Physics for Elementary Teachers

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Abstract

Physics for Elementary Teachers (PET) is a new one-semester curriculum for inservice teachers. The learning goals include improving teacher knowledge of physics, understanding of the nature of science, and awareness of their learning. Content is consistent with elementary school curriculum and is organized around central themes of interactions, energy, forces and explanations. The goals are accomplished using guided inquiry and a modified learning cycle consistent with a constructivist approach. Evidence for the guided inquiries comes from hands–on and micro-computer based laboratories, and web-based simulations. A unique aspect of the course is the Elementary Science Ideas (ESI) in which teachers view videos of elementary students discussing physics ideas and use these conversations to reflect on both the elementary student ideas and their own learning. Pre- and post-testing of teachers' content knowledge was conducted in the Fall 2003 and have shown a statistically significant improvement in physics knowledge.

Introduction

Physics for Elementary Teachers (PET) was developed as a new one-semester curriculum for inservice teachers by Fred Goldberg (San Diego State University), Steve Robinson (Tennessee Technological University) and Valerie Otero (University of Colorado at Boulder) with partial support from the National Science Foundation (grant number ESI-0096856). PET had four goals;

- Develop a deep understanding of a set of physics ideas that align with the elementary school curriculum.
- Practice and understand the scientific process for developing knowledge focusing on using evidence, collaboration and consensus.
- Increase awareness of how an individual's physics ideas change and develop and the role of the learning environment and curriculum in changing the ideas (Meta-cognition).
- Analyze elementary student thinking and to make connections between children's learning of physics and the teacher's own learning.

The curriculum design was based on constructivist theoretical perspectives [1] and built on the conceptual change model [2]. The physics content and the nature of science goals followed the recommendations of the *National Science Education Standards* [3] and *Benchmarks for Scientific Literacy* [4]. The emphasis was on a qualitative conceptual understanding building towards a more quantitative mathematical understanding.

1 Curriculum organization

The curriculum was structured around seven cycles with each developing a specific set of physics ideas. Cycles were: interactions and energy, interactions and force, interactions and fields, models of magnetism, electric circuits and electromagnetic interactions, light and infrared interactions, and interactions and energy conservation. Common themes across the cycles included interactions between objects, transfer of energy between interacting objects, and construction and evaluation of scientific explanations.

Each cycle contained a sequence of guided inquiries designed to build on teachers' prior knowledge, to provide several hands-on and computer-based activities to test initial ideas, and to provide collaboration opportunities. Teachers worked in small groups and were required to express their ideas in writing. Graphic organizers included concept maps and energy diagrams.

Inquiries within the cycles were organized as a modified learning cycle and contained two types of inquiries. Serving as the exploration phase, the development inquiries posed a key question, elicited the student's initial ideas, collected and interpreted evidence, summarized the results, and finally had the teachers reflect on how their ideas have changed.

Development inquiries were followed by class discussion that compared evidence and ideas and therefore reach a class consensus on the content with guidance from the professor. This served as the explanation phase. The applying idea activity followed and began with the application of their thinking to some new phenomena. Teachers constructed explanations by identifying the interacting objects, drew energy and/or force diagrams, wrote explanations, and evaluated explanations using a set of criteria.

2 Pedagogical tools

Collaboration and social interaction were facilitated through out the curriculum. Inquiries incorporated group discussions resulting in a consensus on their thinking. Groups shared their ideas in whole class discussions and supported claims with evidence from the inquiries. Social interaction shifted the "authority" away from the professor and toward the teachers. The professor supported the discussions, helped clarify ideas and added scientific language to the teachers' ideas.

Inquiries included hands-on activities using simple materials commonly found in elementary school classrooms. Inquiries were supplemented with several powerful technology tools. Activities used both microcomputer-based laboratories (MBL) and specially designed computer simulations. MBL activities used commercially available motion sensor and force probe on a track with low-friction carts. Simulations were accessed via the web for both in-class activities and homework assignments. Simulations allowed the user to manipulate several variables, record the results in several manners including graphically, and rerun the virtual experiments.

The Elementary Students' Ideas (ESI) activities engaged the teachers in the analysis of video segments of elementary students working through physics activities. By evaluating the learning of others, the teachers gained an understanding of their own learning process. In addition, the ESI provided the teachers with an opportunity to apply their physics knowledge in a new and authentic context.

3 Pilot study results

PET materials were piloted in the Fall 2003 at Furman University with twelve in-service teachers participating. A diagnostic test developed as a PET evaluation tool by Dr. Mark Jenness (Western Michigan University) was administered as a pre- and post-test. The test consisted of five situations with each requiring one multiple-choice response and a free response essay in which the teacher explained their reasoning. A rubric was used to evaluate the essays.

A paired t-test was completed on each item and on the total score. Table 1 shows the results. The change in scores from pre- to post-test was highly significantly at alpha<=0.02 for each item score and the total score. The results are consistent with anecdotal evidence gathered during the class including tests, reflections, and reports.

4 Future study

During June of 2004, twenty in-service elementary teachers will participate in a PET course. Evaluations will include the Views on the Nature of Science (VNOS)[5], Conceptual Survey in Electricity and Magnetism (CSEM)[6] and the 5-item PET pre- and post-test previously used. Teachers will be observed teaching during the Fall 2004 semester.

Table 1. Results of t-Test

	Pre-test average	Post-test average	Gain score
Total score highest score=19	5.2	15.2	10.0*
Item 1: force, 3 pts	1.2	2.8	1.6*
Item 2: force, 3 pts	0.8	3.0	2.2*
Item 3: motion, 3 pts	0.0	2.4	2.4*
Item 4: light, 5 pts	2.4	3.8	1.4*
Item 5: energy, 5 pts	0.8	3.2	2.4*

* Statistically significant alpha<=0.02

Conclusions

The pilot evaluation of the PET materials demonstrated that they are successful in improving teachers' conceptual understanding of the physics content. Additional research is needed to evaluate the impact of the curriculum on teachers' understanding of the nature of science, awareness of learning, and classroom teaching.

References

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