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Engineering Education, Lack of Innovation and Unemployability of Engineers in India

A Research Reference Article

By
Abhishikth Savarapu

In India, there has been a dearth of employable engineers from 2011 and an outdated educational system in most engineering schools (Tier 2 and 3 level) which mostly follow a theoretical and a conceptual (memorization) teaching methods rather than a balance between pure understanding by interconnecting concepts and practical application of real-life scenarios. In 2014, McKinsey, a renowned global strategy and management consulting firm had mentioned in a report titled "India's Tech Opportunity: Transforming Work, Empowering People" that "The country's IT services industry still needs to invest in training for many graduates of Indian engineering and computer sciences colleges to make them job-ready, an indication of some of the challenges facing higher education in India." Similarly, in 2016, another report by McKinsey titled "India's ascent: Five Opportunities for Growth and Transformation" also stated that "The overall impact on net job creation could be neutral to positive as technology opens new geographical markets and new segments of consumers. But potential jobs will be created only if employees are equipped to shift to higher-value-added work. The country's educational systems must be up to meeting this challenge." While the statement from the 2016 report does not explicitly relate to engineers, the statement does refer to the education quality and how it affects the employability of workers. Aspiring Minds, headed by a Varun Aggarwal, a 2007 MIT graduate in Electrical Engineering and Computer Science, has released 5 National Employability Reports each in 2010, 2012, 2014, 2016 and 2019. In 2019, Aspiring Minds had published a report titled the "National Employability Report Engineers Annual Report 2019" states that "only 40% of engineering students in India perform internships and only 36% undertake projects outside their assigned coursework. As a consequence, the engineering discipline in India is very theoretical. Internships are win-win for industry and academia." In this article, I intend to collect and present information from reputable sources which discuss and explain in depth about Indian engineering from a perspective of 3 characteristics: Educational, Innovative, and Employability. In this article, I do not exhibit any of my personal opinions and biased judgement nor do I have the intent to mislead the reader. I solely intend to present a compilation of information to support the claim that Indian engineering has improved significantly over the years while having more room to improve and produce reliable engineers. I hope that this article is of strong help to you.

Education, Employability and Innovation

The educational characteristic of Indian engineering explains the background of engineering education which is important for Indian engineers to develop practical and theoretical skills for real life application. The "National Employability Report Engineers Annual Report 2019" conducted by Aspiring Minds states "It is safe to conclude that the Indian higher education system has not been helped by the small ad-hoc changes to which it is accustomed, and is rather in need of fundamental change." [2] An article by the Business Line also states that "Engineering principles learned in college are rarely applied in the world of software or product development. Freshly minted graduates are not really career-ready to take on the task of developing and maintaining the world's computer systems, or build the next-generation killer engineering product." [3] Growing practical, social and conceptual skills and balancing practical and theoretical learning are necessary since engineering is an applied field. Education is the foundation where students choose their career and pursue their profession; however, ineffective teaching methodologies in Indian schools is only 1 major of many influences. The Hindustan Times states that "Their aspirations [students] mirror that of India's youth at large: the latest CSDS-KAS Youth Study, released in April 2017, found that 65% of Indian youth would prefer a government job; just 7% wished for a job in the private sector. The lure of a government job is obvious: job security, allowances and better pay at the entry level." [4]. Social and peer pressure on developing engineers mentally distorts their ability to rationalize and judge. The gap of discontent, in proportion, expands and clouds the mind to when students cannot perform capably. Also, the lack of determination many students have for their career in engineering is another factor mentioned in the Aspiring Minds report that 60.7% of the engineering students haven't taken any 2-month long internship while 82.6% haven't done any technical projects. [2]. Focusing on emergence, India Today states that "Technological advancements and developments that are taking place around the world have led to the increase in demand for new specialist roles like automobile designers, mixologists, laboratory technicians, artificial intelligence, machine learning and block chain specialists. Despite the

emerging scope of jobs in India, the **theoretical orientation of our education system** is the main reason why the youth is unskilled in handling the industrial upgradation." [5]

The employability characteristic of Indian engineering explores unemployability of engineers in India considering the factors of this epidemic. Multiple articles were written on this between March to July of 2019. The Business Today quotes that "The new

Annual Employability Survey 2019 report by Aspiring Minds reveals that 80% of Indian engineers are not fit for any job in the knowledge economy and only 2.5% of them possess tech skills in Artificial Intelligence (AI) that industry requires." [6]. Another report was made by the McKinsey Global Institute, a renowned management consultant firm founded in 1926. [7] The report titled "India's technology opportunity: Transforming work, empowering people", published in December 2014, stated that "The country's IT services industry still needs to invest in training for many graduates of Indian engineering and computer sciences colleges to make them job-ready, an indication of some of the challenges facing higher education in India." [8] With the Aspiring Minds report [2] more relevant in 2019, many news articles such as the Deccan Herald [9], Hindustan Times [10], Your Story [11], Business Today [6], The Economic Times [1], and The Hindu [12] gathered information or mentioned the Aspiring Minds report and the unemployability of engineers. The education quality received affect employability by mentioning that engineers must be trained properly to become "job-ready".

The Innovative characteristic discusses the growth of Indian engineering and the advancement of societies and the progression of technology in infrastructure and problem solving. This section judges the crucial nature it has to the growth of the country's economy and reputation in engineering. When the methods of manufacturing, developing and learning are improved, the quantity of innovative ideas are more advanced. The Moore's Law in 1965 gives an exponential prediction that the effectiveness of a computer will increase every 2 year. [13] It is indeed similar to the growth of innovation and service improving a progressive world. Specifically, the innovation tfrom engineers and institutions will develop a more sustainable country; however, the growth would be focused on an infrastructural improvement which is more needed in India and a "key driver for the Indian economy."
[14] Recently, the Global Innovation Index of 2019 has ranked India at the 52nd place out of 129 countries with a score of 36.58 out of 100 being categorized based on globally impacting innovation. [15] On a positive note, the Business Line, states that
"Speaking at an event here, Dara Khosrowshahi, the CEO of Uber mentioned, 'What my prediction is that India is going to be a significant source for innovation and innovation that is unique in developing markets. One example of that is the Uber Light that we provide and has been developed here in India.'" [16] Another article written by The Better India gives 10 examples of innovative solutions proposed by students from IIT (Indian Institute of Technology), a prestigious university for engineering in India. One such solution was the Water-For-Plastic Machine which encouraged people to give plastic waste in exchange for water. [17] The World Economic Forum quoted "There is a burgeoning start-up and innovation culture, as shown by the Global Innovation Index, where India has improved its ranking from 81 to 52 between 2015 and 2019. In addition, the country has improved its reputation in terms of the risk posed to foreign investments and, in 2019, ranked third in the world in terms of attracting investment for technology transactions." [18] It also states that by improving "government regulations to encourage support for technological innovation" and by training "tech talent", making it stay in the country, and by attracting "foreign and domestic investment in technology", India will have an "unmatched potential" to be the "world's next Silicon Valley". [18]

How does this research article impact the target audience?

The Times of India states that "The engineering curriculum in India is more focused on theoretical aspect than the practical knowledge. Due to which studying the subject becomes boring after a point and gets stagnant for the students."[19] The same article then gives an example of a study involving 150,000 engineering students who graduated in 2013, showing that only 3% (4,500) were employable in the software/product market while 7% (10,500) could handle engineering tasks. [19] The Hindustan Times also quotes "Ironically, Indian colleges grant nearly a million engineering degrees annually, flooding the job market with a huge supply of engineers, with skills that have very little demand." [20] With this in place, the possibilities of engineers to be admitted (due to a competitive arena of students) and having certified graduates with 21st CE skills are reduced. The efforts the students are investing in exchange for leaving with inadequate learnt survival tactics for the globalized world are also disrespected. The time in 4 years the students took to learn engineering and the faculty's time have no value if the graduates are incapabl e to adapt in the real world. It is also necessary for the students

to take responsibility of their own learning and to develop an independent mindset when the teaching is insufficient. Also, regardless of whether the college is not efficient, it is the students' responsibility to learn and develop their skills through participating more in the activities given by institutions. In this research reference article, parents, teachers, and faculty members associated with engineering students are the target audiences who would know about averting risks for the students in this time of inadequacy. Be conscious about the college/university chosen for the students to pertain, being aware of the type of education the students are receiving, involving the students in internships and extracurricular activities related to engineering, and making the students seek guidance/counselling for job applications are very practical ways for students to engage with the curriculum and the field of engineering.

Education

Currently, in India, the quality and the methodology of educating engineers has more room for improvement. With the current condition of education in India, especially, that of higher education, the selection of professional designations for the future is also affected. With many global professionals in the world, the drive for economic and social development also varies while the global development and perspective progresses as people further understand about the global trends that are taking place. In the case of India, "Ironically, Indian colleges grant nearly a million engineering degrees annually, flooding the job market with a huge supply of engineers, with skills that have very little demand." [20] While acknowledging that India produces a mass number of engineers with over 100 top engineering colleges, the number of unemployable engineers lacking in skill set is also unfortunately common. From a 2019 report conducted by Aspiring Minds, a research organization, "employers said 80 percent of Indian engineering graduates did not meet the minimum requirements of the companies looking to hire them. Many such firms say prospective candidates lack sufficient industry experience because their courses are too theoretical." [2]

Being unemployed is usually a signature that one doesn't have the capable standards to be registered in a profession; however, external factors such as the demand for employment in response to the level of demand an enterprise's products have is also a form of causality. To focus on the institutions that educate, the AICTE has chosen to regulate their activities while they have "decided to not permit new engineering colleges from the academic year 2020-21" with the rising need to adapt institutions to teach new concepts relating to the modern trends such as "artificial intelligence, blockchain, robotics, quantum computing, data sciences, cybersecurity and 3D printing and design." which not many engineering colleges in India are addressing currently. Not adapting to the global trends is very dangerous for any company and individual to prosper since there is a weak global perspective. Moreover, such an outlook affects the amount of valuable global opportunities available. The students learning in such institutions are not acquiring a global outlook of technological innovation and enhancements which affects applying for prosperous job applications. As students today have become more aware of the hazards of studying in most of the engineering colleges, there was a scarcity of seats. The same article quotes that "A report by Indian Express found that there were no takers for 51 per cent of the 15.5 lakh B.E/B.Tech seats in 3,291 engineering colleges in 2016-17. The investigation found glaring gaps in regulation, including alleged corruption; poor infrastructure, labs and faculty." With this, the engineers were not only insufficiently equipped, but due to this, engineers today are considered "unemployable". [22] The severity of education standard in Indian engineering schools is also outlined by a quote from a recent report published by the AICTE stating "to be able to cater to the next-generation of engineering skill requirements, we need to facilitate quality and accredited technical education at scale." By this, it is meant that engineering education given by colleges needs change by applying more relevant concepts to be taught. The report also mentions that "Traditional engineering disciplines such as Mechanical, Electrical, Civil and Electronics engineering capacity utilization around 40% as opposed to Computer Science and Engineering, Aerospace Engineering, Mechatronics being in the high 60%." Following this, the report states that "We recommend that no additional seats are approved in traditional engineering areas, but institutions need to be encouraged to convert current capacity in traditional disciplines to emerging new technologies." [23] By adapting institutions and colleges to global perspective through newer technologies, the local and global development of different countries and the world would progress while newer innovations and solutions would be proposed.

To discuss about the education quality in the perspective of engineering students, another article quotes "The recent Annual Survey of Education Report (ASER) 2018 brought to light that the student's learning capacity is poor and they cannot do basic math at their expected level." while the demand for automobile designers, technicians, artificial intelligence, and machine learni ng specialists is rising. The article also mentions that "Despite the emerging scope of

jobs in India, the theoretical orientation of our education system is the main reason why the youth is unskilled in handling the industrial upgradation." [5] Overall, one of the main and the persistent causes of the improper education quality received is the incompetence of ***most*** institutions to nurture relevant innovative thought-provoking mindset in engineering students. Another quote from an article states "Engineering principles learned in college are rarely applied in the world of software or product development. Freshly minted graduates are not really career-ready…" while another quote states (from the same article) that "Professors had few clues about the vision of their managements; most confessed to not having the rapidly-changing technology skills to impart them to students, so they resigned themselves to teaching books to an exam."

The article also criticizes the inefficiency of most management teams in the institutions claiming them to have "often have l ittle experience in the field of engineering education" and that they have "The motive to increase revenues and improve branding is paramount, and building impressive campus infrastructure to attract students." Also, the management "generally have little to show in terms of student or teaching outcomes." while the level of corruption in the management and the employers is exposed

through these statements: "The motive to increase revenues and improve branding is paramount, and building impressive campus infrastructure to attract students is a common approach. They use all the right words on stage and in conversation — sustainable development, eco-engineering, innovation and incubation cells — but generally have little to show in terms of student or teaching outcomes." and "Employers are flummoxed by this disoriented state of affairs and regard most engineering graduates as unemployable, unless re-trained in basic job and technical skills." [3] The corrupt and unjust practices taking place for material gains and popularity has been a frequent issue in India in many political and educational designations. Due to these inconveniences, the development of the country is hindered and stunned; however, many people are aware about the consequences of corruption. Even in the higher education of future engineering graduates.

Another article states that "Except IITs and other prestigious technology institutes, most engineering colleges are unable to provide education to engineering student that would get them suitable jobs." The education received by the institution is also proportional to the employability of engineers (since unskilled engineers are less likely to be employed by desperate companies and small to medium enterprises which are common). The article also mentions about the frequency of low-quality colleges in India and how these affect the students to be employed. As a result, these colleges have reduced enrollments resulting in closings. This is a vicious and a repetitive cycle which affects both the employability and the level of skills that the students must be equipped with working in real life and promoting solutions. This slows down the ability for the development of India in an economical and an infrastructural lens (since increasing the literacy rate of a country allows for effective management of the affairs of a country). In 2018, the scenario was very severe and damaging resulting in 80,000 less seats in engineering with 200 low-level to average colleges closing. Also, the article refers to a study comparing Russian and Chinese to Indian engineering students. The study concluding that the latter were better than Indian students in terms of High Order thinking Skills (HOTS); however, the Indian students were better in mathematics and critical thinking. The study was conducted by Stanford University and the World Bank. [24]

A recently published article states that "Indian engineers may figure among the most powerful CEOs in the world, but the country's BTech/BE degree has lost its sheen over the years." which implies that engineering institutions in India are facing a crisis associated with admissions (since many have outdated curriculums). Based on the following information, engineering education in India is heavily influenced by the curriculum adapted and most importantly, how it relates to the global world and how it would make learners globally aware and adapted. Considering this is important for the increased rate of development of innovation. "During the boom in the IT industry, engineering colleges mushroomed all across the country. But these institutes lacked an updated curriculum and focused on non-existent linkages with industry and had poor student-faculty ratio." With this as one of the main reasons behind the poor education received, these institutions were considered as burdensome for the students where the "uneven growth in engineering colleges over the last decade left seats vacant, which led to devalued degrees." Also, in 2019, the admissions in colleges were very weak while with "14.9 lakh seats, roughly 10 lakh were filled." The lack of applications signifies that students are becoming more aware of the issues of learning engineering. The globally irrelevant education and certificates received by the students negatively impacted their chances to apply for flourishing jobs. However, while noting multiple problems and issues tied with the education

standards in these institutions, it is difficult to avoid the fact that engineering, the 4th major stream in India is very popular with 40 lakhs (4 million) students enrolled (information from [25]). Responding to this, many institutions were not intending to improve their curriculum and learning pattern while loosening the admissions criteria to increase demand and enrollment. Unfortunately, an ineffective response of not conducting background checks on the ethicality institutions took place. From 2018-19, 26 colleges shut down while AICTE is proposes to close institutions and colleges that have less than 30% of admissions. The rapid and very strong popularity and attention for learning engineering had resulted in employers increasing their markets to only employ engineers limiting the opportunities for other professions such as medicine. The article states, "the industry bodies had never come up with credible figures of employment opportunities in different sectors." and "education entrepreneurs saw an opportunity in the education sector and made the best of it. This is a recipe for oversupply in some and under supply in other sectors." The article also refers to the teaching-learning process of these institutions as "predominantly theoretical."

The implementation of recent concepts in demand such as AI and Blockchain with more extracurricular activities (internships) is vital. The government has also recognized the issue of engineering education by introducing the "Technical Education Quality Improvement Programme (TEQIP)" for institutions while the AICTE is investing heavily in their efforts to regulate the institutional expansions and to improve the education methods taught by urging to implementing practical application through more lab activities related to modern emerging technologies. Hence, resulting in a higher frequency of an innovation culture and more globalized engineering students. [25]

To guide focus away from the institutions, students also had minimal interests to learn beyond what was taught according to the Aspiring Minds National Employability Report of Engineers 2019 (40% of students took internships while 36% took extra projects). Based on this, it is also important for students to choose a field of education based on personal interests and significance instead of the influence of peer and societal pressures. An article states that the competition for engineering in India is very intense to get into IITs and other medical and business schools. However, the pressure to get into the colleges are intense to the point where mental health is at a severe risk. Even though some students may not be interested in engineering, securing a position in a glorious institution is vital for most who have financial issues and for those whose families are dependent (such as the children of "manual laborers or business tycoons"). "To prepare, students from across India travel to the historic northern city of Kota, spending months or even years away from their family and home." which is an ambition by many. The competition in Kota is very fierce that "the threat of failure can prove psychologically overwhelming – and even fatal. In recent years, Kota has earned a more unfortunate reputation for a spate of suicides." In response to this, numerous steps have been taken to implement modified fans, prevention hotlines, apps, and biometric scanners (to register entries and exits). However, due to the competition, the students are developing a mentality to worry about their grades and marks rather than the actual learning taking place. Because of this, the resulting graduates are cornered in skill level (and are unable to practically implement the concepts taught). This is also accompanied with outdated curriculums in most institutions that don't focus on concepts that are relevant to the present globalization in innovation. Also, the acceptance rate of prestigious and academically relevant universities such as IIT's ha ve a passing of 10,000 applicants per 1 million students (which is determined by entrance examinations) and many of the universities, colleges and other institutions are not academically upgraded in conceptual teaching and that these education sources have chances of following corrupt practices to enroll students (since engineering has a high demand in India). [26] In fact, the desperation to be admitted into a private engineering institution is very common that "parents get hyperactive, spending heft y amounts or taking loans to send their children to private schools mushrooming all over the country." and that education is more of a billion-dollar market in India with attention from "corporate captains, real estate developers and foreign colleges". To support the arguments presented, another quote states that "there aren't too many alternative courses for children to follow. Educationists, social scientists and human resources managers feel that students need to seek alternative courses and not make run-of-the-mill choices, if they are to beat this pressure. More importantly, however, parental behavior needs to undergo a serious change." The article ([27]) also states that "Parents rarely put pressure on education boards to add newer, innovative or creative courses, nor do they wish their children run for such courses." which is another inhibitor for the rise in innovation and global perspective. Another scary fact about the aftermath of being graduated with inefficient education strategies and exposure is stated according to a poll in January 2017 Ishani Dutta, a director, showing that "people who had trained formally as engineers hadn't practiced engineering, but drifted to running restaurants, medicine stores, real estate brokerage and adventure sports. Some even became editors and some ran advertising agencies." [26] On a concluding

note about the student perspective on learning engineering, a change in individuality is needed at the highest for students to legitimately choose engineering as a field of study, In this way, more effective and passionate engineers would be produced as a response contributing to the global economy.

Having read all these research articles, interviewed heads of engineering departments, professors, students, and alumni of many engineering institutions, it is evident that there is clearly a gap between expectations of students and the reality of what can be provided to nurture these students. The reality is that India is still a growing economy with its limited resources, would only be able to fund several institutions with the much needed facilities to focus on dynamically changing and technological advancements, such that students can be most effective during their tenure in college to apply the learning to real life business problems. Also, it is understood that the quality and the relevance of the education from most of the universities in India is not up to the standards when connecting with modern engineering and technological trends. With a more theoretical than practical outlook (labs and hands on experiences) and an outdated and presently irrelevant curriculum, the lack of arranged and collaborative internships, the lack of experienced management and faculty, loosening criteria for student admission, and the lack of interest most students have to learn engineering (due to parental and societal pressure), the education given in the institutions are not up to date to help graduates succeed after college/university to innovate and work.

Employability

National Employability Report 2019's research on Indian Engineers Employability concludes that "Only 2.5% of Indian engineers possess the skills in artificial intelligence (i.e., machine learning and data science) that industry requires. Only 1.5% - 4.5% of
engineers possess the necessary skills in data engineering, while only 2.8% - 5.3% are qualified in wireless technologies. These figures pale compared to the percentage of engineers (5.5%) that are qualified for basic programming."

With approximately 1.5 million engineering graduates (in 2016) being set out to face the real world each year, a report published in 2019 by Aspiring Minds states that 80% of the engineers are unemployable for any job while only 3% of engineers are able to get into core jobs related to engineering. This record is disheartening considering the impact that Indian Engineers would have in the global scale. It is also unfortunate that there hasn't been a major change in the employability of engineers since 2010. The unemployability of engineers in India also accompanied specific challenges such as finding "the right company/profile to apply" as the most frequent job challenge (38.6% of challenges faced by graduates) along with "clearing interviews" as the second most (18.4%). Apart from challenges after graduation, the report also paints a picture of how most engineering students are relying on education given by colleges (63.3%) compared to outside, web and other forms of training (31.5%) while most of the learning obtained by the population of engineering students are usually from Tier 2-3 colleges (top private-average institutions and government colleges and not central colleges such as IITs) which have a high number in India. While knowing that many engineers in India are being educated by institutions, why is it that 80% of the engineers are being unemployed? I also believe that the real question here is whether these engineering students are gaining the much-needed skills required to perform in the real world. The practical methods of education along with introducing students to have the right exposure to business challenges will extremely help every individual to face a glimpse what they would face in any realistic business environment. [2]

"The country's IT services industry still needs to invest in training for many graduates of Indian engineering and computer sciences colleges to make them job-ready, an indication of some of the challenges facing higher education in India." - MGI India's technology opportunity: Transforming work, empowering people (December 2014) [8]

The employability of engineers in India has been a pressing issue for a long period of time; however, the scenario still stagnates today. Also, the severity of finding jobs has been renowned to an extent where in 2014, McKinsey, a well-known and reliable global consulting company, has quoted about this issue. Other reports such as that from MIT's 'The global state of the art in engineering education' (March 2018) presents an educational perspective quoting "The impact of these restrictions [government higher education regulations and national accreditation requirements] on the structure, content and delivery of undergraduate programs was particularly noted in countries such as China, India, Brazil and Canada; in consequence, they 'leave little room for experimentation and new ideas." The latest reports, from Aspiring Minds, an analytical firm

in India and that from the AICTE present their views in 2019. [8]

"India Skills Report/ 2019", a report by the All India Council for Technical Education (AICTE) mentions that the employability of engineers has improved gradually from 33.95% in 2014 to 47.38% in 2019 based on a study of 350,000 candidates in 29 states and 7 union territories. The report also shows that the B. Tech domain has the highest employable talent of 2019 of 57.09% while the Polytechnic domain has the lowest employable talent of 18.05%. Also, the top demanded job sectors in 2019 are software/hardware designations, manufacturing and BFSI (Banking, Financial Services, and Insurance). The report also gives an account of the graduates that were most likely to be hired based on their field of engineering. Graduates that took BCA, BBA, B. Com, and other disciplines were 22% more likely to be hired while those taking part in BE and B.Tech. were 23% more likely to be employed with high hiring activity in Karnataka, Delhi, and Maharashtra. Andhra Pradesh, Delhi, and Uttar Pradesh had the
most employable talent of graduates in 2019. [28] The employability of engineers, while lacking significantly in India, is an inhibitor for the progression of economic and infrastructural development of the country. Also, this is a cause for the inefficiency of proposing a mass number of innovative ideas and proposals although, today, efforts are being taken to propose many creative solutions to problems in India and awareness is being spread quicker. The poor employability o engineers is a result of poor quality of education received by future engineers. However, jobs in BPOs such as call centers and customer services are becoming automated with the rise of AI and the current schools are not equipped with the modern conceptuality needed to guide engineers in the present world of emerging technologies. Also, due to the lack of proper practical guidance related to current trends in AI and machine learning, employability for Indian engineers is difficult to attain globally. At a national level, many engineers are inefficient in their job having difficulty to implement the concepts taught in school (since many schools reward and focus on root learning and grades rather than applying the actual learning in real life scenarios). It is also very unfortunate that engineering graduates are not being able to find relevant jobs. An article quotes "In spite of completing their education and training from leading colleges and institutions, engineering students are unable to find the right tech job. Often, it has been seen that even though these students have scored good grades through the duration of their course, they face constant rejections during interviews, which leaves them frustrated and low on confidence. This, in turn, leads many of them to switch careers and settle for a non-tech job instead." The same article also mentions about the lack of practical knowledge in the professional world leading to a major gap in skill. [21]

To restate, the employability of engineers is directly proportional to the education received. Aspiring Minds severely states that "Good coding skills (the ability to write functionally correct code) are possessed by 4.6% of Indian job applicants, 2.1% of Chinese candidates and 18.8% of the US candidates in the IT and software industries. However, if we consider only those candidates who can write correct code with few errors, the gap between China and India narrows (8.6% vs. 9.8%, respectively). Interestingly, while the percentage of Indian engineers who code well is greater than the number of Chinese engineers, a much higher proportion of Indian engineers (37.7%) cannot write a compliable code compared to Chinese engineers (10.35%). This means that India must do more to educate its general population in proper coding skills. By comparison, the US engineers perform four times better than Indian engineers in coding: only 4% of the US candidates cannot write compliable code even though the base of the engineering population in the US is approximately four times smaller than in India." While mass customer services are being automated by AI, the skill sets of engineers in India must be relevant to modern emerging technologies (which customers are accustomed to) for today's graduates to be employable. Similarly, students' skills in other fields such as mechanical, electronics, electrical, civil etc. Must be nourished in a way to create realistic expectations in the engineering students' minds. This will highly help in growing the economic situation not only across India but across the world. Both students and colleges have responsibilities to increase the employability of engineering graduates. Specifically, students must be extracurricular active to learn beyond their coursework (by internships, seminars, webinars, attending lectures and meets sponsored by other companies/institutions/experts, and online learning) while the institutions, colleges, and universities must balance theoretical and practical education arrangements. Since engineering is an applied discipline, institutions must not reward memorization and rote learning. Rather, cognitive thinking and analytical skills with conceptual understanding should be promoted. Additionally, higher education must not be a business market to profit off numerous engineers and produce graduates that are not accompanied to the professional world. Also, the institutions must provide genuine educational experiences for the students without corrupt practices to gain materialistic gains such as money and fame. Due to this, many engineers are not being educated effectively and provided with useful

skills. Jobs are also becoming more difficult to attain for unskilled engineering since most of the enterprises in India are small to medium in size which demand high skill sets from employees. Also, these enterprises do not have enough resources to educate and train employees unlike larger counterparts. While this is not controllable in the hands of graduates, the most reliable option for engineers would be educated about modern technologies such as AI, Machine Learning, Blockchain, and Data Science. On a concluding note, the employability of graduates would improve if relevant education is received and if students chose higher learning based on personal interests and passion instead of parental pressure.

A research focused article published recently by Hans India gives a very disturbing account into the gradual legacy of young engineering graduates that "Chennai (a major metropolitan city in India) witnessed an unusual event [in the year of 2019] when around 4600 of youth sent their application for 14 posts like sweepers and sanitary workers. The applicants had professional qualification like B.Tech, M.Tech, Master of Business Administration. These are evident indications which show how drastically the country is suffering from job crisis." It is very difficult to acknowledge the legacy of these engineers in such scenarios. Another frightening piece of data (from the Aspiring Minds report) states that the "past nine years made no changes on aggregate level and Indian education system needs systemic long term changes in higher education." the article also concludes that "the majority of cases the skills or training acquired by the youths do not match or suit the core demand of the job. So at first the government must step up for reformation, innovation and renovation of the standard of education in universities and colleges." [29]

"Therefore, the country needs to ensure that its engineers are trained in cutting-edge digital and data skills including AI, Internet-of-Things, data engineering, robotics and mobile technologies. How and what the students are taught are largely also dependent on 'who' they are being taught by. Hence, as per the findings of the report, the initial focus must be on building capacity f or faculty that are already familiar with information age technology."

Innovation

Dr. Richard Mark Felder, a professor from the Chemical Engineering at North Carolina State University, Raleigh, North Carolina raises the idea of creative teaching being a combination of "Techniques of Creative Thinking plus Traditional Methods of Engineering Education". With ineffective and unhelpful systems of teaching in higher education in India involving mostly theory, the idea that "teaching methods intended to develop creativity and high-level thinking skills should not take too much class time" is relevant in this context. The India engineering education system has been consumed with traditional methods of classroom learnings while historically evolved in four different periods. Each of had added to the previous methods of teaching mechanism. Source: Delhi Technological University's report on "Evolution of Technological Universities in India and the way Forward for 21st Century Technological Universities". Below is a brief representation of the development of Indian education development.

Pre - 1950:

- Institutions focused on engineering practice
- Design according to codes and well-defined procedures
- Limited use of mathematics
- Many faculties with industrial experience and/or strong ties with industry

1950 - 1999:

- Focus on engineering sciences
- Fundamental understanding of phenomena and analysis
- Majority of faculty trained for teaching and some research

2000 – 2010:

- Focus on teamwork and collaborative working
- Integration in design and manufacturing
- Continuous improvement
- High scientific caliber, analytical ability and adoptability

2011 Onwards:

During this stage, the collaboration with external partnerships from school has popularized due to the formation of global interconnectedness through the internet. While not all engineering institutions have taken the responsibility to produce creative engineers that can apply practical knowledge in real life scenarios, this issue was recognized early while efforts to enhance the learning atmosphere combining advanced teaching strategies with traditional methods was implemented. Due to this, students would be able to think in different perspectives and achieve their critical thinking and problem-solving skills. For

Engineering Institutions to develop a goal-based thinking pattern in students, the following below are the fundamental success attributes for achievement being to -

- Identify new problems rather than depending on others to define them
- Transfer knowledge gained in one context to another in order solve complex problems
- Believe in learning as an incremental process, with repeated attempts that will eventually lead to success – in a way, have students realize that failures are welcomed to attain at a solution for a larger problem
- Focus their attention in the pursuit of a momentous goal or set of goals not just in a situational result

Since 2014, many reforms in the education system have taken place with this period applicable to create a desired eco-system which promotes a culture of innovation. Present-day engineering institutes such as IITs, have understood the importance of creative learning environments to be competitive and for students to focus and understand long term goals. Maintaining innovative education depends on the learning environment in general which provides the foundation for skill development through a balance between practical and theoretical learning.

In India, the present century poses as a resourceful opportunity to creating a sustainable market of Engineering resources, Product Innovation and Business Excellence. China, in this scenario, had captured large areas of market share in many countries including Asian (including India), African and North American countries. Specifically, due to progressing as a technologically enhanced environment promoting innovation and creativity. India, while having sufficient resources, is capable of technological development through reform in many engineering institutions through educational practices and learning. Michael Porter, an economist and social theorist, had defined the methods organizations utilize to be competitive mentioning about 5 forces (1. Competitive Rivalry, 2. Threat of new Entrants, 3. Threat of Substitutes, 4. Bargaining Power of Buyers, 5. Bargaining Power of Suppliers) which enhance profitability and competitiveness in an organization. [30]

The model emphasizes on an attractive economy where these 5 forces will increase creative and innovative potential in students and bringing healthy competition among institutes. While an unattractive system will be the one where the collective collegiate impact of the forces will drive down the overall impact on students to achieve less or adjust themselves with what has been provided. However, industry structure changes over time and at times, circumstantially due to political and economic change in developed countries. Over time, technological and managerial innovations become highly sophisticated where global innovation and focus on these concepts are very applicable for the real world. With these changes in technological trends, institutes must be equipped and able to teach the relevant concepts to familiarize students with theory, practicality and innovation occurring in the present to become efficient to achieve once they graduate.

In each institute; however, there will be issues to implement such a system of innovative teaching while in response to this, government funding (taking place today) is very helpful. In the case of most medium-low level engineering institutions, strict admission barriers for students are not implemented (resulting in some students adjusting with the concepts and some struggling to). Healthy competitive learning environments are effective for students to learn and apply skills relevant to global trends (such as blockchain and machine learning); however, with threats such as students choosing better schools (and the difficulty in admission in these schools due to population), the available institutions have the responsibility to supply better and efficient education. With this, many institutions will be equipped with very useful concepts and learning fundamentals (allowing a mass of graduates from these institutions to innovate and settle comfortably in the real world).

The Global Perspective of Educational Innovation in India

India with its 73 years of Independence, had achieved significant growth ranking amongst top future focused countries while producing millions of engineers over the years. However, the archaic 19th Century model of rote-based learning, the 'chalk-and-talk' system, where the teacher dictates and the student listens passively has discouraged questioning, discovery, experimentation and application in the school classroom. While tacking this issue is in action today, it is important to consider the teaching methodology in class enabling stimulated student thinking and action. While technology increasingly will play a major role in disrupting legacy education models, it will emphasis on human beings' capacity to create and innovate in rapid change and complexity. This result would require a surge of curiosity, awareness, observation, experimentation, association, application and networking. Through active learning, the education system can effectively catalyst positive change. [31] [32]

In this complex system of teaching and not preparing for unpredictable events, India has lost over a decade of market growth to sustain for a longer term and become a prominent global market for which Engineering could have been a major contributor. However, recently (from 2014 to 2019), India has made improvement due to India's performance while ranking in the Global Innovation Index, 2019 to 52nd position among 129 countries by the World Intellectual Property Organization (WIPO). India also outperformed on innovation relative to its GDP per capita for nine consecutive years, only matched by three other countries. While China further ranked from 17th position from 20th, India ranked from 29 spots in last five years from 81th position in 2014 to 52th position in 2019. [33]

A report titled "Global Innovation Index 2019 Creating Healthy Lives – The Future of Medical Innovation" places India, China and Russia among middle income countries, in the top 3 positions relating to the quality of innovation (including that of local universities), internationalization of patented inventions and scientific publications, while India ranks 26th globally. The report states that "India ranks 2nd among the middle-income economies, with top positions in quality of universities and in quality of scientific publications," while also mentioning that the Indian Institute of Technology (IIT) situated in Bombay, Bengaluru and Delhi occupied the 8th, 9th and 10th rank respectively among the top 10 universities in the middle-income countries. [34]

India's share in world R&D expenditures increased since the 1990s; however, less sharp than other middle-income countries in Asia such as China and the Republic of Korea. Due to this, India has lost the markets of economic advancement and opportunities such as manufacturing equipment to provide better products for the large farming population. Electrical innovation on the other hand, was delayed with more than 31 million households in Northeastern part of India currently not have power supply. [35] In contrast, Africa with low power supply, utilizes innovative products from large corporations while the electronics sector in India with minimal change lost to capture the markets of countries including India itself due to the inability to create industries of mobile, computer equipment manufacturing and other relevant production. With the efforts continuing, Indian engineering education must continue to focus on innovative and creative methods to produce skilled engineers to not lose the advanced technology markets share on modern technologies such as IOT, robotics, AI, Cloud Infrastructure, and urbanization with latest technology sources such that major industries and organizations would rely on India as a progressive hub. This way, India could become an innovative country for major corporations across the globe. [36]

Solutions & Attributes

How to maintain highest quality of education?

With numerous engineering institutions in India such as IITs, NITs, State Universities, Deemed Universities and other affiliated engineering colleges, there is a major difference in methods that each institute pursues to educate students. In general, IITs engage in teaching, research and business focused extension activities along with product development to empower the nation with world class human resources, R&D and innovations. Due to this, IITs are very competitive and progressive among other institutions while highly respected. Many IITs and a couple of NITs are listed amongst the top 100 to 200 engineering institutions in the world several times in the past decade by the QS World University Rankings for Engineering. [37] While the IITs are as recognized as MIT or Stanford, they could be fiercely competitive if continued with efficient learning strategies while focusing on changing dynamics of major markets to grab opportunities. Likewise, few other premier institutions have also been recognized globally for providing quality employability output over the years while India has approximately 3500 technology institutions. [38]

Also, due to the nature of teaching, implementing practical methods such as labs, seminars, webinars, case competitions, industry specific business partnerships and other creative product innovative class activities, internships with seminars organized and hosted by both the colleges and organizations will highly help students to achieve their highest potential of creating solution focused products right in college itself. The overall creative learning of engineering including examples from real life can be improved and evoked to a more advanced state allowing engineers to demonstrate their range of skills to be employable in their fields of interest. This would help in contributing to the global economy and innovative development. India's higher technical education is predominantly dominated by the self-financing institutions some of them have received recognition as deemed to be universities with almost 90% of India's higher technical education (degree level onwards) is under private ownership. The underlining assumption was that the private ownership shall promote quality and relevance much better than those under the public ownership system which is predominantly dominated by the Government and public policy. This objective has however not been realized to a large extent and as such is a major area of concern. The low employability of engineering graduates and the relevance of the capabilities nurtured in them for the purpose of employment in today's knowledge intensive, quality and productivity conscious, technology savvy industry environment are serious concerns. As

mentioned earlier in "Employability" section of this article, employability is directly proportional to the quality of education that students receive.

What solutions must engineering institutions focus on?

While many solutions have been mentioned above in the article, another perspective from The Delhi Technological University, in a study of evolution of technological institutions in 21st century under the guidance of the Vice-Chancellor Prof. P B Sharma, had identified the major concerns of Indian education and how it relates to the stagnation of innovation, graduate wellbeing (in settling in the real world), and economic growth [39]:

- Quality of Graduates in each institute
  - Allowing low pass percentage holders as eligible for engineering admission significantly damage the quality of intake in engineering degree institutions and the reputation of the institution itself
  - The frenzy for numerous seats of admission to engineering institutions created a system existing in many states in India where the last rank in admission tests consist of vacant seats. No reputed institution in any advanced country in the world would allow engineers with lowering entry qualifications to fill-up vacant seats
  - In a country like America, there are no more than 70,000 seats for engineering despite that America commands a lead position in respect of engineering and technology education, being the hub for renowned universities such as Harvard, MIT, Stanford, Caltech and many others
  - Create world quality at a larger scale than in advanced countries such as US and Europe is a current challenge that India is facing
- Quality of Faculty, Integrity and Preparedness for Integration into the Knowledge Revolution in institutes
  - Industry relevant focus and learning, driven by technology
  - Network powered by intelligent Knowledge Management System
  - Innovative design of curriculum design and execution
  - Promoting collaborative teaching, collaborative research with strong Industry Interface
  - Eco-system for knowledge creation and industry relevant innovation
- Lack of environment for Creativity and Innovation
  - Break traditional departmental boundaries for curriculum design and degree programs
  - Promote a seamless environment of synergy between Science, Engineering and Human Values
  - Mix an open learning and expert orientation through live, virtual classrooms, labs, case competitions, business partnerships, and internships
  - Enrich universities with 24 X 7 facilities to enhance learning experiences
  - Structure a system of decision making which employs the concept of flexibility and accountability to protect merit and scholarship
- Gobal subject matter of practicality instead of an academic curriculum heavily oriented towards traditional theoretical approaches such as sole examinations
  - An eco-system of a fully involved school rather than isolated departments with institutions connecting to the vast body of knowledge. This will ensure that the power of connectivity and power of networking is well utilised by the students and faculty in promoting innovative approaches and practices
  - Integral faculties combining the strengths of academic rigor, business partnerships and traditional engineering departments with advanced research engineering departments of business focus to solve real world problems. Engineering education must be effective with mechanisms for collaboration between universities and institutions in India and globally
  - Technology incubation (innovation center) is fundamental in all universities of 21st Century e.g., MIT Center for Information and Innovation and / or Entrepreneurship Lab etc. This attribute promotes collaboration, cooperation and alliances with R&D organisations at national and global levels.
  - Smart classrooms connected to national knowledge network with global research focused

faculty. This vital flow of knowledge on latest events, enhances outreach to the vast body of research and strengthens the academia industry interface. Institutions can set up portals for curriculum, knowledge, technology, new product and
innovations while being enhanced through external partnerships

- Research oriented laboratories promoting solution thinking about resolving real global issues. It is important that the institutions focus on their society to addressing the major problems (energy efficiency, energy conservation, environmental degradation and water quality management) and create trained manpower in new
technologies while also partnering with local schools to enhance the desired interest in science and engineering.
- Central administrative authority tuned to appreciate merit and concern of quality. Some globally renowned universities also include recently graduated students as part of the executive council
- Faculty recruitment based on critical evolution of capabilities for teaching and research, flexible pay packages, and tenure track system of permanent absorption. This promotes faculty development and with peer pressure learnings can result in quality and relevance.
- A system of reward and recognition for intellectual achievements and sharing of wealth through knowledge creation and patents by leveraging business partnerships.
- Promotion of student and faculty start-ups and support for inter-disciplinary student teams engaged in innovation and new product development.

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