Physics Education Research Conference 2000: Teacher Education

University of Guelph, August 2-3, 2000

In tandem with the 2000 summer meeting of the American Association of Physics Teachers.

Planning Committee: Richard N. Steinberg (Chair), City College of New York
Robert Beichner, Constantinos P. Constantinou, David Hammer, Seth Rosenberg

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Participants must register for the AAPT meeting. The registration cost is an additional $50.

Please scroll down to see links to complete papers. Click here to see presentation abstracts.

Agenda

Wednesday, August 2

Afternoon - AAPT meeting invited session and panel discussion
PER: Teacher education

Preparing teachers as diagnosticians
David Hammer, University of Maryland

Preparing teachers to teach science by inquiry: Insights from research
Peter Shaffer, University of Washington

Reflections on long-term professional development of physics teachers in Israel
Bat-Sheva Eylon, Weizmann Institute of Science

How can the computer facilitate the development of physics knowledge among prospective elementary teachers?
Fred Goldberg, San Diego State University

7:00PM - 9:00PM - Reception/PER contributed poster session

Organizer: Seth Rosenberg, The Ohio State University
Physics education research talks from the general AAPT meeting will be displayed in poster format.

Thursday, August 3

8:00AM - 8:15AM - Welcome and overview

Richard N. Steinberg, City College of New York

8:15AM - 10:15AM - Invited session and panel discussion
Perspectives of pre-college teachers

Action research on underpinnings for physics
Jeff Hengesbach, Mountain Pointe High School, Arizona
David Hestenes, Arizona State University

Research and the high school classroom: Confessions of a PER junkie
Robert Morse, St Albans School, Washington, DC

Crossing the gap from research on preconceptions to standards-based practice
Jim Minstrell, Pam Kraus, and the Physics Teachers' Network, Seattle, WA

10:15AM - 10:30AM - Break

10:30AM - 12:30PM - Invited poster breakout sessions

Four parallel sessions:

Elementary/Middle School Education

Moderator: Jerold Touger
Room A
10:30 - 11:30 posters
11:30 - 12:30 discussion

Learning about static electricity and magnetism in a fourth grade classroom
Dave Henry, Buffalo State College

Attitudes of future teachers to teaching and learning
Kirsten Hogg, Kansas State University

Characterizing the development of scientific meanings by preservice teachers in a guided inquiry physics course
Andy Johnson, Black Hills State University

Physics by Inquiry
Lillian C. McDeromott and the Physics Education Group at the University of Washington

A perspective on teaching physics courses for future elementary-school teachers
David E. Meltzer, Iowa State University

Learning by inquiry in a physical science course for prospective elementary teachers: What do the students think?
Roger Nanes and Vincent Smith, California State University, Fullerton

Factors affecting students' small-group discussion of force and motion in a middle school physical science course
Cody Sandifer, Sad Diego State University

What is "physics" for prospective primary school teachers?
Manju D. Sharma, R. Millar and K. Wilson, The University of Sydney

High School Education

Moderator: David Maloney
Room B
10:30 - 11:30 posters
11:30 - 12:30 discussion

How should teacher training incorporate research about students prior conceptions?
Andy Elby, University of Maryland, College Park

Bridging studies of physics and education
Noah Finkelstein, University of California, San Diego

The need for improved physics education of teachers: FCI pretest scores of graduates of high school physics courses
Richard R. Hake, Indiana University

The effectiveness of guided inquiry for the teaching of heat and temperature at the high-school level
Michael Jabot, Oneida High School; Christian Kautz, Syracuse University

Modeling Instruction works for ALL high school physics teachers
Jane Jackson, Arizona State University

Assessing to Learn (A2L): Researching the role of formative assessment in high school physics
Jose Mestre, William Gerace, Robert Dufresne, and William Leonard
University of Massachusetts, Amherst

Instructional Technology	**Assessment**
Moderator: Edward F. Redish **Room C** **10:30 - 11:30 posters** **11:30 - 12:30 discussion**	**Moderator: Robert Beichner** **Room D** **10:30 - 11:30 posters** **11:30 - 12:30 discussion**
Educating pre-service physics teachers at Högskolan Dalarna in Sweden Jonte Bernhard, Linköping University **Designing professional development for a facet-based learning environment** Pamela Kraus and Jim Minstrell, Talaria Inc. **Computer simulations in teaching motion in two dimensions: Long term action research in a high school classroom. part 2** Robert A. Morse, St. Albans School **Video classroom data: Results, methodology, and video analysis tools** Valerie K. Otero, San Diego State University **Student-oriented science: Enabling teachers** Ronald Thornton, Tufts University	**Developing an energy concept inventory** Dwain Desbien, Arizona State University **Assessments as diagnostics instead of as exams** Dewey I. Dykstra, Jr., Boise State University **The "0.7 Barrier" on the FCI -- a suggestion of the underlying problem and a proposal for further research** Jerome Epstein, Polytechnic University **Assessment with the Force Concept Inventory** David Hestenes, Arizona State University **Connecting research in physics education with teacher education** E. Leonard Jossem , The Ohio State University **Is It Finally Time for a Physics Counterpart of the Benezet/Berman Math Experiment of the 1930's?** Sanjoy Mahajan, University of Cambridge and Richard R. Hake, Indiana University **Investigating the impact in the classroom of an inquiry-oriented summer course for teachers** Graham E. Oberem, Paul G. Jasien, and Betsy R. Strick, California State University, San Marcos **Rethinking assessment in light of constructivist learning approaches** J. van Aalst, Simon Fraser University

12:30PM - 1:30PM - Lunch

1:30PM - 2:00PM - Discussion / question and answer session

A view from the NSF
Duncan McBride, National Science Foundation

2:00PM - 3:00PM - Poster session summary and discussion

Elementary/middle school education
Jerold Touger, Curry College

High school education
David Maloney, Indiana University-Purdue University Fort Wayne

Instructional technology
Edward F. Redish, University of Maryland

Assessment
Robert Beichner, North Carolina State University

3:00PM - Final comments, conference ends

Pages prepared by Richard N. Steinberg

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Physics Education Research Conference 2000: Teacher Education

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In tandem with the 2000 summer meeting of the American Association of Physics Teachers.

Conference Abstracts

AAPT meeting invited session and panel discussion
PER: Teacher education

Preparing teachers as diagnosticians
David Hammer, University of Maryland
It is clear that in some respects the preparation of prospective physicists must go beyond that of prospective teachers. Physicists, for example, need to have practiced a range of calculational and experimental techniques, as familiar tools rather than as objects of study.
In other respects, the preparation of teachers must be more rigorous. Teachers, for example, must be familiar and able to speak substantively to alternative ways of understanding physical phenomena. More to the point, teachers must be able to recognize and follow the sense of their students' reasoning, including when that sense differs from physicists'.
Teachers, in other words, need to have practiced the diagnosis of student thinking, and effective teacher preparation must specifically address this need: A significant component of teacher education should involve careful, substantive examination of student thinking in authentic instances of learning and instruction.

Preparing teachers to teach science by inquiry: Insights from research
Peter Shaffer, University of Washington

Reflections on long-term professional development of physics teachers in Israel
Bat-Sheva Eylon, Weizmann Institute of Science
The professional development of physics teachers in Israel has undergone a profound change in the last several years: From short-term courses focused on acquainting teachers with existing and new curriculum materials to long-term programs aimed towards general professional development of teachers. These programs take a comprehensive view of teachers' knowledge including: Subject matter knowledge, general pedagogy, pedagogical subject matter knowledge, views about teaching and learning, practical knowledge and the development of a reference group. The formation of long-term frameworks for

teachers has resulted from the realization that systematic teacher learning is a life-long process and must be scaffolded beyond the preservice stage. A national center for physics teachers has been established at the Weizmann Institute to towards this end. This center trains leadership personnel, develops new models for professional development and accompanies the activity with research. Following experience of six years, I shall give an overview of this work and will focus on issues rising from the intense long-term characteristic of these programs.

How can the computer facilitate the development of physics knowledge among prospective elementary teachers?

Fred Goldberg, San Diego State University

To use computers effectively in the classroom it is important to understand how particular types of computer software and pedagogical structures can support interactions that lead to meaningful learning by students. The role that the computer plays in students' learning in a collaborative environment depends not only on the ways that students use the computer and software but also on how they interact with each other as they use the computer. In this talk I will describe some results of studies that were conducted in collaborative guided-inquiry physics courses for prospective elementary teachers. In these courses, each group of three students had access to its own computer. I will describe how the computer can be used as a representational tool to support meaning-making conversations in small student groups, and how specially designed computer simulators make it easier for groups of students to construct robust conceptual models.
*Work supported in part by NSF Grant ESI-9454341

Invited session and panel discussion
Perspectives of pre-college teachers

Action research on underpinnings for physics

Jeff Hengesbach, Mountain Pointe High School, Arizona
David Hestenes, Arizona State University

The Arizona Science and Technology Partnership (AzSTEP) is a statewide program to cultivate physics teachers as leaders of science education reform in their schools and school districts. AzSTEP organizes and supports Action Research Teams to promote reform. Action Research (AR) is conducted by inservice teachers to make specific improvements in teaching practice. We discuss the plans and activities of one AR Team charged with examining the science background (underpinnings) appropriate for students starting high school physics, studying exemplary curricula for developing that background, and utilizing it in the design of a 9th grade physical science course. The objective is to develop a workshop for physical science teachers to help them improve their teaching and coordinate it with subsequent physics and chemistry courses. Members of the AR Team will conduct the workshop and work closely with physical science teachers in their schools.
(*Supported by NSF grant PHY-9819461)

Research and the high school classroom: Confessions of a PER junkie

Robert Morse, St Albans School, Washington, DC

In which the author recounts his use of results of Physics Education Research in the classroom, his attempts to engage in PER, his adventures in curriculum development involving PER and his interactions with the PER community. An attempt will be made to draw some useful conclusions.

Crossing the gap from research on preconceptions to standards-based practice*

Jim Minstrell and Pam Kraus, and the Physics Teachers' Network, Seattle, WA
Teachers are under pressure to get their students to meet standards. Increasing content understanding of teachers is important. Curricular lessons that foster deep understanding of content aligned with standards are necessary. The project described is designed to help teachers focus on learning and to monitor progress through embedded assessment based on research and practice related to standards. We will describe how diagnostic questions, guidance to interpretresponses, and benchmark lessons are being used by teachers to build on students' useful facets of thinking and challenge their problematic understanding. These tools will be served over the web along with professional development on effective use.
*This project is supported in part by grants from the National Science Foundation.

Invited poster breakout sessions

Elementary / Middle School Education

Learning about static electricity and magnetism in a fourth grade classroom

Dave Henry, Buffalo State College
Students begin to develop mental models to explain electrostatic and magnetic phenomena throughout childhood, middle childhood and high school, although these mental models are often incoherent and unscientific(Maloney 1985; Borges, Tenico et al. 1998). This is a case study of a classroom of grade four students and the mental models of magnetism and static electricity they used during a six-week science unit. The 22 students studied magnetism and static electricity using inquiry activities structured to create an environment where students would be likely to construct powerful scientific ideas (Goldberg and Bendall 1995).
Multiple data sources, including students' writing, student assessments, teacher interviews, student interviews, teacher journals, and classroom video and audio recordings were used to uncover how fourth grade students made sense of static electricity and magnetism before, during, and after instruction. The data were analyzed using a social constructivist framework to determine if students were able to develop target scientific ideas about static electricity and magnetism.
In general, students were found to have three core mental models prior to instruction: 1) Static electricity and magnetism are the same "substance"; 2) This substance exists on the surface of a magnet or a charged object and can be rubbed off; and 3) Opposite substances attract. During the activities, students had many opportunities to observe evidence that contradicted these core mental models. Using evidence from direct observations, the students practiced differentiating between evidence and ideas. Through group and class discussions, they developed evidenced-based (scientific) ideas. Final assessments revealed that students were able to construct target ideas such as:
1) static electricity and magnetism are fundamentally different;
2) there are two kinds of static "charge;"
3) magnet-rubbed wires act like a magnet; and
4) opposite substances move toward each other, like substances push away from each other.
Some target ideas, such as "Magnetic materials are made up of magnetic domains that align to give an overall magnetic effect" were found to be difficult for students this age to develop. This case study will augment research about effective science teaching, teacher development and the support necessary for curriculum change.
References
Borges, A. T., C. Tenico, et al. (1998). "Models of Magnetism." International Journal of Science Education 20(3): 361-378.
Goldberg, F. M. and S. Bendall (1995). "Making the invisible visible: A teaching/learning environment

that builds on a new view of the physics learner." American Journal of Physics 63(11).
Maloney, D. P. (1985). "Charged Poles?" Physics Education 20: 310-316.

Attitudes of future teachers to teaching and learning*

Kirsten Hogg, Kansas State University

The physics education community has invested considerable time and effort in to improving pre service teacher training over the past 15 years. At Kansas State University we attempt to prepare elementary teachers through a learning cycle course Concepts of Physics [1]. The course is strongly activity based, and the students work through a series of explorations and applications to build an understanding of mechanics, energy, electricity and magnetism. As part of an evaluation of this course we asked students about their attitudes to learning and teaching physics. This poster reports on the rather complex perceptions and attitudes students have about their own learning processes, how their knowledge informs and influences their teaching and their expectations for children's learning of physics.
Additional information is available at http://www.phys.ksu.edu/perg/
*Supported by the National Science Foundation under grant CETP 98-76676
[1] Dean Zollman, The Physics Teacher 28, 20-25 (1990) & Physics Education 29, 271-275 (1994).

Characterizing the development of scientific meanings by preservice teachers in a guided inquiry physics course

Andy Johnson, Black Hills State University

The constructivist view of learning problematizes communication because it assumes that knowledge can't be transferred from one person to another. If we take this view, then we have to explain how different individuals can develop new - and apparently similar - understandings of physics ideas. The knowledge development process warrants scrutiny in its "natural setting" of day to day classroom conversations. This poster reports on a study in a physics course for pre-service teachers. The students' sense-making discussions - which were guided and supported by course materials - resulted in new and valuable understandings of magnetic interactions and materials. This poster will describe categories of small-group interactions that accomplished both the development of new ideas, and the coordination of understandings among members of a group. These categories may aid classroom observations and research on learning processes, and inform the development of new course materials for preservice teachers and other students.

Physics by Inquiry

Lillian C. McDeromott and the Physics Education Group at the University of Washington

A perspective on teaching physics courses for future elementary-school teachers

David E. Meltzer, Iowa State University

Given typical time constraints, what are realistic expectations for conceptual learning in physics courses for preservice elementary-school teachers? Are there some topics which should be avoided for such courses? What are the bottom-line tradeoffs between breadth of topical coverage and depth of conceptual learning? What are possible implications regarding optimum strategies for science education in the elementary schools? I will offer some reflections on these questions based on data and observations from seven years of experience teaching inquiry-based physics courses for elementary education majors and other nontechnical students.

Learning by inquiry in a physical science course for prospective elementary teachers: What do the students think?

Roger Nanes and Vincent Smith, California State University, Fullerton

An inquiry-based Physical Science course has recently been developed and implented for prospective elementary teachers at Cal State Fullerton and the syllabus defines the following major goals of the course:
(1) to help students construct an understanding of physical science concepts that can be applied to explain phenomena that are interesting, related to real-world experiences and typically included in an elementary school science curriculum; (2) to help students develop positive attitudes about science and to help develop confidence in their ability to do science and, (3) to help students take an active role in learning and thinking about science, rather than passively listening to lectures and reading a textbook.
Most students will teach the way they learn. Given the desirability of modeling good pedagogy for prospective teachers, research on student attitudes and expectations about learning science and teaching science is particularly important for this target audience. This paper will present the results of a series of interviews that were conducted with four students over the duration of the Course. Several themes that emerged from the interview transcripts were analyzed with a view towards gaining insight into how student attitudes and expectations were affected by the Course pedagogy and active-learning environment. Also discussed will be the extent to which student attitudes influenced the achievement of the above-mentioned goals and some implications for instruction will be presented.

Factors affecting students' small-group discussion of force and motion in a middle school physical science course*

Cody Sandifer, Sad Diego State University

This study had two purposes: 1) to document the quality of students' small-group scientific discussion, and 2) to identify classroom, curriculum, and group factors that support or hinder small-group scientific discussion. Participants in the study consisted of 2 middle school groups working through the Force and Motion unit in the Constructing Ideas in Physical Science (CIPS) curriculum project. Quality of discussion was measured by the degree to which students made explanations, inferences, and predictions, sought out new information, and searched for knowledge compatibility. Results showed that the quality of discussion varied over groups and activities, and that a number of factors influenced these discussions: teacher guidance, the activity's level of difficulty, the degree of student collaboration, and group members' view of science and scientific methodology.
*Work supported by NSF Grant ESI-9812299

What is "physics" for prospective primary school teachers?

Manju D. Sharma, R. Millar and K. Wilson, The University of Sydney

The University of Sydney, Australia, offers a degree program for prospective primary school teachers with a one year Science Foundations course with equal components of chemistry, physics, biology and geology offered within the specialist departments. For the physics component, we have designed and implemented two hour workshops with the aims of enhancing students' confidence in their ability to understand and communicate physics. The workshops are structured with students working in cooperative learning groups on qualitative and quantitative problems, selected lecture demonstrations and explicit practice-teaching presentations. Together with evaluating the various aspects of the workshops, we investigate if students are confident in seeking answers for themselves and discussing physics concepts. The poster reports on students' perceptions of physics, previous experiences with formal instruction in physics, attitudes towards physics and their perception of the need for primary school teachers to understand some physics. We investigate various prompts and their influence on learning processes. Given that most students will teach the way they learn we discuss the implications of the prompts for instruction.

High School Education

How should teacher training incorporate research about students prior conceptions?

Andy Elby, University of Maryland, College Park

How should teacher training programs incorporate the research about students' prior conceptions? We could focus on the methods, helping teachers become deep listeners, informal "diagnosticians" of their students' intuitive ideas. Alternatively, we could focus on the results of the research, making teachers aware of specific misconceptions they can expect to encounter. Given the harried schedules of pre-service teachers, it's probably impossible to focus deeply on both agendas. How shall we strike a balance?

Videotape data from my high school class (1998-99) bears directly on this issue. Four students work together on two conceptual lab questions. Students discuss each question among themselves before the teacher comes over. Based on his interaction with the students, the teacher (me!) assumes that their difficulties stem from common, well-documented misconceptions. The students' discussion prior to the teacher's arrival, however, reveals that misconceptions are only part of the story; the students' difficulties stemmed just as much from context-specific intuitions and misapplied pieces of prior knowledge. During his interaction with the students, the teacher missed cues that could have led him to these issues.

I argue that he failed to do so for two reasons. First, when the students interact with the teacher, their ideas sound "cleaner"-more conception-like-than they really are; less articulate ideas get downplayed. Second, the teacher has a lingering tendency to "hear" misconceptions more readily than he hears other forms of prior knowledge.

This analysis emphasizes the importance of training teachers to be deep-listening diagnosticians. Especially if students' ideas sound artificially "conception-like" during interactions with the teacher, teachers who expect to hear specific misconceptions-and who fail to listen for more context-sensitive prior knowledge-will miss out on much of their students' thinking, and will therefore be less effective at helping students construct a better understanding.

Bridging studies of physics and education

Noah Finkelstein, University of California, San Diego

This works describes a new course for physics majors/graduate students who wish to consider careers in teaching and issues related to teaching and learning physics. The new course provides a model for coordinating education, research, and outreach. This work details students improvement in command of physics content, teaching expertise, and epistemological / metacognitive skills which support the the mastery of each domain.

The need for improved physics education of teachers: FCI pretest scores of graduates of high school physics courses*

Richard R. Hake, Indiana University

For Indiana University "pre-med" 1994 Spring (1995 Spring) courses [Am. J. Phys. 66(1), 64-74 (1998)] the FCI pretest average for those (a) 43 (45) students who had not taken High-School Physics (HPS) was 32% (37%), (b) 123 (164) students who had taken HSP was 42% (43%). If one assumes that the "b" group graduates of HSP, before they took HSP, would have averaged about the same as the "a" group, then the nomalized gains of the "b" group would have been <g> = 0.15 (0.09), compared to the usual <g> = 0.2 for traditional courses. The very low hypothesized <g> of the "b" group may reflect (1) a rapid decrease in <g> in the years following HSP, as might be expected if only incoherent and loosely related bits of physics understanding had been acquired, (2) a low <g> even directly after HSP, or (3) some combination of "1" and "2". In any case, the results - consistent with those of TIMSS - suggest the ineffectiveness of HSP to promote conceptual understanding and the need for improved physics education of teachers in interactive-engagement (IE) rather than traditional (T) classes. Teachers need IE rather than T courses because they (a) "tend to teach the way they were taught," (b) should understand physics concepts.

*Partially supported by NSF Grant DUE/MDR-9253965.

The effectiveness of guided inquiry for the teaching of heat and temperature at the high-school level

Michael Jabot, Oneida High School; Christian Kautz, Syracuse University

This paper describes an attempt to evaluate two different methodological approaches to the teaching of heat and temperature. Two groups of high-school students were involved in this study. One group of 74 students was taught using guided-inquiry as the main mode of instruction. A second group of 55 students was taught in a traditional, lecture-based format. Written pre- and post-tests were used to assess student understanding of the topic before and after instruction, taking into account frequencies of correct responses as well as correct reasoning. Evaluation of these measures suggests significantly greater gains by the guided-inquiry group.

Modeling Instruction works for ALL high school physics teachers*

Jane Jackson, Arizona State University

Half the physics teachers in Arizona use Modeling Instruction. Of the 100 Arizona teachers who use Modeling Instruction, 20% teach in urban schools and 25% are rural (chiefly low income). 30% are women. Almost all physics teachers in the Phoenix inner city use the Modeling Method. Student FCI gains for "ordinary" Arizona teachers, 80% of whom were not physics majors, are almost as high as those for leading teachers nationwide. Teachers who implement the Modeling Method most fully have the highest student posttest FCI mean scores. The modeling approach has proven success with students who have not traditionally done well in physics, while enhancing the performance of all students. Consequently, enrollments are increasing in classes of teachers employing the Modeling Method.
*Supported by NSF grant PHY-9819461

Assessing to Learn (A2L): Researching the role of formative assessment in high school physics

Jose Mestre, William Gerace, Robert Dufresne, and William Leonard University of Massachusetts, Amherst

Assessment in education has been used predominantly for evaluating student achievement. These so-called summative assessments, usually in the form of an hour exam, are used to "sum up" the achievement levels attained by students, and are neither viewed as learning experiences in themselves nor used in a meaningful way to inform subsequent instruction. An important area for the physics education research community to consider is the design and implementation of formative assessments for purposes of guiding and informing instruction. We will describe an ongoing research and development project to investigate the design and use of formative assessment items that also promote learning. Our approach combines classroom communication technology with concept-based problem solving in a way that blurs the line between instruction and assessment.

Instructional Technology

Educating pre-service physics teachers at Högskolan Dalarna in Sweden*

Jonte Bernhard,** Linköping University

In Sweden physics is taught as a separate subject from the Swedish grade 7 (13 years old). Pre-service teachers who study to become certified as science and physics teachers in Swedish grade 4-9 take calculus based physics. The minimum requirement for graduation at Högskolan Dalarna is the study of Young-

Freedman "University Physics" including Modern Physics and also a short course in Astronomy and some Electronics. The Physics course also includes a short introduction to Physics Education Research. Microcomputer Based Labs (MBL) in physics teaching were first introduced at Högskolan Dalarna in the 1994/95 academic year and first used by pre-service teachers in the 1995/96 academic year. In physics courses for pre-service teachers we have used MBL-labs in mechanics, thermodynamics and electricity/electronics courses. The students have very well received these labs. Typical pre-test values for the pre-service teachers on the FCI have been around 50% with post-test values between 65 - 72%.
A secondary, but very important, effect of using MBL-labs is the training of the pre-service teachers in the use of computers and it's use in a science education context. Since teachers tend to teach in the way they have been taught it is very important that pre-service teachers have experience using computers and experience of active engagement methods from their own training. Thus the MBL-labs serves the dual purpose of better educating the pre-service teachers in physics and in physics teaching.
* Partial financial support from the Swedish National Agency for Higher Education, Council for Renewal of Undergraduate Education, is gratefully acknowledged.
** The work described in this paper was mainly done while the author was employed at Högskolan Dalarna.

Designing professional development for a facet-based learning environment

Pamela Kraus and Jim Minstrell, Talaria Inc.

We will describe several approaches for supporting teachers in implementing the Diagnoser and related instruction. This project is closely linked with Washington State's educational reform efforts, which includes professional development on classroom-based assessment. One approach is to use the Facets of student thinking aligned with the state standards and the Diagnoser as a context for developing and using research-based assessments as tools to inform decisions on needed instruction.

Computer simulations in teaching motion in two dimensions: Long term action research in a high school classroom.

Robert A. Morse, St. Albans School

This paper looks at a long term project to integrate computer simulations of motion with classroom experience and class discussion to help students understand motion in two dimensions. An initially unsuccessful attempt to use the Dynaturtle simulation evolved over time into a better integrated curriculum unit. Comparisons over time of classroom test results and informal observation were used to assess the effectiveness of curricular modifications.

Video classroom data: Results, methodology, and video analysis tools

Valerie K. Otero, San Diego State University

Research on the process of learning static electricity in a CPU collaborative-inquiry, computer-based physics course for prospective elementary teachers will be discussed. A scheme that relates students' interpretations of simulator results to students' interpretations of results of laboratory experiments will be presented. A video data analysis tool (Vprism) and video coding and interpretation methods will be described and demonstrated.

Student-oriented science: Enabling teachers

Ronald Thornton, Tufts University

The research of the Center for Science and Mathematics Teaching at Tufts University and that of others has shown that students (and teachers) are more likely to achieve fundamental understandings of science in activity-based learning environments. Unfortunately most teachers of physics and physical science are unable to help their students achieve these understandings because they either lack sufficient mastery of

the basic science concepts or pedagogical resources. Unhappily, in many cases, they lack both. This presentation will concentrate on a short teacher education program that enhances pedagogical repertoires to include the effective use of guided inquiry, peer collaboration and modern technology in teaching basic science concepts while improving teacher understanding of those same concepts. The participants to engage in active, inquiry-driven learning experiences in which they use Microcomputer-Based Laboratory equipment and software to explore the physical world by collecting data and displaying the results graphically and digitally in real-time. After collection they can manipulate and analyze data in a variety of ways. The processes in which they engage are the same as those of scientists. The short series of workshops has resulted in changed instruction for 90% of the participants. A Teacher Education Module will help others implement this program.

Assessment

Developing an energy concept inventory*

Dwain Desbien, Arizona State University

The Modeling Research Group at ASU is developing an instrument, called the Energy Concept Inventory (ECI), to assess student qualitative understanding of energy concepts. It is similar in design and purpose to the highly successful Force Concept Inventory (FCI), previously developed within this group. For ease of use it has a multiple-choice format that forces discrimination of scientific aspects of energy storage and transfer from their common sense alternatives. Like the FCI, the ECI is intended for use in comparative studies of student knowledge and learning at all grade levels from middle school to graduate school. That includes aspects of energy understanding that are essential to chemistry and biology as well as physics.
*Supported by NSF grant DUE-9910458

Assessments as diagnostics instead of as exams

Dewey I. Dykstra, Jr., Boise State University

If the next generation of teachers is to take into account findings of research in physics learning, assessments of student work have to move from being traditional exams to being diagnostics of student understanding and skills. Exams are typically designed to "indicate" whether the students can reproduce particular skills, facts, or explanations. Frequently on exams the presence of alternative views based on student alternative answers to exams is unconvincing because the exam questions are developed with only one conception (the "right" one) in mind. Conceptual diagnostics can be designed to systematically reveal more than one point of view in a more convincing fashion. The Force and Motion Conceptual Evaluation (Thornton & Sokoloff, AJP 66(4):338-352, 1998) is such a diagnostic capable of revealing at least two alternative views of force and its relationship to motion. Data from several hundred students over several semesters in a course that has large numbers of students who are training to be teachers was analyzed for the prevalence of patterns of choices indicating an alternative view of force and its relationship to motion. Several new ways of presenting the evidence of these views and change in the views will be displayed.

The "0.7 Barrier" on the FCI -- a suggestion of the underlying problem and a proposal for further research

Jerome Epstein, Polytechnic University

Careful research of Richard Hake, surveying a large number of physics programs of both the traditional and interactive variety, has shown a maximum normalized gain of 0.7 in pre-/post-instruction scores on the FCI. No explanation for this barrier has yet appeared. This author has been doing a large amount of diagnostic testing of basicskills in recent years, using an instrument that has shown a considerable predictive power and has uncovered deficiencies at extremely basic levels that are not generally known, even among researchers in math and science education. The most stunning results have been found among elementary teachers. This paper will discuss the results of this diagnostic test. A comprehensive program, developed 20 years ago, and designed to meet this problem head-on, will also be discussed, at least in basic outline. The program has been run at a number of universities, parts of it have been used in teacher training programs, and it is currently running at a New York City public high school. Material from the program has been successfully used with students as young as 6th grade. It is proposed that the "0.7 barrier" may well be due to students inphysics classes who have nowhere near the basic skill and cognition levels to benefit from a sound "Interactive ENgagement" program, that such students can be diagnosed with an instrument like the one discussed above, and that a program such as the one mentioned above given BEFORE a good IE physics course will cause this barrier to Fall. Discussion of what would be involved in testing this hypothesis will conclude the paper.

Assessment with the Force Concept Inventory*

David Hestenes, Arizona State University

The Force Concept Inventory (FCI) has been administered to 20,000 high school physics students across the United States. This provides a rich data base for calibrating and interpreting FCI scores. It shows that FCI data is exceptionally reproducible, reliable and informative. The FCI is used to evaluate the effectiveness of traditional instruction and compare it with "Modeling Instruction" by teachers who participated in the NSF-supported Modeling Workshop Project. Substantial differences are found.
*Supported by NSF grant PHY-9819461

Connecting research in physics education with teacher education

E. Leonard Jossem , The Ohio State University

The ICPE book Connecting Research in Physics Education with Teacher Education (Andrée Tiberghien, E. Leonard Jossem, Jorge Barojas, General Editors) was undertaken on behalf of the International Commission on Physics Education (ICPE) of the International Union of Pure and Applied Physics (IUPAP) - with support from UNESCO - to make available the results of research in physics education world-wide to physics educators working with pre- or in-service physics teachers. Contributors to the book have been drawn world wide, primarily from countries where research in physics education is most active. In addition to a general introduction,the book contains four sections: Perspectives on physics , Students' knowledge and learning, Teachers attitudes and practices, and Curriculum development, assessment and teaching situations.
The book is available on line and on a diskette.

Is It Finally Time for a Physics Counterpart of the Benezet/Berman Math Experiment of the 1930's?

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Should teachers concentrate on critical thinking, estimation, measurement, and graphing rather than college-clone algorithmic physics in K-12? Thus far physics-education research offers little substantive guidance. Mathematics education research addressed the mathematics analogue of this question in the 1930's [1,2]. Students in Manchester, New Hampshire were not subjected to arithmetic algorithms until grade 6. In earlier grades they read, invented, and discussed stories and problems; estimated lengths, heights, and areas; and enjoyed finding and interpreting numbers relevant to their lives. In grade 6, with 4 months of formal training, they caught up to the regular students in algorithmic ability, and were far ahead in general numeracy and in the verbal, semantic, and problem-solving skills they had practiced for the five years before. Assessment was both QUALITATIVE - e.g., asking 8th grade students to relate in their own words why it is "that if you have two fractions with the same numerator, the one with the smaller denominator is the larger;" and QUANTITATIVE - e.g., administration of standardized arithmetic examinations to test and control groups in the 6 th grade. Is it finally time for a physics counterpart of the Benezet/Berman Manchester math experiment of the 1930's?

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1. L. P. Benezet, "The Teaching of Arithmetic I, II, III: The Story of anExperiment, " Humanistic Mathematics Newsletter #6, May 1991, pp. 2-14 (reprinted from The Journal of the National Education Association, Nov. 1935, Dec. 1935, Jan. 1936); on the web <http://wol.ra.phy.cam.ac.uk/sanjoy/benezet>.
2. Etta Berman, "The result of deferring systematic teaching of arithmetic to grade six as disclosed by the deferred formal arithmetic plan at Manchester, New Hampshire, " Masters Thesis, Boston University, 1935.

Investigating the impact in the classroom of an inquiry-oriented summer course for teachers

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At California State University San Marcos, we have been involved in a three-year NSF-funded project to offer a summer Inquiry-Oriented Physics course for in-service high school teachers. A component of this project has been a study of its impact in the classrooms of the participants. This research has included an investigation of the short- and long-term learning gains of the teachers, the extent to which teachers have adopted an inquiry-oriented approach to teaching, and a survey of student attitudes towards science. We will present an overview of our research in the classrooms and a summary of our preliminary findings.

Rethinking Assessment in Light of Constructivist Learning Approaches

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As the (US) National Research Council has stated in the National Science Education Standards, "Assessment and learning are two sides of the same coin. The methods used to collect educational data define in measurable terms what teachers should teach and what students should learn." Therefore, if we want to cultivate "thinking like a physicist," in van Heuvelen's words, we must make it important in how students are evaluated.

In British Columbia students in Grade 12 physics take and provincial matriculation exam, and this is perceived by many teachers to produce a conflict with the goals of curricula and learning strategies that have resulted from physics education research. The paper consists of a literature review of assessment in science education and proposes a framework for rethinking assessment in ways that are more commensurate with constructivist approaches to learning. Central to the framework are three dualities: (a) content and process, (b) explicit and implicit knowledge, and (c) individual and group learning. The argument will be illustrated with examples of a content analysis of several recent matriculation exams in British Columbia and the Netherlands. The paper is not meant to propose a tested framework, but to stimulate discussion of relevant issues. The implications of the proposed framework for teacher education are worked out in terms of competencies required of teachers in doing justice to all three of the above dualities in assessing physics learning.

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