

Innovation Skills for Engineers

Industry ready Innovation skills development in higher education

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Abstract—today, the critical need for Innovation in organization growth and also national economic growth is very clear across the globe. India has embraced the current decade as the decade of innovation. To realize this vision our workforce skills in innovation needs to be developed and enhanced. Today innovation skills are not emphasized sufficiently as part of the formal education system while the current methods are not effective in imparting the industry ready innovation skills to the students. The opportunities for imparting and learning innovation skills, in Undergraduate (UG) and postgraduate (PG) academia, the challenges, deficiencies and recommendations are presented.

Keywords- course; Undergraduate; Postgraduate; Innovation; skills; development; effective; teaching; learning

I. INTRODUCTION

The President of India in an address to the Parliament on June 4th, 2009, declared the decade 2011-2020 as the decade of innovation in India¹. This makes it clear that India has to move up the value chain by moving from routine work to being innovative. According to one of the latest reports the annual R&D spend of India is about 1% of GDP. According to Zinnov Consulting's Conclave2013², MNCs who have stark shortage of engineers in native countries are setting up R&D centers in India. India is increasingly the global choice for a R&D set up with increasing number of MNCs setting up such centers in the country, which according Zinnov stands at 850. It says that India has an inherent innovation potential and to attract skilled engineers, truly leverage their competencies are critical to achieve this potential. In a letter to the prime minister, the National Knowledge Commission chairman Sam Pitroda, stated "... the most critical external barrier for both large firms and small and medium enterprises is skill shortage arising out of lack of emphasis on industrial innovation, problem-solving, design, experimentation, etc. in the education curricula.". The Indian formal education system does not effectively impart innovation skills development. There is no formal, mandatory or optional course designed as a part of the curriculum that ensures the graduates are equipped with effective innovation skills. Without adapting our formal education system, that too quickly, to include innovation skills

training we will not be able to meet the challenge as outlined by Mr. Sam Pitroda and realize the Innovation potential dream of our nation to achieve national prosperity. We need ways to impart innovation skills to our students in effectively in higher education and especially in UG and PG courses.

Only one tenth of students of tier 2, 3 and 4 engineering colleges are readily employable, says the national survey of a private educational agency³. Even after interventional training, one third of them are not employable, it says. Amit Bansal the CEO of Purpleleap, an entry level talent management firm, says the survey was conducted across 12 states among graduates who had scored more than 60 percent marks. More than communication skills, it is the lack of technical skills that featured more prominently, he added.

An observation of various job sites and job descriptions for typical fresh and mid-level engineering jobs reveal what industry is really expecting from its potential employees. The job advertisements are all asking for more or less the same two things, the ability to use your own initiative, to think for yourself, to be creative and pro-active and the ability to resolve problems, to think logically and/or laterally, to use ingenuity to overcome difficulties and to research and implement solutions. This is what generally innovation skills equip them with. Usually there are several avenues of imparting and learning innovation skills during the Undergraduate (UG) and Postgraduate (PG) courses. However these avenues do not always result in effective innovation skills development. Also the opportunities are many times applied ineffectively. This will be a critical loss of opportunity for teachers to teach and students to learn innovation skills. In this paper various possibilities to impart innovation skills as a part of the UG and PG courses and their effectiveness is presented, along with some recommendations to make them effective.

II. INNOVATION SKILLS DEVELOPMENT CONTEXT

It is to be understood that innovators are made up of certain skills apart from core engineering skills. These innovation skills are generally application skills and also include attitudes and behaviors. These skills can be taught, learnt and practiced to be effective innovators. Application of these skills repeatedly like many other skills, will also improve the

1 Source : Press Information Bureau, Date : March 10, 2010

2 <http://www.confluence2013.com>

3 http://articles.timesofindia.indiatimes.com/2012-07-30/coimbatore/32941250_1_jayaprakash-gandhi-graduates-employable-students

proficiency of innovation skills. There is a need for education and practice of these skills amongst the students under the guidance of the faculty. The skill level can be different from one student to another and hence the skills to focus upon can also be very different per student.

A typical UG or PG course includes several academic and associated components as a part of the curriculum. The major set of such components are opportunities for learning of technical and developing innovation skills and is listed in table 1. There is a continuous availability of opportunities during the typical course of a UG or PG education to develop the innovation skills. However during the tenure of a typical UG or PG course the opportunities listed in table 1 will be interspersed with one or the other with varying degree of opportunities for applying different skills.

Table 1 - List of learning opportunities in UG and PG

Table Head	Learning Opportunities & applicability ^a		
	Learning opportunity	UG	PG
1	Internal Assessments	Y	Y
2	Theory Exams	Y	Y
3	Practical Exams	Y	Y
4	Assignments	Y	Y
5	Projects	Y	Y

a. Y = Applicable, N = Not Applicable

While the main objective of the various learning opportunities is to impart proficiency in technical knowledge they are also valuable opportunities to develop, apply and practice certain other skills such as Innovation skills, communication skills, etc. So these opportunities offer ideal platform for learning and teaching such skills in an integral manner.

The focus of this paper is to identify those opportunities during UG and PG that provide a platform to impart innovation skills and assess the effectiveness and recommendations for the use of such opportunities.

A. Innovation skills to be imparted

There are several skills that make up a good innovator. These skills as said earlier are non-technical skills. The skills as listed in table 2 are recognized as critical to be imparted and learnt at UG and PG level. These skills will be critical when the students after their education become part of the work force as an entrepreneur or a professional in an organization. It is to be noted that professional training on personal innovation skills today are typically on the job, and many times by trial and error. So a student who has the necessary technical education and also a complementary innovation skill set would be ideal candidate for firms looking to fuel its growth and hence requiring technically competent, innovative people. These students surely position themselves better for employability than those who lack such innovations skills. In other words when all things are equal those with innovation skills will have

a clear edge in being valuable contributors to nation building. The innovation skills are classified along the lines of thinking orientation, execution orientation and association orientation and are shown in table 2.

Table 2 - Desired skill set from UG, PG students

	Innovation Skills		
	Skill plane	Primary	Secondary
1	Thinking Skills	Observation	Intuition
		Framing	Parallel thinking
2	Executing Skills	Experimenting	Facing Failure
		Hard-working	Passion
3	Associating Skills	Validation	Insight
		Networking	Risk Assessment

There are three skill planes identified each having a pair of critical primary and supporting secondary skills for innovators. Thinking skills are those that are needed to frame valuable problems and selecting the best ideas. Thinking skills include spotting the right problem or opportunity from a huge pile of information which is available in the public domain. So thinking skills is about having the same data as others but thinking something different. Executing skills are those that are needed to create a solution or Proof of concept, from the selected ideas. In other words, executing skills bring ideas to reality. The association skills deal with the environment or market where the innovation will be applied. The value of the innovation will be matched to the environment where it will be applied and hence a context for the innovation is validated. For an innovation to be successful all the three steps are important and critical. Hence an effective innovator needs mastery of these three skill sets.

III. EVALUATION OF LEARNING METHODS

Several of the skills in table 2 can be imparted and learnt via diverse pedagogies during various stages of the UG and PG courses. The various opportunities recognized to impart and learn these innovation skills are listed below in table 3. These are referred to as 'opportunities' for imparting and learning innovation skills during a UG or PG course.

Internal assessments are the academic related periodic tests and assessments where students answer questions and solve problems as per the syllabus. This predominantly involves thinking skills while execution or association skills are not invoked. A Semester exam typically consists of theory and practical exams. Theory exams test the theoretical understanding of the student. The Theory exams are similar to internal assessments but with a bigger part of the syllabus covered and application of theory is also tested. Here again similar to internal assessments the thinking skills take prime importance. The practical exams test the application knowledge of the students where experiments are to be conducted to demonstrate a given concept. This involves thinking and executing skills while association skills are not needed.

Assignments are given periodically to contemplate and research on an emerging trend or an interesting topic or a specific problem, etc. The student or a group of them then present the findings to a wider audience in oral or written form, typically a written report along with a presentation. This again sharpens the thinking and execution skills while the association skills are not emphasized. Projects, as a part of their academic curriculum, is where students select certain ideas, develop them into a design and implement them. In this opportunity there is a chance for the involved students to use all the three skill planes of innovation. By doing so these skills are exercised and hence proficiency can be developed. External events are those where the students participate in seminars, contest and conferences both within the institute and various other institutes and forums. The aim is here is to learn and present on various topics of interest or demonstrate projects that they implement. In this opportunity again all the innovation skill planes can be exercised as there is room to do so.

Based on the opportunities available and the skills to be developed, a mapping of the opportunity and the skills to impart and learn can be created. This mapping is shown in table 3.

Table 3 - Learning opportunities and Skills map

Opportunity	Innovation Skills ^a		
	Thinking Skills	Executing Skills	Associating Skills
Internal Assessments	Y	N	N
Theory Exams	Y	N	N
Practical Exams	Y	Y	N
Assignments	Y	Y	N
Projects	Y	Y	Y
External events	Y	Y	Y

a. Y = Applicable, N = Not Applicable

A. Evaluation of carriers for innovation skills development

While the various opportunities are used for imparting skills their effectiveness in using those opportunities is an important parameter too and one of the key focal points of this paper. Though table 3 shows all the opportunities for various skills in reality these opportunities are not used effectively. Where there are options to exercise a certain skill set students are not using that chance and hence rendering that opportunity ineffective for the development of innovation skills. Based on the carriers available and skills the effectiveness of the carriers of learning is assessed.

Using the data of about 1250 students and faculty from various branches of engineering in UG and PG the effectiveness was observed and is reported in table 4. This shows which carriers have been effective in imparting which of the desired and possible innovation skills. Based on the observation and analysis of internal assessments and exam performance, both theory and practical, these opportunities are reasonably well utilized to develop thinking skills. The observation of

performance during assignments, projects and participation external events revealed that most of the times the opportunities are not utilized to its potential. There appears to be multiple reasons for these opportunities being ineffective, while faculty view and student view differs to some extent on these reasons.

Some reasons, as per faculty, appear to be the lack of interest shown and insufficient effort put in, by the students. During assignments students do not spend sufficient time to frame the right problem statement or topic for research. In addition the students do not have very good hands on, prototyping ability which is a critical innovation skill. The reason for projects being not effective for innovation skill development is similar to the assignment opportunity and in addition lack of market orientation. The project ideas do not find any possible commercial value or outdated in terms of technology and application.

The students on the other hand attribute the key reason to be the lack of time, to fully engage in to such activities during the course of a busy academic year. The reason of students is also the missing, appropriate guidance from faculty and administrators during the course of assignments, projects and engaging in external events. Students claim that they do not have sufficient guidance in selecting problems, technology or during implementation which makes up the thinking and execution skills of innovation. The students feel that faculty is not able to support them regarding the association skills which provides the necessary market connection to the projects and assignments selected, attributed to the lack of industry connects of faculty.

The role of industry in imparting the innovation skills are UG and PG levels are crucial. The industry academia interactions form the back bone of this skill development philosophy. While the academia maintains industry contacts the industry needs to do the same with academia. Industry experts should update the faculty using faculty develop programs and other platforms. Also the industry experts should mentor the students to develop the right innovation skill levels so that their contribution to industry, society and the nation can be meaningful and significant.

Table 4 - Opportunities and Effectiveness map

Opportunity	Innovation Skills ^a		
	Thinking Skills	Executing Skills	Associating Skills
Internal Assessments	Effective	N	N
Theory Exams	Effective	N	N
Practical Exams	Effective	Effective	N
Assignments	Not Effective	Not Effective	N
Projects	Not Effective	Effective	Not Effective
External events	Not Effective	Not Effective	Effective

a. N = Not Applicable

IV. CONCLUSIONS

Several opportunities for imparting and learning innovation skills during a UG or PG course were presented along with their applicability and effectiveness. Not all the methods are yielding effective results, specifically Assignments, Projects and External events participation. The reasons for their ineffectiveness were discussed. The methods of assignments, projects and participation in external events have to be looked at as to how they can be made effective. Assignments can be emphasized to include proof-of-concepts and prototyping activities which will allow both thinking and executing skills to be learnt. Projects usually are executed but thinking skills are not really focused upon. Efforts should be made to ensure students come up with new ideas before they take it for execution. Further all projects should also be subject to market orientation and assessment thereby imparting and developing associating skills. This can be a great asset when these students enter the professional world. In external events the selection of topics and events to participate is the first step to be done better. Demonstrating to a diverse group of experts and peers in unfamiliar environment will test the robustness of the understanding, idea and design and also can lead to new ideas.

With the awareness of various UG and PG opportunities for learning innovation skills, which of those are not yielding the right results, the observed reasons for the ineffectiveness, several recommendations are made to improve them. This should, enable the innovation skill building in a more effective way, even in the current system of UG and PG. The awareness of this and role played by industry, faculty and the students to improve this skill development is critical in making all the opportunities being effective.

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B. Recommendations for improvement

Based on the opportunities available, the innovation skills to be developed, and the observed ineffectiveness and reasons for the same, the recommendations are as follows.

Students need to focus on assignments, projects and external event participation to work on their innovation skills. The focus during assignments should involve understanding the real issues, identifying the latest trends in technology, shifting customers, behaviors and demands and also about markets. Based on these, localizing and framing a valuable problem and solutions can be done effectively. Further to brainstorm and come up with ideas based on all options available, implicitly and explicitly, is important. This in-depth study to identify the real issue and develop and select an idea for a potential solution will sharpen the thinking skills. Further developing a rapid and iterative proto-typing ability will ensure the development of execution skills. Regarding projects, a well done research to select the project idea is critical. This should also make sense as an end product or service when the project is completed. This means that a project should be attractive to an industrialist or entrepreneur to develop a business out of it. So the project should be assessed and developed in this context. This will ensure both thinking and association skills are developed.

Faculty, need to question the assumptions of students when they come up with the ideas for assignments or projects. The students should be encouraged to spend time thinking and planning their work rather than focus on execution only. Faculty should guide the students thinking in all the three planes by asking relevant questions for each stage. Faculty can also help students by connecting them to the industry for broadening their horizon and developing their innovation skills. Importantly the faculty should motivate the students to put in the effort needed and reward them accordingly. Faculty and administrators can also help the students by encouraging them technically and supporting them financially to participate in external events. Encouraging memberships in various national and international forums will also enable the development of execution and association skills. This will not only allow students to develop their own network, but also provide recognition of and feedback on their work which can further inspire and motivate them. The faculty, in general can inspire and help the students to be confident, which is a critical ingredient for effective innovators and contributors.