The Role of Innovation Education in Student Learning, Economic Development, and University Engagement

By Christy Bozic and Duane Dunlap

Abstract

A model is suggested for the inclusion of innovation education in engineering technology academic programming to enhance student learning, drive business growth, and advance university engagement. Specifically, academic programs that include experiential educational opportunities focused on innovation theory coupled with business and industry partnerships provide a framework for engineering technology students to apply their knowledge benefiting the students, companies, and the regions we serve. These strategic partnerships provide faculty and students with the opportunity to drive economic development through basic research, applied research, workforce education, training, technology transfer, and technical assistance. Successful university-industry collaborations are examined in this paper. Additional research is needed to develop collaboration impact measurements, learning outcomes assessments, and appropriate metrics to quantitatively measure successful collaboration activities.

Key words: Innovation Education, Engineering Technology, Technology Education, Economic Development, University Engagement, Curriculum Development.

Introduction

The need for the integration of innovation curriculum in colleges and universities has been a topic of ongoing discussion at the national level. The Council on Competitiveness, a national organization of CEOs, university presidents, and labor leaders working to ensure American prosperity, held a national innovation initiative summit in 2005 that convened researchers, educators, and business leaders to discuss innovation. From this initiative, the council published a report titled, Innovate America: Thriving in a World of Challenge and Change (Council on Competitiveness, 2005). The report details a national innovation agenda focusing on talent, investment, and infrastructure that allows for innovation growth. The Council on Competitiveness suggests that talent, and more specifically, engineering talent, is our nation's essential innovation asset, although the number of engineers entering the field are not replacing retirees in sufficient numbers (National Science Foundation, 2012). While filling this engineering gap, universities have the opportunity to incorporate relevant innovation-based curricula that are reflective of ill-structured, real-world scenarios for applied engineering and technology students. Colleges and universities are best suited to respond to the challenge of fostering the skills of creative thinking and innovation in their engineering and technology students through engaging and relevant curricula (Sandeen & Hutchinson, 2010).

A university's contribution to local economic development has been long studied and well documented. Historically, universities have viewed traditional research and education as major contributors to economic development (Smith, Drabenstott, & Gibson, 1987). Though discovery and knowledge transfer remain essential cornerstones to university engagement missions, there has been increasing emphasis on expanding the role universities play in innovation and competitiveness to create wealth. The Association of Public and Land-grant Universities' Commission on Innovation, Competitiveness and Economic Prosperity (Milliken, 2012) published a summary of suggestions from business and education leaders for areas of engagement. These suggestions include developing and commercializing technology, increasing industrial collaboration, developing economic policy, developing STEM talent, fostering entrepreneurship, and creating deeper partnerships within P-16 education. Universities are incorporating these strategies to play a key role in building knowledge-based innovation economies. Higher education leadership teams can accomplish this by placing emphasis on creating an entrepreneurial culture to cultivate a fertile ecosystem to promote new business growth. As a result of this culture shift, these universities tend to attract more creative entrepreneurs who have a penchant for innovation and can discover and commercialize new technologies focusing on business attraction.

According to one research-based, Midwest university's economic development working group, ". . . universities have a huge role in this new economy: helping to support research and innovation. . . build communities that will meet the needs and expectations, and be attractive, to those with the creative mindsets that are essential for fostering innovation and entrepreneurship" (Deason, 2008, p. 4). This university views its role as a crucial link in the "educational supply chain" (Deason, 2008, p. 4) by creating an innovation culture for faculty, students, and partners.

Universities play a key role in economic development by generating and attracting talent. One of the most critical mechanisms of knowledge transfer from publicly funded universities comes from recently employed skilled graduates in industry (Wolfe, 2005). Research intensive universities produce graduates who enter industry with high levels of research training and applied knowledge. While it is often difficult to quantify these benefits, Bramwell and Wolfe (2008) suggested that students represent the key transfer mechanism to channel scientific research from government-funded universities into industry for the broader purpose of economic development. Engineering technology educators have the opportunity to impart technology-creating skills to students while fostering an innovation mindset (Green, Smith, & Warner, 2012). Providing students with opportunities to apply theoretical knowledge to solve real-world problems allows educators to meet the stated educational mission while contributing to an economic engagement mission.

Applied engineering and technology curricula that incorporate topics such as innovation theory or the innovation process have been shown to better prepare engineers for the global economy (Orr & Eisenstein, 1994; Steiner, 1998). Today's global economy requires engineers to assume the lead role in innovation and idea generation. Although innovation and innovation theory are important topics in engineering technology education, they are not typically taught or embedded within engineering curricula. If innovation and entrepreneurship theory are applied, students can learn to solve ill-structured, real-world business and industry problems (Sandeen & Hutchinson, 2010). Even without an innovation curriculum in engineering and technology degree programs, approximately 60 percent of the CEOs in the Fortune 100 companies have engineering or science degrees (President's Council of Advisors on Science and Technology, 2004).

Innovation and Entrepreneurship Education

At the national innovation summit, the Council of Competitiveness defined innovation as the intersection of invention and insight, leading to the creation of social and economic value (Council on Competitiveness, 2005). Additionally, innovation can be defined as "the process by which technological ideas are generated, developed and transformed into new business products, processes and services that are used to make a profit and establish marketplace advantage"(Mogee, 1993, p. 410). Common to these definitions is the concept of the creation or manipulation of a product or process to be used in a new or different way. During a State of the Union address in 2011, President Obama said, "The first step in winning the future is encouraging American innovation. In America, innovation doesn't just change our lives. It is how we make our living." The president emphasized the role of government and universities to drive innovation through discovery, education, and university engagement. "But because it's not always profitable for companies to invest in basic research, throughout our history, our government has provided cutting-edge scientists and inventors with the support that they need" (The White House Office of the Press Secretary, 2011). Additionally, President Obama underscored the need for further investment in university research and development, challenging educators to focus on education initiatives that promote innovative ideas. To meet this need, universities and colleges are partnering with government, business, and industry by offering educational programs that promote innovation education. Even though these academic programs often contain the word innovation in their title, much of the curriculum is focused on subjects that could be encompassed under the umbrella of entrepreneurship. Entrepreneurship and innovation are often combined into a curriculum and treated as the same theory or subject. Innovation and entrepreneurship are really

quite different in both theory and practice. Innovation and entrepreneurship can be viewed as a continuum with innovation as an input in the form of invention and/or product and process development. As a consequence or outcome of this innovation, new businesses or existing business growth is recognized as entrepreneurship (Duval-Couetil & Dryrenfurth, 2012). Many of terms used in the definitions of entrepreneurship concentrate on business concepts such as market trends, leadership, and new business ventures. Terms like these are markedly different than the terms previously mentioned in the definition of innovation. Drucker framed the theories of entrepreneurship and innovation as complementary, but with distinct differences. Innovation is described as a function of entrepreneurship, whether in an existing business or a new venture. When describing entrepreneurship, Drucker stated, "The term, then, refers not to an enterprise's size or age but to a certain kind of activity. At the heart of that activity is innovation: the effort to create purposeful, focused change in an enterprise's economic or social potential" (Drucker, 1998, p. 149).

The study of innovation and innovation theory in engineering and technology is essential for understanding new product and process development, effective decision making, strategic marketing, and leadership excellence. The power of innovative ideas can revolutionize companies and spur new markets. A poll of the top 1,500 international CEOs cited innovative creativity as the top leadership trait for their companies (Dyer, Gregersen, & Christensen, 2009). Figure 1 presents the words or phrases CEOs use to describe the top leadership characteristics for today's economic environment (Berman, 2010).

Given the importance of innovation for new business growth, the theory of innovation can and should be taught to technology students. One such example of innovation theory is that of disruptive innovation. A disruptive innovation creates a new market by applying a different set of values, which ultimately (and unexpectedly) overtakes an existing market (Christensen, 1997). The examination of Netflix's role in the video movie rental market provides a simplified case of disruptive innovation. Netflix is a service that allows customers to stream movie content to any web-based device on demand, thus eliminating the need for customers to drive to video rental stores and choose from in-stock movie title options. Using a customer-focused and low-cost business model, Netflix disrupted the traditional business model of competitors such as Blockbuster. Disruptive innovation theory explains how new companies can utilize "relatively simple, convenient, low-cost innovations to create growth and triumph over

Figure 1: Word cloud with top leadership qualities CEOs cited as most important

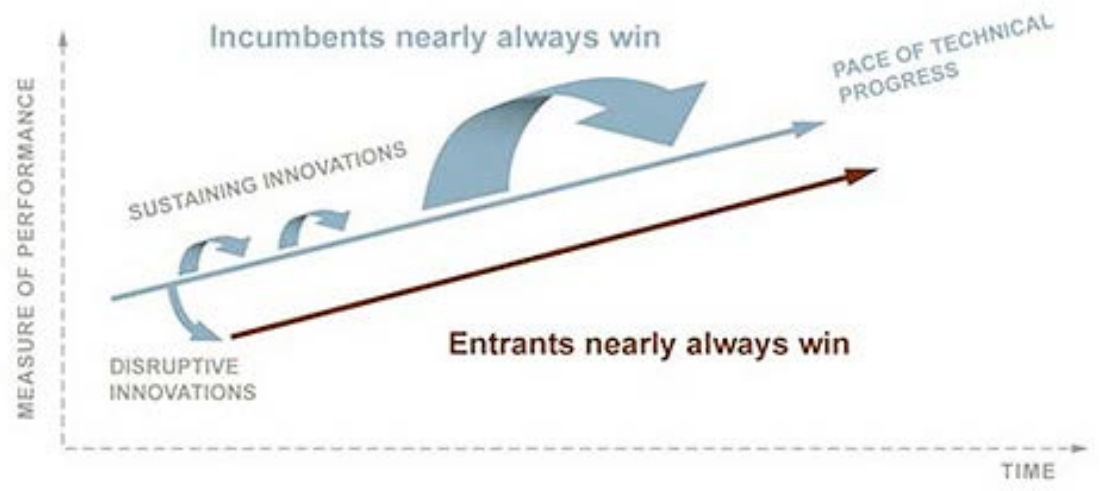

Figure 2: Disruptive innovation model. Reprinted from Clayton Christensen, Disruptive Innovation, by C. Christensen, 2012, Retrieved from www.claytonchristensen.com. Copyright 2012 by Clayton Christensen. Reprinted with permission.

power incumbents" (Christensen, Anthony, & Roth, 2004, p. xv). Additionally, the theory of disruptive innovation suggests that large market leaders or existing companies can maintain market share and market position when an entrant company introduces an innovation that is considered sustaining. A sustaining innovation is one that improves upon existing products or processes (Christensen & Raynor, 2003). When an entrant company introduces a product or service that is disruptive in nature, it changes the entire market because the innovation introduces the new product to an entirely new customer base. Figure 2 provides an illustration of disruptive innovation theory. The lines with arrows illustrate a company's product or process improvement trajectory in a given market. Disruptive innovation theory suggests the incumbent companies in the market will most likely win additional market share on sustaining innovations that marginally improve an existing product as detailed in the top curved arrow. Companies have historically invested in the development of these sustaining innovations charging higher prices to their current customer base with these marginal improvements. It is with these sustaining innovations that companies serve their most sophisticated or demanding customers at the top of any given market to recognize more immediate profits (Christensen, 2012).

By serving top-tier customers, incumbent companies are left open to competition by entrant firms with disruptive innovations to dominate the bottom of the market. These disruptive innovations usually introduce the product family to an entirely new market base who may not be market participants if not for this disruptive product. Innovative disruptions are usually lower in cost, quality, and performance than what the incumbent company produces. Because of the lower cost, slimmer margins, and the perception of inferiority, disruptive innovations are often unattractive to incumbent firms based on well-established performance metrics, yet they are attractive to customers who make purchases based on price over quality. Students who understand the innovation process through the study and application of its theories can make an immediate impact in their careers. Educators can provide students with foundational innovation education to effectively drive or manage innovation to improve productivity and global competitiveness. For example, the partnership between Proctor and Gamble (P&G) and the University of Cincinnati links students with industry to accelerate innovation for P&G's consumers. This collaborative academic-industry partnership developed a modeling and simulation center to advance P&G's product and process development. As a result of this

simulation center, P&G has hired 10 students as full-time employees because they were able to "hit the ground running on day one" (UIDP, 2013, p. 2).

Colleges and universities increasingly offer entrepreneurship-focused academic programs, certificates, and minors (Bordogna, Fromm, & Ernst, 1993; Robinson & Haynes, 1991; Seymore, 2001; Standish-Kuon & Rice, 2002). Although there is growth in entrepreneurship education, there is still a need for educational credentials with a specific focus on innovation. One recent study identified only eight undergraduate academic programs focused on innovation. They included three bachelor degree programs, three minors, and two certificate programs (Duval-Couetil & Dryrenfurth, 2012). Additionally, at the graduate level, Dartmouth University offers a Ph.D. program in innovation by combining engineering and business courses with an applied business or industry internship (Dartmouth, 2011). For the innovation core, Dartmouth combines four engineering courses with four business courses to provide graduates with the foundation to build businesses based on technological innovation.

The Need for Research in Innovation Education

Although an innovation curriculum is gaining popularity, published research on effective teaching and learning methods of innovation education for all students, and more specifically, for engineering and technology students is needed. The Ewing Marion Kauffman Foundation (2012) has recognized this need. The Kauffman Foundation's mission is to advance entrepreneurship and improve the education of children and youth through four program areas: (a) entrepreneurship, (b) innovation, (c) education, and (d) research and policy. The Kauffman Foundation supports research and publication specific to innovation and innovation education at all educational levels. As one example, Kauffman sponsored the USC Global Innovation Challenge Summer Program, which supports educators who teach students to develop innovative skills to promote business growth in developing countries. As part of a global collaborative effort, this program teams USC students with students in India to develop innovative solutions to local problems. Through this program, students develop projects and launch companies to meet global challenges. To promote research in innovation, the Kauffman Foundation supports dissertation fellowships and junior faculty fellowships for those graduate students and new faculty who establish a record of scholarship in the area of innovation (Ewing Marion Kauffman Foundation, 2012).

If engineering educators are to meet the need for innovation and economic growth (National Academy of Engineering, 2005) it is important to contextualize innovation and innovation education in terms of engineering and technology curricula. Because research overwhelmingly points to a call to action for applied engineering schools to include innovation and innovative thinking in their curriculums (Bordogna et al., 1993; Gopalakrishnan & Damanpour, 1997; Steiner, 1998), it is important to explore not only the need for innovation theory and practice in engineering and technology education, but also to examine successful and effective instructional methods for this population of students. Steiner (1998) suggested innovative engineering education should focus on management and innovation skills as important hallmarks of success in an engineering career, whereas Bordogna et al. (1993) recommended developing the engineer holistically to encourage innovation and not treating engineering education as a serial process with filters and gates. Whether the innovation curriculum is integrated holistically, programmatically, or as a module within an existing course, the opportunity exists for effective curriculum development and implementation that contains problem-based or work-based education that will benefit both the student and the participating partners. Industry and university collaborations provide the framework for engineering technology faculty to incorporate industry-based projects into their research and instruction.

Although engineering as a practice is highly technical and data driven, the education of engineers and engineering technologists is far from scientific. Engineering educators often rely on intuition, or feeling, rather than gathering data and proving which instructional methods are most effective for engineering students in different learning environments. "Unlike the technical community, wherein data-driven results

from one lab have widespread impact on the work of peers, many educational reformers have not incorporated research on learning into their work" (National Academy of Engineering, 2005, p. 26). Additionally, because engineering and technology students learn most effectively in a setting that allows them to apply knowledge actively with projects and case studies (Prince & Felder, 2006), university partnerships with business, industry, nonprofits, and government can provide students with the opportunity to work on real-world projects as part of their innovation education. Industry-based projects encourage students to learn and apply knowledge immediately. This situated cognition allows students to understand abstract concepts and procedures while actively deploying theory (Brown, Collins, & Duguid, 1989) in a controlled workplace setting.

Leveraging University-Industry Partnerships for Innovation Education

Universities can form purposeful and meaningful partnerships with industry for the benefit of students. These collaborative partnerships provide students with a relevance to their academic learning process. For example, colleges can use industry-sponsored senior capstone projects for student teams to solve problems or challenges faced by companies. These projects provide students with the opportunity to apply their knowledge and gain valuable experience,

". . . students want relevance in the content of their courses and are interested in learning how to do things that will enable them to be successful as practicing engineers. They are also interested in learning things that will be of value to their prospective employers and will be seen as such on their resumes" (Todd & Magleby, 2005, p. 204). Additionally, these partnerships allow companies to access a pool of potential new engineers without the expense of traditional recruiting activities. Further, it is an opportunity for industry to reach out to academic resources to assist them with product or process challenges. Leaders in industry often seek access to research within academia to which they can quickly apply for a competitive market advantage (Todd & Magleby, 2005; Yamada & Todd, 1997). Building upon the foundation of innovation theory, students can be effective pipelines for innovation for industrial partners. Successful frameworks for university-industry partnerships are ones in which all stakeholders benefit through an open line of communication, collaboration, and a well-defined accountability structure. Although industrial and educational collaborations can be successful in many forms, we suggest these partnerships define and document goals and expectations in the following three areas:

Mutual Benefit

First, an industrial partner must see the benefit of partnering with a university. The most effective partnerships between universities and industry are the ones in which the benefits to both parties are explicitly defined and continually revisited. These partnerships should be formed around mutual needs and market demands where there is value added to both parties as a result of the collaboration (Ryan & Heim, 1997). One example of a successful university-industry partnership is the relationship between DuPont and Penn State. Both partners have a shared interest in total quality management (TQM). DuPont sought to outsource research and development in this area, whereas Penn State viewed this as an opportunity to expand research in this area. Penn State and DuPont collaboratively focused on human resource development, continuing education, and technology transfer through this TQM relationship.

Single Point of Contact

Penn State attributes the success of this relationship to maintaining a single point of contact at each organization to drive measurable results. This two-person team ". . . has taken on the role of technology liaison between the two institutions, each representing the mission and interests of his respective organization" (Ryan & Heim, 1997, p. 43). From this partnership, Penn State expanded its corporate training programs, refined its academic advising process, and revised its manufacturing engineering program's curriculum to better emphasize the "interdependency of design in a business environment" (Ryan & Heim, 1997, p. 44) to benefit both the student and the company.

Defined Research Area

Industrial partners often fund and engage with university centers or technology incubators for the purpose of cooperative research, knowledge

transfer, and technology transfer (Santoro, 2000). These centers are primarily focused on one particular research area, for example, energy, the environment, advanced manufacturing with the sole purpose of driving research and innovation within that focus area. Often, similar companies invest in these centers as a consortium to strengthen research and development as an industry (Geisler, Furino, & Kiresuk, 1990). An example of a university-based research center is Carnegie Mellon University's Center for Iron and Steelmaking Research, which is funded by 15 manufacturers associated with the iron and steel industries. Initially the center was funded by the National Science Foundation in 1985, but it has remained self-supporting primarily through funding from industry. The mission of the center is to conduct basic fundamental research to support the efficient production of iron and steel while educating students for these industries. This is accomplished by connecting both graduate and undergraduate students with industry and company-specific research projects (Fruehan, 2006).

However these partnerships are formed and managed, it is through these collaborative efforts universities play a role in economic development by accelerating organizational learning and building communities of innovation (Carayannis, Alexander, & Ioannidis, 2000). Industry-university partnerships spur discovery, promote application of knowledge, and build a more innovative and talented workforce. Others support this view:

> The key then is to move away from the limited concept of the university as an engine of economic development and begin to view the university as a complicated institutional underpinning of regional and national growth. If nations and regions are really serious about building the capacity to survive and prosper in the knowledge economy and in the era of talent, they will have to do much more than simply enhance the ability of the university to transfer and commercialize technology. (Regional partnerships) will have to act on this infrastructure both inside and surrounding the university in ways that make places more attractive to and conducive to talent. (Branscomb, Kodama, & Florida, 1999, p. 607).

Recommendations

Universities have a unique opportunity to contribute to the economic vitality of the regions they serve via connecting students with industry through work-based educational experiences. Students can serve as a pipeline of innovation by applying theoretical and applied knowledge to solve actual industry challenges. Engineering technology educators teach mechanical/electrical theory along with the application of those theories to students for the purpose of product and process design. Instructors can and should incorporate innovation theory into the technology curricula to spur future technology business growth from graduates.

If educators are to meet the growing demand for engineering and technology talent and cultivate an innovation mindset in graduates, further research is needed to identify effective teaching and learning strategies that include work-based learning and case studies in the classroom. To measure the effectiveness of these programs, appropriate metrics should be developed to accurately report the benefits to not only faculty and staff, but also to the companies and regions served through these collaborations. Additional research is needed to assess the learning styles of engineering technologists with regard to the application of entrepreneurship and innovation education.

Universities should address common roadblocks in university-industry collaborative partnerships. The topics of intellectually property ownership, liability, and memorandum of understanding are often debated, ill-defined, and over-negotiated to the point where it is no longer feasible for these partnerships to exist. Often these partnerships are sought out by either the university or the company to exploit a specific opportunity, which can quickly expire before the time the contracts have been agreed upon. Universities should develop and follow a streamlined process for engagement that allows students, faculty, and administrators to be proactive and nimble regarding the needs of their business partners and the regions they serve.

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