article:1495

A Systems Model of Innovation Processes in University STEM Education

Research Question:
We determined to explore how knowledge generated by scientific researchfinds it way to practical use in education. We proposed anexploratory project to the National Science Foundation (NSF) and theygraciously provided support [Grant No. 0352239; John Cherniavsky,Program Manager].

Background:
David Roessner and Alan Porter, the PI's, are not educationalresearchers. Rather, we share complementary interests in studyinghow research and development result in innovation in products andservices.

Theoretical framework:
Our conceptual framework develops from decades of study of innovationprocesses. We ask: what works well to take scientific andengineering findings on through to useful applications? Ourpremise was that analogous reasoning from the industrial R&D arenato education might offer some fresh perspectives. In particular,we drew upon the notion of a "technology delivery system" propounded byWenk and Kuehn. This suggests that one think in terms of internaland external forces and factors that affect the prospects of successfulinnovation taking place. Internally, what is required to take anew idea or invention forward to mate with a marketplace of welcomingcustomers? In general, one needs adequate organization,management, intellectual and financial resources, and keycapabilities. If one's organization doesn't have all of these,then partnering with others is needed. Externally, one mustaddress whether a supportive infrastructure is in place, whatcompetitors have to offer, and ways in which environmental componentswill help or hinder the innovation.
We developed a conceptualmodel of research knowledge utilization. This pointed to fivemajor elements: A) a given research community, B) other researchers, C)technical users, D) non-technical users, and E) research-drivenoutcomes. We then particularized this to the educational arena.

Methodology:
We conducted extensive "research profiling" to capture thousands ofarticles addressing research knowledge utilization in education. We searched on a range of terms, including evidence-based practice,knowledge utilization, and research utilization. We searched anddownloaded research abstracts from databases, including ERIC, Web ofKnowledge, INSPEC, EI Compendex, MEDLINE, and ABI. Weconsolidated results to understand "RKU" (Research KnowledgeUtilization) studies over time, research emphases, and lessonslearned. This helped us sharpen the scope of our study to key onscience, technology, engineering, and math education (STEM),particularly at research universities.

The centerpiece of thisarticle is a conceptual model of research knowledge transfer in supportof STEM teaching in higher education. The article juxtaposesresearch universities from primarily undergraduate and otherinstitutions. This systems model emphasizes that STEM teachingand learning are complex, multiply influenced processes. Themodel distinguishes 7 tiers that warrant consideration by universityadministrators, teachers, and students:

- Research – distinguishing disciplinary science, disciplinarypedagogy, and general pedagogy (from experiential knowledge) – aspotential sources of new knowledge that could promote STEM innovations
- Mediators – a range of players and support structures impinging on research knowledge transfer
- Teachers – playing a central role in STEM innovation, withattendant factors (motivation, knowledge, opportunities, and teachingperformance)
- Settings – contextual factors affecting STEM, including classroom and non-classroom, institutional and disciplinary climates
- Learners – characteristics and motivations
- Performance – multiply determined, with both immediate and long-term elements
- Assessment – of learning, with feedback to players in the system

Results:

Comparing researchknowledge utilization (RKU) for STEM education at research universitieswith RKU for industrial innovation spotlights a glaringdifference. The key "innovators" in industry, whoare striving to develop new products or services, work withinincentive structures that strongly motivate them to find and useresearch knowledge. The would-be innovators in STEM education(teaching faculty) face a totally different situation. Theirprimary motivators are to generate research, not to improve teaching(i.e., to innovate in STEM education, whether drawing upon research orother knowledge resources). The "dual roles" of faculty has direconsequences for STEM innovation, given the priority placed on theother role – research.

Implications:

Contrasting STEMinnovation vs. industrial innovation paints research universityeducational change prospects darkly. Attempts to improve STEMinnovation need to think systematically. Single-factor solutionsare almost guaranteed to fail. Besides the disincentives for thewould-be innovators (teaching faculty), there is a notable lack of"pull" for improved STEM learning. However, there are signs ofinterest in effecting institutional change. The Boyer Commissionon Educating Undergraduates in the Research University, and follow-on'shold promise. NSF's introduction of Criterion II requirements onresearch proposals – to address impacts of the research, includingeffects on teaching – could exert profound influence, because theFederal Government's dramatic increase in provision of academicresearch support has strongly stimulated the research universities'emphasis on research. Coordinated policy actions at the nationallevel would have the best chances of altering incentive structures tofoster STEM innovation.

Author 1: Alan Porter alan.porter@isye.gatech.edu

Author 2: David Roessner david.roessner@pubpolicy.gatech.edu

Author 3: Sarah Oliver gte806i@prism.gatech.edu

Author 4: David Johnson gtg846g@mail.gatech.edu

Article Link: www.asee.org

: Back to 2006 Summer Issue Vol. 2, No. 2

: Back to List of Issues

: Back to Table of Contents