Title: Integrating Creativity and Innovation in Indian Engineering Education System

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Abstract:

The Indian demographic dividend has been a prime mover in increasing relevance and significance of Indian engineering education system at the global level. The system has around 3400 colleges that turnout over 1.5 million engineers every year. While some of them are instrumental in engineering successes in a myriad of areas across the globe, many other seem to be challenges in fulfilling requirements of their employers. The system, given the size and potential, needs to intensify its efforts to understand the competencies required of the 21st century engineers and ensure that they are developed.

It is universally accepted that one of the key competencies of the 21st century engineers is ability to be creative and innovative. The intake of the engineering education system – K12 product – tends to perform poorer on the competencies and the engineering education system has to ensure the transformation. The Indian system has been working in that direction, albeit in some what scattered manner. That consists of various types of workshops, semester long courses, design courses that encourage innovation and a number of competitions that motivate the students to undertake innovative projects. It is important to channelize learnings of all those initiatives and architect a robust and a formal framework.

The paper proposes such a framework that can be deployed across various institutes for fostering creativity and innovation. The framework envisages various pathways such as research, corporate, socio-managerial and enterprenurial. For each of them, the paper proposes appropriate ongoing measurements and commensurate activities with expected outcomes starting right from the third to the last semester. The framework would have the facility to develop a network of various educational institutes especially to share the learning in this area. The framework mandates that the students think of real life problems and create innovative solutions and deploy them to deliver value, right from the early years. All such projects are expected to culminate into worthwhile and industry quality capstone projects.

Right now, the Indian system has around 180 credits which is much on the higher side as compared to the other systems. Bodies of knowledge of all the disciplines are increasing rapidly, resulting in demand of adding several new courses, leaving little space for such initiative. Therefore, we have to be innovative and aim for seamless integration with the existing program structures. That may entail replacement of some and redesign of many courses. The redesign will require the faculty members learn and develop state of the art pedagogical techniques. The institutes may have to undertake the change in a phased manner. All these can synergize into developing creative and innovative Indian engineers. That will not only facilitate the students to become ‘industry ready engineers’ but also give them confidence needed to transform their visions into realities.

Keywords: Indian Engineering education, Creativity and Innovation Competency Development, Framework.
Introduction:

While engineering education in India has a long history, it has assumed critical significance on the global scenario only in the last few decades. Today, it boasts of about 3400 engineering colleges that are churning out 1.5 million graduates every year. However, various industrial bodies complain that these graduates are not able to meet their requirements. NASSCOM-McKinsey report (2011) has pegged the employability number at 25 % whereas Aspiring Minds' National Employability Report (2013) estimates it to be merely 17 %. The latter study had analyzed 55,000 IT and computer engineering students from 250 colleges across the country. According to a survey done by the World Bank and Federation of Indian Chambers of Commerce and Industry (FICCI), 64% of employers are “somewhat”, “not very”, or “not at all” satisfied with the quality of the engineering graduates they hire. As per planning commission study, the employability of engineering graduates in India is 17.5 % while that in Malaysia is 27% and in the US 76 % (Global Employability List 2012) This poses grave concern not only at national level but also at the international level as many developed countries are looking up to India to fulfill their requirements of engineering graduates to a good extent.

This requires serious review and action on war footing. The outcomes of an educational system largely depend on the faculty. And they have to act. The faculty is involved in teaching, assessing, researching, mentoring as well as developing academic processes and infrastructure as well as establishing collaborations with academia, industry and alumni. Unfortunately, currently the education system is facing shortage of good faculty resulting in shortcomings in all the areas mentioned above. The shortage results in their engaging in age old lecturing method and not paying attention to and assimilating the leading edge research in the area. This has to change. There have to be initiatives – coming from faculty members themselves - to develop the competencies required of the 21st century engineers and increase their students’ employability.

One of the most critical among them is the ability to innovate. The current Indian engineering education system appears to inhibit the competency. Till the recent past, the Indian industry, especially the manufacturing sector, was driven by imports and offered mainly production, support and maintenance jobs. The academia was playing to the requirement and not nurturing problem solvers and knowledge creators and neglected both application-oriented and fundamental research. This is reflected in producing just 1000 PhDs per year as against 3500 in the US – even when the US has only 10% of engineering graduates as that of India. Another reflection is in dismal number of patents. India ranks 17th with 5170 patents while Japan and US are well above 200,000 mark (Patents, 2013). China is not far behind them and South Korea is touching the 100,000 mark. Indian education system has to do a lot of catching up so that India can leverage their demographic dividend and not face demographic disaster.

This paper proposes a framework that can help to integrate development of innovation competencies with regular engineering curriculum. That is the main theme of the paper. There have been many organizations and individuals who are working to develop the competencies. The government of India has established national and state level innovation councils. The Indian Institute of Science, Bangalore organizes a competition ‘The Jed-i project challenge’. It is
designed to identify and showcase the best final year engineering projects. Indian Institute of Technology, Mumbai organizes an event ‘Techfest’ for promoting technology, scientific thinking and innovation in engineering students. It provides an international platform to the youth to showcase their talents and skill sets in fierce competitions, display cutting edge technology and research from all over the globe. ‘Tryst’ is the annual science and technology festival of the Indian Institute of Technology, Delhi. Every year, collegiate students from various parts of the country attend this technical extravaganza, in an atmosphere which makes them learn and unlearn through an application-oriented approach. Many institutes in India organize such competitions at local, regional and state levels to provide platforms for engineering students to showcase their technological and engineering prowess and nourish creativity. There are innovation centers that are charged with making innovation a way of life as well help incubate bright ideas into new ventures. There are collaborations across colleges through great initiatives like ‘LEaders Accelerating Development’(LEAD,2014) and Ignited Innovators of India (I2I, 2014)

We believe that there is a need to plough back learnings from all these efforts and develop a robust framework that can facilitate the integration. The framework posits four pathways for engineering students – entrepreneurial, socio-managerial, corporate and research. It uses various personality assessment techniques in their second year to identify right pathway for each student and provides flexibility to change that as they proceed to the final year. The framework hinges on project based learning that is supplemented by two theory courses – one in the third and one in the sixth semester. It proposes four projects along with competition at different levels to cross pollinate learning and encourage better performers. At least some of the projects can be merged with the current curriculum and be executed.

The next section covers literature survey and is followed by articulation of the proposed framework and ends with concluding remarks. The main contribution of the paper is explaining the need of a framework and detailing out its design.

**Literature Survey**

Even though Innovation has been identified as a key competency in (Male, S. A. et al., 2009; Jakobsen M.M., 2012), there do not seem to be any efforts to develop framework to build that competency. Various bodies and groups have worked to develop a framework to inform stakeholders about what competencies need to be developed but do not seem to have focused on how to develop them (Esparragoza I.E. et al, 2013; Male, S. A. et al., 2009). There have been studies to develop different frameworks for developing competencies like project management and design (R. Suikki et al, 2006,Esparragoza I.E. et al, 2013). However, innovation and allied competencies like creative thinking, problem solving do not seem to have attracted attention of researchers.

To develop innovation competency, one can use varied techniques like project based learning, benchmarking and sharing through various competitions (Techfest 2014, Tryst 2014, Jed-i project challenge 2014) and team based learning. There have been many reported studies on
efficacies of these elements and analysis of different aspects involved in them. (Voorhees and Paulson, 2002; Sudsomboon W., 2007; Male, S.A. et al, 2009)

Engineering students have a multitude of opportunities beckoning them. They end up choosing one of them based more on exterior factors like money, international travel, current hype in the market and not internal factors like their ability and aptitude. This is very crucial – especially in case of innovation. It requires critical thinking and perseverance that can be found and accentuated if one has aptitude, ability and liking for the area. There do not seem to be studies that help students to choose right pathways like entrepreneurial, socio-managerial, corporate and research. There have been ample instruments that have been researched and put into practice to understand individual students (Chapman, A., 2006; Steve M. 2012). Some of them can be used to help students choose pathways that resonate with their inherent strengths.

A competency development framework will consist of various interventions. It must have learning objectives and assessments of fulfilling them. Many educators have worked on both the aspects (Sudsomboon W., 2007; Male, S.A. et al, 2009; Gilliot Jean-Marie and Gabrielle L., 2008; Papanikolaou and Boubouka, 2010)

**Design of Framework**

The salient features of the proposed innovation competency development framework are displayed in Fig.1. It has four poles – Project Based Learning, psychometric assessment, benchmarking and varied career options.

![Fig.1](image_url)
The diversity is an essential ingredient required for developing innovation competency. It can be brought in many ways. One of the ways is to use competitions at various levels. This will enable networking and cross-pollination of ideas. The winners of the competition will also get motivated (Techfest 2014, Tryst 2014, Jed-i project challenge 2014).

Engineering is a remarkably broad field of study serving basic needs of the humanity. Students can choose varied professional pathways such as socio-managerial, entrepreneurial, corporate and research depending on their inherent strengths. The innovation needs in the pathways tend to be different. The proposed framework accommodates this breadth. The students are supposed to choose projects in line with the pathways and also take an elective to acquire the required theoretical background. The framework also provides opportunities to change the pathways. (Fangel, M., 2004., Jafaari, A., 2004, Biesta, G. 2007, (Smith W.F., 2011, Lackéus, M. et.al. 2013, Lackéus, M. 2013)

**The Framework**

The framework is broadly divided into three stages – Inception, Elaboration and Transformation (Figure 2) and follows spiral approach (Lohani 2006). The inception introduces the innovation, its criticality and expects students to work on their first project – P0. The Elaboration phase consists of a project P1 from students’ chosen discipline and a project P2 of interdisciplinary nature and a theory course. All of them will provide elaborate idea about their pathways. The last stage primarily consists of their capstone project and helps the students to transform into innovative and employable individuals. The figure 3 elaborates the framework further.

![Fig.2 The Transition Stages](image-url)
Concluding Remarks

The Indian engineering education system is at an inflection point. It is the largest system across the globe and had its share of successes and failures. India is aspiring to become a member of the Washington Accord by June 2014, and get her degrees professionally recognized on a wider global platform. There is a serious paucity of qualified engineers in the developed world and is expected to become worse. India, can leverage its demographic dividend, fulfill the requirements of the globe and help her grow in both economical and technological dimensions. That will require revamping of the system, though. As of now the system is criticized for its poor performance on the employability of its graduates. If the revamping is not done expeditiously
and appropriately, there is a danger of India losing on opportunities of serving the globe and facing the prospects of turning the demographic dividend to demographic curse.

All the leading engineering education bodies (ABET, 2010; EA, 2005, EAB, 2011; NBA, 2013) have meticulously worked with their stakeholders to identify requirements of the engineering graduates. They have converged on the requirements such as ability to innovate and work in teams cutting across disciplines and cultures. This paper proposes a framework to integrate development of innovation competency with the Indian engineering education system.

The framework is based on the principles of project based learning, psychometric assessment to choose appropriate pathways and competitions at different levels to enhance cross pollination of ideas and sharing of solutions. It offers various pathways and opportunities to switch them as students learn more about themselves. The framework would transform the engineering students into effective employable professionals.

The paper is at a conceptual level and only proposes a framework. While many of its ingredients are being used in India and elsewhere; we have not come across deployment of such framework. Waychal, et al. have found that simple solutions lend ease of deployment. We have tried to keep the framework simple to increase the chances of success. We, however, cannot ignore the findings of Borrego et al., that despite the decades of efforts focused on improvement of engineering education, many recent advances have not resulted in systemic change. They have studied diffusion of seven innovations in engineering education across the US and found that even though the awareness rate was as high as 82 percent, but the adoption rate was merely 47 percent.

Since it is a conceptual framework we solicit feedback from all the educators and researchers to improve it. We are planning to run a pilot in our institutes, we will be happy to support if any other institutes are willing to join the bandwagon.

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