Embedding innovation in a typical engineering curriculum

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ABSTRACT: The process of innovation must precede the process of entrepreneurship and must involve experts from the business and the legal community. The process must start from students' first day at the college to their successfully seeking placement in a company. The scope of introducing innovation is taken seriously in the College of Engineering and Engineering Technology (CEET) at Northern Illinois University, DeKalb, Illinois, USA, and is introduced in the first course for engineering students. There are several subsequent initiatives undertaken by the College to prepare students on how to respect their ideas and nurture them to conclude in commercialisation. The process of embedding innovation in the engineering education programmes, as well as a philosophical discussion with real examples of initiatives that have been taken by the CEET to embed innovation into the curriculum are presented in this paper. In this paper, the authors also endeavour to raise awareness for a g lobal community to understand and collaborate on facilitating innovation.

INTRODUCTION

Usually, the sequence of creating wealth starts with innovation leading to entrepreneurship. For several decades, the concept of innovation was embedded in research and design activities of a company and was not given an identity of its own. Due to the poor economy and the need to support entrepreneurship, the word innovation has assumed a new identity, which is being universally recognised by academia, industry and government agencies [1].

One can find several solicitations by funding agencies across the world to bring innovation to all professions. Innovation can easily be applied to all professions, as there is tremendous scope in creating novelty and change in every profession.

For example, the teaching profession can use innovation by trying out new methods to satisfy the learning needs of all the students in the classroom. They may embrace innovation either by using/applying new learning strategies or by using new technological tools. Physicians, on the other hand, are always looking for new ways to treat patients and find new cures for diseases. Their profession is also one of the major professions that relies on innovation. Every profession strives to find creative ways to make or do things better, easier, more creatively and faster at less cost.

It is safe to assume that the catalyst for innovation in several fields is technology [2]. The development of the Internet and its ability to bring the worldwide audience closer has paved the way for innovation. Obviously, the mindset is the key to bringing about innovation. Effective use of technology and deriving benefit from technology can only be drawn if people have the mindset to change themselves and their work environment. One profession that can be singled out for having its foundation in innovation is the *engineering profession* [3]. The reasons supporting this claim are listed below.

THE ENGINEERING PARADIGM

1. *The Engineering profession is futuristic*. It is always looking forward and solving problems for the society. Engineers must be innovative in order to look at new strategies, new environments and new challenges to create optimum solutions.
2. *The Engineering profession is the backbone of other professions*. Since technology is a major aid in facilitating innovation, and the engineering profession is the keeper of technology, it has the responsibility of understanding the needs of other professions and, then, must be able to adapt technologies to find innovative solutions to complex problems. This aspect also ensures that engineers must have a broad understanding of societal issues and some information about the needs of other professions. This aspect has been realised by accrediting agencies, such as ABET, because they have incorporated this expectation within their accreditation criteria. Their expectation that

an engineering student will be able to solve complex problems and have an understanding of contemporary issues is a reflection on part of ABET to understand the effective role of the engineer as an innovator.

3. *The Engineering profession is globally portable*: The fact that the engineering profession is portable empowers it to work easily in a global environment and solve global issues. Globalisation has enabled corporations to be located at multiple locations and work in diverse socio-economic and cultural environments. The common language of engineering principles and fundamentals is the key for engineers to work globally without any technical restraints. Their ability to address global economic development issues through innovation is something that is proving to be extremely beneficial. The engineering designs needed to create engineering solutions are the same irrespective of the location. Engineers are in a perfect position to create innovation [4].
4. *Engineers will lead process innovation*: Several of the earlier decades were focused on product innovation. Products such as computers, LCD TVs, Ipods, Ipads, etc, have dominated the world in creating wealth. The global consumer has been targeted for product marketing and wealth creation. The current environment of global challenges has made the US manufacturers understand the need and importance of process innovation. US manufacturers stuck with the high cost of labour have no other alternative but to reduce the process costs to stay competitive and viable. While the US manufacturers are addressing their innovation needs related to optimisation, productivity, effectiveness and safety, the manufacturers in India and China have also begun to understand the concept of process innovation. While it is driven by cost in many cases, it has become a necessary requirement for all participants of the global supply chain to be optimum and effective. The world is concentrating its attention on process innovation and engineers will be the ones responsible to achieve it [5].

INNOVATION IN THE ENGINEERING CURRICULUM

Innovation in engineering programmes has always existed in the form of engineering design and similar endeavours. In the current context, there is a need for innovative strategies to infuse innovation into the programmes. Several initiatives and programmes have been undertaken at NIU to embed innovation into engineering curricula. The process starts from the first course students enrol in as freshmen. The course is titled: *Introduction to Engineering*. The College has done several iterations of the course to incorporate innovation in the course.

For three years, the course had fundamentals of nano-technology and its applications for freshmen students. The course was supposed to excite students about emerging technologies and introduce them to future trends in engineering. Students were required to make presentations and discuss their ethical dilemmas while studying nano-technology principles.

Currently, the course has been modified to include design engineering principles. The academic staff from different departments teach the course in a team format and synergise learning in the classrooms to enable students to learn a systems approach to engineering. The activities in the classroom encourage students to think out of the box and come up with unique solutions to simple technical problems.

NEW DEGREE PROGRAMMES

The fact that discipline-specific degrees provide discipline specific knowledge means that they provide an opportunity for innovation in curricular reform. Industries and employers are looking for students with diverse preparation and with knowledge of more than one field [5]. The trend has been to expect cross-disciplinary knowledge from engineering graduates. CEET at NIU works closely with 200 companies and has five different industrial advisory boards. Most of them have expressed a keen interest in interdisciplinary subjects and curriculum.

Consequently, NIU-CEET has developed several overlapping curriculum materials in the past five or six years. Some of the areas include systems engineering, mechatronics, simulation and modelling, reliability, nano-technology, health systems engineering, sustainable engineering, engineering management, biomedical engineering, environment and energy, etc. This innovative approach has enhanced the marketability of students in the region and has facilitated a transformation of curriculum. The students graduating from these programmes are better prepared to handle challenges of a technological society and are innovative in their approach to finding engineering solutions due to their understanding of diverse fields and their needs.

One of the unique curriculum developments has been to combine two degrees sequentially. The engineering and law schools have worked together during the past two years to come up with a six year engineering law degree. The salient feature of the programme is that it allows programmes to provide dual credit for courses and the students graduate with two degrees: engineering and law. The degrees are still accredited by ABET and the American Bar Association (ABA). This innovative approach was used by the College in response to a need expressed by the legal community to have better-trained intellectual property lawyers. The students prepared by the six-year engineering law sequenced degree will have expertise in engineering as an ideal preparation to pursue a degree in Intellectual Property (IP) law.

In addition, to enable students to understand the importance of protecting one's intellectual property, an Innovator's Club was started in the Academic Housing Unit of the Science Engineering and Technology (SET) House. There are 250 students in the SET house from various engineering, science and technology disciplines. They were invited every

week to an informal meeting to discuss their ideas. Experts from IP law, technology transfer and patent processing were, then, invited to meet with the students to educate them on the journey from perceiving an idea to converting it to a commercial product. The information included differences in the IP laws as they exist in different parts of the world and strategies to protect one's original idea. NIU-CEET has partnered with an active group of student-led research companies that are in the process of exploring commercialisation ventures in advanced areas of engineering design [6].

RECENT INNOVATIONS AT NIU-CEET

The infusion of direct assessment into teaching and learning at NIU has introduced innovation in several courses within the engineering programmes. The academic staff are using innovative methods to teach due to their involvement in the Institute of Teaching and Learning (ITL) launched by the College. Seven academics were trained to understand and utilise one or more of the 22 teaching pedagogies into their classrooms. The teaching and learning in those classrooms has changed for the better and has resulted in innovative ways of teaching, evaluating and learning.

The formation of research clusters from different departments and colleges is giving academic staff members an opportunity to write innovative grants to seek federal funding. A recent grant involving several stakeholders from industry, business, and government brought in US$2.4 million from federal agencies to accelerate innovation and research in an industrial cluster. These are a sample of things happening at NIU-CEET to promote innovation and creativity.

CONCLUSIONS

Innovation is an essential element of being an engineer. What is done and what is expected is nothing else but innovation. If the academic programmes do not integrate innovation into teaching and learning, it could be disadvantageous to the functionality of the students.

Knowing fundamentals and learning formulae is not enough. The engineering curriculum must be participative and should include the innovative use of technology and theory. The programmes must include experiential learning into the programmes at the course level to enable students to bridge theory with practice through innovation. The engineering leaders of tomorrow will be the practitioners of innovation.

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