Radical Development of Engineering Institutions in The Industrial Corridors

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Abstract

In the last fifteen years, lakhs of engineering students have not gotten any employment and more than 1000 engineering colleges were closed. The reasons are insufficient qualified faculty members, nonaccredited programs, no exposure to industries, poor infrastructure, and colleges not having linkages with the industries. The global review indicates that almost all engineering institutions are offering various industry-relevant courses and the students are undergoing adequate industrial training, have sufficient attributes, and are industry-ready. This enables the graduates to get industrial placement. The objectives of this research are to review the global practices in offering industry-specific curricula, on-the-job training, a framework to improve the linkages with the industries, the art of nurturing industrial collaboration, and a policy framework for radical developing industry-ready graduates. An action research method has been utilized in this project. It is concluded to actively create a link with the companies in the nation, develop industry-relevant and/or industry-specific and flexible curricula, and offer it with active collaboration with industries in the corridor. Ten suggestions are recommended to improve the abilities and skills of the engineering graduates and the faculty members. It is suggested to nurture various stakeholders and bring a win-win solution.

Further, this focuses on creating a policy framework and cooperation of professional associations. All these focused on radical innovation in outcome-based curricula with active collaboration with employers.

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1. Introduction

After globalizing the Indian economy [1], a large number of foreign companies have established their manufacturing centers to meet the needs of India as well as for export [2]. This created a need for more skilled workers, technicians, engineers, managers, software personnel, and human resource developers. Based on the new market potential, many entrepreneurs established many engineering colleges nationwide. The initial rush to join the colleges made many entrepreneurs start two or more colleges but they faced severe problems in locating colleges in urban areas, getting well-accomplished faculty members, and getting industrial linkages for on-the-job training and placement. Meanwhile, a few private colleges started focusing on recruiting recently retired and well-accomplished faculty members, developing linkages with some companies, and focusing on training the students. Due to the explosive growth of engineering colleges, the market has become a buyers' market [3]. A large number of graduates could not get placement[4][5]. According to the Times of India, more than 60% of engineering graduates in India every year remain unemployed [6][3]. According to Roshni Chakrabarty (2019) [7], only 3 percent have suitable skills to be employed in the software or product market, and only 7 percent of engineers can handle core engineering tasks [8]. According to Raghu Mohan (2016)[9], 80% of India's engineers remain unemployable in the software sector. Many engineering colleges lack the required space, industry-focused and outcome-based curricula. Around 50% of the colleges were not accredited.

1.1. Prime Industrial Corridors in India [10][11][12][13][14][15]

In the last twenty years, the Government of India established several industrial corridors. They are the new economic growth paradigms in India. They are pivotal to economic growth since they reduce trade barriers and increase the transfer of goods to consumption regions. Well-planned Indian corridors have achieved high economic growth, increased contribution to the Indian GDP, and connected to leading ports. The Government of India has implemented a national project for building a Pentagon of Special Export Zones (SEZ) connecting all metropolitan cities [16][6]. The project aimed at manufacturing high-quality products, improving its contribution to GDP. They contribute to radical development, inclusive growth, and the gainful employment of well-trained human resources. They offer effective integration between industry and infrastructure. They lead to overall economic and social development.

The most significant corridors in India are:

Table 1. Corridors and States Connected

No.	Name of the Corridor	States Connected
1	Amritsar Kolkata Industrial Corridor (AKIC)[10]	Punjab, Haryana, Uttar Pradesh, Bihar, Jharkhand, and West Bengal.
2	Delhi-Mumbai Industrial Corridor (DMIC)	Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh, Gujarat, and Maharashtra.
3	Bangalore-Mumbai Industrial Corridor (BMIC	Mumbai-Pune- Bangalore
4	Chennai- Bangalore Industrial Corridor (CBIC)	Tamil Nadu, Andhra Pradesh, and Karnataka.
5	Vizag-Chennai Industrial Corridor (VCIC)	Chennai-Nellore- Visakhapatnam

The industries in these corridors need engineering graduates who possess the needed attributes and industry industry-ready. Further engineering institutes need to create linkages to place the graduates and offer executive training. The alumni can provide needed advanced courses, modern resources, and topics for research.

1.2. Potentials of Industrial Corridors

According to NASSCOM [17], global enterprises are increasingly adopting tech-enabled business models to stay relevant and continue their growth trajectory. Almost all companies shift towards outcome-based engagement between customers and suppliers. These companies are rapidly embracing consortium and cooperative approaches to innovate, generate new revenue streams, and stay relevant to their customers. The advent of new-age technologies is driving digital transformation. In pursuit of the new era of engineering and manufacturing, enterprises are implementing Industry 4.0 solutions. Engineering R&D players are creating technology Centres of Excellence (COE) to support the global technology needs of customers. Adding to India’s attractiveness as an Engineering R&D destination is the active collaboration of enterprises with start-ups engineering colleges and technical universities. Further, technical universities have to diversify expertise that is dedicated to solving real-world problems with effectiveness and efficiency. India is expected to continue having one of the youngest populations in the world until 2030 and India is expected to have the largest human resources in the world. India can offer highly skilled and diverse human resources for setting up R&D facilities. Indian engineering R&D players like state technical universities, national institutes of technology, and institutes of national importance have to take appropriate initiatives to complement the growth of the future-ready talent pool. With efforts from the Engineering R&D ecosystem stakeholders, engineering institutes have to address the future engineering R&D imperatives of global enterprises. All the engineering institutes have to design outcome-based and industry-specific curricula, and collaborate with the companies in the industrial corridor by jointly planning interdisciplinary research and development works. All the well-trained graduates with the necessary attributes will be employed.

1.3. Success Stories of Engineering Colleges Linked to Industries

Autonomous engineering colleges in and around industrialized cities have many success stories. A few well-established autonomous engineering colleges in Madurai, Tiruchirappalli, Salem. Chennai, Mysore, Bangalore, Hyderabad, Mangalore, Vizagapatam, Kurnool, etc. They need to collaborate with well-established enterprises in and around these cities and undertake joint research and development programs.

2. Literature Survey

2.1. Strategies to Reduce Unemployment in India Through Outcome-based Education [18][19][20][15][4][21][22][5]

Autonomous Institutes have to establish branch-wise outcome-based curriculum development centers and evaluate the existing curricula through alumni and representatives of employers. The companies will benefit from collaborating in this venture and get ample industry-ready graduates, can jointly plan executive development programs, and offer consultancy projects. They can share the resources of both organizations for developing many innovative products.

3. Objectives of this Research

The objectives of the research are:

1. To review the global practices in offering industry-specific training programs to engineering students
2. To develop a radical framework to improve Industry-Institute collaboration for creating linkages between them
3. To identify institutional strategies for Industry-Institute cooperation
4. To suggest methods for nurturing the collaborative process from the government
5. To identify a policy framework for radical innovation in developing industry-ready engineering graduates

3.1. Research Methodology

The research methodology consists of an action research process. This method focuses on the best practices in leading global universities and creates a model for Indian engineering institutions. The role of stakeholders is identified and appropriate actions are suggested.

3.2. Shortages in Various Engineering Curricula

The following information is from the Ph.D. theses of the research scholars in Engineering Education completed by the research scholars of the National Institute of Technical Teachers Training and Research, Chenna.

Table 2. Significant Shortages in Selected Curricula

S. No.	Program	Shortages	Ref. No.
1	B.Sc. (Computer Science)	Not exposed to industrial applications & methods	[23]
2	Bachelor of Computer Applications	Industrial needs are not included	
3	B.E./B.Tech. degree in Mechanical Engineering	Industrial needs, design processes, manufacturing methods, and maintenance procedures are not included	[4]
4	P.G. Program in Embedded System Technology	Should focus on employability in the companies	[24]
5	U.G. Program in Building Technology and Management	Needs more focus on Building Technology, current practices, and project management	[25][26]
6	B.E./B.Tech. Mechanical Engineering	Needs more exposure to design competencies	[4]
7	Diploma in Manufacturing Technology	Needs to include industry-specialization	[27]
8	Diploma in Civil Engineering	Needs to include internships in construction firms	[28]
9	P.G Program in Transportation Systems	Needs case studies in regional planning, and multimodal transportation systems.	[29]
10	Deep Foundations	Needs an exposure to the current practices and management	[29]
11	Diploma in Instrumentation Technology	Needs to be exposed to the instruments manufacturing industry	[24]

3.3. Industry and Academy Expectations

According to the Royal Academy of Engineering,[20] the UK government has proposed the development of a new research and technology funding agency to fund high-risk, high-pay-off emerging fields of research and technology, broadly modeled on the US Advanced Research Projects Agency (ARPA). This sets out a blueprint for an agency that supports radical innovation. Autonomous institutions can be modeled on ARPA to plan to develop needed products jointly. The outstanding faculty teams need to be exposed to the challenges and scaffolded to undertake interdisciplinary research programs.

3.4. Roadmap to Effective Industry-Institute Collaboration [30][31][32][33][34][35][36][16][37][38][39]

Effective industry-institute collaboration can be established based on the following factors: outstanding faculty team members with in-depth problem-solving capabilities, established track record of successful consultancy projects offered to industry, modern resources, active supporting staff, supportive government policies on industrial collaboration, and active governing boards. The industry should be ready to avail the services of the faculty members. Further, the executives should be ready to offer needed industrial exposure and on-the-job training to the students and offer research projects to the faculty members as and when they face problems in analysis, design, prototype development, testing, modifying, selecting cost-effective manufacturing, marketing, and maintenance. The institutes should establish active linkages with the MSMEs in the state, region, and nation. A few institutes of national importance, autonomous institutes, and state-technical universities have excellent track records of empowering outstanding faculty members to bid for consultancy projects under various multinational corporations (MNCs) and international development agencies (IDAs). Many of these institutes have been well-recognized by MNCs and IDAs. These institutes have to nurture young and middle-level faculty members to get sufficient industrial exposure, undergo internships, and get funds from national councils to undertake research and development projects. These faculty members have to focus on disruptive technologies and be ready with the needed skills and abilities to undertake complex projects. The government also should support the linkages of the institutions with the companies and provide tax incentives to the companies on the expenditure met in these activities The Government of Singapore has policies to grant funds for training the students.

3.5. Global Universities' Models of Offering Industry-Specific Engineering Programs [31][32][33][40][34][18][41][42][36][43][16][44][45][46][47][37]

In the last 100 years, many outstanding global universities in the UK, the USA, Germany, Canada, India, and Singapore have developed more policies to collaborate with global companies. They enjoy academic autonomy, administrative autonomy, and financial autonomy. Almost all academic administrators have integrity and follow ethics and equity in all institutional development processes. They continuously strive to generate needed funds for research through consultancy projects. Further, they specialized in developing many innovative programs to create outstanding engineers. Some of the programs are presented in the next section.

3.5.1. American Model: Cooperative Programs [40][34][48][49][44][47][50][39]

Cooperative education combines classroom instructions with work experience in a company. Its goal is to provide an environment for industrial problem-solving to facilitate learners to apply their classroom knowledge. Herman Schneider founded cooperative education in 1906 at the University of Cincinnati [42]. Engineering students get their first experiences working on real-life problems in an industrial environment. Due to this field experience, these graduates are recruited before their graduation. The employers get industry-ready engineers who possess more work-related experience. Engineering colleges choose appropriate companies to provide needed workers' experiences and get more shopfloor managerial skills. They also assist the department in getting ABET criteria for accreditation of the program. In India, many sandwich (Cooperative) programs are successfully offered to B.E. degree students and they also get stipends from the Board of Apprenticeship Training for one year. They usually get better placement. The graduates possess better industry-relevant skills comparing regular B.E. graduates.

3.5.2. Students Transfer from Community Colleges to the University Bachelor Degree Programs (Lateral Entry)

Most vocational students after completing their Associate of Arts in Community Colleges get admission in the third year Bachelor degree programs in the engineering colleges through the lateral entry scheme. They earn more industry-specific skills in AA programs and this helps them to acquire advanced courses in the B.S. degree programs and get jobs easily. In India, polytechnic graduates join the second year of B.E. through a similar lateral scheme.

3.5.3. American University Model: Double UG Programs [49][51]

Modern industries have a substantial influence on engineering institutions by creating an enormous demand for engineering and technology graduates. Engineers provide needed development leadership to the community through their creative skills and develop goods and services.

3.5.3.1. Undergraduate Programs of Massachusetts Institute of Technology (MIT), Boston, USA[51]

Table 3. Selected Engineering Programs of MIT that Focuses on Industrial Needs

Program	Engineering Courses	Interdisciplinary Courses
New Engineering Education Transformation (NEET): Aims: Reimagine and Rethink what and how undergraduate engineering students learn by focusing on preparing them to develop the new machines and systems that they will build in the middle of the 21st century.	Primary major and a second one in another area	Management, political science, economics
Flexible Engineering Degree Programs	Department-based courses, robotics, and controls, computational engineering, or engineering management	Energy, health, & environment
David H. Koch School of Chemical Engineering and Practice: Programs Partnership with Industry		
System Design and Management (1997)		
Deshpande Center for Technological Innovation (2001)		
The Undergraduate Practice Opportunities Program (2011)		
Leaders for Global Operations (1988)		
The Bernard M. Gordon-MIT Engineering Leadership Program (2008)		
MITx and edX (2011)	Massive Online Open Courses (MOOCs)	
Super UROP (2012)	Training, resources, and guidance necessary for deep scientific and engineering inquiry leading to publication-worthy findings	
Start MIT (2014)		
The MIT Sandbox Innovation Fund Program (2016)	Seeks to help students develop the knowledge, skills, and attitudes to be successful innovations and entrepreneurs	
The Flexible BS in Engineering Degree	Mechanical Engineering Chemical Engineering Civil and Environmental Engineering	Aeronautics, Astronautics
The Undergraduate Practice Opportunities Program (UPOP)	Internships and Intensive experiential learning workshops	Development of professional abilities and attitudes

3.5.3.2. Joint and Dual Degree Programs of Columbia University in the City of New York[40]

Goal: Increase graduate's value to potential employers with a dual master's degree;

Offer integrated curricula and interdisciplinary coursework in an advanced degree program;

These programs uniquely prepare the graduates for a world of new career options.

Sample Programs:

- ***MS in Management Science and Engineering*** Complement graduate's engineering studies with insight into business concepts and management; designed to help graduate develop advanced skills in solving problems, making decisions, and managing risk in complex systems
- ***MS in Computer Science and Journalism*** Advanced graduate career in data journalism. Gain foundation skills in

writing, reporting, computer science, and software design to effectively leverage technical skills to support content development.

- ***MS in Data Sciences:*** Learn to apply data science techniques, such as computation and analysis, to decision-making. Help the graduate to develop the skill to extract meaningful insights from data and apply those insights to problem-solving in his/her field.
- **MBA and MS in Industrial Engineering**: Merge the graduate's interest in business with his /her skill in engineering with this unique five-semester dual-degree program. The graduate will develop a solid understanding of business management, leadership, and team building, as well as mastery of new technology.
- **MS in Business Analytics**: Designed for those who want to focus on learning the modeling techniques and data science tools that help businesses use data to make better decisions, this program offers a capstone project that provides an intense consulting engagement with clients and their real-world business problems over the entire course of the three-semester study.
- **Dual MBA/Executive MS in Engineering and Applied Science**: This program is designed for entrepreneurs, engineers, or product managers looking to move their organizations forward by leveraging new technologies or designing and implementing innovative products and solutions. The program pairs the foundational skill sets of business with those of engineering. Participants in the 20-month program will receive two degrees: a master of business administration and an executive master of science in engineering and applied science.

3.5.3.3. British Model: Sandwich Programs[8]

University Course plus Industrial Exposure Sandwich courses are a form of training designed to provide learners with a foundation of knowledge and industrial experience before they are exposed to an actual workplace. Undergraduate students are posted to a particular industry or field. The industry offers learners valuable hands-on training, financial assistance, and insight into the industry. During the course, students learn how to apply the skills they've learned to the real world. In the UK, most employers prefer candidates with a degree and relevant experience. Sandwich courses are available in both undergraduate and postgraduate programs. Sandwich programs are usually four or five years long. The UK universities may include a one-year or two-year placement and are available for various courses like business, science, and engineering. For international students, sandwich degrees offer an additional industrial placement year. Most internships last 12 weeks. The advantages of pursuing a sandwich course are financial assistance, competitive edge, enhanced pre-placement opportunities, and personality development. The typical course structure in a thick sandwich consists of university courses in the first and second years. In the third year, the students are placed in an industry. In the fourth year, they return to complete university courses. In a thin sandwich pattern, an interval of two shorter periods is encapsulated.

3.5.3.4. German Model: Dual Programs Leading to Industrial Training[41]

German higher education offers various opportunities to combine theoretical education with the development of practical skills and knowledge. Dual studies (German: duale Studien) refers to a mode of study that combines practical work with academic training. Further, students get paid a fixed salary (approximately 700-1500 euros per month) throughout their dual studies. Students of dual study programs are enrolled at a higher education institution. The institution has contracts to offer practical training from various companies. They maintain an equal distribution of theory and practice.

Table 4. Two Models of German Dual Programs

Model	University theoretical classes	Industrial training	Lecture free period
The block model	April to July;	October to January August to September (Manufacturing Company	February to March
The week model	Theory: Informal youth education- Social work @ university 3 days a week	Job work: 2 days a week	

Qualification: Double qualification: An academic degree & Completion of an officially recognized vocational training.

3.5.3.5. IIT Madras' Dual Degree Programs: UG and PG Combined 5-Year Programs[52]

Goal: ***"From concept to a component that meets a desired function"*** aptly describes engineering design; that is a decision-making process, often iterative, in which the basic sciences and engineering sciences are applied to convert resources optimally to meet stated objectives. Learners are offered courses on the design process in the first year along with applied mathematics, science and engineering, graphic art, design, and aesthetics. They are trained not only in the mechanical aspects of design, but also in controls, electronics, and embedded systems for all-round skill development. Courses in geometric modeling, finite elements, materials engineering, human anatomy, and physiology, are also offered in the first three years of the program. Most of the theory courses are planned with laboratory practice. Product dismantling and assembly enable the learners to dismantle products and re-engineer them. The graphics art laboratory and clay modeling laboratory offer the learners experience in the art of making products with an aesthetic appeal. Other important labs are digital and analog electronics, mechatronics, and control systems.

Learners can choose their specialization at the end of the fourth semester and the domain specialization happens from 5th semester onwards**.** Learners get the opportunity to understand the nuances of design for a particular domain. Automotive design, biomedical design, and robotics (0nterdisciplinary dual degree) are the current specializations. In the engineering design curriculum one-semester internship in the industry offers them to work on a project and they receive exposure to current global design practices. They can undertake the capstone project in the final year. Further, they can get jobs in many companies like Titan, Philips, GE, Bosch, Siemens, etc.

3.5.3.6. Interdisciplinary Programs of Indian Institute of Technology (IIT), Kharagpur[53][54]

Engineering Students often plan to pursue careers in areas that are in focus within industry. IIT Kharagpur offers interdisciplinary programs, wherein learners can opt for them either as regular degree programs or as micro specializations. This provides an academic opportunity for learners to gain competencies across disciplines and enables them to make career choices irrespective of their qualifying degree. Interdisciplinary courses cover a wide range of highly relevant areas and use the unique diversity of academic courses and research capabilities.

3.5.3.7 Interdisciplinary Dual Degree Programs of IIT Kharagpur[53][54]

They offer interdisciplinary exposure while the learner pursues two degrees that are awarded in a consolidated period. While the B.Tech. is undertaken in one major discipline, the M. Tech. can be undertaken in another branch. Learners who joined a 4-year B.Tech./5-year dual degree program can opt for an Interdisciplinary Degree at the end of their first year.

Table 4. Examples of Dual Degrees

Aerospace Engineering	**Agricultural & Food Engineering**	**Civil Engineering**	**Chemical Engineering**
Aerospace Engineering	Agri. & Food Eng. / Farm Machinery & Power	Civil Eng./Hydraulics & Water Resources Eng	Chemical Eng./ MBA
Aerospace Eng. / MBA	Agri. & Food Eng/ Soil and Water Conservation Eng.	Civil Eng./ Transportation Eng.	
	Agri. & Food Eng./ Dairy & Food Eng.	Civil Eng./Structural Eng.	**Computer Science & Engineering**
	Agri. & Food Eng./ Water Resources Development & Management	Civil Eng./Environmental Eng. & Management	Computer Sc. & Eng./ MBA
	Agri. & Food Eng./ Aqua Cultural Eng.		
	Agri. & Food Eng./Post Harvest Technology		
	Agri. & Food Eng./MBA		

3.5.3.8. Singapore Incentive Strategies: Financial Incentives to Companies[37]

Singapore government provides funds to companies to organize training for vocational students, polytechnic technicians, and engineering graduates. The companies support them by offering many types of on-the-job training programs.

3.6. Needed Radical Innovation [55][56][38][20][57][58]

The Indian government has to propose a new research and technology funding agency as a mechanism for research programs that should deliver innovative answers to solve ambitious real-world and technology. It should fund high-risk, high-payoff emerging fields of research and technology. There is a need for high-caliber program managers, with technical expertise and experience that are crucial to success. They have to be selected and offered to apply their knowledge and abilities to solving ambitious challenges. The nature of the role will have to maximize the use of their skills with full responsibility and freedom to develop the program, draw on leading capabilities in the private and public sectors, and allocate funding to strategically drive forward at pace. Decentralization and autonomy are required to facilitate fast decision-making, flexibility, and the freedom to allocate and release funds.

3.7. A Radical Framework to Improve Industry-Engineering Institute Collaboration

Program Educational Objectives are to be based on the needed human resources, and industrial needs and should focus on innovation. A flexible framework that has to be approved by AICTE. The program has to be credit-based and flexible. Around 40-50% of the courses in Applied Sciences, Engineering Drawing, Design, Computer Applications, Economics, and Human Resources are to be offered in the first three semesters. Engineering core courses could be offered in the third and fourth semesters. Advanced courses are to be offered from the fifth to seventh semesters. Industrial training, industry-specific project works, analysis-product design- and prototype development-testing-improvement have to be offered from the fourth to seventh semesters. The eighth semester has to be devoted to the capstone project. The courses are to be evaluated by industry representatives. Industrial training has to be evaluated and appropriate credits are to be offered.

Table 4. Needed Initiatives

Sl. No.	Engineering Institutions	Needed Initiatives	Reference
1	Engineering Universities	Collaboration with state and regional industries	[32][33][34]
2	Engineering Institutions	Generating smart goals for cooperation with local companies	[35][18][42]
3	Industry-Institute Collaboration	Needs linkages and government support	[59][36][16]
4	Executive Development	Institutional Policy and Strategic Planning	[37][60]
5	Continuing Education Programs	Establishing a unit for continuing education programs	[43][61][44]
6	Industry-Institute Alliance Building	Planning long-term cooperation based on the needs of both organizations	[45][62][63][46][47][64]
7	Collaborative dissertations	Sustainable linkages with the companies	[65]
8	Narrowing the gaps between Industry-Institution	STEAM R: Science-Technology-Economics-Art-Management- Radar	[21][2][66]
9	Radical and Virtual Innovation Center (RVIC)	Policies for collaboration, resources, high-performing faculty teams	[22][67]
10	Research Cluster	Well-performing faculty teams in all collaborating institutions and supporting resources	[68]
11	Sustaining Industry-Institute Partnership	Scaffolding the faculty teams, and linkages with the industry	[67]
12	Corporate University	Resources, experts, technology, funds, strategic plan	[21]

3.8. Nurturing Collaborations: Combined Initiatives of the Government (UGC+ AICTE), Universities, Colleges, Faculty Members, and Learners

Table 5. Nurturing Collaborations

S. No.	Issues	Needs	Ref. No.
1	Faculty Development	Faculty training from recruitment to retirement	[65]
2	Global Challenges	Decentralized administration and empowered project leaders	
3	Winning Culture	Inspiring culture of high-performing faculty	[21]
4	Multidisciplinary HRDI under P-P-P	Active collaboration of I-I and continuous support of the government	[2][22]
5	Leadership	With equity, ethics, integrity, humility, and outstanding culture	[5]
6	Continuous Collaboration	Sustainable long-term relationships, resources, continuous exchange of resource persons	[67][66]
7	Executive Development	Empowered expert faculty teams, modern resources, active linkage, and sustainable relationships	[60]
8	In-House Executive development	Resources, continuous supportive policy, well-trained experts	[60]
9	Project-based learning	Collaboration between the industrial experts, institutional resources, scaffolded faculty teams	[29]

3.9. Policy Framework

Engineering education is one of the most important aspects of Indian higher education and is central to India's future economy. Engineering as a field of university study in India has grown by leaps and bounds in the last 35 years, most of it in private institutions and highly varied quality, from the internationally renowned Indian Institute of Technology to low-quality unaided private institutions. In this huge and varied engineering education system which India depends on to make it a major player in the global economy (Philip. G. Altbach). Major challenges in Indian engineering education are overzealous expansion and the resultant supply-demand mismatches which are reflected in high rates of unemployment, inequities in education by gender, caste/religion, and region, poor quality of education as revealed in lower employability of graduates besides, limited public financing and issues relating to affordability (Narendra Jadhav). Mohan Reddy (2020) has recommended the following initiatives: i) Encourage the institutions to convert current capacity in traditional disciplines to emerging new technologies, ii) Develop the competencies of the faculty in the areas of new age technologies and research through rigorous faculty development, iii) Bring about the needed change in the pedagogy in the immediate term, focused industry visits for faculty for hands-on exposure to the current technologies, iv) Utilize the services of various industry associations, v) Utilize MOOCs to train the faculty members, vi) Build project management capabilities through interdisciplinary research, vii) Assess the needs of graduates through tracer studies, viii). Evaluate the impact of various teaching methods, ix). Promote innovation, incubation, and start-up ecosystem, x) Introduce entrepreneurship as a minor elective, xi) Setup tinkering labs similar to Atal Innovation Labs, xii) Introduce courses on Artificial Intelligence (AI), Internet of Things (IoT), Embedded SW, Mobility Analytics and Cloud, xiii). Introduce undergraduate courses in AI, IoT, Blockchain, Robotics, Quantum Computing, Data Sciences, Cyber Security, 3D Printing & Design, AR/VR, xiv). Introduce multi-disciplinary engineering courses like computational biology, biotechnology, biomedical, mechatronics, aerospace, agriculture, and environmental engineering, xv). Introduce methods of solving real-life socio-economic problems using technology, and xvi) Introduce open book learning.

3.10. Win-Win Initiatives

Introduce soft-skill training, conduct additional courses through finishing schools, review the curriculum through a tracer study before implementation, develop outcome-based courses in consultation with the executives of the companies, assess the needs of industries every year, get on-the-job training for the faculty members, and introduce the apprenticeship training to the students during summer breaks.

3.11. Institutional Organizational Structure

Introduce Student Personnel Administration to plan on-the-job training, tracer studies, internship, training, and placement section**.** Introduce mini projects, industry-sponsored dissertations, case studies, reviews of current publications, and seminars based on the projects completed**.** Include adjunct faculty to assess the projects completed.

3.12. Cooperation of Professional Associations

Professional Associations like the Consortium of Indian Industries (CII), Federation of Indian Chambers of India and Commerce (FICCI), and Local MSME Associations will provide more support for Industry-Institute cooperation by offering on-the-job training to the engineering students, offering projects for dissertations, developing industry-specific graduate and postgraduate programs, and campus selection of graduates.

3.13. Planning Company-Specific Outcome-based Cooperative Programs [60]

Institutes can plan many company-specific outcome-based cooperative programs that will offer industry-ready graduates. These programs could be flexible so that the students can undergo many on-the-job training courses in different companies. The graduates can also undertake many industry-specific projects for dissertations. In the long run, an active professional linkage can be developed. Further, interested graduates can plan entrepreneurship programs. The institutes can offer executive training programs to the companies. Regional competitiveness will increase. This is a win-win model of sustainable cooperation.

3.14. Facilitating Focused Industrial Training of the Students [5]

Considering the new opportunities of availing more planned on-the-job training (OJT), the following steps are suggested: i). Establishing a satellite center with hostel facilities for the students while undergoing OJT. This center can offer facilities for hosting seminars and workshops. It could be a part of the Board of Apprenticeship Training (BOAT)[5 TO 8] of the Ministry of Education. ii). Considering the utilities of digital media, steps can be made to produce video programs on the industrial production process and upload them to the web of the BOAT for the use of the faculty and students. The Ministry of Education can fund the cost of production and the National Institutes of Technical Teachers Training and Research can undertake needed videos through its annual production plan. iv). Advanced courses on Kaizen can be introduced in all branches of engineering. v). There is a need for developing case studies on the fast-changing industrial processes. Appropriate cases can be chosen they can be developed and copies can be distributed through the National Institutes of Technical Teachers Training and Research. vi) Periodically well-planned mass open online courses (MOOCs) can be prepared based on advanced industrial product design, prototype development, testing, and efficient manufacturing and marketing, vii). Appropriate short-term faculty development courses can be planned on the innovations of industrial production as a part of AICTE’s ATAL program. Indian Society for Technical Education (ISTE) can be commissioned and funded for this activity, ix). Peripatetic programs for the faculty members can be planned through the Confederation of Indian Industries (CII) and the Federation of Indian Chambers of Commerce and Industries (FICCI), and x) Dissertation topics on the industrial problems can be identified by a group of executives of various industries and can be offered to the postgraduate students. Further, seed funds of reasonable amounts can be offered as an incentive to the students to meet the expenditure. Profit-making companies in the corridor can also meet some of the activities under their Corporate Social Responsibility (CSR). Best dissertations can be selected and awarded so that many students will be interested in taking sponsored dissertations. These ten suggestions can be implemented without any difficulty. The outcome of all these mini-projects will enhance the skills and abilities of millions of engineering graduates.

3.15. Annual Program Audit and Improvement

Every year the outcome of the courses, feedback from the faculty members, students, and participating companies are to be reviewed. The shortcomings are to be analyzed and improvements are to be planned and validated for implementation. Further, an impact study has to be undertaken to assess the overhaul gain achieved by all stakeholders.

4. Discussion

Indian engineering graduates suffer from the following problems: i) Curricula are not developed based on the needs of fast-growing disruptive technologies, ii) Most of the faculty members don’t have thorough exposure to the current industrial practices, iii) Only a few institutions are implementing sandwich/cooperative programs, iv) Very small number of institutions have created linkages with companies in the region or state v) Very rarely the postgraduate students take industry-sponsored dissertations/ project works, vi) Very limited number of engineering institutions have established a continuing education centers to offer executive development programs, vii) There are very limited case studies in various topics in engineering, viii) No credits are added based on the industrial training, ix) Rarely a few institutions undertake research and development projects under various engineering industries in the state, and x) No affiliated college planned and implemented industry-sponsored postgraduate programs. Under these circumstances, a new opportunity has arisen due to the massive development of industrial corridors in the country. If desired linkages are made, the above-stated problems can be solved. To do this, there is a need for a national policy on creating industry-institute collaboration. It should offer more tax incentives to the companies for incurring expenditure on various tasks on training the faculty members, and students, offering consultancy projects, and utilizing the expertise of the engineering faculty members who can offer executive development projects. Most global engineering colleges have developed dual programs which offer specialization in two branches. A few Indian Institutes of Technologies offer five-year dual programs which include both a bachelor's degree and a postgraduate degree. There is an urgent need to create outcome-based engineering degree programs and offer them on a cooperative model. Further, the companies in the industrial corridors can plan effective linkages with the engineering institutions in and around the corridors or industrial hubs. Ultimately every organization should collaborate.

5. Conclusion

Due to liberal policy on establishing engineering colleges in the private sector, the mushrooming of engineering has happened. Initially, due to the fast growth of multinational companies in India, engineering graduates were absorbed. This created a rush to establish a large number of engineering colleges in the nook and corner of the states. When these institutes could not recruit outstanding faculty members, the quality of the graduates reduced and led to unemployment. Even around 1000 colleges were closed when they could not attract students. A review of global practices in offering industry-specific training programs indicated updating the existing engineering curricula with well-focused program educational objectives and outcome-based courses. Further, there is a need for a radical framework to improve the industry-institute collaboration. The engineering institutes have to develop industry-specific curricula, train the faculty members and as well as the students in the industries in the corridor. Many of the existing colleges in tier I cities and a few in tier II cities have established excellent linkages with the companies in the nearby industrial hubs and corridors. This success strategy has to be followed and more colleges have to establish satellite institutes in the corridor. There is a need for introducing financial incentives to the industry through tax reduction for the expenditure met on industry-institute collaboration similar to the Singapore government. AICTE has to offer more faculty development programs in planning industry-specific curricula, undertaking industry-sponsored dissertation projects, and cash incentives for establishing consultancy centers in the corridors. Ten suggestions based on the emergence of industrial corridors will bring a win-win strategy. It will bring more innovations and eliminate the unemployment of engineering graduates.

5.2. Shortcomings in this Radical Model

This research is based on the action research model and focuses on the success stories of global universities.

5.3. Suggestions for Further Research

Large-scale research can be proposed and can be funded by appropriate funding agencies like CSIR, the Department of Science and Technology, or AICTE.

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