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Introducing discipline-specific education research: A professional development course for teaching assistants

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Abstract: *Discipline-specific education research has exposed problems in student learning and suggested various solutions. A growing number of lecturers are familiar with this research, however fewer teaching assistants (TAs) doing research in their own fields have knowledge of the education issues relevant to their teaching. This paper describes a semester-long course designed to provide TAs with a working conceptual knowledge of the cognitive theory of learning, problems with student understanding, rationales underlying instructional reforms and so on. The main activity of the course was the discussion of education research articles and chapters from a textbook (Redish, 2003). The short presentations and essays submitted at the completion of the course as well as the course survey suggest that most of the short term objectives have been attained. The objectives, design and evaluation of the course could easily be adapted to suit any departmental TA development program.*

Keywords: *development course, teaching assistant, education research*

Introduction

We have been aware of the fact that the present generation of students is different in many respects from their counterparts of a few decades ago. In the past, students were expected to be independent and well-prepared upon entering their tertiary study. Current students, particularly first-year undergraduates, have been described as generally less ready for college than their predecessors (Leamson, 2001). Not only has the student population changed, the state of affairs of teaching and learning have been affected. Students coming to introductory physics are often found to possess physics ideas which are not compatible with the accepted concepts in textbooks. Examples of these incorrect ideas are: heavier objects fall faster than lighter objects, a motion implies a force, and bigger objects exert larger force upon smaller objects (Hestenes, Wells, and Swackhamer, 1992). These ideas are not easily rectified by the so-called traditional instruction approach because they have been constructed for many years, they are effective in predicting some everyday phenomena (Mestre, 1991; Tao & Gunstone, 1999), and they have been ignored by teachers (Hestenes, 1987; Van Hise, 1988).

Numerous innovations in teaching methods have been proposed to remedy incorrect pre-conceptions and, more importantly, to help students learn physics more effectively. Many of the reformed teaching approaches necessitate smaller classes for tutorials and/or laboratories (see for example Cummings, Marx, Thornton, & Kuhl, 1999; Hake, 1992; Laws, 1991; McDermott, 2001; Redish, Saul, & Steinberg, 1997; Sharma, Millar, & Seth, 1999; Steinberg & Donnelly, 2002). These classes are usually handled by teaching assistants (TAs) who consist of tutors in tutorials or demonstrators in laboratories.

Physics TAs are mostly graduate students who are conducting research in specific areas of physics. Many lecturers are not aware of students' problems mentioned above (Hestenes, 1987; Van Hise, 1988; Gardner, 1993); we suspect that TAs are equally unaware. In our experiences, TAs do not acknowledge their students' physics concepts nor are they aware of the difficulties faced in trying to alter these concepts by conventional instruction. This is an unfortunate situation because TAs have more intensive interactions with students in the small classes than do the lecturers in the big lecture theatres. TAs need to be knowledgeable about problems in physics education, not only to induce motivation to improve their teaching skills but also to prepare them to become future academics.

TAs' duties, problems and training

The typical responsibilities of physics TAs in undergraduate tutorial sessions are modelling problem solving, recording attendance, marking homework, administering quizzes and responding to students' inquiries. TAs also supervise students in laboratories, grade lab reports, invigilate exams and carry out review sessions (Druger, 1997). In short, TAs' roles are to assist the course lecturer in various areas of instructional, curricular and assessment activities (Kurdziel & Libarkin, 2003). The TAs' duties may be extended beyond the classroom such as seeking out students who need extra help (Doucette, 1994), providing office hours, developing curricular material and taking care of a class webpage (Goff & Lahme, 2003). TAs are not only helping to lessen the lecturers' burden of teaching a large group of students, they also act as a "crucial intermediary" between lecturers and students (Stoeker, Schmidbauer, Mullin, & Young, 1993). They assist students by clarifying the lecturers' ideas and inform the lecturers about students' state of understanding. Effective TAs facilitate the otherwise one-way communication between students and their lecturers. Fingerson and Culley (2001) find that TAs also motivate the lecturers to seek ways to promote students' active participation.

Various TA training programs have been suggested to prepare new TAs as well as to improve the skills of senior TAs. McComas and Cox-Petersen (1999) categorize the training and support for TAs in four levels: from the so-called *laissez-faire* approach where no formal program is offered, to a lecturer-specific apprenticeship where TAs work closely with their mentors. A number of science TA training programs are presented in Kurdziel and Libarkin (2003), while Jossem (2000) outlines an extensive list of resources for programs to prepare physics TAs.

Despite the aim to provide TAs with the appropriate knowledge and skills, orientation programs organized by universities or departments for new TAs sometimes do not fully support their teaching tasks. Experienced TAs can be in denial concerning problems with their work. As a result, the performance of TAs is often unsatisfactory (White, 1998). Many TAs are not aware that they are failing to help students learn effectively. Etkina (1999) observes that TA concerns focus on the students' skill in plugging numbers into equations or taking experimental measurements. They rarely assess whether students have comprehended the concepts underlying the problem solving or the meaning behind the experimental data. Interviews with first-year TAs (Gilreath & Slater, 1994) and responses to a training program application (McComas & Cox-Petersen, 1999) reveal TAs' hopes and expectations to be better teachers. They would like the lecturers to advise them how to teach. In addition, they want to improve their teaching skills so that they are able to effectively clarify physics concepts to their students.

The next section will describe a course set up in a Physics and Astronomy Department to provide TAs with some basic knowledge upon which they can build their teaching expertise. Although the course was tailored for physics TAs, the objectives, design and evaluation could be adapted to suit any departmental TA development program. To be able to engage in their work professionally, we believe that TAs need to be conversant with issues in the education research of their discipline. They need to know a little of the general research on education including cognitive theory of learning as well as subject specific educational research including typical conceptual misunderstandings and rationales underlying instructional modification. We sought to change our local physics education community by introducing the TAs, and some of their professors, to international research on understanding student learning. By introducing the scholarship of teaching early in a TA's career as a prospective member of academia, the course should assist them to position themselves in this dynamical aspect of education and help them to take actions for making further improvements.

Description of the course

The course PHYS425: Introduction to Physics Education Research was established with a long term goal of improving the quality of undergraduate physics teaching in our department. In particular, the aim of the course is to introduce TAs to issues in physics education research. On completion of the course, TAs are expected to:

- appreciate the scale of educational and cognitive research
- acknowledge the impact of this research on efforts to reform teaching
- be aware of typical students' preconceptions and state of understanding
- be sensitive to the skills and preconceptions of students in their class

An instructional reform was initiated in an introductory physics course (Cahyadi, 2004) which included tutorial sessions. It was observed that the TAs involved in the course had some difficulties in interpreting their responsibilities associated with the teaching modification despite the weekly meetings to enlighten them about their tasks. We argue that in order to promote the effectiveness of the approach, it is important that everybody involved, including the TAs, understand the rationales underlying the modification. This inspired us to establish the PHYS425 course as an adaptation of a Master of Science education course. PHYS425 may be seen as a unique model for training physics TAs where the TAs, as beginning astronomy and physics researchers, were exposed to research in education relevant to their teaching.

All current tutors and demonstrators were encouraged to enrol for the course. Three lecturers presented the course, while fifteen TAs and five academic staff participated. There were three categories of participant: three lecturers, ten enrolled students and ten non-enrolled attendees. The assessment consisted of contribution to weekly seminars, a short presentation on relevant topics and an essay extended from the presentation. While all participants were expected to actively contribute in the seminars, only the enrolled students were required to give the presentation and submit the essay.

The course ran for 13 weeks with a term break in the middle of the semester. The class met weekly for 100 minutes to read and discuss various issues in physics education from journal articles and a textbook (Redish, 2003). The latter contains a summary of research on cognitive development, curriculum design, student preconceptions and expectations, before offering guidance on using a variety of teaching tools. In the first half of the course the topics covered were student misconceptions (Halloun & Hestenes, 1985; Hestenes, Wells, & Swackhamer, 1992), expectations (Redish, Saul, & Steinberg, 1998), difficulties (Kim & Pak, 2002), and cognitive problems (May & Etkina, 2002). In one occasion the participants were asked to do the Force Concept Inventory (Hestenes et al, 1992) to assess their own Newtonian beliefs. The second half of the course addressed a rationale to teach science (Longbottom & Butler,

1999), physics education in the UK and Europe (various articles from *Physics World*), and a range of teaching strategies (Hake, 1998 and the last five chapters in Redish, 2003). Supplying the participants with such reading material aimed to familiarize them with physics education research and to provide some resources for teaching ideas (Ishikawa, Potter, & Davis, 2001).

The participants were motivated to interpret the reading material and to share their teaching experiences. The last two seminars were allocated for short presentations for the enrolled students. At the completion of the course, every presenter submitted a comprehensive essay on their seminar idea. The students were allowed to choose any topic of interest in physics education for their presentation and essay. They were advised to include analysis based on the weekly discussions, readings and their experiences.

Evaluation of the course

At the beginning of the course, some participants were observed to be rather apprehensive about the reading topics. The majority of the participants were graduate physics students who experienced at least one semester of teaching in tutorial or lab sessions. However, very few had come across articles or discussions on issues in science education. They perceived the method, analysis and conclusion presented in many of the research articles as inappropriate. There was little awareness that physics education was an area different from the physics they are doing in research. After a few weeks into the semester, the participants seemed to get more comfortable with the line of thought evolving from the readings and discussions. They were able to put forward their ideas relevant to the reading topics. Moreover, most participants attempted to relate their prior experiences as an undergraduate student and current work as a TA to the discussion issues.

The short presentations and essays submitted at the conclusion of the course ranged from a philosophical critique of ancient Greek teaching to a practical recommendation of organizing a tutorial session. The participants were able to examine a variety of situations, for instance a certain tutorial session, the present tutorial practices, the condition of physics teaching and even the state of education in general. They made use of the reading material and discussion topics to base their suggestions for improving the situations they were focusing on. To provide a convincing support for their arguments, most participants utilized other references outside the given articles. One of the aims of the course mentioned previously, i.e. to familiarize the participants with physics education research, seems to have been accomplished.

As a follow-up of the course, the participants were invited to complete a questionnaire six months after the course finished. The questionnaire was meant to be a standard course survey which is a customary practice in the institution. The University Centre of Teaching and Learning (UCTL) assisted in administering the questionnaire. Participants were made clear of the assurance of their anonymity and information about the purposes of the questionnaire. The latter included seeking feedback on the effectiveness of the course and refreshing the participants' memory of the course. The survey results indicate that some of the course objectives have been met.

Comments from the participants can be categorized into the following entries:

- **Evaluation of the course:** The participants were able to assess the course itself in terms of organization, content and method of delivery. They recognized that the course became much better as the semester progressed. Most wanted more practical examples of better teaching approaches although these were already touched on in some discussions. One participant, obviously inspired by the reading topics, suggested having some alternatives for executing the course. The majority of the responses included constructive feedback to improve the course.

- Impact of the course: The course has definitely produced some impact on the participants as was revealed by the following examples of verbatim transcript:
 - *“It made me more aware of the language I used to explain physics concepts (i.e. Using words like ‘power, force, heat etc’ in their correct physics contexts.) I hadn’t realized the impact of everyday English on physics and how this may confuse students to whom English is a 2nd language.”*
 - *“... the course was very effective at making me think about my teaching methods and to grapple with poor performance of students in physics.”*
 - *“As someone supervising tutors I found that the tutors who had been on the course were more open to think critically about the teaching/learning taking place in a tutorial. As a result I could have a more constructive dialogue with suggestions and feedback and they were more open to new ideas. This made my job easier.”*

- Plan for the near future: Most responses described the participants’ intention to carry out some actions as a result of attending the course. The following presents the plans revealed by the survey:
 - *“I am also teaching the physics Prep course next month. Some of what I learned from the course will be used during this time.”*
 - *“I will continue to reflect on my teaching practice and read others’ ideas and choose whether or not to implement them just as I did before the course.”*
 - *“Hoping to get into academia, I intend to apply what I learnt ASAP.”*
 - *“I strongly recommend the course to all the academic staff in the Department of Physics and Astronomy. ... I could then use that course as a model to other departments to develop similar course.”*

Discussion

There have been lively discussions on physics education research in the scientific literature and among lecturers over the past three decades. We come to the recognition that alternative physics concepts are tenaciously clung to the students’ mind even after (traditional) instruction. The findings also propose a range of modified teaching approaches, many of which utilize TAs, aimed to rectify the problems. We argue that it is imperative that both lecturers and TAs are knowledgeable in physics education research. TAs do not only deal with mundane tasks, but must be actively engaged in assisting the lecturer in the effort to enhance the quality of teaching and learning.

The course described in this paper has been designed to meet the challenge. The principal aim of the course is to familiarize TAs with issues in physics education research so as to gain a higher level perspective than they otherwise would. From this perspective they are motivated to, and we hope, be able to improve their teaching techniques. Having been enlightened with well-researched students’ difficulties and various proposed solutions, it is anticipated that TAs will establish their own conceptual framework that accommodates the improvements.

The main activity of the course was the discussion of articles and textbook chapters on physics education research. It was inevitable that the course participants had to struggle to make sense of the ideas involved in the reading topics, many of which were new for them. As the course progressed further, the participants grew more comfortable and better able to cope with the material discussed. The short presentations, essays submitted at the completion of the course and the course survey suggest that most of the short term objectives were attained. The finding that TAs participating in the course were more open to ideas indicates their appreciation of the effort to reform teaching, as did recommending the

course to academic staff and encouraging other departments to develop similar courses. By engaging the participants in the reading and discussion throughout the course, they developed an understanding for the methodology, and respect for the utility of research in physics education.

It is too early to claim that the course has made impact to the first-year students whom the TAs are working with. The course is the first of its kind in our department and perhaps in our institution. We still have a long way to go towards the goal of enhancing the quality of undergraduate education in the department. The course has established an awareness of issues in physics education and encouraged participants to devise action plans for implementing what they learned. Improvements to the course are planned and further support for the TAs is needed as we strive to enhance the quality of undergraduate education.

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