APS physics

Forum on Education

American Physical Society

Spring 2008 Newsletter

Karen Cummings, Editor

IN THIS ISSUE

Articles

Any news or comments for the Summer 2008 *Forum on Education Newsletter* should be sent to Larry Woolf, larry.woolf@ga.com. Submissions are due by June 15.

Letter from the Chair of the Forum on Education of the APS

David Haase, January 31, 2008

Like several previous *Forum on Education Newsletters*, this one has a theme. It is built around reports from the summer, 2007, conference *Foundations and Frontiers of Physics Education Research* (PER). The Forum partially supported this conference. I voted for support because I think that physics education research is one of the special ways that physicists can contribute to the overall betterment of education. Our discipline can be proud that it has produced PER products that positively affect not only how we teach, but also how other disciplines teach. The effects of physics education research have implications from K-12 to graduate study.

For all of the success in PER, we have yet many challenges in physics education. Why are not more students enrolling in high school physics? Why is high school physics often an elective course, not required like biology or chemistry? Why do physics classes and programs include lower percentages of women and minorities? Why are the innovations resulting from PER not quickly and willingly adopted by university and high school teachers? Why have we not educated the public about the importance of understanding physics as part of general literacy?

Physicists demand solutions, but the questions above are not solved in the same sense that physicists use the word "solve." There are no fundamental theorems to apply to these questions. Over the last 30 years I have visited with people from other cultures and learned new languages, in particular the expressions they use with regard to science and education. I have learned new words like "partnerships", "leverage", and "stakeholders." These words are, of course, from the languages of the cultures of public education, business and politics. The three words above are just as meaningful and nuanced in those cultures as "force," "momentum" and "solve" are in our culture.

Many physicists committed to education and to improving education have had the same experiences. We realize that we bring a lot to the classroom and to public forums. Yet, we are surely not the possessors of all the knowledge needed to improve science education. If we really want to make a broader impact on education, beyond our classroom, laboratory or campus, we must learn to hear and to speak in these other languages.

The Forum on Education offers opportunities to learn new languages at its invited paper sessions at the March and April meetings. Often the sessions bring in speakers from outside the APS to talk about education as they see it. Recently the speakers have included leaders from teacher preparation programs or science museums or education outreach coordinators associated with research laboratories, or writers who try to explain science to the public. There is no reason why there should not be invited speakers from public schools, corporations or government who could speak to us in their language about the place of physics in their education worlds.

I strongly urge you to attend the FEd sessions at the March and April meetings. They are good ways to increase your language skills. Please also volunteer to organize invited sessions that will help us physicists enlarge our vocabularies so we may speak to other cultures about the value of physics education. The APS is an organization rich in the talents and expertise of its membership. We are fortunate to participate in the enterprise of physics research and teaching. Education is one way we share our good fortune with the world, and coincidentally support the long-term health of our field.

Background on Working Group Reports from the Foundations and Frontiers in Physics Education Research

Karen Cummings

The Foundations and Frontiers in Physics Education Research Conference was held for the second time August 6–10, 2007, in Bar Harbor, Maine on the beautiful campus of the College of the Atlantic. The conference is a week-long residential meeting intended to foster direct and in-depth discussion among specialists in the field of Physics Education Research. Speakers at the conference examine the current state of the field and explore potentially fruitful new directions. Plenary lectures were given by Lei Bao (The Ohio State University), Andy Elby (University of Maryland), Paula Heron and Peter Shaffer (University of Washington), Christian Kautz (Hamburg University of Technology, Germany), Cedric Linder (Uppsala University, Sweden), Miriam Reiner (Israel Institute of Technology) and Michael Wittmann (University of Maine).

The conference was organized by Michael Wittmann, Rachel Scherr (University of Maryland) and Paula Heron.

Evening sessions at this conference included meetings of topical groups interested in specific research issues, a contributed poster session and meetings of several working groups. These working groups discuss important issues of community-wide interest. Their reports have been transformed into the four articles which follow.

A grant from the APS Forum on Education allowed graduate students to attend at a greatly reduced registration cost. The third Foundations and Frontiers in Physics Education Research conference will be held during the summer of 2009. More information regarding past and future Foundations and Frontiers in Physics Education Research conferences can be found at http://perlnet.umaine.edu/~ffper/2007/index.html.

Karen Cummings is Associate Professor of Physics at Southern Connecticut State University and (retiring) Editor of the Spring APS Forum on Education Newsletter.

Second Foundations and Frontiers in Physics Education Research Conference

Seated: Miriam Reiner, Andy Elby, Chris Kautz, Lei Bao, Cedric Linder, Peter Shaffer, Paula Heron, Michael Wittmann Standing, left to right: Jing Wang, Ellie Sayre, Jerry Feldman, Laura Buteler, Tanya Antimirova, Bhupi Nagpure, Carol Koleci, Georgia Bracey, Cornelius Bennhold, Brant Hinrichs, Genaro Zavala, Sahana Murthy, Dewey Dykstra, Steve Kanim, Dodie Albers, Andrew Boudreaux, Padraic Springuel, Mila Kryjevskaia, Brian Frank, Jennifer Blue, Mike Loverude, Mac Stetzer, Rebecca Lindell, Yuhfen Lin, David Meltzer, Joe Redish, Warren Christensen, John Thompson, David Brookes, Ian Beatty, Sam McKagan, Leslie Atkins, Bill Reay, Lillian McDermott, Andrew Heckler, Katrina Black (and Ben), Brian Pyper, Enrique Coleoni, Tom Bing, Renee Michell Goertzen, Brad Ambrose, Don Mountcastle, Ayush Gupta, Brandon Bucy, Sebastien Cormier, Homeyra Sadaghiani

Non-Traditional Methods of Publication

David E. Meltzer

Working Group Members: Brad Ambrose, Ian Beatty, Lillian McDermott, Sam McKagan, David Meltzer, Bill Reay, Miriam Reiner, Jing Wang

This working group had the task of arriving at a position on the value of non-traditional publications such as online published volumes, arxiv.org, white papers, blogs, and others. I will present the outcomes of the group's discussion by enumerating the principal topics that arose.

arxiv.org [http://www.arXiv.org]

arXiv.org is an on-line e-print service in a variety of technical fields including physics. It is owned, operated and funded by Cornell University. Publishing on arxiv.org ensures open access to authors' work; however, posted items can never be removed. (Modified versions may be added, making earlier versions less easily accessible.) As a consequence, after a paper is published in final form in a journal or elsewhere, an obsolete copy of the paper will continue to exist permanently on the web and, presumably, be visible to search engines. Some authors would see that as undesirable.

A potentially significant advantage is that items which may not easily be accessible in any other form (such as papers in obscure conference proceedings) may be posted on arxiv.org. Papers that are not yet accepted—which the authors may not wish to revise until some time in the future—may be posted on arxiv.org to ensure some degree of dissemination.

PER-Central [http://www.compadre.org/per/]

This site is a collection of hundreds of citations and links to articles and dissertations, research groups, PER-based curricular materials, news and events, and many other things of interest to the PER community. Recently, this site has published a small number of invited review papers that provide extensive discussions of research-based curriculum and instruction projects. Our group wondered whether, at some time in the future, PER-Central might serve as a venue for posting preprints, preliminary versions of instructional materials and/or resources, and similar materials. As of now, it provides links to these materials when they have already been posted on another web site.

ERIC (Education Resources Information Center) [http://www.eric.ed.gov/]

ERIC is sponsored by the U.S. Department of Education; it calls itself "the world's largest digital library of educational literature." It provides free access to more than 1.2 million bibliographic records of journal articles and other education-related materials and, if available, includes links to full text. Many PER journals and conference proceedings are included in the index. ERIC microfiche archives are widely available in research libraries nationwide, but the current thrust is for digital publication. According

to their site, "ERIC is actively seeking individual submissions of high-quality education-related materials for inclusion in the ERIC database. Types of materials appropriate for individual submission include research reports, conference papers and presentations, and dissertations and theses. ERIC does not accept lesson plans, blogs, or individual Web pages." Our group felt that ERIC might well be a resource that is underutilized by members of the PER community.

Review Papers and Collections in Book Form

The group felt that it would be useful to have more review articles including, perhaps, full-length "review books" (similar to the lengthy invited papers posted at PER Central). These could include guides to the PER literature, which might have special value for graduate students. Examples that were proposed were an expanded and updated version of the McDermott/Redish Resource Letter (*Am. J. Phys*. **67**, 755-767, 1999), and an annotated version of the tabulation of PER papers published in AJP which is posted at http://www.physicseducation.net/current/index.html. Another possibility would be to have book-length collections of overview papers or papers focused on a single theme. As an example it was noted that the APS and AAPT, as part of the PhysTEC project, together plan joint publication of a book of scholarly papers focused on the topic of physics teacher preparation (http://www.ptec.org/features/newsDetail.cfm?id=139).

Research-Group Web Sites

Some research groups post on their own web sites a wide variety of items that are unavailable elsewhere, for example:

- "white papers" and opinion pieces
- reports
- very short articles
- teachers' guides
- meeting notes
- validation studies of curricular methods and materials, etc.

There may be other viable publication venues for these types of materials, for example, newsletters (such as the APS Forum on Education), the new periodical AAPT *Interactions*, and the ERIC digital library.

Issues of Quality Control and Peer Review

The group addressed the question of how curricular materials might be subjected to some form of peer review or quality control by the PER community, apart from authors publishing articles in refereed journals that discussed the development of the materials. This was considered to be an important issue since peer review is given paramount importance in the physics community generally, and a large portion of PER work is related to the creation of curricular materials.

It was suggested that developers should report enough background information regarding self-testing so that, in principle, the testing would be reproducible by other groups. For instance, developers could provide specific diagnostic questions that others could use in their own assessments. Reports of this type of validation study should be published and disseminated in some fashion so they might be evaluated by peers. It might be possible to publish the validation studies by themselves, without extensive additional commentary.

There was discussion as to whether it might be possible to have a "validation stamp" of some type for curricular materials, provided by AAPT or some related group. There was skepticism about the practicality of this approach and the discussion was inconclusive. A separate question arose as to whether potential users actually cared much about peer review of curricular materials they might be considering. It is not clear that either peer review or formal validation studies play a significant role in convincing instructors to test or use new materials.

Printed Curricular Materials in Book, On-line, or other Formats

Research-based curricular materials are becoming available in increasing numbers of formats, both printed and electronic. The issue of peer review is obviously a key concern. It was proposed that on-line reviews of curricular materials (a single review or perhaps multiple reviews by users) might be posted on PER-Central or other sites.

A key issue is to assess the advantages and disadvantages of on-line accessibility to curricular materials. Among the advantages are wide availability to users, and relative ease for developers to update and modify the materials. If materials are made available only on CD, for example, they can be relatively hard for the developer to modify or update. On the other hand, some developers would have a concern that, in some cases, it might be too easy for potential users to "misuse" on-line materials in ways not intended by developers (e.g., leave out important parts, modify files, etc.) and disseminate the altered materials. However, this is strongly dependent on the dissemination format since, for some materials such as computer animations, modifications by users may be very difficult to carry out. Examples of such materials are the Colorado PhET animations. These have been disseminated on CD to some extent; however, they are primarily intended for on-line use and thus they are easy for the developers to update. Another option is for open-source-style dissemination done online via a "hidden" website, for which access is given mainly to non-PER instructors who attend workshops or directly contact the curriculum developers. An example of this is the *Intermediate Mechanics Tutorials* [http://www.compadre.org/per/items/detail.cfm?ID=5522].

Graduate Students and Post-Docs

The group discussed the various incentives and disincentives for graduate students and post-docs to publish. One issue dealt with appropriate publication venues, e.g., are they the same as or different from those for faculty? It was felt that students can start by writing proceedings papers and similar short items for publication, but that post-docs should also be encouraged to publish in major journals.

Dissemination of Grant Proposals

It is possible that voluntary posting of funded or unfunded grant proposals, perhaps after some delay (e.g., 1-2 years), could benefit both the poster via dissemination of their work, and the PER community by providing a model of fundable work presented in a successful proposal. The Group wondered whether, in addition to individual researchers' web sites, PER-Central might be used for this purpose.

Additional Issues for Discussion

The group discussed a number of other issues without reaching consensus on appropriate recommendations. A number of questions were raised. Among the issues discussed were these:

1. Obtaining tenure removes one of the significant incentives to publish, and after obtaining tenure faculty members may focus on other activities determined by their own or their institution's interests. This could be seen as a problem for the community as a whole, since significant work may not get adequately dissemi-

nated. What changes might be made to alter this situation–or should it be changed?

2. There is a distinction between "research-based" materials (which employ results of research) and "research-validated" materials (which have gone through a testing and validation process employing research methods and techniques). These distinctions can be important; should they be emphasized more strongly than is commonly done?

3. PRST (and numerous other journals used in PER) are not yet indexed on the Web of Science (Science Citation Index). What impact does this have, and what are the prospects for it to change? (Recently, Google Scholar may be growing in importance due to more comprehensive scope.)

David E. Meltzer is a Senior Research Scientist with the PhysTEC project and a Research Scientist in the Department of Physics at the University of Washington. He is also the 8th-grade science teacher at Seattle Country Day School.

PER and TA Preparation

MacKenzie Stetzer

Working Group Members: Delores Alber, Katrina Black, Andrew Boudreaux, Warren Christensen, Carol Koleci, Andy Elby, Jerry Feldman, Renee Michelle Goertzen, Mila Kryjevskaia, Cedric Linder, and Peter Shaffer.

The Working Group on PER and TA Preparation was given the task of identifying and broadly defining areas of research related to TA preparation that might be investigated by the physics education research (PER) community. Due to the wide variety of contexts in which TAs are expected to teach (traditional laboratories and recitation sections, collaborative problem solving sessions, tutorials, etc.), it became clear that it would not be practical to seek a consensus on a single, universally applicable model for TA preparation. The Group therefore chose to limit the context of the discussion to that of graduate and undergraduate TAs teaching in small group sections using reformed PER-based curricula. The goal was to identify broad themes of research with the potential to inform TA preparation in this particular context.

The general strategy of the Working Group was to begin by identifying TA practices and characteristics consistent with results from research on student learning. These would, in turn, be used to help identify the desired outcomes of TA preparation. The research questions that the Group proposed were closely related to these outcomes. It was anticipated that the findings from such research would be of use in refining notions of TA best practices and desired TA preparation outcomes, and would have implications for the design and practical implementation of TA preparation programs. (The focus of the Working Group, however, was not on the details of implementation.)

Common vision of TA best practices and characteristics

After considerable discussion, the Working Group arrived at what it felt constituted a provisional list of TA best practices and characteristics. These were grouped into three broad categories: (1) knowledge and skills associated with physics content, (2) nature of interactions with students, and (3) metacognitive skills. The list generated and refined by the Group is outlined below.

Knowledge and skills associated with physics content

The TA should possess a deep understanding of or facility with the following:

- Subject-matter content
- Pedagogical content knowledge
- Common student ideas, difficulties, and resources
- Nature of science
- Relevant scientific process skills (e.g., proportional reasoning)
- Critical thinking
- Epistemological goals of the course
- Representations and conventions of the course

Nature of interactions with students

During instruction, a TA's commitment to constructivist epistemology should be reflected in his or her interactions with students. The TA should:

- Not assume a traditional authority role, but rather be both approachable and professional
- Attend to both answers and reasoning, and listen for both substance and correctness
- Be attentive to student behavior, level of engagement, and emotional state; "listening" to both verbal and non-verbal com munication and also knowing when to leave a group
- Practice formative assessment through effective questioning
- Recognize the difference between surface-level understanding and deep understanding
- Choose appropriate step sizes when guiding students

- Attend to intragroup variability and foster appropriate group dynamics
- Manage available time and resources, and set priorities as necessary (i.e., be able to apply triage)
- Inculcate attitudes, critical thinking skills, etc., including the capacity for self-directed learning
- Hear student complaints with thoughtful respect while maintaining course integrity
- Advance student thinking beyond the specified curriculum when appropriate

Metacognitive skills

The TA should be comfortable with and well practiced in:

- Reflecting on his or her own learning
- Reflecting on his or her own teaching

Desired outcomes of TA preparation and implications for areas of research

The above list of best practices and characteristics of TAs guided the Working Group's reflections on the desired outcomes of TA preparation. The Group argued that an effective TA preparation program should (1) build capacity for TA best practices, (2) engender among TAs favorable attitudes toward research-based curricula and reformed instruction, and (3) help improve student conceptual understanding and attitudes. (Note that the first two outcomes focus on the TAs, whereas the third outcome highlights the impact on students in the course.) While this list is tentative and certainly not exhaustive, it served to define, in a natural way, three different strands of research that might be pursued by physics education researchers in the context of TA preparation.

Existing research base on TA preparation

While much of the research on teacher preparation and professional development has implications for TA preparation, the Working Group noted that, to date, the physics education research community has not yet produced an extensive research base on TA preparation. Most published studies have focused on TA best practices, including investigations of TA content knowledge and student-TA interactions [1]. One recent study by Koenig et al. is notable in that it probes both best practices and the impact of those practices on student conceptual understanding [2]. Ongoing research on TA preparation is being conducted at several different institutions, including the University of Colorado at Boulder, the University of Maryland, and the University of Washington. During Group discussions, however, it became clear that considerably more work needs to be done before truly research-based TA preparation programs can be developed.

Open research questions

For each broad area of research on TA preparation, the Working Group sought to identify several research questions that were both illustrative of the area and critical for gaining greater insight into TA preparation. Specific examples of questions posed by the Group are given below.

Research emphasis on capacity for TA best practices

- What productive resources (e.g., epistemological and content-based) do TAs already possess? What deficits do they seem to have?
- To what extent does TA preparation affect TA capacities and skills?
- To what extent do specific TA best practices affect student learning and development?
- To what extent does the graduate student environment affect TA practices?

Research emphasis on favorable attitudes to reformed instruction

- To what extent do TAs who have participated in a TA preparation program apply the same methods and instructional approaches to subsequent graduate TA assignments?
- To what extent do TAs who have participated in a TA preparation program adopt the same methods and instructional approaches if and when they become faculty?
- To what extent does familiarity with relevant PER literature influence TA behavior?
- Does the experience of learning via reformed instruction as an undergraduate influence subsequent graduate TA teaching practices?
- Does the amount of time it takes for a new graduate TA to recognize the value of reformed instruction influence his or her future teaching practices?

Research emphasis on student conceptual understanding and attitudes

- How dependent on the TA are the gains in student conceptual understanding and/or attitudes resulting from research-based instructional materials?
- Are there certain topics for which student learning is more dependent on specific student-TA interactions (and thus more

instructor dependent)?

• How does the graduate school environment in which a TA is situated affect the learning of his or her students?

These are a small sample of the types of questions the Group felt would be both intellectually engaging and of considerable value to the broader physics community. Findings from investigations pursuing such research questions could have significant impact on the types of TA preparation advocated and offered by the physics education research community.

Conclusions

The general consensus of the Working Group was that more research in the area of TA preparation is needed in order to help the PER community refine and sharpen its notions of TA best practices and desired outcomes of TA preparation. Specific findings are required in order to guide the development of TA preparation programs that have a documented effect on TA behavior and student learning. On the basis of Working Group discussions and the large number of research questions the Group identified, it is clear that the area of TA preparation promises to be a rich field of inquiry for members of the physics education research community.

Acknowledgements

The author, as facilitator of the Working Group, would like to thank all of the other members of the Group for their insights, thoughtful comments, and substantive contributions.

References

1.See, for example: T. O'Brien Pride, S. Vokos, and L. C. McDermott, "The challenge of matching learning assessments to teaching goals: An example from the work-energy and impulse-momentum theorems," *Am. J. Phys* **66** (2), 147 (1998) and R. E. Scherr, R. S. Russ, T. J. Bing, and R. A. Hodges, "Initiation of student-TA interactions in tutorials," *Phys. Rev. ST Phys. Educ. Res*. 2, 020108 (2006).

2. K. M. Koenig, R. J. Endorf, and G. A. Braun, "Effectiveness of different tutorial recitation teaching methods and its implication for TA training," *Phys. Rev. ST Phys. Educ. Res*. 3, 010104 (2007).

MacKenzie Stetzer is a Research Assistant Professor with the Physics Education Group in the Department of Physics at the University of Washington.

The Perfect Parent Organization for PER

Edward F. Redish and David Brooks

Working Group Members: Rebecca Lindell, Leslie Atkins, Eleanor Sayre, Sebastien Cormier, Tanya Antimirova, Michael Loverude, Donald Mountcastle, Edward F. "Joe" Redish, David Brookes, Cornelius Bennhold, Paula Heron

1. Introduction

Our group had the task of identifying the perfect parent organization for the field of physics education research (PER). Our group decided that, in order to identify a parent organization (PO), we needed to first answer the question: What do we as a community need or want from a professional organization? Having answered this question, we examined how well we thought our needs were currently being met by existing organizations such as the American Association of Physics Teachers (AAPT) and the American Physical Society (APS) and the ways in which a parent organization (PO) might be able to meet those needs in the future. Finally we asked: What should our relationships be to existing professional organizations, or should we create our own? This report will endeavor to present as much of a consensus viewpoint of our group as possible.

2. Our community needs and how well they are currently served

Our group identified a number of professional activities that we engage in as a research community. We then identified and prioritized ways in which a parent organization would be able to support those activities. We debated how well we felt each of these activities was currently being supported by existing organizations such as the AAPT and APS. We believe that our parent organization should be involved in helping to facilitate, support, provide venues and environments to support the following needs and activities:

2.1 Interacting with each other as a research community

There are a number of ways in which a PO could support and encourage interactions with each other. We prioritize these activities

and venues as follows:

1. Priority 1: PER publications and PER conferences. With regards to publication venues, we feel that the current diversity of organizations (AAPT, APS, AIP, ComPADRE) is a fairly good one. Having all these different publication venues seems better than "putting all our eggs in one basket." With regards to conferences, we feel that we have enough conference time, but would like more control over how our conferences are run. Two possible models are: 1) Conduct our own conferences within bigger (AAPT or APS) conferences, similar to the APS March meeting, in which different subfields of physics run sessions fairly autonomously. 2) Hold our own separate conference, similar to the Foundations and Frontiers in PER conference but without a size restriction. Our PO would provide organizational support for such a conference.

2. Priority 2: A clearinghouse for employment opportunities, information sharing and collaborative activities; venues for matching potential collaborators; recruitment of faculty and graduate students into our field, and professional development. Many of these needs are currently met in some form. While there are many events that promote collaboration and professional development at conferences, online venues for collaboration or job advertisements are insufficiently centralized. Ideas include a) a single PER job website in Wiki format (already initiated by Sebastien Cormier at http://perjobs.blogspot.com/), and b) a "professional facebook" to facilitate collaboration between researchers at different universities and promote matching of researchers with common interests. Ideally, all these venues would be run from a centralized server, overseen and financed by our PO.

3. Priority 3: Interactions in multiple modes and venues, databases and information collection, and recognition of achievement within the field. Currently comPADRE provides some of these services. We envision a greatly expanded system including: 1) concept inventories (with password protection), 2) institutional review board information and sample responses and forms, 3) curricular materials, 4) research data in many different forms, 5) information on journals for promotion packets (impact factors, acceptance rates, etc.), 6) a description of what PER is with a link to the APS statement, 7) a "canon" collection (a list of seminal PER papers), 8) a PER Wiki, and so on. With regards to recognition of achievement, we have APS fellowships and AAPT awards but feel we need fellowships for a larger collection of contributors.

2.2 Interacting with and disseminating to our "consumers"

This includes the following activities: **Informing potential consumers about PER and its value, publishing overviews and reviews of PER, disseminating instructional materials, and reaching new faculty**. Our goal should be to inform physics faculty on the purpose and classic results of PER, and to help them understand both the practical value of PER for their instruction and its value as an intellectual discipline.

We currently have workshops and conferences and "evangelizers." We would like to expand these resources to include: a) a speaker list and b) a well-marketed journal that reaches a large fraction of faculty who are specifically interested in improving their teaching. Some ideas that emerged were: a) short summaries of research, b) a collector journal, and c) distribution of information about what is happening in PER to highly read venues (for example, articles in the Chronicle for Higher Education or Science). In summary, our PO would encourage and help PER folk create these products.

2.3 Interacting with related disciplines

We would like a professional organization to facilitate sharing of information with related disciplines including meetings and even summaries of significant research results. Our parent organization would facilitate open bi-directional lines of communication to education, cognitive and learning sciences, and other STEM education research fields.

2.4 Public relations

Our PO would be involved in lobbying with legislature, lobbying funding agencies, advisory panels, and public advocacy.

3. Our relationships with existing professional organizations

In reviewing the activities listed above that we would like our parent organization to facilitate and support, we realize that many of our activities are at least partially supported by either the AAPT, the APS, a combination of the two, or by the alliance of organizations that support comPADRE. We note a number of successes of satisfying our needs in these communities, such as the creation of the PER topical group and the PR-STPER journal under the APS.

In identifying our parent organization, we realize that we have strong representation in the AAPT. In the APS, we are a much smaller part, but are a part of the largest subunit: the Forum on Education. In this Forum, we are well represented in the leadership. In summary, we are respected as an important and vital part

of both of these organizations. Many of us are conflicted about throwing our lot in with one organization or the other: To become a recognized part of the physics community, we need to be a part of the APS, yet much of our dissemination audience resides in the AAPT and in science education organizations. Choosing one organization over the other as our parent organization may involve sacrificing part of our community mission. In our view, we have identified unmet or inadequately met needs and should, at present, push to get those needs satisfied within *both* the AAPT and APS.

We call on those who have ideas for specific mechanisms to communicate their ideas to the leadership of the PER Topical Group (in the AAPT) and the Forum on Education (in the APS), and be willing to do the work to help get them started. We hope that, over time, individual start-up efforts (e.g., a PER job rumors blog) will be incorporated into more organized institutional structures.

Edward F. Redish is a Professor of Physics at the University of Maryland in College Park.

David Brookes is a post-doctoral research associate at the University of Illinois at Urbana-Champaign.

A Ph.D. in Physics Education Research

Jennifer Blue and Stephen Kanim

Working Group Members: Tom Bing, Georgia Bracey, Brandon Bucy, Dewey Dykstra, Brian Frank, Andrew Heckler, Brant Hinrichs, Sahana Murthy, and John Thompson.

In the past, most researchers in physics education have come from other areas of physics or from other disciplines. As physics education research (PER) has grown, however, it has become increasingly common for students to be able to choose physics education as a research emphasis for their graduate studies. Our working group convened at the Foundations and Frontiers of Physics Education Research conference in August 2007 to make recommendations concerning the curriculum content and process of the education of PER graduate students. Our focus in this letter is on Ph.D. students who will do research in PER.

Although these students have many things in common with other graduate students in physics and in education, there are issues and constraints that are specific to PER. First, while it is beneficial for our community to have non-overlapping areas of expertise, establishing a common knowledge set serves to facilitate communication between researchers. Unlike more established disciplines, PER has not yet settled on what we might assume other researchers in the field will understand. These assumptions will necessarily change as the field evolves, but discussion of a tentative core curriculum serves at least to promote reflection about the strengths and weaknesses of existing programs.

Second, since our field spans several traditional research fields that have diverse expectations and academic cultures, there is a distinct need to balance a broad exposure to these fields (including physics, education, psychology and cognitive science) with depth of understanding of the content and research techniques of a subset of these disciplines. As with other research areas, the interests and institutional constraints of academic departments with PER faculty are diverse, and so the specific means through which this understanding will be acquired will vary. At some institutions, it may be possible acquire this knowledge through coursework in physics departments as well as in education, psychology, and cognitive science. In others, this acquisition will come about through apprenticeship with an advisor, from journal clubs or departmental seminars, from workshops at conferences, through communication with other groups, or from working on one's own.

It is crucial to the health of our field that students obtaining a graduate degree in PER have a solid physics background. All of our students will need to take advanced courses in physics, and should be prepared to demonstrate their physics background by passing a qualifying exam in a physics department and/or by earning a master's degree in physics. Many of our students will teach in physics

departments, and they should have the content knowledge necessary to do this successfully. Furthermore, the pedagogical content knowledge that they develop as part of their research requires a deep understanding of the associated physics.

Knowledge of how people think and learn is also essential. However, knowledge about learning and teaching comes from many fields, and students and their advisors will have to make choices about which parts of this body of knowledge are relevant to the intended research focus, which parts will be pursued through coursework or through teaching and research experience, and which will be left out. PER graduate students might want to study educational psychology, cognitive science, neuroscience, or artificial intelligence. There are also more general education courses that might be valuable for individual students: history of education, social psychology of education, sociology of education, philosophy of education, politics of education, and critical pedagogy. In addition, there is a growing body of knowledge specifically about science education. We have seen courses in the history and foundations of science education, trends in science curricula, student misconceptions, and PER-based curriculum. Some of these are based in physics education, and some are broader and encompass all of the sciences. There are methods courses for preservice science teachers that offer significant pedagogical content knowledge. More and more universities are offering courses specifically in PER; if one is available it should be taken. Students should also take advantage of resources such as the published canon of PER (Ambrose & Thompson 2005) and the resource letters about PER that have been published in the *American Journal of Physics*.

We expect that PER graduate students will be apprentices in research just as other graduate students are. The research techniques of PER are often different from those of other physicists and more like those employed in the social sciences, and a graduate student in PER may need to learn statistics, survey design, how to create an assessment instrument, how to evaluate a program, how to construct an interview, perform ethnography, and how to code qualitative data. There are courses offered in most schools of education with titles such as "Research on Curriculum" and "Research on Instruction," which may be useful. Many PER students will learn these skills directly from their advisors. We do recommend, however, that all PER students should learn both quantitative and qualitative research techniques well enough to judge the research of others, no matter which techniques they intend to use in their own work. We also expect that, as part of their research experience, PER graduate students will work with their advisors to prepare and present posters, to give talks, to help write grant proposals, and to write papers. They should be given the opportunity to attend national meetings where PER is presented (such as the American Association of Physics Teachers national meetings, the Physics Education Research Conference, or the Foundations and Frontiers of Physics Education Research conferences) in order to develop a sense for the breadth of the field.

Finally, PER graduate students should have some exposure to the *practice* of teaching. Almost all graduate students benefit from moving into a research associate position and gaining more time to spend on their own projects. However, while skipping a stint as a teaching assistant may have advantages for some physics graduate students, it is probably not a good idea for our students unless there is some other means of gaining teaching experience. Optimally, a PER graduate program will incorporate a teaching experience with coursework or group meetings that encourage discussion of how theories of education inform (and are constrained by) educational practice, and the student will gain experience in both traditional courses and in courses that have been modified on the basis of physics education research. PER students should be given the opportunity to attend workshops at AAPT meetings about instructional innovations that are not offered at their own university.

PER graduate students often have the ability to be involved in teaching to a degree unusual in physics graduate students. They may be able to write test questions, develop courses, and develop curriculum. This might be best done as an apprentice with an experienced instructor. Depending on the career goals of the student, these opportunities could be provided in community colleges, high schools, or elementary schools. PER graduate students may also be able to teach other physics TAs or teach methods courses for preservice science teachers. All of these experiences as part of a well-designed PER education will develop teaching expertise and the practice of teaching, contributing to the educational develop-

ment of the student–and will not be teaching roles intended primarily to serve departmental needs.

We recognize that this list is too long. We do not expect that all PER Ph.D. students will learn everything that any one practitioner of PER knows; that is as unreasonable as it would be in any other field. Rather, we hope that this paper can spur discussion among students and advisors and illuminate both the challenges and opportunities of our relatively young field.

References

1. Bailey, Janelle M. & Timothy F. Slater (2005) "Resource letter AER-1: Astronomy education research" *American Journal of Physics* **73**, 677.

2. Hsu, Leonardo, Eric Brewe, Thomas M. Foster & Kathleen Harper (2004) "Resource Letter RPS-1: Research in problem solving" *American Journal of Physics* **72**, 1147.

3. Jossem, E. Leonard (2000) "Resource Letter EPGA-1: The education of physics graduate assistants" *American Journal of Physics* **68**, 502.

4. McDermott, Lillian C. & Edward F. Redish (1999) "Resource Letter PER-1: Physics Education Research" *American Journal of Physics* **67**, 755.

5. Thompson, John & Bradley Ambrose (2005) "A Literary Canon in Physics Education Research". *Forum on Education of the American Physical Society Newsletter*, Fall 2005.

Acknowledgements

First drafts of this letter were a collaborative effort of all members of our working group, and all contributed their time and ideas during our discussions at the conference.

Jennifer Blue is an Assistant Professor of Physics at Miami University.

Stephen Kanim is an Associate Professor of Physics at New Mexico State University.

Report of the FFPER 2007 International PER Working Group

Genaro Zavala and Brian Pyper

Working Group Members: Enrique Coleoni, Chris Kautz, Mila Kryjevskaia, Yuhfen Lin, Cedric Linder, Brian Pyper, Padraic Springuel, Jing Wang, Genaro Zavala.

The International PER working group had the task of comparing different PER communities around the world in a way that helps build bridges and further the work of all. The group itself was very international with four out of ten members being from outside the US and four other members originally from outside of but working in the US. Since the task was very broad, we implemented a survey asking people attending the conference about the importance of having connections with other PER groups around the world and the actions the US community should take to make those connections. The following report is a combination of the survey results and our own group discussions on the matter.

PER outside the US

There are some differences among the PER communities around the world resulting in part from educational-structure differences. For example, in some Latin-American countries, universities are composed of self-contained schools: an engineering school, for instance, will have engineering professors teaching physics to its students. This arrangement limits the opportunity for physics education research in many universities. In Germany, most physics education research is done with students at pre-university levels, since the structure of the educational system limits access to university students.

Importance of International PER connections

We collected 32 survey respondents of the 48 that were handed out. Respondents reported 25 international connections of various kinds ranging from close collaborations to email consultations and sharing of pre-prints. These connections were found in 15 countries. Despite PER being different and country-dependent, international links among established PER groups around the globe are beneficial. Good reasons for the US PER community to foster international collaboration include:

- Gaining ideas for productive new research areas or projects in terms of new research approaches or perspectives/ideas;
- Obtaining access to probe culture, different populations, social interactions and language in physics education research;
- Avoiding unnecessary replication in research;
- Improving legitimacy of research through awareness among colleagues of international applications of the goals of PER;

- Attracting potential students and researchers;
- Supporting each other's research through visits– colloquia or forum talks, sabbatical or Fulbright visits, etc.;
- Gaining awareness of the structure and challenges of foreign school systems;
- Broadening the scope of productive thinking about PER issues through better understanding of foreign perspectives;
- Improving communication among researchers to foster international understanding among nations;
- Fostering opportunities for international collaborations –especially in applications where access to particular research questions is restricted by cultural or language barriers; and
- Increasing the appreciation of other cultures, variety and diversity.

Recommendations to the US PER community

There is a consensus among the conference participants that that international links will benefit our community. Of the several ideas collected from the surveys, some stood out as more popular among the conference attendees. We filtered these ideas into ten recommendations, which we grouped into three categories: A: We should enact these recommendations immediately, B: We should consider these recommendations for the near future, and C: We should keep these recommendations in mind as we work.

A: *Enact Immediately*

1. Invite more international speakers to AAPT/PERC/FFPER and local meetings and colloquia. Specifically, AAPT RIPE and International Physics Education Committees should co-sponsor an "International PER" session at national meetings. [Note: During the 2008 AAPT Summer National Meeting in Edmonton, the Committee on International Physics Education and the Committee on Research in Physics Education are co-sponsoring a session called "PER around the world." This is a good step the community has taken to start fostering international collaboration and recognition.]
2. Compile a list of people willing to help the AAPT Committee on International Physics Education or APS International Relations Office with language and cultural issues in publication, and advocate for foreign research to be included in US journals.
3. Add international PER group information to a central web site (such as PERCentral).
4. Refine ideas for possible meeting formats for fostering international connections such as joint meetings, cross-pollinating existing meetings (such as GIREP, ICPE, ESERA, CIAEF), etc. This meets the suggestions we received for international meetings, visiting exotic locations, and sampling ethnic cuisine.

B: *Consider for the near future*

5. Might we consider a PER committee on international relations?
6. Consider funding for international collaborations in grant proposals.
7. Take opportunities to read international journals, consider reviewing up-to-date foreign research for the US PER community (on PhysLrnR or another appropriate venue), and consider submitting your research to international journals for publication.

C: *Keep in mind*

8. Share your international connections.
9. Consider taking your next sabbatical in an international setting.
10. Watch for opportunities to be involved in international collaborations.

Genaro Zavala is an Associate Professor of Physics at the Tecnologico de Monterrey, Monterrey, Mexico. Email: genaro.zavala@itesm.mx.

Brian Pyper is a Professor of Physics at Brigham Young University–Idaho, Rexburg, Idaho. Email: pyperb@byui.edu.

Section on Teacher Preparation

John Stewart
University of Arkansas

There continues to be a dramatic shortage of physical science teachers with subject specific training and certification. One of the primary reasons for this shortage is the fact that 40% of teachers leave the profession by their fifth year of teaching. If this situation alone could be addressed, much of the shortage would be alleviated. Since the decision to leave the teaching profession happens after a student graduates, the problem of retention offers different challenges for teacher preparation programs than the problem of graduating more qualified teachers. In this issue, David Grosnick and James Watson will describe features of Ball State's program that has achieved a remarkable 100% retention rate over the last eight years. The article provides a model for using a Teacher-in-Residence to manage outreach and networking for new science teachers. Laura Lising and Cody Sandifer will discuss mentoring in the early science education program at Towson University.

The possibilities offered by improved retention are immense. If you have a teacher mentoring, networking, or retention program that is showing particular promise, please contact me at johns@uark.edu.

Plugging the Leaky Bucket: Retention of Physics Teacher Graduates from Ball State University

David Grosnick and James Watson
Department of Physics and Astronomy, Ball State University, Muncie, IN 47306

Introduction

During the past several years, there has been a growing concern over the numbers of qualified science and math teachers in grades K-12 in the United States [1]. The physics community has also been concerned [2] with the number of qualified physics teachers, and in 2001 this concern resulted in a $5.76-million grant from the National Science Foundation to the American Physical Society, in partnership with American Association of Physics Teachers and the American Institute of Physics [3]. This grant led to the formation of the Physics Teacher Education Coalition (PhysTEC), which involved six primary institutions committed to producing more and better-trained science teachers. Since then, PhysTEC has grown to 12 institutions, and, in addition, PTEC was formed as a national coalition of 88 institutions dedicated to improving physics and physical science teacher preparation.

A simple model may be used to describe the number of current high school physics teachers: the water level within a bucket. Newly-graduated teachers are being poured into the bucket, and good recruitment efforts from the student pool or from the professional ranks may increase this inward flow. Unfortunately, the bucket never seems to overflow, so a surplus of physics teachers is not observed. The bucket also has some natural leaks associated with it, for example, when qualified teachers leave the field through retirement, or other changes in a family situation. However, more and bigger leaks in the bucket may be due to other issues, such as job dissatisfaction.

Beginning Teacher Attrition	
Years of Experience	Cumulative Percentage of Teachers Leaving Profession
1	11%
2	21%
3	29%
4	33%
5	39%

Table I. Physics teacher attrition from the Ingersoll study of Reference (4).

Data [4] presented in Table I show that approximately 40% of teachers leave the field within five years, and the primary reason for leaving is job dissatisfaction. Retention is then one way to plug

some of the leaks to increase the water level in the bucket. Therefore, the retention of qualified physics teachers currently in the field becomes a very important issue, and it has become a major component of the PhysTEC project through the introduction of effective induction and mentoring programs for pre-service and new in-service teachers.

As an example of the water level in the bucket in Indiana, there has been a 20% shortage of experienced physics teachers in the past 10-20 years, and more recently, a 10% shortage in the past five years. An approximately 3% retirement rate per year was expected, and data show that the production of new physics teachers was about 4% per year. Therefore, there must be some leaks in the bucket, or new teachers are moving elsewhere.

Ball State University has had a long tradition of producing teachers within the state of Indiana, and has led the state during the past ten years in producing physics teachers. According to Indiana Department of Education data for this period, 27 institutions in Indiana produced nearly 200 standard certifications in physics; of those reported certifications, Ball State produced 18%, or approximately five times the average.

During the past 8 years (2000-2007), Ball State has produced 41 physics teaching graduates and/or certifications. Of these, 37 are currently teaching in Indiana, while one graduate is teaching in each of the surrounding states of Ohio, Illinois, and Michigan, and one will begin a new position in the next few months. Therefore, 100% of Ball State's graduates have remained in the teaching profession, a remarkable result given the national data just presented above.

This retention result is probably due to many different factors, and not due to a single cause. It is believed to be due in part to the cooperation between faculty in the Department of Physics, in Science Education, and in Teachers College. In addition, a number of the other elements of the Ball State program, which consists of both induction practices and continued mentoring, will be described that may lead to this retention rate.

Induction Strategies for Preservice Teachers to Promote the Retention of Physics Teachers

In the following section, university and departmental practices at Ball State University will be discussed that are believed to promote effective induction and mentoring of pre-service physics teachers.

- Early identification of physics teaching majors: The university's enrollment management system provides the names of physics teaching majors to the Department of Physics each semester; therefore freshmen are identified from this list and also from their introductory physics classes as soon as they enroll in the university. During the past 11 years, as many as a total of 25 students (with an average of 17) were identified in departmental teaching programs per year that lead to physics certification.
- Introducing students to the teaching profession as freshmen: Over the years, beginning teachers at Ball State must immediately enroll in a course that introduces them to the teaching profession. The nature of scientific inquiry, developing basic science teaching skills and disposition, and beginning the process for attaining a teaching licensure are just a few of the issues addressed.
- Connecting beginning students to physics faculty: The strategies identified in the SPIN-UP study [5] are applied to teaching majors just as they are applied to departmental majors and minors. As soon as the beginning pre-service teachers have completed the introductory courses, these teaching majors are invited to become laboratory assistants and/or work with faculty on either teaching or research projects.
- Advising of pre-service teachers: The program advising of pre-service teachers is performed by faculty from the Department of Physics, typically a member in physics education and the Department Chair. Courses for teacher programs are listed in the university catalog under the Department of Physics.
- Connecting pre-service teachers to the department and profession through student organizations: Pre-service teachers are encouraged to become active participants in the department's Society of Physics Students (SPS) and the Cardinal Association of Teachers of Science (CATS), which is affiliated with National Science Teachers Association. Members of CATS are pre-service, secondary science teachers from all science disciplines. SPS members often participate in physics outreach to local schools.
- Including pre-service teachers in the weekly notification of the department's seminar series: Pre-service teachers are encouraged to attend and participate in the weekly seminar. They are also encouraged to join physics majors and minors in the department's dedicated study room/lounge for undergraduate students.
- Developing a departmental culture and attitude toward producing physics teachers and serving physics teachers: The faculty in the Department of Physics values the recruitment and production of physics teachers and physics majors equally. Since 1982, the department has offered a Summer Updating/Retraining Program [6] that provides master's degree, certification, and professional development opportunities for in-service teachers; nearly half of the department's faculty have offered courses for teachers in this format. Pre-service teachers have both formal (in required classes) and informal opportunities (as laboratory assistants) to participate with the in-service teachers in the summer workshop environment. Many graduates remain in informal contact with the department through visits, electronic mail, and conference attendance.

Mentoring of New Inservice Physics Teachers: A Case for Teachers-in-Residence

As part of the licensing process for new teachers, the state of Indiana requires school corporations that hire new teachers to provide their new teachers with a two-year mentoring program [7] that is conducted by an experienced teacher of that corporation who has completed the state's mentor certification program. The certified mentor does not have to be in the discipline of the mentee. A quali-

ty mentor with a common science interest can be a valuable source of advice, support, and encouragement.

An important part of the PhysTEC project has been to sponsor the position of Teacher-in-Residence (TiR). These TiRs are master teachers selected from local schools and join the faculty at the college level for one year before returning to their home school. They perform a variety of tasks, such as the recruitment of new teachers, assisting Science Education faculty in teaching methods courses, and providing induction and mentoring of newly-graduated teachers. The TiRs have been an extremely valuable resource to both students and faculty, and have contributed significantly in the retention of science teachers.

Since 2003 at Ball State, the TiRs have taken the leading role in developing and expanding the mentoring program [8]. They made contact with pre-service teachers, and then continued this relationship as they become in-service teachers at various schools throughout the state. As a part of mentoring, the TiR would visit the classroom to observe and discuss learning strategies. This mentor/mentee relationship was never judgmental or evaluative, but served as a forum for questions and answers, which continued outside these visits. The number of TiR visits depended on each mentee, but was typically once per month per mentee; sometimes fewer visits were made due to the large distance involved (the farthest school was about 200 miles distant). Sometimes the TiR would bring instructional materials and equipment that might not be available at a school, and sometimes the TiR would run a special day, such as a "Physics Day," that would give a brief respite for the teacher. Mostly, however, the discussions would revolve around the materials and resources that the teachers had available to them in their classroom. During the past four years at Ball State, 18 in-service teachers were mentored by the TiRs using this approach, and all mentees have remained in the teaching profession.

Another aspect of mentoring in-service teachers is through a continuing-education program of workshops for professional development. During the school year, Saturday workshops are held on a variety of topics, such as the physics of toys or how hot-air balloons work, and are well-received and well-attended. Often, teachers requested a topic of interest to them, and workshops would be developed to address this interest.

The Teachers-in-Residence also discussed the role of "teacher" in the science education and methods courses. The TiRs spoke to the science education classes about their experiences in the classroom, and provided insights and knowledge about teaching in the "real world." To more advanced classes, they would talk about topics usually not covered in a classroom, such as how to obtain professional development grants and how to deal with safety plans for their classes. The students were eager to hear about the stories and realities of being a science teacher.

The previous examples provide strong evidence for the importance of the role of Teacher-in-Residence in the entire retention process. Being master teachers themselves, they are natural candidates for being excellent mentors and role models. They have also been important leaders of the science workshops for professional development. Finally, they give needed credibility and insight to pre-service teachers on a variety of topics related to classroom matters.

Summary

Ball State University's induction program for pre-service teachers has produced a 100% retention rate for the 41 in-service and pre-service physics teachers that were certified during the past eight years. Similarly, 100% of the 18 mentees of Ball State's TiRs continue in the teaching profession. The practices of the university and the Department of Physics that are believed to support this outcome have been presented, and are summarized below:

- Most departments have been attempting to provide induction opportunities for pre-service teachers. However, PhysTEC has brought an emphasis to the importance of mentoring new teachers as an effective way to retain them.
- Physics faculty must respect the production of physics teachers and physics majors equally; there may need to be a culture change from a mindset that a physics department's first measure of success is the number of physics Ph.D. students produced.
- Advising of pre-service physics teachers is performed by physics faculty and the Department Chair; physics certification programs are listed with departmental major programs in the catalog.
- SPIN-UP recruitment and retention methods, and the best practices of course reform, apply to both physics majors and pre-service physics teachers, as well as to physics majors.
- Effective mentoring of new in-service teachers and increased retention of physics teachers provide strong evidence for the important role of TiRs in a physics department.
- Physics Departments need to provide alternative certification and professional development opportunities for in-service teachers at times that they can take them; summers, evenings, and weekend offerings are encouraged. The retraining of in-service science and mathematics teachers as physics teachers is an important source of physics teachers, in areas where shortages exist.

Retention is an important part of plugging some major leaks in the bucket, thereby helping to lessen a crisis in the number of science teachers.

Acknowledgements

The authors wish to thank those individuals at Ball State University who have given much time and effort into induction and mentoring for retention, the Teachers-in-Residence: Elaine Gwinn, Neil Anthony, Jeff Sayers, Jim Bogan, and George Hill; and to Dave Ober as Department Chair. Without their dedication, this achievement would not be possible. We also extend special thanks to John Layman, Paul Hickman, and Sharon Schultz, whose collaborations have made significant contributions to the mentoring program for the PhysTEC project, and to the dissemination of mentoring publications. Finally, we also regret the passing of Mike Wolter, who

was truly the Master Mentor and an outstanding role model for many new physics teachers. Without his tireless efforts, the model of mentoring would be only a shadow of what it is now. He will be greatly missed.

References

[1] "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, National Academies Press (2005). (http://www.hq.nasa.gov/office/oer/nac/documents/Gathering_Storm.pdf)

[2] See, for example, the joint letter to Physics Department Chairs: (http://www.aip.org/education/fulett.htm)

[3] On August 23, 2001, a five-year, $5.76 million grant was awarded by the National Science Foundation to APS, in partnership with AAPT and AIP. On September 13, 2001, the Fund for the Improvement of Postsecondary Education (FIPSE) in the U.S. Department of Education awarded a three-year, $498,000 grant to enhance the evaluation, induction, and dissemination components of the PhysTEC program. http://units.aps.org/units/fed/newsletters/fall2001/stein.cfm; following is a link to the current Physics Teacher Education Coalition (PhysTEC) website: http://www.phystec.org/about/index.php

[4] Ingersoll, Richard M., "Turnover Among Mathematics and Science Teachers in the U.S.," Report to the National Commission on Mathematics and Science Teaching for the 21st Century, Chaired by John Glenn, (February, 2000). (http://www.ed.gov/inits/Math/glenn/compapers.html)

[5] "Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP)," National Task Force on Undergraduate Physics, http://www.aapt.org/projects/ntfup.cfm

[6] "Summer Updating/Retraining Programs for Elementary, MS, and HS Teachers," Winter AAPT Meeting, San Diego 2001. http://www.bsu.edu/physics/media/pdf/winteraapt2001.pdf

[7] For further details on the program, see the site: http://www.doe.state.in.us/dps/beginningteachers/

[8] The successful Ball State mentoring program, along with contributions from several collaborators, has produced a mentoring manual, "Characteristics of an Effective Mentoring Process," 5th Annual PhysTEC Conference, Xavier University of Louisiana, (2004), which has been the basis of several workshops at meetings of the American Association of Physics Teachers (AAPT) and PhysTEC. A recent version of this manual may be found at: http://www.bsu.edu/physics/media/pdf/mentor_reference_manual.pdf

Jim Watson is in his first year of retirement after a long career at Ball State. He received the 2004 AAPT Distinguished Service Award. He has been interested in physics education for most of those years, and specifically in the physics of toys, so that pre-service elementary education teachers can use toys in their classrooms.

David Grosnick is in his 9th year at Ball State and still participates in experimental particle physics research with the STAR experiment at Brookhaven National Laboratory. He has also participated in PhysTEC since its inception in 2001. He has a long history of interest and involvement in physics education since then.

A Broad Approach to Mentoring in an Inquiry-Focused Early Teaching Experience

Laura Lising and Cody Sandifer
Department of Physics, Astronomy and Geosciences

Introduction

The science teaching reform movement in the U.S. is well organized and strong, with clear standards and benchmarks laid out in the National Science Education Standards (NSES) [1] and Project 2061 *Benchmarks for Science Literacy* [2]. The results of a wealth of research point to a need for transforming classroom science teaching from traditional lecture and rote learning environments to student- and idea-centered inquiry learning environments. Like many other institutions, Towson University has been working to meet the challenge of nurturing inquiry appreciation and expertise in our elementary education graduates. With funding from the APS's, AAPT's, and AIP's Physics Teacher Education Coalition (PhysTEC) program [3], Towson has reformed its elementary science education program [4], focusing primarily on our early teaching experience course. Given the focus of this newsletter issue, this article will motivate the importance of the early teaching experience as an excellent context for making effective reforms in an elementary science education program, and discuss particular reforms that serve many of the broader goals of mentoring, with an emphasis on peer group mentoring and "self-mentoring." These alternative modes of mentoring have unique benefits that are different than those of traditional "expert-novice" mentoring.

Background

The *Benchmarks* call for "Field experiences [in P-12 schools] that allow experienced teachers to share the full picture of teaching with novices." However, interaction between experienced teachers and education students around issues of science teaching often does not occur in elementary student teaching. At Towson University, for example, surveys have shown that, of the 84% of elementary student teachers who receive frequent mentoring (advice, coaching, resources, and support) from their supervising teachers, approximately one-third of these (32%) receive no science-specific mentoring. In addition, of those experienced teachers who come in contact with student teachers, the fraction who are experts in teaching science as inquiry is likely to be low. So even when the student teachers are mentored in science, it is unlikely that the mentoring is inquiry-focused. Clearly there is currently a pressing need for innovative, effective, inquiry-focused science mentoring at the pre-student teaching level. An early science teaching experience presents just such a mentoring opportunity.

Early field experiences are widespread in teacher preparation [5]. According to a 1997 survey by the American Association of Colleges for Teacher Education (AACTE) and the National Council for the Accreditation of Teacher Education (NCATE), over 70% of teacher preparation programs require field experiences in the first or second year of an education student's college career.[1] However, we have been unable to ascertain the prevalence of science-specific early field experiences. The NSES and *Benchmarks* argue, and we would agree, that early science teaching is an important aspect of teacher education. This is especially true given the lack of science-specific mentoring in student teaching, which means that early teaching experiences often represent the first and final opportunity for students to experience inquiry-focused science mentoring that is linked directly to teaching practice.

What types of mentoring activities can occur in an early science teaching experience? We suggest that, in the context of early teaching, it is important not to limit one's notion of mentoring to traditional mentor-mentee relationships, in which mentors are typically conceived of as being more experienced, expert, senior, older, knowledgeable, or successful than their mentees [6]. As valuable as these traditional mentor-mentee relationships can be, there are other types of mentoring relationships that offer unique benefits and can be more flexible and sustainable than the traditional expert-novice relationship. For instance, the NSES argues that "Some of the most powerful connections between science teaching and learning are made through thoughtful practice in field experiences, team teaching, collaborative research, or peer coaching" and the *Benchmarks* emphasize the importance of peer relationships in sustained in-service teacher development. While peer mentoring [7-8] does not fit the usual expert-novice mentoring paradigm, peers can provide useful resources, coaching, and support.

Another alternative to traditional mentoring is "self-mentoring," [9], which includes exercises where a preservice or inservice teacher positions him- or herself as his or her own mentor during reflective activities or self-"observations."Although these activities do not involve interpersonal relationships like expert-novice mentoring or peer mentoring, they can help a teaching student or practicing teacher coach and support him- or herself more effectively. Self-mentoring can also be considered a facet of reflective practice [10], which is recognized as being crucial for effective teacher development.

Towson's early science teaching experience

At Towson, elementary education majors have three science courses in their third year of study: an earth-space science course that is a mixture of content and teaching methods, a biology content/methods course, and a science internship (the early teaching experience). In the internship course, elementary education students (hereafter referred to as "interns") practice teaching science and learn additional teaching methods.

In reforming the internship, our project team developed a number of means to support course improvements, including mentor teacher workshops, instructor workshops, methods activities and other resources [11]. For instance, we were able to establish minimum teaching requirements; consequently the percentage of interns who teach fewer than four class lessons has decreased from 28% to 0% over the past four years. We also established four "Core Principles of Inquiry" and related methods activities for the three science courses mentioned above. The Core Principles are aligned with, but more concise than, the NSES inquiry guidelines, and emphasize children figuring out concepts on their own as much as possible in an idea-centered, minds-on, cooperative learning environment.

Since we began reforming the course over three years ago, we have been measuring progress according to our primary reform goal–increased teaching of science as inquiry by the interns. Using an observation protocol based on the NSES "Changing Emphasis" statements, we have seen a shift from mostly traditional teaching to mostly mixed or primarily inquiry teaching. For instance, in our baseline semester, 9 of 11 lessons observed primarily involved interns demonstrating science content (more traditional), whereas only 2 involved interns having the children investigate science content (more inquiry). In contrast, by the third year of the project, the data collected over both semesters revealed primarily demonstration of content in no lessons (of 22 observed) and investigation of content in 14 lessons, with the remaining 8 lessons containing a mixture of both approaches.

Mentoring in Towson's early teaching course

Mentoring by "experts": the course instructor and the classroom teachers.

New course instructors are trained in science inquiry methods before teaching, and thus the interns are supposed to receive some inquiry-specific mentoring of their teaching practice during this course. Our observations, however, show that there is still a wide range in the quantity and quality of feedback the interns receive from their course instructors, especially among those who are new to inquiry. This is continually being addressed. The elementary mentor teachers, in whose classes the interns are placed, are also oriented to the course and its inquiry emphasis in a three-hour workshop. We have seen some changes in the feedback to be more aligned with the goals of inquiry. For instance, some teachers have come to expect investigations to take several class periods rather than wrapping up each day, and counsel interns to be patient and help the children evaluate and build on their own ideas.

Peer group mentoring in the context of lesson planning, teaching, and analyzing children's ideas.

One of the most important aspects of the course is the team planning/teaching structure. Three to six interns are placed in each elementary classroom, with each intern working with one small group of children each week for the majority of each lesson. With this arrangement, each intern teaches every day rather than taking turns with other team members and also gets to be well-acquainted with the children in the small group reducing the number of classrooms placements has various benefits. With fewer classrooms, for example, we can do a better job of choosing schools and classrooms to ensure that the cooperating teachers are supportive of inquiry. Reducing the number of classrooms also allows all interns in a given course section to be placed in the same school, with the result that their Towson instructor is available to every intern every week for guidance and mentoring. However, one of the most important benefits is that, within the teaching/planning groups, the interns become *de facto* peer mentors themselves: they share lesson plan ideas, engage in formal and informal teaching discussions, and provide motivational, pedagogical, and content-related support for one another. Advantages of peer group mentoring, for interns as well as practicing teachers, include making the mentees feel less isolated and–because they are being mentored by peers rather than higher-status expert mentors–allowing the mentees to be more forthcoming about their teaching fears and frustrations [8]. Evidence for the interns' appreciation for group planning is most visible in their summative course reflections, a portion of which is often dedicated to the interns' recognition that group planning is helpful. Many of the interns also discuss plans to use their peers (many of whom are friends by the end of the course) for help in their continued growth in the future.

The importance of anticipating and analyzing children's ideas is emphasized by many of the course instructors as central to inquiry teaching. A variety of course assignments are used to help the interns practice this type of anticipation and analysis, including the explicit requirement of anticipation/analysis sections in the interns' lesson plans and teaching reflections and special assignments in which the interns analyze transcribed audio recordings of their lessons and other lesson artifacts to help them develop interpretive skills and use these skills in their teaching. Delving deeply into possible meanings of children's statements, drawings, etc. is a difficult endeavor and interns generally rely strongly on their peers for help, with the result that these assignments frequently provide natural contexts for peer mentoring to occur. The peer collaboration that emerges in these activities (which we encourage the interns to continue once they have their own classrooms) is similar to the successful "Science Inquiry Group" model of in-service peer mentoring [12].

Self-mentoring through focused reflections and "self-observations."

The course includes an array of activities to help the interns more effectively analyze their own teaching. In addition to their lesson reflections, the course includes end-of-semester reflections that require interns to assess their progress in teaching and devise a plan for continued growth. Another activity is a type of self-observation, in which the interns audiotape their lessons and analyze their own teaching according to provided guidelines. For instance, one assignment asks students to analyze and categorize the "metamessages" [13] in their statements. Metamessages are ideas or values

communicated indirectly. For instance, saying "That's correct" to a child sends a different message about what a teacher is attending to at the moment (correct answers) than saying to the whole class "Does that make sense to you?" (sensibleness and others' understanding). Interns are typically very surprised to find such a strong discord between their most common metamessages and their personal goals and they spontaneously devise plans for resolving this discord through continued self-monitoring. Such self-mentoring holds the possibility of being more honest and more motivating, and it is available when other forms of mentoring are not. We would like to thank Pamela Lottero-Perdue for helpful advice and resources.

References

1. National Research Council. (1996). *National Science Education Standards*. Washington , DC : National Academy Press.

2. American Association for the Advancement of Science. (1993). *Benchmarks for Science Literacy*. Washington, D. C.: Oxford University Press.

3. http://www.phystec.org

4. For overviews of our project, please see: Sandifer, C., Lising, L., and Tirocchi, L. (2006). Our PhysTEC project: Collaborating with a classroom teacher to improve an elementary science practicum. *2006 Conference Proceedings of the Association for Science Teacher Education*, Sandifer, C., Lising, L., and Renwick, E. (2007). Towson's PhysTEC course improvement project, years 1 and 2: results and lessons learned. *2007 Conference Proceedings of the Association for Science Teacher Education*, and http://www.phystec.org/institutions/towson/index.php

5. Huling, L. (1998). *Early field experiences in teacher education*. Washington, DC: ERIC Clearinghouse on Teaching and Teacher Education, (ERIC Document Reproduction Service No. ED429054)

6. See, for example the influential papers by Levinson et al., Kram et. al., and a host of more recent references as well: Levinson, D. J., Darrow, C. N., Klein, E. B., Levinson, M. H., & McKee, B. (1978). *Seasons of a man's life*. New York: Alfred A. Knopf, and also Kram, K. E. (1985). *Mentoring at work: Developmental relationships in organizational life*. Glenview, IL: Scott, Foresman and Company.

7. Kram, K. E. and Isabella, L. A. (1985). Mentoring alternatives: the role of peer relationships in career development. *The Academy of Management Journal*, 28, 110-32.

8. Huling-Austin, L. (1992). Research on learning to teach: Implications for teacher induction and mentoring programs. *Journal of Teacher Education*, 43(3), 173-80.

9. Boreen, J., Niday, D. and Johnson, M. K. (2003). *Mentoring Across Boundaries: Helping Beginning Teachers Succeed in Challenging Situations*. Portland, ME: Stenhouse.

10. Schön, D. A. (1983) *The Reflective Practitioner: How professionals think in action*. London: Temple Smith.

11. http://pages.towson.edu/csandife/phystec/Elem_Internship_Resources.zip

12. van Zee, E.H. (2000). Documentation and interpretation of the emerging practices of the Science Inquiry Group. Report to the Spencer Foundation Program for Practitioner Research: Communication and Mentoring Grants.

13. Tannen, D. (2002). *I Only Say this Because I Love You*, New York: Ballantine.

Laura Lising and Cody Sandifer are science education faculty in the Department of Physics, Astronomy and Geosciences at Towson University. Both have backgrounds in physics and physics education research. Dr. Lising's work currently focuses on science inquiry, elementary science education, teacher education, and personal epistemologies of p-16 students and teachers. Dr. Sandifer's work currently focuses on science inquiry, elementary science education, teacher education, and p-16 curricular reform.

[1] Twenty-five percent of field experiences are solely observation-based (i.e., in 25% of field experiences, the interns observe the science instruction of cooperating teachers without engaging in teaching activities themselves). In part, this is why the term "early teaching experience" is used in this article in place of "early field experience"–to clarify that our focus is on early teaching rather than early observing.

Executive Committee of the Forum on Education

Chair: Ernest Malamud
(04/08 - 03/09)
Univ of Nevada-Reno

Chair-Elect: Peter Collings
(04/08 - 03/09)
Swarthmore College

Vice Chair: Lawrence Woolf
(04/08-03/09)
General Atomics - San Diego

Past Chair: David Haase
(04/08-03/09)
North Carolina State Univ

Secretary/Treasurer: Bruce Mason
(04/08-03/11)
Univ of Oklahoma

Councillor: Peter Zimmerman
(01/05-12/08)
Kings College

Member-at-Large: John Thompson
(04/08-03/11)
Univ of Maine

Member-at-Large: Noah Finkelstein
(04/06-03/09)
Univ of Colorado-Boulder

Member-at-Large: Olivia Castellini
(04/07-03/10)
Univ of Wisconsin, Madison

APS/AAPT Member: G. Samuel Lightner
(04/07-03/10)
Westminster College

APS/AAPT Member: Stamatis Vokos
(04/08-03/11)

APS/AAPT Member: Mel Sabella
(04/08-03/09)

Newsletter Editor (Fall): Thomas Rossing

Non-voting Members

Chair, Committee on Education: Michael Marder
Univ of Texas, Austin

APS Liaison: Ted Hodapp
APS Director of Education & Diversity

AAPT Representative: Harvey Leff
AAPT Past President
California Polytechnic State Univ-Pomona

AIP Representative: Jack Hehn
AIP Director of Education