Modifying Sophomore Physics: A Gateway Course [1]

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For this PTSP research project, I will create, implement, evaluate and disseminate new materials in the sophomore physics course: modern physics. Sophomore year is recognized as a time critical to students' decisions of major. Through this project I seek to create and evaluate materials that will promote student understanding of and interest in physics and science, technology, engineering and mathematics (STEM) more generally.

In this project I will create and document how new course materials and practices can positively influence students' abilities to make interpretations in modern physics – an activity students naturally engage in; however an area that we generally have not explicitly addressed in our courses. Prior research has demonstrated that over the course of instruction in our introductory physics sequence students develop an increasingly realist and deterministic perspective (where all physical properties of a classical system can be simultaneously specified and thus determined at all future times).1 Such a perspective can be problematic for introductory quantum physics students, who must develop new perspectives (non--?local, probabilistic, or quantum perspectives) in order to properly interpret what it means to have knowledge of quantum systems. Prior research has shown, after instruction in modern physics, many students are still exhibiting a realist perspective in contexts where a quantum perspective is needed.1 We further find that this effect can be significantly influenced by instruction, where we observe variations for courses with differing learning goals. Simultaneously, we note that students tend not to employ either a realist or a quantum perspective in a consistent manner. This project will develop, implement and evaluate new course materials (lectures, homework, and readings) that emphasize a quantum perspective, and study the impact of these new materials.

Beginning in fall 2012, I hope to teach two consecutive years of sophomore physics (Phys 2130 or 2170, pending departmental approval). I will study how implementing these new course materials and practices (homework questions, readings, and reflective essays on interpretation, as well as topics of interpretation in lecture) can support the development of students' skills at interpreting physical phenomena from appropriate interpretive perspectives. This study will also focus on how these perspectives (realist or quantum) are tied to students' development of more traditional content mastery (such as conceptual mastery and problem solving skills).

In course offerings AY 2012--?13, I will apply a mixture of quantitative and qualitative measures that I have successfully used in prior studies.2 This work is informed by research on learning and education 3 and will focus on identifying practices that lead to student development. Quantitative data will be collected in the form of previously validated

instruments that measure student conceptual mastery, problem solving and attitudes and beliefs (such as the CLASS,4 QMCS,5 and QPCS6), as well as targeted survey items and essay questions employed in prior offerings of the modern physics course (e.g. questions that track student understanding of the double slit experiment and models of the hydrogen atom). Results from these data collections may then be compared with previous versions of modern physics courses at the University of Colorado. Short, weekly essay assignments will lend insight into the development of student perspectives; at the same time, these reflective essays will benefit students by having them reflect on their learning and articulating their understanding on a regular basis. Each form of data collection, whether survey instrument, observation, interview, or project--?based assessment will be used both formatively, to shape this research project, and summatively, to evaluate outcomes. Analysis of results will occur following each semester course offering. By fall 2014, outcomes will include new course materials that improve our modern physics sequence and a more robust understanding of how students learn the sophisticated skills of interpretation physics. I will publish findings in journals such as the American Journal of Physics, or the Journal of College Science Teaching, and national AAPT meetings.

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1 C. Baily and N. Finkelstein, Phys. Rev. ST Phys. Educ. Res. 5, 010106 (2009)
2 see prior work at spot.colorado.edu/~finkelsn
3 Bransford, J.D. Brown, A L and Cocking, R. R (eds.) How People Learn (Natl. Acad. Press, Wash., DC, 2002) 4 W. K. Adams, et al, Phys. Rev ST: Phys. Educ. Res. 2, 1, 010101 (2006).
5 S. B. McKagan and C. E. Wieman, PERC Proceedings 2005 (AIP, Melville, NY, 2006)
6 S. Wuttiprom, et al, Int. J. Sci. Educ., 31:5, 631 (2009).

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Links
[1] https://www.cu.edu/ptsp/modifying-sophomore-physics-gateway-course