Comments on Technology-Based Curricular Innovations at Purdue University

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Student success is a top priority for virtually all graduate schools, particularly in the rapidly changing engineering and science fields. With the explosion of new knowledge, university (and society) pressures to reduce attrition and time-to-degree, budgetary challenges that can include reductions and rescissions, and student interest in online learning options, providing high quality graduate education at an affordable price can be challenging. We believe technology will continue to play an ever increasing and important role in enhancing the quality of graduate education as part of integrated curricula spanning on-campus and online modalities.

This paper provides an overview of some of the technology-based innovations being explored at Purdue University that show promise in assisting graduate students. These innovations fall into three broad categories: simulations, analytics, and professional skills technologies.

Simulations, or, more precisely, modeling and simulation environments, have been created to provide experiential learning and accommodate the integration of research into program curricula. Simulation environments, in general, provide an opportunity to engage students in experiential learning with flexibility not practicable in conventional laboratories. Often criticized in the past as an unrealistic substitute for hands-on experience, many simulations being considered now are overcoming the commonly cited shortcomings. Distinguishing aspects in favor of simulations include safety, low cost, convenience, and the ability to perform many experiments in a short period of time. If done well, working in a simulation environment can be fun for users and, in some cases, the preferred choice of students.

A number of instructional simulation tools have been developed and are being used at Purdue, such as a virtual dissection tool developed for students in veterinary medicine. Another example is the use of *client communication simulations*, to help veterinary students improve their interactions with clients who have sick animals. But, arguably, the best example of an innovative modeling and simulation environment employed at Purdue is the nanoHUB. Operated by the Network for Computational Nanotechnology (NCN), the nanoHUB provides a platform for running modeling and simulation tools that support research and education in *nanotechnology* areas that include bioengineering, electronics, materials, mechanics, and photonics. The nanoHUB is open to scholars from all over the world. The NCN actively encourages scholars to contribute presentation materials, lectures, animations, and analysis tools to the HUB. Tools in the nanoHUB can be hosted as executables or released as open source code at the authors' discretion.

Widespread dissemination is a strength of the HUB, which attracts a large audience of users who can use the tools. Authors of nanoHUB materials and tools are cited in top-tier publications by users throughout the world. Hence, both the HUB contributors and nanoHUB users receive recognition. The nanoHUB has had a very positive impact on graduate students engaged in PhD research, in the sense that research products published on the nanoHUB can be accessed and used *immediately* and cited by the international community. This kind of

recognition through the nanoHUB can put students in a much stronger position at the time of graduation when seeking employment in academia or industry.

In terms of instruction, the nanoHUB allows instructors to incorporate simulation-based learning in the classroom as well as share lecture materials, which can be found on the website under "Available Teaching Resources." The impact of the HUB has been tremendous. With over 3,900 resources hosted on the HUB by over 1,000 contributors, the HUB serves more than 255,000 users on an annual basis.

The second broad category of innovation highlighted in this paper is the application of academic data analysis, a.k.a. analytics. The use of data analysis in business to improve performance has been underway for decades, but is far less developed in academic circles. Many universities, Purdue included, are developing and deploying analysis tools to help improve time-to-degree and reduce student attrition. A noteworthy example at Purdue is the *Signals* system, which was developed to provide early warning to students about their risk of falling behind in class. The feedback provided by *Signals* to the students via the web includes detailed steps they can take to improve their performance. At this point, more than 50 instructors at Purdue have used the *Signals* system in one or more of their classes, impacting more than 11,000 students. While usage on the Purdue campus has primarily been at the undergraduate level, the principles and technology translate well to graduate education.

The third and last broad category of innovation mentioned in this paper is the class of professional skills technologies. These are technologies to assist students with professional skills that are important for career success. These skills may vary by discipline, but often include effective communication, grant writing, networking, interviewing, and more. While in many institutions, professional skills are not considered a formal part of the graduate curriculum, they are recognized as a valuable part of graduate education. At Purdue University, we are employing plagiarism detection software to help thesis advisors help students understand how to properly reference the work of others and to avoid plagiarism in writing. We are also developing gaming software to help students improve their communication skills. Our current project is a driving game that attempts to improve grammar. We have observed that many of our international graduate students, along with a number of our domestic students, routinely make grammatical errors when presenting (and speaking in general). In the game, the player is driving a vehicle while listening to the radio. When the player hears a sentence that is grammatically incorrect, he or she will have to make a driving decision—take a left turn if the sentence is correct or a right turn if the sentence is incorrect. All incorrect sentences and phrases are repeated with the correct grammar emphasized. The idea is simply to create an educational activity that is fun and that will be used by students often as recreation.

Space constraints do not allow for a comprehensive overview of technology-enhanced education at Purdue. The examples mentioned above are but a few highlights from among the numerous technology-based education tools and applications being used on the Purdue campus. It is clear we are seeing a rapid increase in the rate at which educational technology is being adopted by faculty, both in the context of in-class and online education.