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Innovation in research and engineering education: key factors for global competitiveness
Innovación en investigación y educación en ingeniería: factores claves para la competitividad global

# INNOVATION IN INDIAN ENGINEERING EDUCATIONAL SYSTEM: STUDY AND ANALYSIS

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## Abstract

In its most basic form, engineering is defined as "The branch of science and technology concerned with the design, building, and use of engines, machines, and structures." This highlights a very important fact that, creativity and innovation are an inherent part of engineering. Through the ages, be it the 20th century, where engineering was dominated by physical capital and goods, things like electrification, automobile, advent of space flights, petrochemicals etc took place or now the 21st century, where intellectual properties and universal consolidation dominates and things like energy conversation, global communication, virtualization, AI etc are taking place, the symbiotic relation between innovation and engineering is always very eminent.
The changes have to come from the grass root level. Engineering education and innovation have to supplement each other. The gap between the industry and the education given at colleges is to decrease. The commitment of the engineering community must be towards a more creative based curriculum, instead of the theory based class room study. In the context of India, a country with a billion possibilities and engineering potential, concepts like smart classrooms and integration of engineering curriculum with sustainability and innovation are still in a very nascent stage and need to be implemented on a more mass scale.

There are strengths as well as weaknesses of the Indian technical education system. The rate, at which present India is producing a technical manpower of about 0.5-0.6 million per year, is still ranking low in knowledge economy index. Innovation is not a strong point of India's technical education system. That needs Rectification. The challenges that India is currently facing in overcoming this issue are much diversified. Funding for research and development is lesser compared to the value that the European and American Universities are investing in. The conventional methodology that is been present in the Indian universities is hard to break with the prevailing perspective.

This paper addresses this issue and analyzes the best practices that has been executed and followed in the recent developing India. The analysis is carried through a detailed case study of two Universities that have brought innovation into its educational system. The need of the hour, as it will be shown through a poll to be conducted in context with the addressed theme, will entertain us with the fact that both the student community and the faculty community is ready to brace this transformation into the innovative and creative engineering education.

**Keywords**: innovation; creativity; engineering education

### *Resumen*

*En su forma más básica, la ingeniería se define como "la rama de la ciencia y la tecnología preocupada por el diseño, la construcción y el uso de los motores, máquinas y estructuras." Esto refleja el hecho muy importante de que, la creatividad y la innovación son una parte inherente de la ingeniería. A través de los tiempos, ya sea en el siglo 20, donde la ingeniería fue dominada por el capital y los bienes físicos, y cosas tales como la electricidad, el automóvil, el advenimiento de los vuelos espaciales, la petroquímica, etc., se llevaron a cabo. Ahora en el siglo 21, donde la propiedad intelectual y la consolidación universal dominan, y cosas como la conversión de la energía, la comunicación global, la virtualización, AI, etc., se están llevando a cabo, la relación simbiótica entre la innovación y la ingeniería es siempre muy eminente.*

*Los cambios deben que venir desde el nivel de básico. La enseñanza de la ingeniería y la innovación tienen que complementarse entre sí. La brecha entre la industria y la educación impartida en los colegios está disminuyendo. El compromiso de la comunidad de la ingeniería debe ser el de desarrollar un plan de estudios basado en más creatividad, en lugar de la sala de estudio de clase basada en la teoría. En el contexto de la India, un país con un millón de posibilidades y el potencial de la ingeniería, conceptos como aulas inteligentes y la integración del plan de estudios de ingeniería con la sostenibilidad y la innovación se encuentran todavía en una fase muy incipiente y deben aplicarse en una escala más masiva.*

*Hay fortalezas y debilidades del sistema de educación técnica en la India. La velocidad a la cual actualmente la India está produciendo personal técnico es de alrededor de 0,5 hasta 0,6 millones, que sigue siendo baja clasificación en el índice de economía del conocimiento. La innovación no es una cuestión fuerte del sistema de educación técnica de la India. Eso necesita un replanteamiento. Los retos a los que la India se enfrenta actualmente para superar este problema son muy diversos. La financiación para la investigación y el desarrollo es mucho menor en comparación con el dinero que las universidades europeas y americanas están invirtiendo en investigación. La metodología convencional que ha estado presente en las universidades de la India es difícil de romper con la perspectiva predominante.*

*En este trabajo se aborda este tema y analiza las mejores prácticas que han sido ejecutadas y seguidas en el reciente desarrollo de la India. El análisis se realiza a través de un estudio detallado de las dos universidades que han llevado a la innovación en su sistema educativo. La necesidad de ahora, como se muestra a través de una encuesta que se llevó a cabo en contexto con el tema abordado, nos entretendrá con el hecho de que juntos, tanto la comunidad estudiantil y la comunidad docente, estamos listos para prepararos hacia la transformación de una innovadora y creativa enseñanza de la ingeniería.*

***Palabras clave**: innovación; creatividad; educación en ingeniería*

## 1. Introduction

There has been much discussion in recent years on the need for creative engineers in industry and the associated need for engineering schools to foster creative thinking ability in their students. The first problem one encounters when thinking about how these needs might be addressed is that while creativity has been extensively studied, it has never been satisfactorily defined. There is general agreement however, that creativity involves the ability to put things (words, concepts, methods, devices) together in novel ways. Moreover, at least some types of creative ability are thought to involve skill at divergent production—generation of many possible solutions to a given problem—as opposed to convergent production, or generation of "the right answer." Academic excellence is synonymous with skill at convergent production, since engineering education normally involves only problems with single correct answers. On the other hand, both convergent and divergent productions are required to solve serious technological problems. The purely convergent thinker is not likely to come up with the innovative solution required when conventional approaches fail, while the purely divergent thinker will generate a great many innovative ideas but may lack both the analytical ability to carry them through to their final form and the evaluative ability to discriminate between good and bad solutions. If engineering educators cannot find enough individuals who can combine these abilities, at the very least there should be someone turning out, who can excel at one and some who can excel at the other. To do this, we must provide instruction and practice in both modes of thinking.

## 2. Engineering Education in India

In the present day, India is the second largest populated country in this world. Its economy has been growing at a very steady rate. The Indian industry has become globally competitive in several sectors and can increase its global market share. With the increase in the population, the demand for commodities has increased drastically. In order to improve the quality of living, innovation and research has to be fostered in the country to meet the rising demands of the growing population, thus projecting the importance of technical education in the country.

The evolution of Engineering Education (EE) in India has been drastic from the British era to the present day. EE in India started during the British era and focused mainly on civil engineering. In 1945 a Government Committee was appointed to suggest options for advanced technical education in India which recommended the establishment of higher technical institutes based on the Massachusetts Institute of Technology in the four regions of India which resulted in setting up five Indian Institutes of Technology (IIT) in Kharagpur (1951), Bombay (1956), Madras (1959), Kanpur (1960) and Delhi (1961) and the 20 Regional Engineering colleges just after independence was one of the first milestone achieved by Independent India. After a gap of over three decades, the sixth IIT was established at Guwahati (1995) and the Engineering College at Roorkee was first made a University and then as the seventh IIT (2001) (Subbarao, 10 JANUARY 2013). Four more IIT's were established in each 2008 and 2009 at different parts of the country. Then, there are a large number of State Government Engineering Colleges, often affiliated to a University and having a limited or no autonomy about curriculum, examinations, degree granting, etc.

The great demand for engineering and technical education has led to the mushrooming of a large number of private engineering colleges, many started by politicians or as money-making ventures. Since the establishment of IIT Kharaghpur in 1951, India has a total of 3,393 engineering colleges as on May, 2012. The table below shows the exponential rise in the number of engineering colleges in India.

| Year | 1977-78 | 2008-09 | 2012-13 |
|---|---|---|---|
| Number of Colleges | 562 | 2,388 | 3393 |
| Total Intake | 134,894 | 820,000 | 148,6000 |

Table 3.1(Subbarao, 10 JANUARY 2013)

Proportionally, the rise in number of engineering colleges increased the number of engineering students getting graduated every year. Whereas the quality of students graduating every year is being deeply criticized as the quantity is not matched with the quality. Experts say that India produces millions of graduates every year but a very few in the count are actually employable in industries.

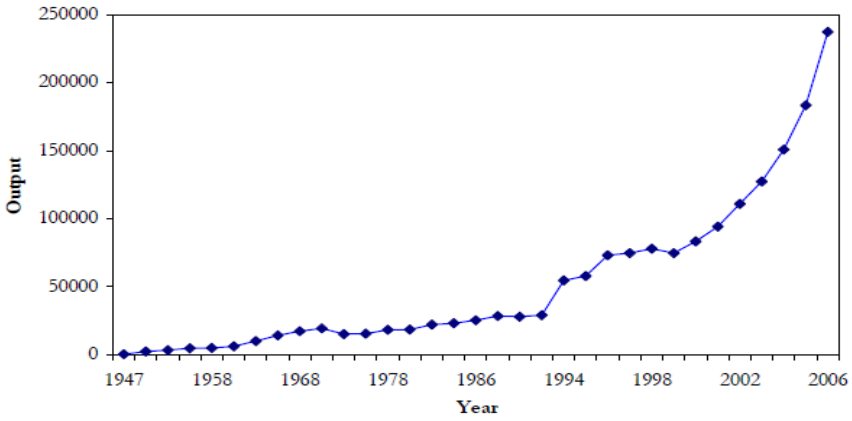


Figure.3.1 Number of Engineering graduates produced every year (Rangan Banerjee, December 16, 2008)

This being the scenario for under graduation (UG), the percentage of postgraduates is dismally small in India. The postgraduate engineering education forms the core for training of future teachers and researchers and for building up international reputation through publications, patents and entrepreneurs. These professional leaders are capable of transforming the industry. The number of professionals with doctorate degree and capable of directing research is not growing at a sufficient rate to meet the requirements of academia and R&D institutions in India.

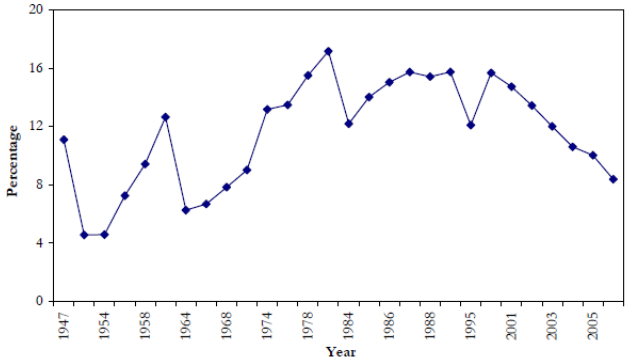


Figure.3.2 Percentage of Masters Output to Graduate engineers Output.(Rangan Banerjee, December 16, 2008)

The figure 3.2 shows a good increase in the masters graduates between 1978 and 1988 after which it has continued to fall. The reason for such variation has been analyzed and understood. From the late 70's till the 80's end, the IIT's started to become famous and Engineering was more than just an education to many in the country. It provided the reputation and opportunities that Arts and Science colleges were unable to provide. Many of the graduates during that period were interested with research and teaching opportunities as the amount of colleges started to increase and a booming professional opportunity was open with Masters becoming a need rather than interest. But from the 90's with the boom in IT industry, engineering education in India became a mere qualification. The Engineering degree was addressed as an entry ticket to the IT industry. This analysis holds good for the PhD scenario as well as shown in Figure 3.3.

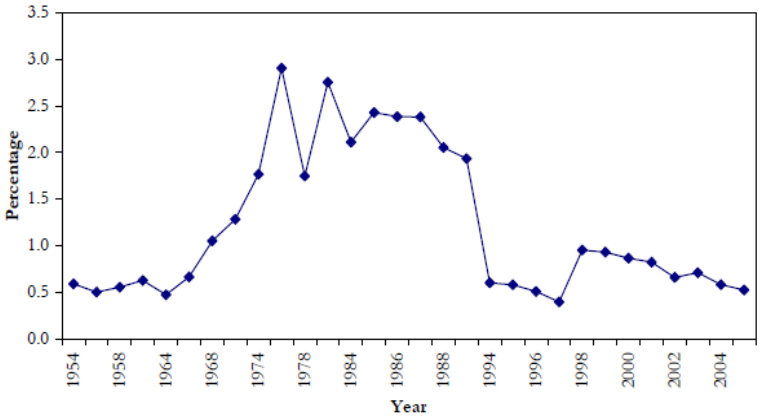


Figure.3.3 Percentage of PhD's Output to Graduate engineers Output. (Rangan Banerjee, December 16, 2008)

It can be seen from the above figures that only a maximum of 17% of all the graduates are opting for higher education and the number is constantly decreasing every year. The ratio for PHD's is even more minimal with the number reducing to 0.5% in 2006. This low percentage has been showing a drastic effect on the innovation and research in the country. The number of publications and patents is very less compared to countries like U.S.A and China.

### 3. Engineering education in China and comparison with India

Engineering is the single largest discipline in the Chinese education system. There were 2222 institutions that had undergraduate engineering programs in 2011, which accounted for 92.2% of the total 2409 higher education institutions (Gaofeng, June 27, 2013). One of the changes in their education system has been the development of vocational education. In the year 2010, 3.105 million were enrolled in the higher vocational institutes, accounting for 47% of all newly enrolled, among which the engineering students accounted for 1.297 million. In order to increase the number of students opting for higher education, the degree of professional master based on application and practice has been approved and seen rapid development. In 2010, the enrollment number for professional degree was 245,000, accounting for 41% and of them, 115,000 were applying for engineering masters (Gaofeng).

For improving the quality of education, some new majors were launched. Some of them included environmental science engineering, information sciences, new materials, new energy and energy conservation, aeronautics and astronautics as well as oceanographic engineering. Another interesting aspect is the inclusion of social and human science, like economics, law and ethics thus diversifying the course even further (Gaofeng). Following these reforms, the number of students opting for higher education and doctorates has improved in the past few years. In comparison to India, the number of publications and patents has also been very high for China. China has produced 12 times as many engineering PhDs as India in 2008 (Subbarao, 10 JANUARY 2013). This number has certainly reflected in the number of world publications out of which India's share in science and technology is 2.5% compared to 9.4% for China. In case of China, the number of patents issued to universities has increased from about 10 in 2001 to 260 in 2010, whereas the numbers are 5 and 10 in the case of India in the same decade indicating the increase in innovation in China (Subbarao, 10 JANUARY 2013).

| Country | Publications | | Patents | |
|---|---|---|---|---|
| | 1999 | 2009 | 1999 | 2009 |

| | | | | |
|---|---|---|---|---|
| India | 10,190 | 19,915 | 2160 | 18,232 |
| China | 15,715 | 74,109 | 7637 | 93706 |

Table.3.1 Publications and Patents from India and China (Subbarao, 10 JANUARY 2013)

These figures have made a significant impact in the world ranking of institutions. China has three in the top 200, 13 in the top 300, 21 in the top 400 and 35 in the top 500 institutions in the world. These results show the increase in innovation and research in China in the recent years (Subbarao, 10 JANUARY 2013).

## 4. Case Study and Analysis

### 4.1.1 University of Petroleum & Energy Studies (UPES)

An analysis was made to understand the need for innovation and creativity in EE through an online survey conducted in four selected universities in India. The profile base of the universities was selected such that two of the universities follow the conventional methodology and two inculcated innovation and creativity in their system. A comparative study was made and it can be clearly seen that the colleges which has imparted innovation and creativity helps the cause of innovation in engineering education by providing out of the box industry specific curriculum and industry interactions, which is still not a trend in the Indian system. The survey includes a result from 50 students who were questioned.

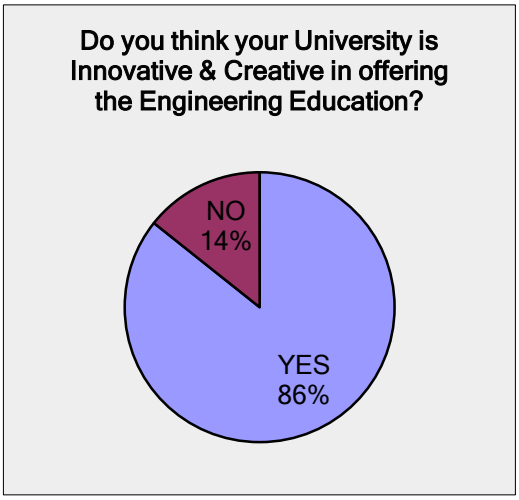


Fig.4.1.1

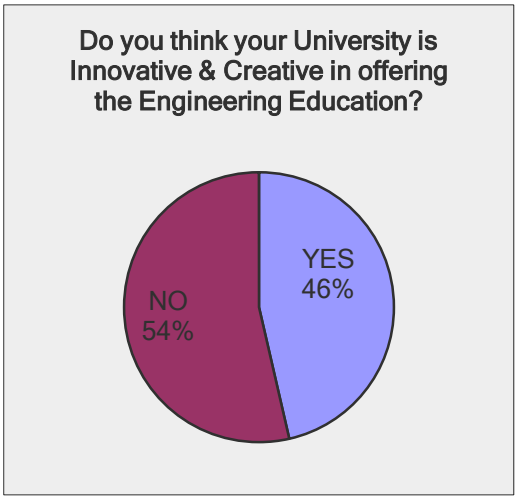


Fig.4.1.2

The graph below clearly shows the fact that as compared to other institutions; UPES provides an edge in terms of innovation in EE. From having an innovative curriculum to giving students the much needed industry exposure, UPES is contributing in the integration of innovation with the traditional education.

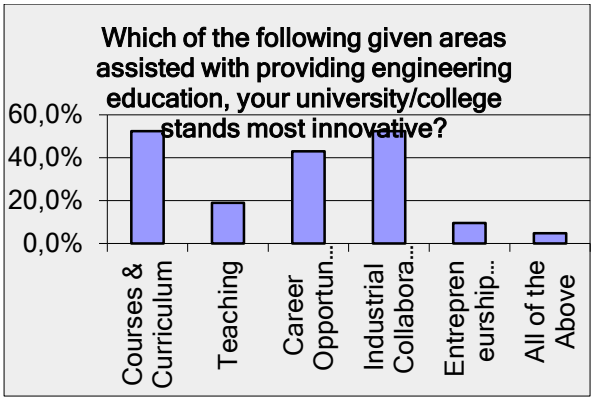


Fig.4.1.3

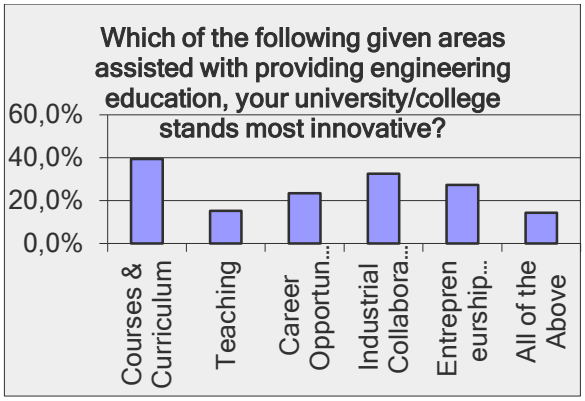


Fig.4.1.4

As a result of providing students with industry tailored courses, the college is also addressing the students with a better post education life which includes opting for higher education.

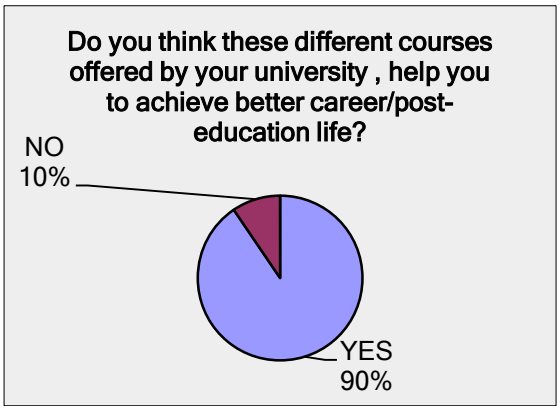


Fig.4.1.5

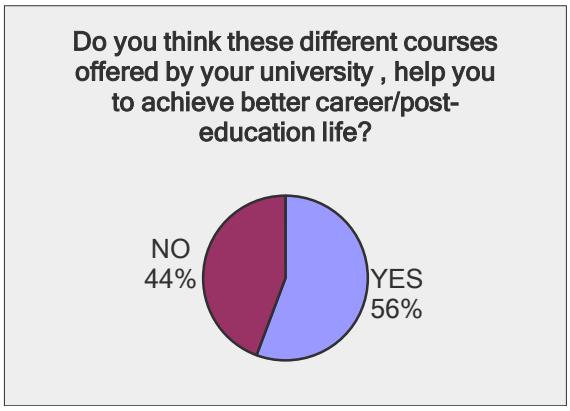


Fig.4.1.6

A very critical aspect of providing good engineering education is the balance between theoretical and application of theory. The Indian system has always been more into theoretical based education, but from the pie chart above it can be seen that UPES is trying to provide both and it helps in balancing the curriculum. Though still not completely enforced, a start has been made which in the future can be a benchmark for EE in India.

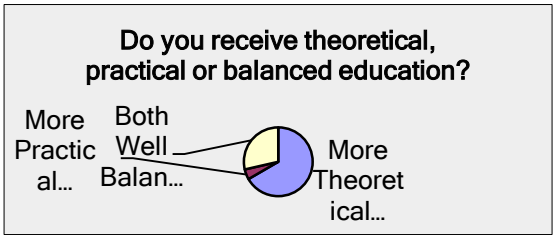


Fig.4.1.7

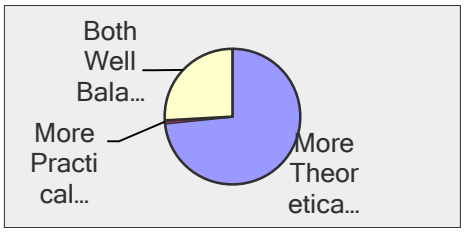


Fig.4.1.8

### 4.1.2 Manipal Institute of Technology:

One of the colleges under our case studies is Manipal Institute of Technology (MIT), a constituent college under the Manipal University. Being one of the pioneer colleges in India, MIT constitutes an Innovation Center to foster Innovation and Incubation. The aim of the Centre is to nurture the Innovation, Incubation and Entrepreneurial skills of the students, faculty and people of the region, facilitate inter-disciplinary Research and Innovation, provide basic funding in the form of Seed Money, and provide resources for start-ups from students, faculty and the university.

One of the successful initiatives of the Innovation Center is Manipal University Technology Business Incubator (MUTBI). It is a new initiative of Manipal University for nurturing and developing Innovation and entrepreneurial skills among its faculty and students. It is one of the 54 TBIs funded by National Science and Technology Entrepreneurship Development Board (NSTEDB), Department of Science and Technology (DST), Government of India to promote Innovation - driven Start-ups in Udupi District, established in March 2010. An incubation program was initiated to start the technology and knowledge based startups by the students and faculty. The applicants must have business proposals for technology based products and solutions. A couple of students have started their own ventures by utilizing this program.

A third year student Gaurav Prakash has received funding and office space for his proposal; he has started three companies in his office. 1. Solutions For Startups: A full service IT Solution Company that caters to startups and SMEs. 2. The Social Media Company: This caters to social media requirements of funded startups and SMEs. 3. The Great White Design Studio: This is a digital agency that is into high end graphic content development. Apart from this, a total of 10 incubates have been developed by faculty and people around the region. Such successful methods has contributed to the innovation and research in engineering education in the country and have motivated young entrepreneurs to start their own ventures.

The survey result taken at Manipal Institute of Technology strongly showcases that the institution is creating more opportunities and support for Entrepreneurship development, which has been a major field under innovation and creativity inculcated in the universities. Engineering education in India, in most cases, is devoid of any courses related to entrepreneurship. This must change, and change rapidly. This change must be reflected in the curricula, but more importantly, in the attitude at the academic institutions. Manipal Institute of Technology has taken an initiative in addressing this need and has successfully shown that integration of Innovation in EE will provide excellent results.

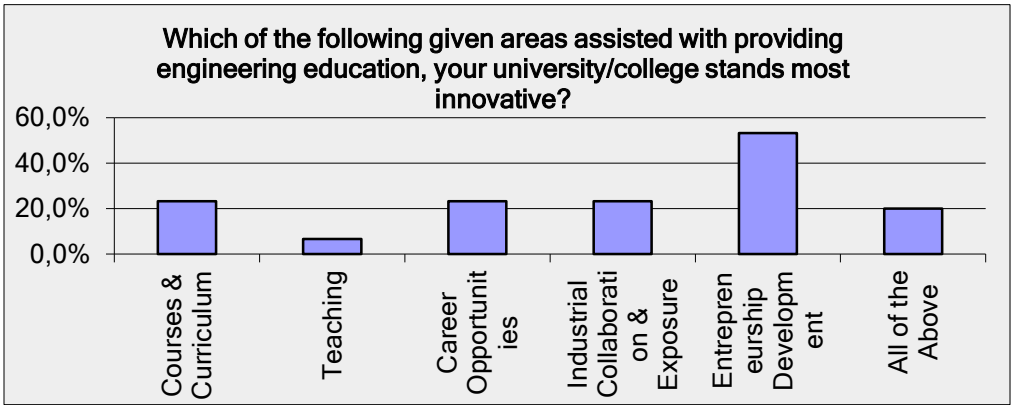


Fig.4.2.1

## Conclusion

To conclude, the real mantle of a developing country like India lies truly in its ability to impart quality EE to its young generation. Millions of vibrant possibilities can be realized only when the workforce is prepared to tackle the engineering challenges coupled with innovation. The large human capital needs careful mentoring for higher education. As seen from the survey results, the two universities which have successfully implemented innovation in their system are generating globally competent engineers and as well becoming the choice of today's youth. This proves that the integration of innovation, sustainability in EE is the need of the hour and we as a country are ready for transition. Innovation should reflect not only in the EE, but overall in the organization, practices and the way we think. We must realize our potential as an innovative nation, leading the world in various spheres of research and development.

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