Teacher-Researcher Professional Development: Case Study at Kansas State University

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Abstract. We report on a case study which provides professional development to advanced undergraduate and graduate research team members of the Kansas State University Physics Education Research (KSU-PER) group. An integral component of a student's professional development is the opportunity to participate in a range of research activities and work in collaboration - both as a mentor and a junior researcher with a range of individuals. In order to coordinate and facilitate these opportunities KSU-PER established an ongoing research project investigating students' conceptions of the physics underlying devices. The project utilized an integrated methodological and administrative framework - combining elements from grounded theory, phenomenology and action research. This framework provides a forum and research setting allowing junior and experienced researchers to act in various project management roles and perform a range of research activities. We will conclude by reflecting upon our experiences.

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INTRODUCTION

How do we prepare our graduate students for a career in physics education research (PER)? We describe here a program for professional development of PER graduate students at Kansas State University (KSU). The primary goal of the program described here is to prepare our students to conduct high quality educational research. We recognize that training students to conduct high quality research should not be the only goal of a professional development program Others such as developing communication and leadership skills are also important. However, they were beyond the scope of the project at this time

Several efforts to enhance graduate professional development exist elsewhere. Physics education groups at some major research universities have their own training programs for PER graduate students. The KSU program shares several commonalities with these programs as well as other programs conducted by the Council of Graduate Studies and AAPT for preparing future faculty. However, unlike other programs, the KSU program described here focuses specifically on research methodologies and draws on a multilayered framework by Kelly and Lesh [1] for multilayered teaching experiments.

Challenges

We face several challenges in the training of our graduate students. Some of these challenges are not unique to KSU, but are common to physics departments at most research universities. Students entering our program often possess a strong background in physics, but seldom have adequate preparation in education or pedagogy. Our program receives a diverse set of incoming graduate students. Many have are unfamiliar with U.S. educational systems and culture. We have students who are pursuing Ph.D.s in Physics or Science Education with a specialization in PER or Physics. We also prepare students with a diverse set of professional goals. Some of our graduates seek future postdoctoral and faculty positions in physics, while others seek positions in colleges of education. We need a flexible professional development program that addresses these diverse needs.

Current Efforts

Traditionally, all of our graduate students take a course titled "Teaching University Physics." The course provides a broad survey of research-based pedagogy and assessment strategies. Students complete a few mini-projects in which they critique curricula and instructional strategies from a PER perspective and a capstone project in which they apply their knowledge of PER to create a teaching module or complete a short research project.

In addition to the above course students are required to complete several courses offered in the College of Education. These include research methods, statistics, curricular design, history and philosophy of science education and constructivism in science education.

Finally, students attend a weekly PER seminar throughout their stay at KSU. The seminar includes discussions of the latest publications in the field and presentations of research progress by other graduate students in the group. The seminar provides a context in which students can learn about and critique each others' research and discuss larger issues in the field.

Need for a New Approach

In spite of the above opportunities, we have found over the years that most of our graduate students have an uphill task in gaining the most benefit from their professional development. They eventually do so through a variety of other activities such as participating in conferences. However, students often have difficulties in applying the principles learned in science and physics education courses to their own research projects. The knowledge learned in these courses is not adequately contextualized; partly because the courses are taken too early in their career to be relevant to their Ph.D. research. It could also be because of the way in which the courses are taught or the content of the courses. In either case, since we did not have control over these courses, we needed a new approach to prepare students to meet their professional challenges as they embark into the future.

A NEW PROGRAM

First Implementation

The weekly one-hour long PER seminar at KSU provided an existing context within which to implement the professional development program for our graduate students in Fall 2004. The seminar consisted of a weekly meeting – each corresponding to various types of qualitative research methodologies such as Grounded Theory, [2] Phenomenology [3] and Action Research. [4] Grounded Theory – a hypothesis-free approach to data collection and fact finding typically forms the first stage of research projects at KSU. Phenomenology – a study of the variations of student behavior and explanations is typically the next stage. Finally action research which is based on implementing and studying change in existing courses forms the third stage. The focus on these qualitative methods was dictated primarily by the projects currently underway at KSU. However, we believe that a program that focuses primarily on quantitative research methods could also be similarly developed. Many of the features of these qualitative methods are applicable in quantitative research as well. For instance, almost all research studies – quantitative or qualitative begin with a fact finding phase, which is akin to grounded theory. Similarly, almost all research – qualitative or quantitative looks for patterns in the data before drawing conclusions, which is akin to the study of variations in the phenomenographic approach.

Because the focus was on qualitative methods, we spent three hours on interviewing techniques. In each session, students were assigned readings prior to the seminar. When they came to the seminar they discussed how each of the three aforementioned methods was useful to their own research. A total of seven graduate students at different stages of completion and one senior undergraduate participated in the seminar.

The seminar, which was led by the authors of this article, was useful in providing an overview of the methods to our students. It reminded students of some of the ideas that they had already visited in previous courses. They learned about the model of dynamic transfer of learning [5] that guides much of the ongoing research by the KSU group. They also learned about interview questioning strategies.

However, on observing students in the discussions during the seminar we found that they often could not see the subtleties present in the methodologies and raised questions that focused on strict recipe-like application of each technique such as "How are the steps for grounded theory different from phenomenography?" Another barrier that our students faced was an almost exclusive focus on the physics content knowledge while designing questions or coding interview responses. This focus was often at the expense of overlooking other interesting information that could be elicited, such as student interest and motivation levels. We concluded that students had these difficulties because our delivery methods were too traditional. It was analogous to lecturing students about constructivism! Students had difficulty in internalizing and applying the new ideas they had been exposed to.

Framework

The framework by Lesh and Kelly [1] for multi-layered teaching experiments provided us with guidance on planning the next implementation. In the framework researchers, teachers and students go through successive and intertwined modeling cycles. The framework provides an iterative process which interconnects the development of students' conceptual models with the models of learning constructed by the teacher and in turn with the model of teaching constructed by the researcher. In our case, although our audience did not include practicing teachers per se, most of our graduate students had experience as teaching assistants and presumably this experience would contribute to their professional development as researchers. However, most of this TA experience was unsupervised, so it might have also posed a barrier to our goals.

The three-tiered framework also helped us realize that to ensure the professional development of our researchers we must involved them in a 'real' research project where they would interact with real students. One option was for each graduate student to connect this paradigm to their ongoing project. However, this was not a viable option because students were at various stages in their respective projects. Also, the students typically worked individually on their research project – yet another drawback in our current program. So, we would need an entirely new project which would provide a common context in which they could all participate and share what they had learned with each other.

Second Implementation

We decided to put together a training program in which all students would work from start to finish on a single research project. This experience, we believed, would help students contextualize their knowledge of various research methodologies, increase their theoretical sensitivity and provide them with a reference forum within which they can reflect upon their own research project. This implementation began in the second half of Spring 2005 and continued through the first half of summer.

<u>Educational research in general</u>: At the first meeting we asked the graduate students a very broad question: "How do you do educational research?" The question was deliberately broad to ensure that a wide spectrum of ideas would be generated. The ensuing discussion focused on clarifying questions from the students: "Doesn't it depend upon the content area?... the problem?" It was clear to us that students had yet to see the big picture and were focusing on the details. Therefore, we decided to provide scaffolding that would facilitate construction of students' ideas. Students were asked to design a research project that investigated student understanding of everyday electrical devices.

<u>Generating themes, topics and questions</u>: During the first week students were asked to think individually and generate lists of ideas that they would explore within the realm of everyday electrical devices. Particularly, they were asked to generate a list of themes, topics and possible questions that they would ask interview participants. We believed that the topic of everyday electrical devices was an appropriate one for the following reasons. First, it was well aligned with the ongoing research focus at the KSU group – investigations of student understanding of principles underlying everyday objects. Second, it provided a context that was anchored in physics, but still connected with other social and cultural aspects of life which afforded student the opportunity to explore these aspects. Students were deliberately asked to "think broadly" and "cast a wide net." This was done without pointing out to the students that in fact they were applying the grounded theory approach.

<u>Narrowing the focus</u>: When students met during the second week, they shared their ideas in a large group and collapsed the themes, topics and possible questions into a combined list. Because this combined list was generated by contributions from different individuals, the ideas generated were rather diverse. For the first time, students had begun thinking past the issues pertaining to the physics of the device and generated ideas that also addressed the societal and cultural aspects.

<u>Designing and conducting interview</u>: For the next two weeks, students first constructed their own set of interview questions. In keeping with the grounded approach, the questions did not focus on a single electrical device, rather they were designed to help the interviewers identify a set of everyday electrical devices that would serve as the focus of the project. They then formed pairs and interviewed undergraduate participants who were currently enrolled in algebra-based introductory physics. During each interview, one student in each pair interviewed the undergraduate and the other student observed the process and took field notes. They then switched roles. At the end of this period all students met together and critiqued their partner's interview in presence of the larger group. It is important to point out that only a preliminary identification of devices was completed in the interview. Exploration of a specific device was left to future research projects.

<u>Transcript preparation and analysis</u>: Concurrently with the aforementioned step of designing, conducting and critiquing interviews, students also transcribed their respective interviews and tabulated their transcript which included a personal log, an analytical log and coding. Students coded and critiqued each others' transcripts.

Research Project Critique: Having completed the important steps in their own mini research project, students critiqued a research project plan prepared by one of the authors (PRF) based on what they had learned in their own mini-project. Thus, they were asked to bring to bear their experiences to critique the work of others and see how the various elements of the research plan flowed together.

Having viewed a completed research project plan and completed their own mini-project, students were asked to create their own project plan based on the template provided the previous week. Preparing this plan required them to integrate what they had learned from their experiences into their own research. It would also become a document for future reference. Students were given about six weeks to prepare their project plan. This project plan was supposed to guide their progress toward a MS or Ph.D. thesis.

STUDENT FEEDBACK

The program described here is in its initial exploratory phase. Therefore, a detailed assessment of our project such as comparing the quality of research conducted by students from this program versus other students would not be possible at this point. However, we asked students to write a one-page write-up about their reflections on how the PER program has contributed to their knowledge of field and to their own research as well as their overall professional development. The following themes emerged from the feedback write-ups from the students. Each theme is followed by representative supporting quotes.

Focus on methodologies:

> "Currently PER Seminar has taken the focus of methodology techniques that could prove useful for physics education research."

Application of knowledge learned to own research:

> "When I first started on my project … there was no methodology base to tie the project together. Luckily once learning about methodologies during these seminars, we were able to map together the project to follow multiple stages and develop a well linked project. I have found it useful to learn about multiple types of methodology techniques that could prove useful and incorporate them for the larger picture of the project."

Sharing ideas presented by others:

> "Group exercise in applying the steps to a 'real' research setting … allowed for solidification of the ideas since we were actually trying to decide how we would apply the methods to a real research project rather than just discussing them in general."

Not all the feedback was encouraging however. One of the respondents stated:

> "The idea of activities was very good but … probably we needed some kind of a sample set of steps, a template - … more physics-related subjects to discuss so we could really use our expertise, not just fantasize how we would implement an algorithmic or heuristic scheme to some subject not directly related to physics."

This quote indicates that some students continue to seek a recipe-based template for their research and focus solely on the physics rather than look broadly.

OUR REFLECTIONS

Our own experiences with the program led us to reflect on its strengths and weaknesses. While most students appeared to have benefited from the focus on qualitative research methodologies and how they could be applied to their research, at least a few students continued to seek a recipe-based sequence of steps. A few also continued to focus solely on physics content.

We will continue our focus on qualitative research methodologies. We will also have our advanced students serve as mentors to incoming graduate students in our group to make this an intellectually and professionally rewarding experience for all. We will also conduct a more rigorous assessment of the program.

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REFERENCES

1. Lesh, R. and A.E. Kelly, *Multitiered Teaching Experiments*, in *Handbook of Research Design in Mathematics and Science Education*, R. Lesh and A.E. Kelly, Editors. 2000, Lawrence Erlbaum Associates: Mahwah, NJ
2. Strauss, A. and J. Corbin, *Basics of Qualitative Research*. 1998, Thousand Oaks, CA: SAGE Publications, Inc.
3. Colaizzi, P.F., *Psychological Research as a Phenomenologist Views It*, in *Existential Phenomenological Alternatives for Psychology*, R.S. Valle and M. King, Editors. 1978, Oxford University Press: New York. p. 48-71.
4. Holloway, I., *Basic Concepts of Qualitative Research*. 1997, Malden, MA: Blackwell Science Inc.
5. Rebello, N.S., et al., *Dynamic Transfer: A Perspective from Physics Education Research*, in *Transfer of Learning from a Modern Multidisciplinary Perspective*, J.P. Mestre, Editor. 2005, Information Age Publishing Inc.: Greenwich, CT.