

### I<sup>3</sup> Graduate Research Proposal for Steven Pollock

#### **Development of pre-post tests for upper division Electricity and Magnetism Tutorials.**

*Introduction:* This proposal is for research support for Steven Pollock during his sabbatical (Fall 2009), the request being for one month of full salary (although the work itself will occur quarter-time over a full semester period.) Prof. Pollock is a member of the Physics Education Research group, and is co-PI on an NSF-funded CCLI project to implement Tutorials in Introductory Physics, and the NSF-funded LA-Test grant.

*Project Proposal:* This research study is part of a broader effort to move beyond research and development of curricular reforms at the introductory level, in order to better address the specialized needs of students in upper-division physics courses. These efforts to date have involved several CU Faculty (M. Dubson and K. Perkins in the PER group, with a large collection of interested and involved traditional physics faculty), and two SEI postdocs (Stephanie Chasteen on E&M reforms, Steven Goldhaber in Quantum). As part of an NSF CCLI grant "**Using a research-based approach to reform Upper-division Quantum I and E&M I**" I have been closely involved in development of research-based materials for the upper-division electricity and magnetism (E&M I) course (Phys 3310). These materials include clicker questions, homework problems, and Tutorial activities. The latter have been a significant new development - over the last 3 terms we have developed and implemented a parallel course, Phys 3311 (1 credit, pass/fail), a "co-seminar" to the E&M course, which involves small group worksheet activities targeting known or suspected student learning difficulties for this content level and population. It is this E&M co-sem curriculum, specifically, which I propose addressing and modifying through further research.

The impacts of our reforms have been assessed to date in two primary ways - performance on a freshman level research-validated conceptual instrument (the BEMA [1]), and through the development of an appropriate upper-division conceptual instrument (the CUE, Colorado Upper division Electrostatics assessment [2]) Such assessment is critical for the larger scale learning goals of this transformed course, but are not aimed at a fine enough scale to serve as a research basis to systematically modify and improve the Tutorial materials. To this end, I propose a new component to our research program, to take place starting this fall (2009), and continuing on through spring (2010), to develop pre- and post- assessment tools on a *weekly* basis, each targeted at one Tutorial episode (thus, one per week). We follow in the model of the University of Washington [3] which developed Tutorials at the introductory level. This level of individual Tutorial assessment is critical for the systematic improvement and validation of these materials.

The project will be "research and development", at its first stages (this proposal) the focus will be on sharpening, articulating, and operationalizing the currently implicit conceptual learning goals of the existing Tutorials. This means working with faculty to further develop clear topical goals, followed by construction of appropriate questions (modeled on the style, length, and depth of University of Washington upper-division Tutorials pre-test surveys) which can be administered fairly quickly (on-line or paper for the pre-test, the post-test will involve clicker-questions or on-line followups) The analysis of student learning outcomes and feedback into iterated Tutorial materials is a second-level effort, which will naturally follow (but is not part of) this proposal.

The SEI, with support from Physics and our CCLI grant, has recently hired a new Postdoctoral science teaching fellow, Rachel Pepper. Rachel will arrive this summer, and this project will be one of her initial research activities, so I anticipate working closely with her on this R&D work.

There are two driving research questions behind this study: 1) what are the dominant student learning difficulties observed at the level of specific topics in upper-division E&M and 2) do our upper division Tutorials measurably impact student performance on high-level conceptually focused questions? Our initial efforts at Tutorial construction were built from our experience and intuition, but cannot yet be considered fully research-based. This project will provide a layer of direct student data which will start the shift of our upper division Tutorials from "research-inspired" to "research-based"

*Benefits:* This project will directly and positively impact the education of, typically, 20-50 upper-division undergraduates per term. Students will be learning not only the traditional problem-solving skills targeted at this level, but through this work we will assess and improve the development of more robust conceptual understanding of the physics and of the underpinning meaning of the mathematics and formalisms used in this course. Because of the reflective and predictive nature of written pre-post testing, students will also develop a more thorough understanding of what it means to learn in physics. We have observed at the freshman level that pre tests serve a useful ongoing pedagogical value, they are not just good for development of Tutorials, but are helpful to the students to elicit their initial ideas, and help them assess their own understanding. We anticipate that well-crafted pre-tests may become a regular part of the Phys 3311 curriculum, and we will develop them in a form which can be easily transferred to other institutions beyond CU. Pre-post data will also benefit future Learning Assistants as they prepare to run and teach Tutorials, much as presently occurs at the lower division.

*Timeline:* First generation Tutorials for upper division E&M were drafted Spring 2008, with effectively non-research based iterations made the following two semesters. The Tutorials (Phys 3311) run each term, so the first new round of pre- and post- tests will be developed Fall 2009, with the first full-scale implementation in Spring '10. The first pass of activities (which this project will support) will be the articulation of learning goals for each of a dozen weekly Tutorials, in a form which leads to concrete conceptual questions (both open ended, and "multiple-choice", in the style of UW materials). I anticipate these materials will be used in paper form at the start of co-seminars in Fall 09, with a full implementation (online, before the Tutorials) starting in Spring '10. We will be producing questions on an ongoing basis during the fall term, testing them in real time, with modifications to be implemented in the spring.

*Advising:* Prof. Pollock will be supervising postdoctoral research Rachel Pepper throughout this project. The course (Phys 3310) has a Learning Assistant, who will also play a role in construction and evaluation of pre-post questions.

*References:*

- 1) Ding, L et al, (2006). *Phys Rev ST: PER*, 2, 010105,
- 2) Chasteen, S.V., Pollock, S.J., "Transforming Upper-Division Electricity and Magnetism" PERC Proceedings 2008, AIP Press (2008).
- 3) McDermott, L, Redish, E., *Am. J. Phys* 67 (1999) p. 755 for many original references from the UW group on the development and impacts of Tutorials.