The Innovation University

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Abstract

Traditionally, universities have been viewed as positioned linearly on a sliding scale between "research" and "education." We assert that to properly appreciate the role of engineering colleges, this linear view must be expanded by adding an additional dimension, "innovation."

The creation of new knowledge is the important role of the research university. The role of the "innovation university" is to innovate new products and services for the benefit of humankind. Innovation is distinctly different from research/invention and is often overlooked as a critical stage in the commercialization path. Given the right environment and motivation, engineering students are ideally positioned to participate in this endeavor. In addition, collaboration in the innovation stage creates a unique and valuable mechanism for universities to engage with leading technology-based companies. We describe two programs, Ecocar and Rose-Hulman Ventures, which bring together science, engineering and technology majors in an environment designed to promote innovation.

The innovation university emulates a real-world workforce where companies are attempting to transform basic research or intellectual property (IP) into products for the market place. That motivation requires an enhancement of the traditional approach of engineering education by integrating the education about innovation into the curricula. If done correctly and through a partnership with industry, the innovation university can be a powerful economic force aiding companies to accelerate their product development cycle. Benefits to students include exposure to real-world work environments, enhanced classroom learning, professional skills experience, internship experience, and clarification of career interests.

Introduction

So what is innovation? Numerous definitions can be found. It can simply mean the introduction of something new; or a new way of doing things; or taking the work of an inventor and introducing it to a broader audience. In a business context, the term "innovation" is applied broadly with a range of meanings including creativity and incremental-to-radical changes in an organization or processes [3,4,8]. In a technical sense, we use the term with a more specific interpretation in the context of the processes of invention and innovation. Varieties of different models have been developed to describe the invention, innovation, and commercialization processes [7]. A simple linear model is shown in Figure 1 and it illustrates the steps from idea creation to introduction to the marketplace. The linear model suggests an orderly process moving forward from one stage to the next. Research activities typically have faculty and scientists focused on the basic science of new inventions/discoveries. Innovation stage activities are characterized by the tasks performed by technical teams focusing on the later stages of commercialization including product development, prototyping, and manufacturing. From an occupational perspective, the members of these 'innovation teams' may include engineers, technologists, technicians, and craftsmen. It is this team structure and working relationship which naturally occurs in the workplace that we work to bring to our academic setting and student projects.

Schoen et al.[7] propose a cyclic model as shown in Figure 2 and suggest that both the invention and innovation processes are far more chaotic and random in nature. In Figure 2, it is suggested that basic research leads to invention with a high percentage of these activities leading to a dead end. It further suggests that the innovation process acts upon inventions in a business context to further the development and progress toward commercialization.

The traditional scale to define the role of the university is a ‘research’ or ‘education’ scale as shown in Figure 3-a. Large universities with a research emphasis focus on the basic research and invention in engineering and the sciences. This work is performed by research faculty and graduate students and is often funded by government agencies or corporate sponsors. It is understood that it is an expensive and high-risk proposition and commercialization benefits may occur many years in the future, if at all. These projects often end at the point of creation of intellectual property, patents, and perhaps a proof-of-concept prototype. It is often left to the private sector to identify the milestones to be moved through in the later innovation stages.

Those universities without a research focus often strive for excellence in education by preparing undergraduates to go directly into industry or graduate school. Because the career paths of graduates span a wide range of academic, industry, or technical roles, the curriculum takes a ‘just in case’ approach and includes a broad overview of engineering tools , skills and disciplinary knowledge. Many education-focused universities do include a component of hands-on project work, and it is increasingly included to meet the requirements of accreditation. Although most engineers work in the innovation stages of development during their careers, real involvement in innovation and related projects is often believed to be beyond the capability of an undergraduate university and, therefore, left to the private sector.

The authors believe that innovation should not be left to the private sector exclusively; rather, it should be included in the curriculum and taught to students. As a matter of fact, Rose-Hulman offers students a range of innovation-stage project work involving collaboration with industry or various collegiate competitions. Here we describe two exciting programs – 1) the Ecocar Challenge, a competition project, and 2) Rose-Hulman Ventures, a division of Rose-Hulman Institute of Technology that provides students with on-campus internships working on industry-sponsored projects. These programs demonstrate that teaching innovation to students can be successfully accomplished.

Over many years of experience with these types of programs, the results have shown that an institution with a focus on undergraduate education in engineering, mathematics, and science can play a meaningful and successful role in innovation-stage projects. Therefore, the traditional categorization of engineering programs having either a ‘research’ or ‘education’ focus may be expanded to include ‘innovation’ as a third dimension as shown in Figure 3-b.

Innovation Projects for Undergraduates

EcoCAR: The NeXt Challenge [10] is a three-year advanced vehicle technology engineering competition established by the United States Department of Energy (DOE) and General Motors (GM), Figure 4. The competition includes 17 universities across North America with a goal to reduce the environmental impact of vehicles by minimizing fuel consumption and reducing emissions while retaining the vehicle’s performance, safety, and consumer styling. Students will integrate their technology solutions into a 2009 Saturn Vue and will follow a design approach modeled after GM’s global vehicle development process [10]. Clearly in the innovation stage of development, students will explore a variety of solutions including lightweight materials, improved aerodynamics, and state of the art ‘clean vehicle’ solutions such as full-function electric, range-extended electric, hybrid, plug-in hybrid, or fuel cell technologies.

Rose-Hulman Ventures was started in 1999 with multiple missions including providing unique educational experiences for students and to have economic development impacts on Indiana based businesses [6]. The program has served as an incubator and technology center over the years of operation and has involved over 100 companies and 600 students working in internship roles. Today, the program operates on a year-round basis with ongoing project work with 18-20 companies involving 70 to 85 student interns and 20 staff/faculty. A unique feature of the program is that students work in co-curricular, paid internship roles under the supervision of project managers allowing the program to take on more real and challenging projects from client companies.

The program has two main goals (1) providing outstanding educational experiences to students as and (2) providing project results and value to the client companies. To achieve these goals, a realistic work environment as an 'engineering services' organization focusing on innovation stage projects has emerged as a successful program model. While not a professional services company, modeling the environment and culture in a realistic manner has proven to be successful for both students and clients companies.

Virtually all of the projects in the program are 'innovation stage' projects (as opposed to research focus) as depicted in Figure 1. The goals and objectives of client project work often includes the activities of design, modeling, prototyping, or testing which clearly fall in the innovation stage of advancing/enhancing a development toward commercialization and the marketplace. The program seeks a mix of projects from small and large companies across a range of industry segments.

An example of a Rose-Hulman Ventures project is FAST Diagnostics. FAST Diagnostics is an Indianapolis-based company that turned to RHV for assistance with innovation-stage, product development work. The company is developing a reusable optical device with a single injectable fluorescent compound that will provide accurate and rapid measurement of the rate by which kidneys filter waste products from the bloodstream.

The original research and 'invention' was developed at the Indiana University School of Medicine and as a start-up company, FAST Diagnostics turned to RHV for assistance in developing a commercially viable prototype system. RHV has developed a medical instrumentation prototype combining optical, mechanical, and electrical technologies. Specific technical projects have included refining the optical subsytems layout, developing mechanical mountings, and designing the electrical system signal processing boards. Over the course of the project, nine undergraduates from five different majors, one faculty member, and two project managers worked on the technical team. FAST Diagnostics is currently progressing with technical and business development activities. This is clearly a case where the original discoveries and intellectual property came from a research university and the follow on innovation-stage development was needed to advance the technology down the path to commercialization and the marketplace.

Outcomes in Innovation Stage Projects

A variety of formal assessment activities have been performed including student outcomes, client outcomes, economic development impact, and performance feedback between project manager and student. Results reported here focus mainly on student outcomes.

Student Benefits

A range of general benefits are commonly reported by students who have participated in the various programs including:

- Enhanced classroom learning - students report that the real project work provides a better background and context to apply and relate classroom concepts,
- Professional skills experience – experience in teamwork, communication, and leadership which are the skills often desired by potential employers,
- Career planning - students report that the experience either confirms their selection of a major and interest area or they learn what career and technical path they do not want to pursue, and
- Internship experience – most important is that it provides 'professional experience' and is often the first opportunity that the student has to work as a technical professional. This is beneficial for demonstrating 'work experience' on the resume, securing the next internship, and is crucial for job hunting.

In addition to these general and anecdotal benefits, periodic assessment studies have been done. Students in the RHV program have been questioned about the technical and professional skills learned in the program, ‘Please indicate the 5 skills learned at Rose-Hulman Ventures that you feel will be the most useful in the upcoming academic year’ and student responses are summarized in Table 1.

Table 1 – Student Ranking of Skills Learned

Rank	**Skill**	**%**
1	Ability to design a product or process to satisfy a client’s needs subject to constraint	90%
2	Ability to apply problem solving skills necessary for engineering practices	75%
3	Ability to work effectively in teams	65%
4	Understanding of the impact of marketing factors in engineering decisions	45%
5	Understanding of the impact of financial factors in engineering decisions	40%
6	Ability to recognize the need for life-long learning	35%
7	Understanding of the role of intellectual property in engineering decisions	30%
8	Ability to communicate effectively orally	30%
9	Ability to understand the impact of engineering solutions in global societies	20%
10	Ability to design experiments	20%
11	Ability to communicate effectively in technical writing	15%
12	Understanding of discipline specific contemporary issues	10%
13	Ability to conduct experiments	10%
14	Recognition of ethical and professional responsibility	5%
15	Other	5%
16	Ability to analyze data	5%
17	Ability to interpret data	0%

It is interesting to note the top skills cited include technical skills but also include team skills, the impact of market and financial factors on engineering decisions, and life-long learning.

A question about different roles played during project work is asked. In Davis et al.[2], the concept of an ‘engineer profile’ is developed describing the skills and behaviors that an engineer needs to exhibit to be successful in the workplace. *The roles identified in the engineer profile of leader, designer, collaborator, communicator, and self-grower are included in the question ‘For each of the roles below (Table 2), please indicate how frequently you fulfilled each role during your Rose-Hulman Ventures experience.’*

Client Benefits

Since inception, the various programs have partnered with or provided services to many companies. These companies have received a number of benefits of the association with the Institute including:

expansion of their engineering capacity in a flexible and configurable way,
- ability to achieve results on important technical needs,
- ability to engage students in a flexible internship program to aid in screening prospective hires, and
- ability to achieve exposure and presence on campus.

Table 2 – Roles Fulfilled During RHV Project

	Never	Rarely	Occa-sionally	Often	Fre-quently	**'Top 2'**
A. *Leader:* take initiative in guiding the project	0%	15	25	40	20	**60**
B. *Designer:* produce work products on time and within budget	0	0	5	50	45	**95**
C. *Collaborator:* contribute constructively to team performance	0	5	5	40	50	**90**
D. *Communicator:* communicate effectively with key stakeholders	0	0	30	25	40	**65**
E. *Self-Grower:* proactively learning and using resources	0	0	0	35	65%	**100**

Benefits to the Educational Institution

Education: The projects naturally lead to the formation of interdisciplinary teams of students which are sometimes difficult to create in a classroom setting. In addition to technical skill experience, the projects provide 'professional experiences' for students that provide a critical career services benefit to students during their job search activities. The faculty involved in the work often take their experiences back to the classroom. The hybrid vehicle work has led to important curriculum innovations in 'model based design' in mechanical and electrical engineering.

Admissions: The programs have also been valuable and a documented differentiator during the recruiting and admissions process. Of current freshmen who had heard of the RHV program before enrolling, the program had an impact on their decision to attend for 50% of them.

Industry Partnerships: The program also clearly has benefit for corporate partnerships and relationships. The programs attract some of the leading technology based companies in the region to the campus. In addition, these relationships may last months or years with the on-going nature of the project work.

Strategic: The programs are of benefit for defining the strategic role that a university with an undergraduate mission can play in 'innovation stage' projects and economic development often alongside much larger universities with a research focus. This breaks the traditional 'research/education' mission for a university and creates a new scale for defining a mission and role in innovation (Figure 3-b) which is distinctly different from research yet unique, valuable, and complementary to a mission in undergraduate education.

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Figure 1 – Linear/Sequential Invention to Innovation Model

Stage	*Idea*	*Research*	*Product and Market Concept*	*Product Development*	*Product Launch*	*Business Scale-up*
Staff	Inventor	Scientist	Engineer/Business	Engineer/Technician	Engineer/Technician	All Fields
Activities	New idea or vision.	Develop and test new scientific results, new inventions, proven technology, and intellectual property.	Develop product concepts and test market feasibility, evaluate technical and market risks.	Develop working prototypes for concepts, refine, and finalize product.	Develop manufacturing processes and scale up, cost analysis.	Develop engineering, manufacturing, and business support systems. Growth and economic impact.

Innovation Stages

Figure 2 – Schoen et al.[7] Innovation Cycle Model

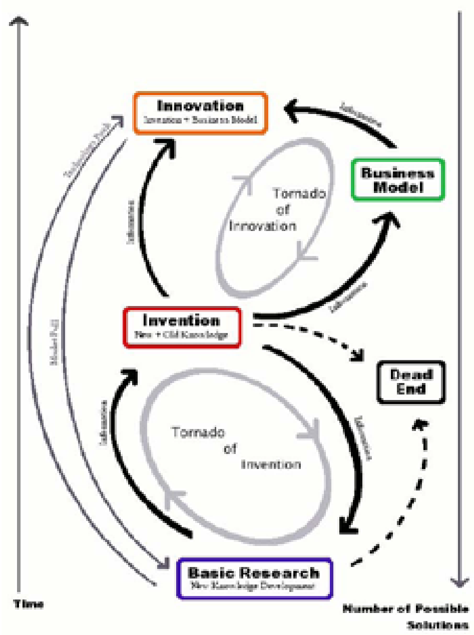

Figure 3 – University Missions in Research, Education, and Innovation

Figure 4 – Ecocar Project Phases and Timeline [10]