Professional Practice Simulations for First-year Engineers

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How can we teach first-year students to think like professional engineers?

And increase diversity?

While using active and self-directed learning inside the classroom?

Motivation

The pool of engineers in the U.S. is neither large enough nor diverse enough to meet the needs of our growing high-tech economy [1].

A recent study showed that women's **lack of confidence as professionals** spurs them to leave engineering [2].

Co-ops, internships and other **experiences of professional practice are important** to STEM learning [3,4] but typically occur late in the curriculum.

Theoretical Framework and Hypothesis

The theory of *epistemic frames* suggests that professional ways of making decisions and justifying actions are informed by **skills**, **knowledge**, **identity** and **values** linked by a unique professional **epistemology** [5].

We hypothesize that engaging in activities that simulate professional practice will promote the development of the engineering epistemic frame and **increase professional self confidence**.

References

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Acknowledgments

This material was performed in collaboration with David W. Shaffer, the Epistemic Games Group (www.epistemicgames.net), and supported by the NSF under DUE-0919347 and EEC-0938517, REC-0347000, DRL-0918409 and DRL-0946372.

Learning Activity Design and Execution

Six aspects of the engineering design process (**activities**) were included, each of which can be linked to **engineering epistemic frame (EEF)** elements (Table 1).

Three additional constraints were imposed : **A compelling challenge** (ideally related to an NAE Grand Challenge), **a complex design space** (Fig. 1), and **multiple clients with conflicting requirements.**

Fall 2010, 120 UW students enrolled in an introductory engineering course with a modular design. Of these, 45 (13 W, 32 M) participated in *NephroTex.* Pre- and post-surveys were with content and attidudinal questions were administered and analyzed with principal component analysis (PCA) [6]. In Fall 2011, another 50 UW students will participate and in Spring 2012, 150 UPenn students will participate in *NephroTex*.

Table 1. Minimum set of activities required for an authentic professional practicum, engineering epistemic frame (EEF) elements promoted by each activity, and representative tasks in *NephroTex* for each activity.

Activity	EEF elements	Representative tasks
Individual research	**Knowledge, skills**	Technical writing, graphing, interpreting graphs
Design space exploration	**Knowledge, skills, epistemology**	Developing and testing hypotheses, evaluation
Feedback	**Values, identity**	Interpreting client feedback, considering differences in client values
Teamwork	**Skills, identity**	Conflict management, team decision-making
Design selection	**Skills, values, epistemology**	Evaluation, individual decision-making
Presentation of results	**Skills, identity**	Professional communication

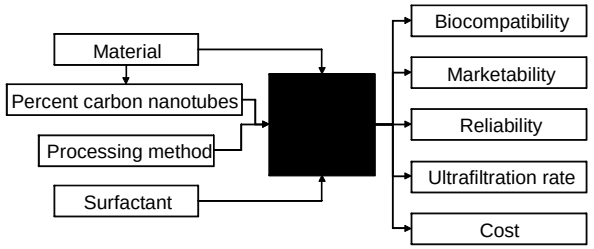

Figure 1. Design space for *NephroTex* – a "black box" with multiple inputs and outputs, in which student-players search for a hemodialysis ultrafiltration unit membrane that meets the requirements of several clients, who are often in conflict.

Results

Students in *NephroTex* made **large learning gains** (Fig. 2).

Women in *NephroTex* reported an **improved understanding of engineering careers** (Fig. 3A) and somewhat **increased motivation to persist in engineering** (Fig. 3B) compared to those in the other modules in the same course (Control).

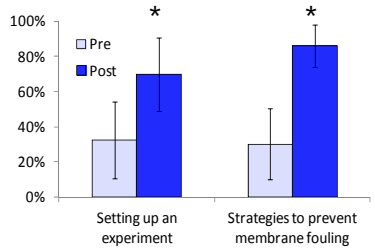

Figure 2. Participation in *NephroTex* led to significant learning gains. Bars represent mean ± SD; * p<0.05 vs. Pre.

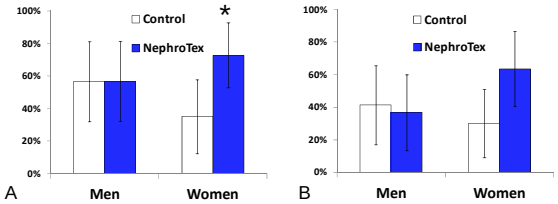

Figure 3. Women in *NephroTex* reported increased (A) understanding of engineering careers and (B) motivation to persist in engineering. Bars represent mean ± SD; * p<0.05 vs. Control.

Future Plans

Research goals: Using epistemic network analysis (ENA) [7] of discourse from *NephroTex*, we hope to investigate the mechanisms by which women had these gains (Fig. 3).

Implementation goals: We hope to obtain funding (from the NSF or industry) to build additional simulations in different domains, implement them in different environments and also develop robust training techniques to accelerate dissemination.

Major Issues to Resolve

Research: While the sample sizes are still small, the lack of an effect on men was surprising. What would make this activity more effective for men and also under-represented minorities?

Implementation: Why would or wouldn't you implement this in your own curriculum or institution?

Funding: Why would or wouldn't you fund continuation of this work? Which aspects would you like to see developed first?