Professional Practice Simulations for Engaging, Educating, and Assessing Undergraduate Engineers

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Problem

To develop theory in the area of engineering student learning it is essential to understand the links between engineering as a discipline and engineering as a professional practice. Engineering students need to develop not only skills and knowledge, but the values, identity and epistemology characteristic of engineering practice.

In our work—specifically in the context of an NSF-funded project on engineering learning—we are examining the following questions, which we believe are directly relevant to the workshop at hand. We ask: How do students develop agency and identity as engineers? What should innovation in engineering education look like? How can games and simulations play a role in changing engineering education? What effect will such activities have on engineering students from under-represented populations?

We look forward to sharing our work and perspective, and to engaging in critical but constructive discussions with others in the learning science community thinking about similar issues.

Objectives

Our project seeks to (a) develop a computer simulation game—*Nephrotex: The Dialysis Redesign Project*—for engineering undergraduates, modeled on authentic engineering practices, (b) incorporate this gaming technology into an engineering undergraduate course at the University of Wisconsin–Madison, and (c) assess learning outcomes through computer gaming platform–assisted data collection and analysis.

Impact

The project is tailored to the newest generation of engineering students who are more computer literate, electronically connected, and simulation game–oriented than any prior generation. It will make significant, positive contributions to knowledge about engineering education by testing an existing theory of professional learning in a novel context, targeting measurable outcomes and conducting a robust project evaluation.

This work advances discovery in teaching and learning and promote training in engineering education among the mixed-level (faculty, graduate student, and undergraduate student) and interdisciplinary team of investigators. The results of the research will be disseminated to the education community and the engineering education community. The developed and tested *Nephrotex* game will be shared with engineering institutions nationwide, enabling engineering educators to customize, contextualize, and adapt it for use and/or research at their own institutions. The project is potentially transformative because it addresses a key aspect of engineering education – professional practice – and critical limiting factors in providing students with opportunities for experiencing professional practice – faculty time and institutional resources. Once developed and

validated, our professional practice simulation can be widely used to engage and educate students about engineering early in their careers. Furthermore, since the skills required for success in professional practice are not identical to those required for success in gatekeeper math and science courses, we anticipate that use of our professional practice simulations early in the undergraduate curriculum will convince a different subset of students that they are capable of being engineers (i.e., by acquiring the engineering epistemic frame) and thus increase the diversity of students who persist in engineering.

Theory

Our project is grounded in the *epistemic frame hypothesis*, which suggests that any community of practice has a culture [2, 15-17] and that culture has a grammar: a structure composed of *skills* (the things that members of the community do); *knowledge* (the understandings that members of the community share); *values* (the beliefs that members of the community hold); *identity* (the way that members of the community see themselves); and *epistemology* (the warrants that justify actions or claims as legitimate within the community). This collection of skills, knowledge, values, identity, and epistemology forms the *epistemic frame* of the community. Put in more concrete terms, engineers act like engineers, identify themselves as engineers, are interested in engineering, and know about physics, electricity, mechanics, chemistry, and other technical fields. These skills, affiliations, habits, and understandings are made possible by looking at the world in a particular way: by *thinking* like an engineer. The same is true for biologists but for different ways of thinking—and for mathematicians, computer scientists, science journalists, and so on, each with a different epistemic frame.

Prior work [3, 5-7, 14] has shown that participation in *epistemic games*—learning environments where young students begin to develop the epistemic frame of a profession—increases students' understanding of and interest in the profession.

Implementation

We are developing and testing *Nephrotex*, a novel epistemic game in which undergraduate engineering students role-play as professional engineers-in-training in order to develop the skills, knowledge, and values of engineers. Since design is a foundational discipline for engineers, we focus on bringing *engineering design* to first-year engineering students. First-year in-class design projects are not new [20, 21], but our approach is novel in several ways. First, our design project is offered not in isolation but as part of a simulated workplace environment for established professionals in practice. Thus, the learning develops in context [22], and the experience has the potential to more realistically mimic the engineering experience. Second, we construct our epistemic game based less on professional practices and more on the practices through which professionals are trained. This apprenticeship approach is more likely to help first-year students feel and be successful in the tasks at hand. Third, we enable all activities to be done in a simulated environment with some automation to interactions, which reduces instructor and client time demands and enhances the potential for scale-up to more and larger institutions. Fourth, we create a data collection platform that has the potential to dramatically improve assessment of learning outcomes through qualitative and quantitative formative and summative evaluation. We predict that, as in earlier studies, this approach will produce a higher return of understanding, motivation for continued learning, and interest in the profession—in this case, engineering.

We have completed the design of the game and are planning to pilot test it during the summer for implementation in Fall 2010.