Enabling and Sustaining Educational Innovation

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Abstract

This paper reviews the responses to questions regarding innovation in engineering education posed to a nine-person panel assembled for The Carnegie Foundation for the Advancement of Teaching's pre-conference workshop at the Frontiers in Education (FIE) 2000 in Kansas City. Questions were focused on the inspiration, enablers, and challenges for innovation. In addition, issues related to innovation institutionalization (or sustainability) and to evidence gathered by the panelists to assess and evaluate the institutionalizing process are discussed. Themes and commonalities of the responses are presented and related to literature on the diffusion of innovation.

1. Introduction

Innovation "is an idea, practice, or object that is perceived as new by an individual, [even if it is not] objectively new as measured by the lapse of time since its first use or discovery."[1] To gain a sense of how innovation is occurring in current engineering education environments in this country, The Carnegie Foundation for the Advancement of Teaching (hereafter referred to as The Foundation) in October 2000 assembled a nine-person panel to discuss several innovations occurring in engineering education at a pre-conference workshop at the Frontiers in Education (FIE) conference in Kansas City. Panel members included Pamela A. Eibeck (Northern Arizona University), Anthony Marchese (Rowan University), Donald Richards (Rose-Hulman Institute), Jacquelyn Sullivan and Lawrence Carlson (University of Colorado at Boulder), Cynthia J. Atman (University of Washington, Seattle), Daniel Frey (Olin College), Eric Van Duzer (Humboldt State University), and Sheri D. Sheppard (The Foundation and Stanford University).

These individuals were asked to respond to (1) what inspired the engineering education innovation they were involved with; (2) what enabled the innovation to begin; (3) what challenges were faced during the initiation and incorporation phases of the innovation; (4) what solutions to these challenges were devised and/or implemented; (5) how the innovation was being sustained at their respective institution; and, (6) what evidence was collected and evaluated that indicated whether institutionalization of the innovation was successful.

2. Contributions of Panelists

Dr. Pamela A. Eibeck, Chair and Professor of Mechanical Engineering at Northern Arizona University, stated that innovation occurred at Northern Arizona because a critical mass of engineering faculty thought that curricular change, including the integration of interdisciplinary

design across all four years, was an extremely critical component to create practice-ready graduates. Pressure from the Accreditation Board for Engineering and Technology (ABET) and the state of Arizona's articulation policies, although minor factors, complemented this belief and inspired innovation. Essential components in enabling the innovation in engineering education to begin included faculty buy-in and ownership, tolerance and/or support from administrators, identification of key leaders, garnering support for counting involvement toward faculty tenure, recognizing the value of teaching, securing additional funding, and gathering supporters who helped pressure those against the innovation. Challenges faced included a rough transition period between the second and third years of activity, overcoming faculty burn-out, and squelching revolts from the non-believers. The building of a community of peer support was a major solution to these challenges. Innovation was being sustained through the attention given to the challenges by the peer community, which was reinforced by positive feedback from industry. Evidence gathered through alumni surveys and being recognized by the 1999 Boeing Outstanding Educator Award indicated that the innovation at Northern Arizona is likely to be institutionalized. Dr. Eibeck may be contacted at Pamela.Eibeck@nau.edu, or visit http://www.cse.nau.edu/Design for more information.

Dr. Anthony Marchese, Associate Professor in the Department of Mechanical Engineering at Rowan University, stated that a gift of $100 million and an advisory council that was in the unique position of defining the mission and goals for the brand new engineering college combined to inspire innovative engineering education at Rowan. The hiring of faculty who had a positive attitude toward innovation and the creation of a very special, cross-disciplinary community including all students and all faculty members enabled innovation to occur. Challenges faced included the identification of inspirational leaders, the recognition of the necessity for collaboration, and the acquisition of additional funding. Solutions to these challenges included the revelation that "new" does not necessarily imply "inertia," and therefore inertia must be self-generated, staying focused on the goals, and hiring new faculty members who supported innovation. Sustainability thus far was only being judged on the number of students graduating--86 out of 101 students graduated in Rowan's first commencement ceremony in Spring 2000. Dr. Marchese may be contacted at marchese@rowan.edu, or visit http://sun00.rowan.edu for more information.

Dr. Donald Richards, Professor of Mechanical Engineering at Rose-Hulman Institute of Technology, stated innovation grew out of individual faculty initiatives and was jump-started when Rose-Hulman joined the National Science Foundation-sponsored Foundation Coalition. Inspiration for innovation came from faculty interest in improving learning through curriculum integration and redesign, the use of technology in the classroom, and through the use of active and cooperative learning strategies. Interaction with other Foundation Coalition schools also helped promote innovation. Up-front training of faculty on teamwork skills and the use of a faculty-student team to help with faculty feedback and buy-in for curricular innovation smoothed the implementation process at Rose-Hulman. Challenges faced included getting faculty buy-in (especially the math faculty who had difficulty buying-in to engineering statistics), gaining resources (including students in the innovation's design), and recognizing that many victories were hollow. Faculty members agreed that piloting the innovation was a good idea yet recognized this process continued too long. The delay in expanding the innovation more generally at Rose-Hulman affected buy-in and forced a reduction in momentum. Collected

evidence suggests integration levels were not as high as hoped and the importance of teamwork was underemphasized. Furthermore, compromise of the innovation's original intentions became necessary. This required both patience to listen and the insight to hear the real concerns of the community. Educators at the college believe sustainability of the innovation will be achieved if faculty members remain focused on their goals, strategically focus their energies, and continue being active listeners. Dr. Richards may be contacted at donald.e.richards@rose-hulman.edu, or visit http://www.rose-hulman.edu/academics for more information.

Drs. Jacquelyn Sullivan and Lawrence Carlson, founding co-directors of the Integrated Teaching and Learning program at the University of Colorado's College of Engineering and Applied Science, stated their inspiration came from their desire to build on the freshman design experience through service to real clients, with a special emphasis on K-16 outreach. Enablers to implement innovation included the support by the administration, attracting new faculty and resources, intellectual and financial engagement of students, and convincing all stakeholders to "think big." Challenges to sustaining innovation--continually expanding hands-on learning curricula, creating more physical space, finding new opportunities, and attracting new sources of funding--are being solved by rewarding leaders and faculty members for their involvement, modeling teamwork and risk-taking among the faculty, and creating a "creative culture" where play and fun happen. Evidence collected to assess and evaluate the sustainability of the innovation included the documentation of promotion and tenure of faculty involved with the innovation and the engagement of an external review team whose specific charge was providing feedback on the innovation and identifying the innovation's effects throughout the curriculum. Corporate feedback is continually sought, and a focus on relevance to the engineering profession continually drives change. A newly emerging focus on product invention and innovation incorporates the world of entrepreneurship into the engineering curriculum. Dr. Sullivan may be contacted at Jacquelyn.Sullivan@colorado.edu, and Dr. Carlson at Lawrence.Carlson@colorado.edu, or visit http://www.colorado.edu/engineering/co_dl.html for more information.

Dr. Cynthia J. Atman, Director of the Center for Engineering Learning and Teaching in the College of Engineering at the University of Washington (Seattle), stated inspiration for innovation in engineering education at the University of Washington came from key administrators making "student-centered learning" a major goal for the College of Engineering. There was also recognition that to accomplish this goal there was a need to provide resources for instructional services specifically designed for engineering faculty. In addition, changes in the classroom needed to be based upon research in engineering student learning. Key enablers for the implementation of innovation included faculty buy-in, funding, time, shared goals, a unified focus, and the creation and nurturing of partnerships between the college and industry. Challenges faced included finding leaders and supporters, locating and acquiring funding, managing expectations, creating networks and communities, and balancing "out-of-the-box" thinking with traditional thinking. The networking of faculty from across the nation, the development of similar innovations at other institutions, the involvement of new faculty members (especially those from non-engineering disciplines) and an increasing sense of community, are believed to each evidence the sustainability of engineering education innovation. Dr. Atman may be contacted at atman@engr.washington.edu, or visit http://www.engr.washington.edu/~celtweb for more information.

Dr. Daniel Frey, Assistant Professor of Mechanical Engineering at the soon-to-open Olin College, shared the mission, vision, and plan for the college at this workshop. Through his experience in helping to develop Olin's programs of engineering education, he presented a hypothesis regarding the sustainability of curricular innovation: a key (perhaps *the* key) to sustaining curricular innovation is to create a system and culture which makes curricular innovation rewarding and satisfying to faculty members. Dr. Frey may be contacted at danfrey@mit.edu, or visit http://www.olin.edu for more information.

Dr. Eric Van Duzer, Assistant Professor at Humboldt State University, shared some of his dissertation research findings regarding the ABET's Engineering Criteria (EC) 2000 impact on both engineering education innovation and faculty organization. These new ABET standards are an innovation. These criteria, especially Criterion 3 (often referred to as "a-k") have forced a change of assessment focus from what a program has to offer students to what students are learning from a program. He found that an emphasis on compliance and the significant burden imposed by the requirement to assess all a-k outcomes limit innovation. He advocated for programs to use the ABET EC 2000 process to focus on real opportunities for improvement in gathering and using information that would benefit the program, not just meet minimum ABET requirements. The fundamental difference between programs that benefited little and those that benefited a great deal from preparing for an ABET EC 2000 visit was whether the process was driven by a compliance mentality or seen as a real opportunity to achieve some positive results for the program. Dr. Van Duzer may be contacted at evv1@axe.humboldt.edu.

Dr. Sheri D. Sheppard, Associate Professor in the Design Division of Mechanical Engineering at Stanford University and Senior Scholar at The Foundation, introduced the new study of engineering education sponsored by The Foundation. This study, entitled "Taking Stock--A Look at Engineering Education at the End of the Twentieth Century and Beyond," began in September 2000 and will be completed in 2002.[2] Its goals are to portray current engineering education, to highlight recent significant developments and approaches to teaching and learning in engineering education, and to offer suggestions and guidelines to enhance future engineering education and the qualities of future engineering educators and practitioners.

The Foundation's study of engineering education is both innovative and timely. The study is innovative in that it is embedded in a larger project at The Foundation that is looking at professional education more generally. It is also innovative in its research approach; its methods engage faculty, students, engineering societies, and practicing engineers from across the country in the attainments of its goals. The study is also timely; declining engineering student enrollments, recent National Science Foundation funding strategies, and changes in the ABET accreditation criteria are but three of a number of factors prompting changes to teaching and learning practices of engineering. The study will assist in identifying changes that these factors have affected.

The study was inspired by The Foundation's continuing interest in professional education. For example, The Foundation began in the early 1900s with a series of "surveys" of professional education, starting with the famous Flexner Report on medical education of 1910, followed by Charles Mann's A Study of Engineering Education in 1918, and Alfred Reed's report on Training for the Public Profession of Law in 1921. One of the biggest challenges the study faces is

defining a scope that is comprehensive enough for the findings to be convincing, but restrictive enough to be achievable within the project timeframe and budget. Another challenge has been in formulating the study in a way so that results will be of interest to all engineering faculty across the United States. In order to address these challenges, The Foundation has recruited a research team whose members have backgrounds in engineering, education, and history. Furthermore, this team is in residence at The Foundation in Menlo Park, California, and is able to focus its professional energies for a two-year period on addressing the study's goals. The research team hopes that by involving engineering schools, deans and other administrators, professional engineering societies, faculty members, students, and practitioners throughout the project, mechanisms for successful dissemination of findings and recommendations will be identified. For more information, Dr. Sheppard may be contacted at sheppard@carnegiefoundation.org.

3. Findings

Several themes and commonalities became apparent during the workshop. *Inspiration* and action are sparked by pressure from external stakeholders, by recognizing an important need, or by seizing an opportunity. *Enablers* include resources, passion, commitment, faculty buy-in, risk-taking, and out-of-the-box intellectual stimulation. *Challenges* include overcoming faculty burn-out, acquiring resources, involving external stakeholders, and transforming an innovation into something sustainable. Creating multi/interdisciplinary teams and networks (involving both internal and external stakeholders which share the same visions, passions, and energies) that are provided working environments in which the culture is nurturing and individuals are recognized as valuable members of the community may be *solutions* to answer the challenges posed by innovation. *Sustainability* of innovation occurs through creating a sense of community and ownership, by changing the existing culture, by enhancing and closing feedback loops, and by recognizing the actions of one's peers through a public reward system. *Evidence* of the institutionalization process includes increased retention and enrollments, positive feedback from all stakeholders, and an energized and committed faculty.

4. Conclusions

The findings from this pre-conference workshop are not surprising in light of the description by Rogers of how innovation is diffused.[3] This five-step process of diffusion (knowledge, persuasion, decision, implementation, and confirmation) usually occurs in "a time-ordered sequence."[4] The nine members assembled for the panel on enabling and sustaining engineering education innovation seem to be firmly established in the implementation stage and bordering on the confirmation stage. This observation may be applicable to the state of current engineering education in this country; the Foundation's current investigation of engineering education may contribute empirical evidence to support this observation.

Bibliography
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3. Rogers, 20.
4. Rogers, 3.

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ACKNOWLEDGMENT
The authors would like to thank Pam Eibeck, Tony Marchese, Don Richards, Jackie Sullivan, Larry Carlson, Cindy Atman, Dan Frey, and Eric Van Duzer for their valuable input at the pre-conference workshop and for input on this paper.