three-year terms and the Vice Chair serves for four years. The Vice Chair position is part of the leadership chain and will become in turn Chair-Elect (currently Tim Stelzer), Chair (currently Randy Knight) and Past Chair (currently Michael Fauerbach). The Vice Chair is responsible for the nomination of new members to the executive committee. The Chair Elect is in charge of planning FEd sessions at the March and April meeting. The Chair is in charge of running the Executive Committee and the Past Chair oversees awards and fellowships.

The nominating process started with the last FEd newsletter which included a call for nominations from the FEd membership. The nominating process continues with the formation of a Nominating Committee containing members selected by the current Chair. While the Bylaws call for the committee to contain two members and the Vice Chair, the committee was expanded this year to include six members invited by the Chair and the Vice Chair. This expansion provided additional diversity on the committee and divided the workload of looking through the entire FEd membership for possible candidates for the upcoming election. The AAPT was also invited to provide a member of the nominating committee and did so. The Chair formally sanctioned the committee in August. The FEd membership list was divided among the committee members with each receiving one-third of the membership list. Each

committee member proposed a list of potential candidates. These six lists were combined producing a list of 85 possible candidates. Nominations from the membership were added to the list. Each committee member then ranked each candidate on a scale of 1-5 for the post of Vice Chair and the post of Member at Large. The current Vice Chair then contacts the highest ranked candidates.

As of this writing, the process of contacting candidates is ongoing.

FEd ByLaws Covering the Nominating Process

The Nominating Committee shall consist of the Vice-Chair, and at least two members appointed by the Forum Chair, in consultation with the Vice-Chair, no later than August 1 of each year. All appointed members must be members of the Forum. The Vice-Chair shall serve as the Chair of the Nominating Committee. The APS Chief Executive Officer shall be invited to appoint one member to the Nominating Committee. The term of office for members of the Nominating Committee shall be one year.

The Nominating Committee is responsible for preparing a slate of candidates for each year's election. No later than August 1 of each year, the Vice Chair shall invite, via email or the Forum newsletter, all Forum members to suggest candidates for all positions that will be elected that year. If as many as twenty-five members of the Forum, or 1% of the membership, whichever is larger, suggest the same person for the same office by October 1, that person shall be deemed nominated. The Nominating Committee, taking into account suggestions received from members, shall nominate at least two candidates for each open position. The Nominating Committee shall submit the slate of candidates to the Secretary-Treasurer not later than October 15 of each year.

Director's Corner

Theodore Hodapp, APS Director of Education and Diversity

I have been closely watching the statistics on female participation in physics for more than a decade. During that time I have heard countless claims of “where the problem lies” and how we can address the low representation in our field. To be sure, things have improved since the time I was an undergraduate, but alas we seem to be stalled or even losing ground with undergraduate female participation. So, one of my goals has been to understand, as well as possible, what the situation is, and where we might apply pressure to the system to make sure everyone who wants to study physics can, and that young women feel encouraged to enter and stay in the field.

There is interesting data from a variety of sources, but my most recent discovery is from the Higher Education Research Institute at UCLA. This survey asks first-year students to indicate what field they intend to obtain a bachelors degree. Before seeing this data, I was convinced I would see a larger fraction of women at this stage than those who ultimately obtain the degree (about 20%). Nope.

Twenty percent seems to be where things begin in higher education, and it persists through all degree stages (according to the

Department of Education), and on to assistant professor hires (according to AIP). To me, this indicates the importance more than ever of educating high school physics teachers – teachers who can deliver the message to their young female charges that studying the subject is fun, rewarding, relevant, and that in fact they might be pretty good at it! There is evidence that they are dissuaded even earlier (actually back to elementary school), but high school is where they actually start to form realistic ideas of what they might “do” with their lives.

So, if you are wondering what you can do to impact this issue, I recommend finding out how to educate and support more high school teachers with a solid physics education, and the right tools to excite students about the subject. If you are unsure about this, I recommend checking out PhysTEC (www.phystec.org) or reading a recent Back Page piece I wrote with Zahra Hazari (at Florida International University) in *APS News* (slated to appear in November as I write this). Lets see what we can do to make sure more young women get encouraged to study physics. They might be our next physics majors, our next engineers, or just really good problem solvers in whatever they choose to do – all good!

Undergraduate Research: Programs and Practices That Can Be Used To Grow Research Opportunities

John Mateja, Murray State University

Over the past several decades, the value of engaging undergraduates in research has been increasingly recognized by the physics and astronomy communities. To date, the American Association of Physics Teachers (AAPT), American Astronomical Society (AAS), American Physical Society (APS), Council on Undergraduate Research's Physics and Astronomy Division (CURPA), and Society of Physics Students (SPS) have authored and adopted statements calling for research experiences for all physics and astronomy undergraduate majors. [1]

Making such declarations and realizing them are, of course, not one-and-the-same. It is now incumbent upon us to make research experiences for all physics and astronomy majors, either on our campuses or through off-campus opportunities, a reality. Sharing ideas that have worked on our individual campuses is one way in which we can increase the number of research opportunities for undergraduates across the physics and astronomy communities. This web site, a collaborative effort of AAPT, AAS, APS Office of Education and Diversity, CURPA and SPS, is being created to enable individuals and departments to share practices, funding strategies, internship placement strategies, and course designs with embedded research opportunities, among others that, if adopted by oth-

ers, would work to increase the number of undergraduate research opportunities across the community. Current submissions, briefly described below, can be viewed in their entirety at http://www.cur.org/governance/divisions/_physicsastronomy_research_vignettes/.

Those wishing to contribute to this new physics and astronomy resource may do so by emailing their contribution to John Mateja at jmateja@murraystate.edu. Articles should be submitted as a Word attachment. Articles have no length limit, they may be as long or as short as you need them to be. Articles will be added to this site as received.

Submissions:

Augustana College: The authors of this article present the story of how off-site collaborations can enable the development of robust research programs despite somewhat limited on-campus resources. The article illustrates why these collaborations are not one-sided and describes the advantages to the larger group and institution of developing and participating in such collaborations.

California Institute of Technology: Integrating research into the curriculum has been a daunting challenge nationally for the

education community. The authors describe a “Design and Build” track that was added to the CalTech Advanced Physics Laboratory. Projects are open-ended, team-based (2-3 students) and require the design and construction of an apparatus. Students have worked on a variety of projects, including 1) electrodynamic ion trapping, 2) magnetic levitation and trapping, 3) weak localization phenomena, and 4) holographic interferometry, among others.

State University of New York – Geneseo: In this article, the author – based on his nearly 30 year career engaging undergraduates in research – provides strategies and insights on good practices one can follow that improve academic survival, enhance a career and grow a funded undergraduate research program.

State University of New York – Oswego: The author describes an innovative initiative, called the SUNY Oswego Global Laboratory, that places students in research laboratories around the world. Among others, students have conducted research at the Federal University of Paraiba and the Federal University of Alogos in Brazil, University of Calcutta and Indian Institute for Science in India, and the National Central University of Taiwan.

University of Alaska – Anchorage: In this article, faculty at six partner universities have developed and tested a “Research-Based Science Education” instructional model that gives students in an introductory-level astronomy class an opportunity to do authentic research with real data. Students are recovering asteroids, searching for classical novae in M31, studying semi-regular variable stars, identifying active galactic nuclei in the Faint Images of the Radio Sky at Twenty centimeters survey, and measuring the photometric redshift of distant galaxies in the NOAO Deep Wide Field Survey. Interested instructors are invited to incorporate this approach and these research projects into their teaching.

University of Wisconsin – Eau Claire: In this article the author describes how undergraduate research is supported through the establishment of a “shared use” Materials Science Center and through a campus-wide, student-initiated differential tuition program.

1. All the statements can be viewed on the Society of Physics Students’ web site at <https://www.spsnational.org/about/governance/statements/sps-statement-regarding-undergraduate-research>; the APS Council’s statement can be viewed directly at <http://www.aps.org/policy/statements/14-1.cfm>

Grand Challenges in Physics Education Research

Rachel E. Scherr, Seattle Pacific University, and Stephen Kanim, New Mexico State

Background

Articulating achievable physics education research (PER) goals will promote discussion within the PER community and provide a basis for communication with non-PER physicists and policy-makers. Previous related efforts have included a decadal study to inform improvement of undergraduate physics education [1] and historical studies of physics education research [2]. The formation of the Topical Group in Physics Education Research (GPER) in the APS prompted reflection by the PER community as to what this new presence in APS might mean for physics education researchers (who are currently associated mainly with the PER Topical Group of the AAPT, PERTG). There is a desire to create an occasion for mutual intellectual engagement about issues of physics education, to build a closer link between the PER community and the broader physics community represented by both APS and AAPT. The result is the “Grand Challenges in PER” initiative.

Charge:

Identify ambitious goals for physics education research that will be achievable within seven years and will have significant societal impact.

Societal impact will be in terms of benefit to physics learners, teachers, scholars, and professionals. Alignment with national documents identifying related challenges in STEM education will increase the potential impact. Some sample Grand Challenges might be:

- Identify high-leverage practices in undergraduate education that recruit and prepare future teachers.
- Identify epistemic, cultural, and educational background factors that cause women and underrepresented minorities to avoid physics, and to establish best practice guidelines to minimize these. Develop an understanding of the cultural resources of women and underrepresented minorities and investigate how these resources might inform and improve the culture of science.
- Develop novel evidence-centered design systems for cognitive and non-cognitive aspects of physics learning, including habits of mind that are particularly valued in physics.
- Identify the specialized content knowledge for teaching physics required at different levels, and develop novel measurement instruments to assess it.
- Develop a suite of research-based curricular materials that better align instruction about energy with societal issues about energy and climate and that take into account learners’ initial states and document the effectiveness of these materials.
- Develop models for effective social networks that promote both science learning and identity for majors, and document improvements to retention resulting from application of these models to learning environments.
- Significantly expand the research basis for understanding effective and appropriate instruction in physics for life sciences

majors, and develop initial sets of curricular materials that reflect new goals for these learners.

Purposes

- Inspire physics education researchers to apply themselves to ambitious but achievable goals with significant societal impact
- Engage policymakers with the achievements and ambitions of physics education research
- Educate APS and AAPT members about the field of physics education research. (These audiences broadly represent both educators with an interest in physics and physicists with an interest in education.)
- Educate physics education researchers about non-PER physicists' interests, needs, and knowledge about physics education
- Inform the activities of GPER and PERTG members
- Strengthen proposed projects
- Strengthen professional society efforts to improve physics education for all

Dissemination

The product of the Grand Challenges initiative will be a policy paper. In order to promote the formation of ambitious goals and articulate these goals for the most general possible audience, the primary audience for the Grand Challenges is the President's Council of Advisors on Science and Technology (PCAST). Secondary audiences include policy makers, the members of APS and AAPT, and the PER community.

Leadership

The Grand Challenges in PER process will be carried out by a joint committee of GPER and PERTG and supported by the respective professional societies (particularly APS leadership in the Office of Education & Diversity). The Grand Challenges in PER Committee co-chairs are Rachel Scherr (currently Chair-Elect of the APS GPER Executive Committee) and Stephen Kanim (currently Chair-Elect of the AAPT PER Leadership and Organizing Council).

Membership

The Grand Challenges in PER Committee will be composed of 10-15 individuals representing diverse interests in PER in the USA, including but not limited to physics teacher education, university physics education, qualitative and quantitative approaches to research, small and large research groups, theoretical and experimental work, curriculum development and implementation, and working with diverse populations. Non-PER physicists on the Committee will include leaders in physics education and policy. Agency liaisons will include physics professional society leaders and officers of funding agencies engaged in education and diversity issues. An Advisory Board of about a dozen additional people representing additional professional perspectives will provide input to and feedback on the activities of the Committee, including perspectives from various senior leaders in PER, non-PER physics faculty, and discipline-based education research (DBER) faculty from other disciplines.

References

1. National Research Council, "Adapting to a Changing World - Challenges and Opportunities in Undergraduate Physics Education," National Academies Press, 2013.
2. K. Cummings, "A Developmental History of Physics Education Research," 2011.

Rachel Scherr is a Senior Research Scientist at Seattle Pacific University, where she conducts research on the teaching and learning of energy, among other projects. She is one of the co-organizers of the FFER conference.

Steve Kanim is an Emeritus Professor of Physics at New Mexico State University. He is active in the field of PER, currently serving as Chair-elect of the PER Leadership Organizing Council. His recent research focuses on helping students to develop the skills necessary for the flexible and generative use of mathematics that is essential for physics.

Race, Ethnicity, Equity and PER: A Working Group Summary from FFPER

Angie Little, Michigan State University, and Stephen Kanim, New Mexico State University

What role do physics education researchers play in supporting the field of physics to be a place where all people thrive, a place where we work together to make racism, sexism, able-ism, LGBTQIA-isms, classism, and other – isms unwelcome in our community? To break off a smaller piece of this question, we, the authors, organized a working group focused primarily on race and ethnicity at the 2015 FFPER conference. Before going into the details of our working group, it is important to acknowledge our other colleagues in PER with long-standing commitments to organizing dialogue around race and ethnicity. The conversations we had at FFPER were made possible by their ongoing work.

Our intention with this working group was to discuss race and ethnicity both as they relate to our roles as educators and as education researchers. We hoped to increase the amount and quality of discussion around these issues at the FFPER meeting. We also wanted researchers to consider the impact of speaking (or not speaking) to race and ethnicity in their own research. Although our goal was to focus mainly on race and ethnicity, we sometimes branched out into discussing other aspects of identity. About one-third of the conference attendees joined our two-day working group, suggesting that this issue is one that many are concerned about.

Although both of us have worked on equity issues in physics, neither of us are experts on researching or facilitating dialogue on race and ethnicity in particular. To prepare, we drew heavily on Parks and Schmeichel's survey article: "Obstacles to Addressing Race and Ethnicity in the Mathematics Education Literature." The article highlights the need to consider race and ethnicity not just as boxes to check on demographic surveys, but as nuanced constructs in relationship to broader U.S. culture as well as particular university and classroom cultures. We asked our working group participants to read this article before attending as well. Additionally, we consulted with colleagues more familiar with having thoughtful discussions around identity to develop facilitation strategies. That being said, we communicated to our working group our still novice-level in the area of race and ethnicity dialogue and research.

We began our working group with an identity wheel exercise (See Figure 1, above), asking participants to fill out how they identified and then reflect on what aspects of their identities were most salient to them in their day-to-day life. We then discussed the exercise and our reactions to it. Our participants brought up the idea that they likely had some privilege along whatever dimensions of their identity that they thought about least often (e.g. many of those that put "white" into the race box did not think frequently about their race). We also asked participants to discuss how it felt to list aspects of their identity into boxes in this way. As physics education researchers, we sometimes use race and gender demographic boxes to bin students, and it is important to consider when our research questions might call for more nuanced discussions of

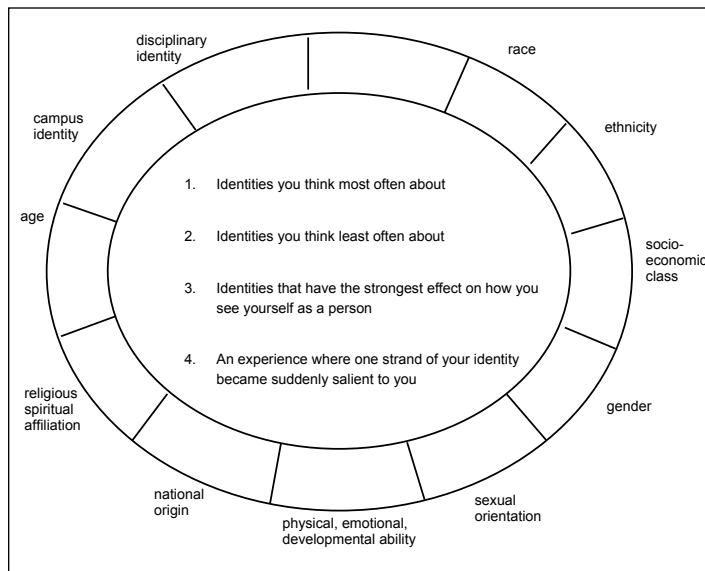


Figure 1. The Identity Wheel Exercise. This is a modified version of Ayush Gupta's identity wheel; many versions of the identity wheel can be found online.

strands of students' identities.

The goal of our second meeting was to spend time listening to undergraduate students, primarily students of color, speak about navigating life on campus. To meet this goal, we watched excerpts from two videos ("If These Halls Could Talk," by Lee Mun Wah, and "Ivy League Trailblazers," by Natalia Osipova) where college students described their experiences with race and ethnicity, and as first-generation students, respectively. In the first set of excerpts, students of color shared the frustration and anguish of trying to be understood and acknowledged on campuses where the faculty and students are predominantly White. In the second video, first generation students (both students of color and white students) across Ivy League universities organized a conference where they could come together to discuss their experiences and support one another. We chose to show this second video to highlight the importance of considering undergraduate students as able partners in working on equity issues. The videos were emotionally difficult to watch, as students shared openly and deeply about issues of race and class affecting their college experiences.

At the end of the workshop we asked participants to reflect on what specific actions they could take to promote equity, and what we as a Physics Education Research community could do to make progress on equity issues. A consensus developed that we should continue this community conversation at future PERC meetings, and we should also invite experts from other fields who have experience supporting effective communication and research about race and ethnicity. At the 2016 AAPT Meeting, there will be a 'Talking about Race' workshop that was spurred into creation by partici-

pants of this working group. In addition, participants planned to pursue opportunities to publish articles about race and ethnicity in physics education.

The working group time was very valuable for us, and we hope that it was valuable for the participants. The PER community is not timid, and at many meetings we are willing to discuss issues on multiple levels: not just as intellectual research constructs, but relevant in personal ways to one's students and oneself. This group was no different, and we were pleased and impressed that people were willing to express personal viewpoints and experiences, and were willing to be vulnerable in order to promote more genuine communication. It was clear that we could have continued these very interesting and often emotional discussions for much more time than was budgeted, and we hope to move the conversation forward at future meetings.

Angie Little is a researcher at Michigan State University. She earned her PhD at the University of California, Berkeley. While there, she co-founded The Compass Project, an APS award winning equity program in the physics department. Little is also a Core Organizer of the recently formed Access Network, an NSF-funded national network to support idea-sharing across equity programs in undergraduate physics. She serves on the APS Committee on Minorities.

Steve Kanim is an Emeritus Professor of Physics at New Mexico State University. He is active in the field of PER, currently serving as Chair-elect of the PER Leadership Organizing Council. His recent research focuses on helping students to develop the skills necessary for the flexible and generative use of mathematics that is essential for physics.

Purpose and Utility of Learning Theory in PER: Report of the FFPER Theory Session

Lauren Barth-Cohen, University of Miami, and David Brookes, California State University, Chico

“He who loves practice without theory is like the sailor who boards ship without a rudder and compass and never knows where he may cast.” “The Notebooks of Leonardo DaVinci” Translated by Jean Paul Richter—1888

Introduction

At the Foundations and Frontiers of Physics Education Research (FFPER) conference held in Bar Harbor, Maine, June 15 – 19, 2015, a working group on theory was formed consisting of roughly 12 members. The group met several times over the course of the conference and discussed concerns and next steps around the role, use, and importance of theories in PER. Although there are many types of theories, including organizational theories and teaching theories, there is often a focus on learning theories. We considered a learning theory to be loosely defined as an explanatory model for how and why change takes place at the level of an individual, collection of individuals or organization.

The working group agreed that the role of learning theory and its development in PER has undergone a change in status over the last 10 years. Learning theory has progressed from a being from being, at best, a tacit part of our work, to playing a much more explicit and central role in the field. At the conference, vigorous discussions centered around whether research in physics education could be conducted free of a theoretical viewpoint. Members of our working group were motivated to challenge the “theory agnostic” paradigm, taking seriously the idea that researchers do approach their work from a theoretical viewpoint, even if it is implicit. We felt that we could be more explicit about our theoretical approaches in our research and writing, and that theory is a fundamental part of our research paradigm. Learning theories influence all stages of the research process from design, data collection, and analysis,

to presentation of findings. They can be complex and it is not always well understood how we build, modify, and integrate theory. Therefore it is not surprising that questions about the practicality of developing and using learning theories along with questions about their utility are common in PER. Many physics education researchers enter the PER field trained in the theories and methods of physics, but less well-versed in learning theories. For those who are new to using learning theory, there is a dearth of available tools and resources, which in turn limits our access to learning theory. Many of our group felt intimidated by the variety and complexity of the learning theories that are currently in existence. Discussions centered around finding entry points into a particular theory. Given these motivations the group broke into three subgroups to address the following questions:

1. Why do we use theories? Why are they necessary or useful?
2. What are the ways in which we build, modify and integrate and use theories?
3. What are the tools or resources we could create to help interested researchers use theories, particularly those who are new to learning theory?

While these questions are not all-encompassing or the only interesting questions we considered, the purpose of this group was not to evaluate or discuss specific learning theories, instead our goals were to think about the purpose and utility of learning theory in PER broadly.

Why do we use theories? Why are they necessary or useful?

The short answer is that theories are useful at all stages of the research process. When running an intervention, such as new instructional technique, theory can provide an explanatory model for why the intervention worked allowing the researchers to move

beyond documenting the fact that it did work. When analyzing data, qualitative or quantitative, theory can direct the researchers for what to pay attention to and what is important in that context. In other words, theory can help sharpen our lens by reducing the experimental space needed to explore and focusing attention on the specific phenomena of interest. This becomes extremely important in complex learning environments like classrooms where the number of things one could pay attention to is potentially overwhelming. Theory helps define the limitations and boundaries of the phenomena of interest and the overall research study. Once the analysis is completed and the research is being presented, theory can help provide justification for the choices made, it can also increase or decrease the credibility of the research. It can assist us to generalize our results to similar or different contexts and learning environments. The incorporation of PER results into physics classrooms could be advanced by organizing the multitude of empirical findings in PER into more general theories of learning. Generalizable learning theory could make PER more accessible to those who want to transform their classrooms and the learning outcomes of their students. Finally, we as researchers all have assumptions about what we find valuable and important and these assumptions guide our work. Often these assumptions are implicit, but theory can aid us in making these assumptions explicit; making assumptions explicit is important for questioning them and helping others understand our assumptions and how they influence the research, which is important for understanding the findings, their contribution and limitations.

What are the ways in which we build, modify and integrate and use theories?

The group that discussed this sub-topic veered away from the question and towards the challenges that educational theorists in PER face. We concluded that there is a need for more awareness within the community that theory-creation work counts as worthwhile research, and should be acknowledged in publication venues. We observed that many proceedings, journals, conference proposal forms, etc. seem to assume that all research is experimental and will involve data analysis. Yet, many of us felt that theory-creation should be viewed as valuable intellectual contribution. These concerns were split into two veins: (a) Working with the research community to encourage the valuing of and paying attention to theory, and (b) Working to develop and improve a theory. In other words, “using” theory vs. “making” theory are both valuable intellectual contributions to our community and many of us felt that they should be recognized as such.

What are the tools or resources we could create to help people use theories, particularly those who are new to learning theory?

The group discussed tools and other resources that could help researchers use theories. There are an abundance of reviews, books, and papers available in the broader educational community (one particularly good one the group discussed was Eisenhart, 1991), but finding and/or making sense of them without a mentor can be challenging for any researcher attempting to coordinate new theories with their own research program. As such, several mecha-

nisms for organizing and translating these articles for the specific contexts of PER were suggested: One option would be a series of review articles that highlight different theoretical frameworks and are written as a primer to each. Another option proposed would be to invite a group of authors to collaborate on a series of short papers around different theoretical frameworks and structure those papers around key questions that cross-cut theoretical frameworks (e.g. What counts as learning? What kind of empirical data is employed and how is it analyzed?). Challenges may include finding authors with relevant expertise and the difficulty of condensing inherent complex theories to a short summary. Yet, if these challenges could be sufficiently mastered the payoff would be more access points for researchers who are new to using learning theories.

Conclusion

Although there is no silver bullet for the challenges we face in developing and using learning theories, the group felt strongly about the importance of learning theories in PER. We recognized that work is needed to continue finding entry points for new researchers into learning theories and for the community to support members in using theory in all stages of the research and dissemination process.

Acknowledgements

We would like to thank all members of the working group, and particularly Leslie Atkins Elliott, Ian Beatty, Rosemary Russ, and Ben van Dusen for their contributions to this working group report.

Members of the “Theory” working group include: Leslie Atkins Elliott, Lauren Barth-Cohen, Ian Beatty, David Brookes, Jesper Haglund, Shuly Kapon, Cedric Linder, Valeria Otero, Rosemary Russ, Ellie Sayre, John Stewart, and Ben van Dusen.

Reference

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Lauren Barth-Cohen is a Research Assistant Professor in the department of Teaching and Learning at the University of Miami. She has a PhD in Science and Math Education from the University of California, Berkeley, and completed a post-doc at the University of Maine. Her research interests include conceptual change in science, physics education, and student and teacher learning through scientific practices.

David Brookes is a faculty member at California State University, Chico. He has a PhD in physics with an emphasis on Physics Education Research from Rutgers University, and he has post-doctoral experience at the University of Illinois at Urbana-Champaign. His primary research interest is in the interplay between language and cognition and how it plays out in the physics classroom.

Teaching and Learning the Second Law of Thermodynamics

Jesper Haglund, Uppsala University, and Abigail R. Daane, Seattle Pacific University

We organized a Collaborative Group session on the topic of “Teaching and learning of the second law of thermodynamics”, as part of the 2015 Foundations and Frontiers of Physics Education Research conference. The Collaborative Group included nine participants, representing a wide range of institutions:

- Abigail R. Daane, Seattle Pacific University
- Benjamin W. Dreyfus, University of Maryland
- Paul Emigh, University of Washington
- Benjamin D. Geller, Swarthmore College
- Jesper Haglund, Uppsala University
- Beth Lindsey, Penn State Greater Allegheny
- David E. Meltzer, Arizona State University
- Trevor I. Smith, Rowan University
- John Thompson, University of Maine

The intended purpose of the session was to compare notes on teaching approaches, and to identify potential research opportunities in the area of the Second Law.

We found a great variety in instructional practices associated with the second law of thermodynamics, both in terms of scope and approach regarding the topic. At the University of Maryland, instructors have increased the emphasis on the second law in the physics course for life science students, starting off with Gibbs free energy. On the opposite end of the spectrum, Arizona State University has omitted the second law entirely in introductory physics courses. Our impression is that the second law of thermodynamics is one of the least standardized topics in introductory physics teaching.

One particular challenge in teaching and learning the second law is the abstract nature of the concept of entropy. There is no consensus about the “proper” way to introduce the concept of entropy. Some argue that if we cannot find a way to teach it that allows our students to be less confused upon leaving our courses than they were when they began, we should not teach it at the introductory level. On the other hand, students have many ideas about energy from their everyday lives, (e.g., sociopolitical or biophysical per-

spectives), which could be used productively in learning about the second law of thermodynamics.

Some participants suggested that introductory physics could incorporate ideas from engineering/biophysics/sociopolitical focuses on thermodynamics, such as the concept of exergy, free or available energy, and different efficiency measures, addressing practical and environmental implications of the second law of thermodynamics in a more qualitative way. As an example, students could investigate the inefficiency of heating their homes with direct electrical heating (basically a set of toasters wasting high quality energy).

Given the highly diverse range of teaching practices designed for learning about the second law of thermodynamics, there exists an opportunity to research the effectiveness of the different teaching approaches at the introductory and advanced levels across a variety of universities and colleges. However, the standardized concept inventories about thermodynamics are few, and the ones that are available are context specific. It may be difficult to compare the different populations because of their contrasting learning goals and desired outcomes.

Jesper Haglund is a post-doctoral scholar in the Department of Physics and Astronomy at Uppsala University in Sweden. His primary research focus is on the teaching and learning of thermal science, particularly on the teaching and learning of entropy. In 2015, he helped to organize a special issue of the International Journal of Science Education on Conceptual Metaphor and Embodied Cognition in Science Learning.

Abigail Daane is an Assistant Professor of Physics at Seattle Pacific University. Her research focuses on K-12 teacher understanding of energy, particularly with respect to conceptual metaphor, energy dissipation, and energy degradation. Abigail has been an instructor for preservice teacher education courses and inservice teacher professional development. Previously, she served as a secondary science teacher.



Section on Teacher Preparation

Alma Robinson, Virginia Tech

After years of anticipation, Cody Sandifer and Eric Brewé have published *Recruiting and Educating Future Physics Teachers: Case Studies and Effective Practices*. Sponsored by PhysTEC, this peer-reviewed volume consists of invited and contributed chapters that are intended to be a practical guide for effective physics teacher preparation programs. In the following article, Sandifer and Brewé outline the structure of the book and summarize the key themes that emerged from their case studies.

If you are an avid reader of the Teacher Preparation Section, you know that many of the institutions that we feature are PhysTEC supported sites. In 2014, PhysTEC widened their support model by trying something new: recruiting grants of up to \$10,000 per year for three years to help develop strategies for recruiting future physics teachers. In this issue, we highlight three of the nine sites that were selected for the first round of recruiting grants.

Steven Maier and Jenny Sattler of Northwestern Oklahoma State University (NWOSU) explain how four Oklahoma schools joined together to answer the request for proposals and created the OK PhysTEC Collaborative. Since receiving funding, NWOSU has developed an updated physics minor, a bridging course for students who have taken the algebra-based physics sequence to tran-

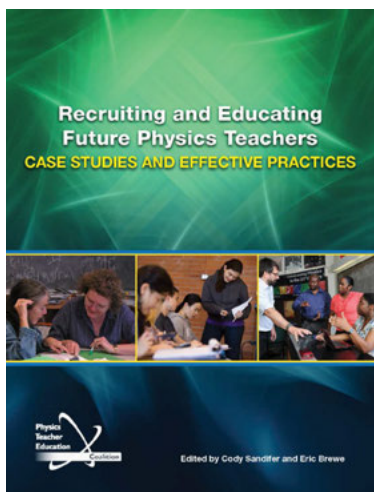
sition to a physics minor without also needing to take the calculus-based introductory sequence, and new pathways for students to become certified to teach high school chemistry and/or physics upon graduation.

Jay Wang, Stephen Witzig, Grant O'Rielly, and Alan Hirshfeld of the University of Massachusetts Dartmouth describe how PhysTEC support has helped them create a streamlined pathway for students to become licensed high school physics teachers through a five year, Physics BS/MATi degree program. In addition to the new degree program, UMass Dartmouth has hired a part-time Teacher in Residence as well as implemented new recruitment strategies to help attract future physics teachers.

Finally, Gail Welsh, Starlin Weaver, and Matthew Bailey discuss how Salisbury University's (SU) recruiting grant has allowed them to attract more students into their existing secondary education track. Although SU's secondary education program was excellent, only a few students graduated from the track. Through targeted marketing, early teaching experiences (both at SU through their Supplementary Instruction program and at local K12 schools), and the help of a part-time Teacher in Residence, their students have shown increased interest in teaching.

Book Release: Recruiting and Educating Future Physics Teachers: Case Studies and Effective Practices

Cody Sandifer and Eric Brewé



To solve the dramatic shortage of well-prepared high school physics teachers, it is essential that physics departments play an active role in recruiting, advising, and supporting prospective teachers. With the number of high school students enrolled in physics doubling in the last 20 years, the need is especially critical now for the physics community to step up to this challenge. With this in mind, we are pleased to announce our new edited book published by the American Physical Society: *Recruiting and Educating Future Physics Teachers: Case Studies and Effective Practices*.

Three years in the making, *Recruiting and Educating Future Physics Teachers* is a peer-reviewed volume sponsored by the Physics Teacher Education Coalition (PhysTEC) that provides a practical guide to innovative, state-of-the-art programs. It includes papers in the following areas:

- Preparing Future Physics Teachers: Overview and Past History
- Case Studies of Successful Physics Teacher Education Programs
- Recruiting and Retaining Future Physics Teachers
- Structuring Effective Early Teaching Experiences
- Preparation in the Knowledge and Practices of Physics and Physics Teaching
- Mentoring, Collaboration, and Community Building

The book contains both invited and contributed chapters. Beyond descriptions of teacher education programs and activities, there is a strong emphasis throughout the book on implementation advice, ongoing challenges, and lessons learned. The book's intended audience is physics department chairs and faculty, as well as education faculty who are engaged in physics teacher preparation. The book is freely available for download at: www.phystec.org/web-docs/EffectivePracticesBook.cfm.

Invited Book Sections

We begin by providing summaries of the first two book sections, which primarily consist of invited chapters.

Section 1: Preparing Future Physics Teachers: Overview and Past History

The book begins with the overview article “Characteristics of

thriving teacher education programs,” by Stamatis Vokos and Ted Hodapp. In this comprehensive summary, the authors argue that physics departments play a critical role in teacher recruitment and preparation. The authors draw on their combined experiences as chair of the Task Force on Physics Teacher Preparation and director of the PhysTEC project (2004–2014), respectively, to outline eight key components of highly successful programs. These components emerged from 15 years of ongoing site visits to successful secondary physics education programs throughout the nation. Detailed examples from universities across the United States are provided to exemplify each component.

Many of the program revisions chronicled in the book are grounded in the authors' participation in the PhysTEC project. In the second article in this section, “Physics Teacher Education Coalition,” Monica Plisch—the current director of PhysTEC—describes the purposes, structure, and necessary activities of the project. The third and final paper in this section is a contributed paper, “The roots of physics teaching: The early history of physics teacher education in the United States,” by Amanda Gunning and Keith Sheppard. This is an enlightening synopsis of physics teacher education from the post-Revolutionary period to the Second World War.

Section 2: Case Studies of Successful Physics Teacher Education Programs

It is common practice in the education field to select an institution (“case study”) and thoroughly document its successes, failures, key personnel, program structure, and institutional context. In reading such articles, members of the community can scrutinize the case study and decide whether the institution's programs and activities might be adapted for use at their home institutions.

We took a case study approach in this book by inviting authors from respected physics departments at Seattle Pacific University, the University of Arkansas, and Middle Tennessee State University to publish the case studies of their teacher preparation successes. Healthy enrollments in their preservice teaching programs and impressive graduation rates provide convincing evidence of the success of their reform efforts.

The case studies are strikingly similar in that all three institutions experienced long droughts of student interest in their respective secondary physics education programs, after which programmatic changes, attitudinal shifts, increased communication, and concentrated recruitment efforts led to dramatic upswings in physics majors choosing high school teaching as a career.

Contributed Book Sections

We outline below the common themes in the remaining book sec-

tions, all of which contain contributed chapters.

Section 3: Recruiting and Retaining Future Physics Teachers

A secondary physics education program cannot thrive without active recruitment and retention, both of physics majors and physics education majors. The articles in this section serve to emphasize this point. It is not sufficient to hope that students will find their way into a preservice teaching program, or be retained in such a program, without help or guidance. Strong recruitment and retention measures must be put in place, or an institution's preservice physics teacher programs will fall short of faculty and administrator expectations.

The contributors to this section suggest that recruitment and retention activities should include expected advertising avenues, such as posting flyers in hallways and classrooms, but also novel approaches that include physics course reform, the creation of physics-specific teaching methods courses, early teaching opportunities, collaborations with area schools and teachers, an increased focus on teaching-oriented advising and mentoring, and the hiring of faculty and staff—including current or retired high school teachers—whose primary responsibility is to support the teacher education program.

Section 4: Structuring Effective Early Teaching Experiences

This section reinforces the idea that early teaching experiences (ETEs) can be used to recruit and retain future high school physics teachers, and can benefit the sponsoring physics department in terms of increased student learning and incremental course reform. ETEs can be structured in a variety of ways, and no single structure works for all physics departments. ETEs can be embedded in both classroom and non-classroom contexts, for instance, and can be organized as Learning Assistant programs, teaching institutes, and early teaching courses that place interns (potential teacher candidates) in different K-12 teaching environments.

Common themes include the observation that the ETEs should be led by physics department personnel, rather than led by outside departments or organizations, and that successful ETEs tend to share common characteristics: careful and in-depth lesson planning, intern participation in “active learning” lessons, explicit reflections on teaching and learning, the involvement of practicing or retired master K-12 teachers, and close faculty or staff supervision.

Section 5: Preparation in the Knowledge and Practice of Physics and Physics Teaching

It is essential to avoid a common pitfall of teacher education reform, which is to assume that the extent of the physics department's involvement in teacher preparation begins and ends with ensuring that a sufficient number of physics course credits are included in the secondary education track or concentration. While content preparation is a crucial component in the preparation of preservice teachers, the authors in this section share a common vision that other factors must also be considered. These factors include the manner in which core physics courses are taught, student participation in physics research and scientific practices, the connections between content understanding and effective instruction, and the respecting and fostering of genuine scientific curiosity and creativity.

Section 6: Mentoring, Collaboration, and Community Building

This section begins with a compelling summary of the powerful roles that Teachers-in-Residence (expert high school teachers) can play in reinvigorating teacher education programs, and continues with persuasive descriptions of how far-reaching mentoring practices, faculty-sponsored learning communities, and a series of physics-specific teaching methods courses can positively impact preservice physics teacher education. Also suggested are steps that research-intensive institutions might take to enrich and expand their physics departments' teacher education efforts.

Conclusion

We thank the chapter authors for sharing the wonderful teacher education activities occurring at their home institutions. It is their dedication to the recruitment and education of future physics teachers that made this book possible. Some information in this book will be surprising, and some will be applicable to your physics department (or not) depending on your institutional supports and constraints—but hopefully each article will be thought-provoking and useful in your mission to address your local physics teacher education needs.

Dr. Cody Sandifer is a K-16 education specialist in the Department of Physics, Astronomy & Geosciences at Towson University, Maryland.

Dr. Eric Brewé is a Physics Education Researcher in the Teaching and Learning Department and STEM Transformation Institute at Florida International University.

The OK PhysTEC Collaborative: A New Physics Teacher Certification Pathway Emerges

Steven J. Maier, Chair, Department of Natural Science, and Professor of Physics, Northwestern Oklahoma State University
Jenny Sattler, Assistant Professor of Physical Science, Northwestern Oklahoma State University

Who knew that in a rural state where entire counties are devoid of high school physics, an initiative for Physics Education would sprout from fertile ground? Such is the story of Northwestern Oklahoma State University's (NWOSU) physics education program. In hindsight, the development began in 2008 with a simple, state-level data request. Rubber hit the road in 2011, and real tangible programmatic change began in 2014—coinciding nicely with our PhysTEC Recruitment Grant.

The backstory and motivation for this change involves exploratory research findings from the State Department of Education beginning in 2008. Data were collected on how many annual statewide certification attempts there were in high school physics teaching, the number of active high school physics teachers in Oklahoma, and the number of high schools offering physics regularly. We found that the trends from state reported data were bleak and inconsistent with national trends; each is in steady decline in Oklahoma.

NWOSU's total enrollment is around 2,200 students, whom are heavily recruited from surrounding counties in the tristate area. At NWOSU, the Department of Natural Science houses biology, chemistry, and physics programs. Until recently, academic majors and minors were only possible in biology and chemistry. Further, although our science education program was accredited, it was only possible to obtain certification to teach high school biology.

To transition the story from one of commiserating to one of action, we will now continue by explaining how we initiated change in a small way, directed at something we knew we could impact: K-12 in-service teacher support. We began hosting AAPT/PTRA summer institutes in 2011 (www.nwosu.edu/ToPPS), funded by the Oklahoma State Regents for Higher Education. At first, the Teachers of Physics and Physical Science (ToPPS) institute only provided professional development in physics. However, subsequent institutes evolved to establish a network of teachers and eventually to become a means of encouraging repeat attendees to earn their certification to teach high school physics.

In 2013-2014, a fortuitous sequence of events occurred: Teacher education program accreditation responsibilities required a reassessment of our biology teacher certification program. Through the process, it became clear just how straightforward it could be to add separate physics and chemistry education programs to the catalog without much extra draw on university resources. After polling other institutions for feedback and details of their programs, it was apparent there were faculty members at other Oklahoma institutions who were interested in collaborating on a physics teacher education program to help cope with low enrollments. In addition,



NWOSU announced the opening of a new tenure-track faculty position in physical science.

In surprisingly short order, these separate pieces dovetailed into a joint PhysTEC Recruiting Grant proposal. NWOSU took the lead as author, with collaborators from East Central University, Oklahoma State University, and Southwestern Oklahoma State University. As a collaborative, we have a healthy knowledge base and can share our extensive experience with successful programs that promote physics education (such as ECU's Oklahoma State Science & Engineering Fair, NWOSU's ToPPS, OSU's OSUTeach, SWOSU's STEM camps, to name a few).

Since becoming a PhysTEC supported site in 2014, three key benchmarks were achieved to serve as a foundation for physics education at NWOSU:

1. The physics minor was revitalized and reinstated,
2. A bridging course for majors of other disciplines to transition to a physics minor was created, and
3. Pathways were created for students to become certified to teach high school chemistry and/or physics upon graduation.

With a new tenure-track physical science faculty member on staff at NWOSU, a door was opened to reinstate the physics minor. Our newest faculty member is qualified to offer upper-level physics and bio-physics courses that pre-health students may take as electives. By cross-listing a selection of these new courses, we fulfilled a need for multiple programs in our department. Because the new physics minor's elective hours now permit medical physics coursework, we hope these course offerings will make a minor in physics an attractive option for traditional biology, chemistry, and mathematics majors.

One way to make the physics minor and physics teacher education degree more accessible to students who are changing majors was

to create a path that made use of the algebra-based sequence that was already completed by them. To this end, we developed the bridging course, PHYS 2011. If a student completes the algebra-based physics sequence followed by this single credit-hour bridging course, then that student will not have to complete the calculus-based physics sequence for the physics minor or the physics teacher certification program.

Within the current structure of accredited teacher education programs at NWOSU, required core discipline courses is commensurate with an academic minor. We capitalized on this by re-envisioning the physics minor as a means for creating a physics teacher certification pathway. With the continued success of the ToPPS program and the alignment with NWOSU's mission, our administration supported the proposal for adding physical science teacher certification programs in chemistry and physics. We can now say we are addressing the physics teacher shortage at both ends: in-service professional development and a new pre-service program.

In short, the resources from PhysTEC have been tremendously helpful in our efforts. While progress had already been made beforehand on a different but related front, the PhysTEC Recruitment Grant served as a catalyst for greater change. With PhysTEC leadership, we developed a physics education program and have proceeded with a Learning Assistant program this fall. With their financial support, we are now positioned to actively recruit physics education candidates statewide and feel we are a part of a supportive community.

Steven Maier is a full time physics faculty member at NWOSU and is currently the chair of the Department of Natural Science. He is the director of NWOSU's Science Education Programs, serving as a member of the Teacher Education Faculty.

Jenny Sattler is a biomedical physicist who joined NWOSU as a full time physics faculty member in 2014. She has taken active roles in program modifications to make the physics minor more applicable and accessible to science majors of other disciplines.

The PhysTEC Project at University of Massachusetts Dartmouth

Jay Wang, Stephen Witzig, Grant O'Rielly, and Alan Hirshfeld, University of Massachusetts Dartmouth

Background and departmental profile. We are a relatively small Physics Department at UMass Dartmouth, offering both BS and MS degrees. The number of physics Bachelor's degrees awarded ranges approximately from 5 to 10 per year, with an average of about 7, slightly above the national average for Master-granting departments of our size according to the American Institute of Physics (AIP) survey data (AIP Statistical Research, <http://www.aip.org/statistics>). The number of Master's degrees conferred typically varies around 6 to 8 per year, placing the Physics Department consistently among the most productive of Master-granting departments in the country by the AIP data. While most graduates from both the bachelors and masters programs go on to Ph.D programs, we see a small but consistent fraction of undergraduate, and a somewhat larger fraction of master's students, choosing to become high school physics teachers. Historically, the majority of these students found alternative pathways towards teaching after seeking preliminary or emergency licenses.

With the PhysTEC recruiting grant, our focus is to increase the number of qualified physics teachers through targeted recruiting and streamlined pathways for teacher preparation. The overall goal is to attract students to physics teaching by moving away from an ad-hoc basis by developing a better-defined pathway towards licensure. Of course, these changes are not completely altruistic. Like many small physics departments, despite the data showing that we perform above national averages by most metrics, we are still under pressure from campus administrators to grow our programs. To that end, we have been intensifying our efforts to

increase the number of physics majors by reforming the physics curriculum and adding a new astronomy-astrophysics option. The PhysTEC project is a natural expansion of our continuing effort to grow both the number of physics majors as well as the base from which to recruit physics teachers.

The PhysTEC project. It is with this background that we embarked on the current project (from 2014 to 2017). The project is a collaborative effort between the Physics Department and the STEM Education & Teacher Development (STEM ED & TD) Department. We are fortunate to have a close working relationship with an enthusiastic STEM ED & TD faculty, stemming from partnerships in various prior projects. This project has the following major components.

Streamlined pathways: We proposed that the Physics and STEM ED & TD Departments work together to streamline the pathways to becoming a fully licensed physics teacher in a five-year program. Previously, physics graduates would enter teaching after graduation and through alternative routes. We put concerted effort into aligning the BS & MS programs with a formal plan of study which leads to Physics BS/MATi (4+1 pathway) degrees. This carefully designed, intentional program replaces the ad-hoc routes students have previously taken.

We have established the Physics BS/MATi as a 5-year pathway between the Physics and STEM ED & TD Departments where undergraduate Physics majors can take 15 credits towards their 30

credit MATi starting in their junior year. These credits count toward both their BS in Physics and their MATi. The 4+1 pathway leverages existing physics courses on teaching pedagogies and other related electives so that students can take courses to suit their individual interests. After the 5-year Physics BS/MATi program, a student will be well prepared in both physics content and education courses to be a highly qualified and certified Physics teacher. It should also be noted that the students in this 4+1 program complete the full complement of undergraduate physics courses and could, if they wished, continue into a graduate program in physics after completing the BS degree.

Recruiting strategies: Empirical data show that about 10-15% of physics students nationwide become physics teachers. To increase teacher production, recruitment is broadly directed at increasing the base population of Physics majors and therefore the number of potential teachers from that base.

For high school students, the plan includes working with University Admissions to more aggressively market our physics programs, including the 4+1 pathway, and highlighting this program to prospective students during University open houses. We are also



Figure 1. A SNEPA meeting and the TIR (right) engaging participants in a physics demo.

implementing some successful recruiting strategies that were highlighted at the 2015 PhysTEC Seattle conference and workshops. To bring awareness of the program to high school students via outreach programs, we have made a conscious effort to connect with local high school physics and science teachers, attend meetings and conventions of Massachusetts science educators and affiliates, and publicize our teacher preparation programs. An integral part of our outreach effort is the Southeastern New England Physics Alliance (SNEPA), which we resurrected as a part of the PhysTEC project. Most SNEPA participants are high school physics teachers who share both their best practices and their challenges in physics teaching (see Figure 1). They are ideal ambassadors for our recruitment effort. Two SNEPA meetings were held in year one of the grant; these were well received and attended.

For the students already on campus, the plan targets students taking the introductory physics courses (approx. 500 per semester), especially the engineering undecided students, by encouraging them to consider options in physics (major or minor), including the 4+1 pathway. The project faculty and teacher in residence (TIR) visit each of the classes and use supporting career data to make a pitch about the benefits of physics and physics teaching. The physics majors are made aware of the 4+1 pathway through individual advising and personal interactions. Once accepted into the 4+1 program, typically at the end of the sophomore year, the student will be assigned a second advisor in the STEM ED & TD Department who advises the student through the graduate portion of their program. This co-advising model is designed to support the students toward Physics teacher licensure.

Teacher in residence: Previous PhysTEC sites (see <http://www.phystec.org/keycomponents/>) have shown that the teacher in residence (TIR) is a key component in the success of teacher preparation programs. Our project has a part-time TIR who is an experienced, enthusiastic, and distinguished teacher from the South Coast region of Massachusetts. The TIR is a vital presence in the Physics Department and a resource for aspiring teachers by engaging with physics students interested in physics teaching, speaking to the students in our Freshman Seminar and Teaching Pedagogy courses, as well as visiting the introductory physics classes to speak about the wonder, reward, and challenges of being a physics teacher. The TIR has also been heavily involved in the local science organizations and outreach activities such as the SNEPA (Figure 1).

Success and challenges. We have just completed Year 1 of the PhysTEC project. We have formalized the 4+1 Physics BS/MATi pathway program; generated awareness among current students that physics teaching can be a rewarding career path and is one that is in high demand; created a supportive environment between the TIR and physics students; and increased the connection and presence of the Physics program in surrounding communities through various outreach activities. We have already attracted three students into teaching and the 4+1 program.

We still face some challenges, including the fine-tuning of our recruiting strategies to increase the base number of physics majors. We are also seeking additional financial resources, including further grant proposals (such as a substantial Noyce proposal recently submitted), to support students interested in physics teaching. These resources would help fund our project, specifically the Learning Assistant program, which places students in physics classrooms in support roles.

We are encouraged by the success of our efforts to date, which was made possible by the support of the PhysTEC recruiting grant. We look forward to working with each of our student recruits as they progress on the pathway to becoming physics teachers, and we also value the contribution that our in-service physics teachers, including our TIR, play in this effort.

Jay Wang, PhD in theoretical physics, is an associate professor in the Physics Department. His research interests are in atomic and computational physics. He is the author of a new textbook "Computational modeling and visualization of physical systems with Python," (Wiley, 2015).

Stephen Witzig, PhD in science education, is an assistant professor in the STEM Education & Teacher Development Department. He conducts research in teaching science, scientific practices, and bridging research relationships among scientists, classroom teachers, and science teacher educators.

Grant O'Rielly, PhD in experimental physics, is an associate professor and chair of the Physics Department. His research interests are in the area of Intermediate Energy Photonuclear Physics, with special emphasis on few-body nuclear physics and pion photoproduction.

Alan Hirshfeld, PhD in astronomy, is a professor in the Physics Department. He conducts research in the history of physics and astronomy. He is the author of several highly acclaimed books including "Starlight Detectives: How Astronomers, Inventors, and Eccentrics Discovered the Modern Universe," (Bellevue Literary Press, 2014).

Salisbury University PhysTEC Recruiting Grant Project

Gail S. Welsh, Department of Physics, Salisbury University

Starlin D. Weaver, Department of Education Specialties, Salisbury University

Matthew A. Bailey, Department of Physics, Salisbury University

Salisbury University (SU) is a regional comprehensive Maryland public university with an enrollment of approximately 9000 total students. The Physics Department offers a Bachelor of Science (B.S.) degree in physics, which may be completed through one of five tracks: Secondary Education, General Physics, Engineering Physics, Microelectronics, and Dual Degree Transfer Physics & Engineering. The tracks are flexible and allow a student to change from one track to another with ease during the first two years. The secondary education track was established in 2002, and we had our first graduate of the program in 2007. In total, we have approximately 100 physics majors, and the majority of the students entering SU as physics majors express an interest in engineering. Historically, we haven't done any specific recruiting for the secondary education track.

The secondary education track is a collaborative program between the Departments of Physics and Education Specialties. In addition to the typical physics core courses, the physics secondary education track includes courses in related sciences, laboratory safety, education foundations, technology in education, inclusive instruction, classroom management, a two-semester sequence of science and reading methods in middle and high schools, and the teaching internship at one of our Professional Development Schools (PDS) and the associated seminar. Students are also required to pass both the Praxis II Physics Content exam as well as the Principles of Learning and Teaching exam for Grades 7-12 for program completion and graduation. Students in the secondary education track are assigned to an advisor in physics and an advisor in education. Through the School of Education, SU offers a second route to teacher certification in physics: the Master of Arts in Teaching (MAT) program. Students with an earned degree (in physics or

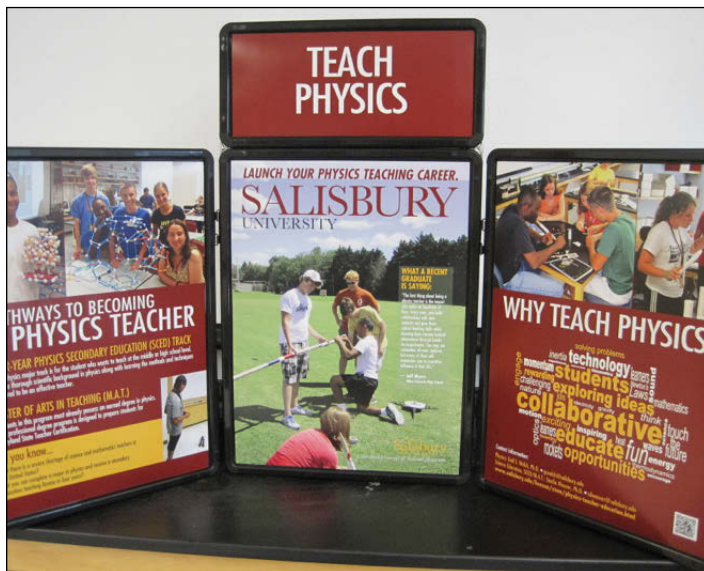
equivalent physics course work) can enroll in the MAT program. Students in both the undergraduate and graduate program are given substantial mentoring by their advisors while at SU to assure their retention in the program. They also develop significant skills in pedagogy, assessment, and classroom management. These skills are critical for their continuation and success in the profession.

Our recruitment plan consists of three inter-linked parts: marketing, early teaching experiences, and a part-time teacher in residence (PT-TIR).

Marketing

Our marketing efforts are both internal and external. Internally we are raising the awareness among students and faculty. For example, we hosted a seminar, "Teaching Physics and Chemistry as a STEM Career," in our Physics/Chemistry Seminar series. This was a panel discussion with a veteran high school physics teacher; a retired high school physics and physical science teacher, who is also our PT-TIR; a second year chemistry, physics, and environmental science teacher; and a physics MAT student intern. The seminar, which was attended by 15 students and 15 physics and chemistry faculty, provoked interesting discussions about teaching careers. We are also developing advising tools for our faculty advisors to use in help guiding students who are considering changing tracks from engineering or general physics to secondary education.

For external recruiting, we have produced a tri-fold display board highlighting physics teaching and are in the process of designing promotional materials, such as brochures, to be used at various recruiting events. We will distribute these materials to incoming physics majors and students in the STEM living and learning community, to local high school college/guidance counselors and science teach-



Salisbury University's Recruiting Display

ers, and to SU admissions, career services, and advising services coordinators. We also recruited at the two-week summer Freshman Orientation, Admission Open Houses, and the Undeclared Majors Fair. Finally, we are developing an online presence with a Physics Teaching website as well as Facebook and Twitter pages.

Early Teaching Experiences

SU has a strong Supplemental Instruction (SI) program. SI is a learning enhancement program designed to organize and improve ways in which students prepare for class outside of class (University of Missouri-Kansas City International Center for Supplemental Instruction (2014), Overview of Supplemental Instruction, <http://www.umkc.edu/asm/si/overview.shtml>). SI provides weekly, peer-facilitated sessions led by SI leaders. In addition to attending all class sessions, SI leaders develop and facilitate study sessions with a focus on connecting “how-to-learn” with “what-to-learn”. Trained in effective group learning pedagogies, such as collaborative and active learning, students who serve as SI leaders gain the skills needed to plan and facilitate effective instruction to a group of peers. Over the course of one semester, each SI leader is paid a semester stipend and has the opportunity to gain over

125 hours of experience facilitating student learning. Anecdotal evidence suggests that students have gotten the “teaching bug” through leading SI sessions. We feel that SI is a good option for smaller schools where Learning Assistant programs in the physics department are not feasible. Our introductory sequence of physics courses is taught in an activity-based blended lecture-lab format. In fall 2014 we introduced Supplemental Instruction to the first year physics majors’ courses. We also offer SI with some of our General Physics sections.

In addition to our SI program, we provide an early teaching experience for two physics majors each semester who may be considering teaching as a career. Our Teaching Exploration Program (TEP) offers placements in the local schools to provide potential physics teachers with early teaching experiences with pre-college students. In the spring, we placed three students in SU’s local PDSs.

PT-TIR

We hired a part-time Teacher in Residence: Brenda Cox, a retired physics teacher who has worked with the Education department as a Mentor and Internship Supervisor. Brenda met the students in the TEP at the schools, provided orientation, and introduced them to the teachers with whom they were placed.

After one year of the grant activities, we have seen some interest from our students in teaching, but it remains to be seen whether the interest turns into a career choice. We look forward to continuing our activities over the next two years.

Gail S. Welsh is an Associate Professor in the Department of Physics at Salisbury University. She is the Physics PI for the PhysTEC Recruiting Grant.

Starlin D. Weaver is a Professor in the Department of Education Specialties at Salisbury University. She is the Science Education PI for the PhysTEC Recruiting Grant.

Matthew A. Bailey is an Assistant Professor in the Department of Physics at Salisbury University. He serves as the Society of Physics Students Advisor and is part of the department’s recruiting effort.

Browsing the Journals

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

- Every month Boris Korsunsky comes up with a challenging problem for physics teachers and students. Page 446 of the October 2015 issue of *The Physics Teacher* (<http://scitation.aip.org/content/aapt/journal/tpt>) has one concerning a hanging rope sliding frictionlessly around a cylindrical peg. To extend the problem, can you find the tension in the rope as a function of the angle around the peg? Can you find the normal force on a differential segment of the rope at that angle?
- An article on page 506 of the June 2015 issue of the *American Journal of Physics* (<http://scitation.aip.org/content/aapt/journal/ajp>) provides an accessible explanation of how electromagnetic waves propagate through a plasma starting from Maxwell's equations, with application to radio waves interacting with the ionosphere. On page 567 of the same issue, a remapping of a charged line segment onto a circular arc is used to provide a geometric method to obtain the direction and magnitude of the electric field due to the segment. In the July 2015 issue, an article on page 621 considers what happens if a set of capacitors are initially charged and then placed in series with a battery and optionally a resistor; this configuration results in trapped charges that could make for interesting new classroom or textbook problems on capacitor circuits. Page 646 of the same issue presents the results of a PER study that shows that allowing too many tries on online homework problems encourages counterproductive tactics; the author recommends setting the maximum number of tries to five. Turning next to the August 2015 issue, an article on page 703 gives a clear exposition of radiation reaction and the resolution of associated energy paradoxes when a charged body accelerates. A short article on page 719 of the same issue uses some clever scaling laws and molecular parameters to deduce the maximum speeds of running and swimming of animals ranging in size from bacteria to elephants and whales. Finally, page 723 presents a marvelous analysis of the following puzzle: If the same amount of heat is transferred to two identical balls, one hanging from a thread and one on a tabletop, which ends up with the larger final temperature, neglecting all heat losses? The standard answer is that it is the hanging one, because the ball on the table has to convert some thermal energy into gravitational potential energy due to its thermal expansion. However, that would violate the second law because we could attach a thread to the ball on the table after its rise and then cool it so that it would rise again, thereby converting thermal energy into useful potential energy with an efficiency that can exceed the Carnot limit.
- A short article on page 564 of the September 2015 issue of *Physics Education* presents experimental results for the nifty effect known as a chain fountain: If the end of a long chain coiled inside a beaker is dropped over the edge of the beaker, the chain in the beaker rises up in a loop above the top of the beaker. The same issue also has an interesting discussion on page 568 of the fact that if one connects ideal batteries in parallel with each other and a resistive load, then the currents through the individual batteries cannot be determined. Turning to the *European Journal of Physics*, Bringuier has a remarkable analysis of damping by entropic forces in article 055024 of the September 2015 issue. In addition, article 055033 about experimentally verifying the Sackur-Tetrode equation caught my eye. Both journals are accessible at <http://iopscience.iop.org/journals>.



Web Watch

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- Physics Classroom at <http://www.physicsclassroom.com/mmedia> has a large number of animations arranged by topic for the introductory course.
- Smarter Every Day has a nifty video about learning to ride a bike rigged so that it turns left when the handlebar goes right. There's a big lesson here about how people learn. Watch it at <https://www.youtube.com/watch?v=MFzDaBzBIL0&feature=youtu.be>. On a humbler level, I recently learned how to better tie my shoelaces at <http://www.fieggen.com/shoelace/grannyknotanalyser.htm>. Who says an old dog can't learn new tricks?
- The National Academy has put together a website about Women's Adventures in Sciences to showcase contemporary accomplishments in science and engineering at <http://www.iwaswondering.org/>. Another useful resource is <http://www.affordablecollegesonline.org/women-in-stem/> which is a guide for women interested in STEM fields.
- The webpage at <http://www.vox.com/2015/3/9/8144825/space-maps> has 40 different maps about the solar system, earth, space-craft, and the universe.
- Colonial Academy emailed me the link to <https://www.titlemax.com/resources/a-guide-to-simple-machines-used-in-cars/> about simple machines used in automobiles. Also see <https://www.titlemax.com/resources/newtons-laws-of-motion-and-car-physics/> about how Newton's laws relate to the physics of cars.
- There has been some discussion in our department about the news feature by *Science* on active learning in science class at <http://www.nature.com/news/why-we-are-teaching-science-wrong-and-how-to-make-it-right-1.17963>.
- Giving a talk at a conference or campus? The page at <http://www.cs.berkeley.edu/~jrs/speaking.html> has some helpful suggestions.
- *Physics World* has a great analysis (complete with videos) of the recent research resolution to the question of how boulders move along Racetrack Playa in Death Valley at <http://physicsworld.com/cws/article/indepth/2015/jul/02/the-restless-rocks-of-racetrack-playa>.
- Practice makes perfect, right? Only if you clarify what should be practiced and for how long, according to psychologists at <http://www.aft.org/periodical/american-educator/spring-2004/ask-cognitive-scientist>.
- Science Daily at http://www.sciencedaily.com/news/matter_energy/engineering/ has lots of regularly updated stories about practical developments in science and engineering. I also like *Quanta Magazine* online at <https://www.quantamagazine.org/>.
- Interested in installing solar panels on your roof? A discussion of the merits of leasing versus buying can be found at <http://www.expertise.com/home-and-garden/home-solar-panels-pros-cons-and-hidden-costs>.
- A great set of physics videos with an entertaining host is at <http://physicsgirl.org/>.
- A lot of activities and materials for teaching about probability can found at http://www.transum.org/Software/SW/Starter_of_the_day/Similar.asp?ID_Topic=30.
- A very well developed set of STEM resources tailored for teachers is online at <http://www.nationalstemcentre.org.uk/elibrary/technology/>.
- If you don't mind a plug for one of my own research interests, read about laser cooling of CdS nanoribbons at <http://www.laserfocusworld.com/articles/print/volume-49/issue-06/features/chillers-and-coolers-breakthrough-of-optical-refrigeration-las.html>.
- Drats, no radio station in my local area carries the weekly program of ambient music called Hearts of Space, but you can subscribe to online access at <https://www.hos.com/>.
- A free tool to remove the background from an image or photograph is at <https://burner.bonanza.com/>.
- *Science* magazine has put together an animated website giving an overview of general relativity at <http://spark.sciencemag.org/generalrelativity/>.
- The PER group at University of Colorado Boulder has materials for physics courses at all undergraduate levels collected together at <http://www.colorado.edu/per/resources/course-materials>.
- Finally, CERN has an educational page for middle and high school starting at <http://education.web.cern.ch/education/Chapter2/Intro.html>.

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