Assessment to Enhance and Demonstrate Graduate Attributes

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ABSTRACT

India has to develop engineers with competencies required for independent practice in which the graduates can work similarly to competent senior engineers and managers. Graduate attributes form a set of individually assessable outcomes that are components indicative of the graduate's capacity to acquire competence to independently practice at the desired level of the industry. In the knowledge-based global economy, the engineering graduates should possess the needed outstanding abilities to solve complex and real-life programs of the fast-growing global industry. A sizable percentage of Indian Engineering graduates are found to be lacking industry-specific skills, competencies and rendered jobless. A snap study on the alumni shows that fine- tuning of assignments based on industrial practice is essential. The SWOT Analysis suggests that the need for continuous quality development programs for engineering students. All the engineering programs are to be accredited under NBA as per the Washington Accord so that the graduate engineers can register in other countries if they migrate. Otherwise, they have to work for a minimum of two years as an intern. India has to establish an Engineering Council for the registration of the engineering graduates as similar to the Architectural Council. The need for industry-focused complex development programs for all students has been identified based on the qualitative research done. It is found that there is an urgent need for graduates to prepare portfolios and plan to acquire desired competence through seminars, research, industry- specific capstone projects, and self-planned practicum. It is suggested to introduce a course on failures, guest lectures on the industrial methods, trends in new technologies, innovations, and offer industry-specific dissertations.

Keywords: Focused Engineering Student Attributes Development, Student Portfolio, On-the-job-training and Development, Role of Industry-based dissertation in offering needed competence.

Introduction

According to International Engineering Alliance Graduate Attributes form a set of individually assessable outcomes that are components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The goal of engineering education is to build on the skills earned through education for professional practice. Graduate attributes form a set of individually assessable outcomes indicative of the graduate's outstanding strength to acquire at the desired level.

The Washington Accord base the judgement of substantial equivalence of programs accredited by signatories on both the Graduate Attributes and the best practice indicators for evaluating program quality listed in the Accords' Rules and Procedures.

As per Washington Accord, Engineering Graduates apply knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to solve complex industrial engineering problems.

Graduate attributes are assessable outcomes, supported by level statements, developed by signatories that give confidence that educational objectives of programs are being achieved. The employers could entrust the planning, design, construction of the structure even in extreme field conditions. The required skills and competencies to undertake the job are due to

well-planned curricula and the instructional system adopted.

Range of Problem Solving according to Washington Accord (IAE 2013):

Table-1 Attributes and Complex Engineering Problems

Attribute	**Complex Engineering Problems**
Depth of knowledge required	Can't be solved without in-depth engineering higher-order cognitive at various levels.
Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering, and other issues.
Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable design models.
Familiarity of issues	Involve infrequently encountered issues.
The extent of applicable codes	Are outside problems encompassed by global standards and codes of practice for professional engineering
The extent of stakeholder involvement and conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.
Interdependence	Are high-level complex problems including many parts or sub-problems.

Table-2 Range of Engineering Tasks (IAE, 2013)

Attribute	**Complex Tasks**
Preamble	Complex Tasks: That has some or all of the following characteristics:
Range of resources	Involve the use of diverse resources like human resources, funds, equipment, materials, information, communication, and technologies.
Level of interactions	Require resolution of significant problems from interactions between wide-ranging, or conflicting technical, engineering or other issues.
Innovation	Involve creative use of engineering higher-order skills and research-based knowledge in novel ways.
The consequence to society and the environment	Have a significant consequence in a range of contexts, characterized by difficulty of prediction and mitigation.
Familiarity	Can extend beyond previous experiences by applying principled-based design approaches.

Table-3 Knowledge Profile as per Washington Accord (IAE, 2013)

1.A systematic, theory-based understanding of natural sciences applicable to the branch of specialization.
2. Conceptually-based engineering mathematics, numerical analysis, statistics, and formal aspects of computer and information, communication technologies to support analysis and modeling applicable to the branch of specialization.
3. A systematic, theory-based formulation of Engineering fundamentals required in the engineering course.
4. Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
5. Knowledge that supports engineering design in a practice are**a.**
6. Knowledge of engineering practice in the practice areas in the engineering discipline.
7. Understanding of the role of engineering in society and identified issues in the engineering profession in the discipline: ethics and the professional responsibility of an engineer to public safety, the impacts of engineering activity; economic, social, cultural, environmental, and sustainability.

8. Engagement with selected knowledge in the research literature of the program.

After globalizing the Indian economy, foreign direct investments (FDIs) have surged through establishing manufacturing plants in the Indian industrial corridors and hubs. This resulted in an unprecedented demand for industry-ready graduates.

All India Council for Technical Education (AICTE) select faculty members to undergo Quality Improvement Programs (QIPs) in Indian Institutes of Technology, Indian Institute of Science (IISc), State Technical Universities, and Autonomous Engineering Colleges. Many state universities offered distance education programs or Massive Open Online Courses (MOOCs). Under World Bank assisted projects in Technician Education (Tech Ed-I to III), and Technical Education Quality Improvement (TEQIP) the engineering faculty members have been developed in many areas of engineering education. Indian Society for Technical Education (ISTE) is organizing summer and winter schools for updating the knowledge of the engineering faculty. Similar to these programs, new interdisciplinary courses are urgently needed for vocational teachers. All these efforts have focused on graduate attributes.

Ministry of Education (Formerly Ministry of Human Resource Development, MHRD) has started faculty development programs through Pandit Madan Mohan Malavia National Mission on Teachers and Teaching (PMMMNMTT). Ministry of education has established Academic Staff Colleges (ASC), now known as Human Resources Development Centers (HRDCs) in many universities for training the in-service faculty members. Now, these HRDCs are developing the faculty of arts, commerce, and science. Many journals are being published by many institutes and professional associations to disseminate the research papers and findings to the faculty members. Many national and international seminars and conferences are organized to publish the research papers and update the abilities and competencies of the faculty members. The organizers also offer many workshops to improve the critical skills of the faculty members with a deep focus on the graduate attributes. Many international organizations like Coursera, World Bank Institute, edX, etc. offer more than 1000 MOOCs for the benefit of the global faculty members, students, and others. Many educational organizations offer webinars. Many universities offer online master's degree programs in many branches. A few universities offer face to face (FTF) summer courses for the benefit of the MOOC participants.

Academic Problems Faced by the Engineering Students and the Faculty Members

Thousands of engineering graduates are NOT considered by employers for NOT possessing needed skills and competencies. Engineering faculty development courses are required to update the curricula, on-the-job training, competencies, attributes, and entrepreneurship development. They never had any mentors.

Unfortunately, many faculty development programs are not properly designed and implemented to meet the needs of various categories of faculty members. Many education administrators do not permit the implementation of sequential advanced faculty development programs in their institutes. Sometimes many curricula are NOT planned to meet the needs of Industry-4.0 which are due to improper linkage with the industries. Many revised and cutting-edge curricula could not be implemented due to the severe shortage of competent faculty members and for want of modern equipment and resources.

Case -1

Postgraduate structural engineering designed a water tank of 100000 liters capacity. After three years, it started tilting. Later it was declared unsafe and was demolished. The reason was, the structural engineer assumed the 'bearing capacity of the subsoil'. The subsoil is an unconsolidated silty soil. Up to 10 m, this loose silty soil is present whose bearing capacity is almost zero. The Structural Engineer should have demanded soil testing and bearing capacity of the subsoil. This shows that he did not possess the needed attributes. All the structural engineers need sufficient knowledge of regional deposits, physical characteristics, bearing

capacity, consolidation coefficient, shear strength, etc. before designing.

Case -2

A factory was constructed for a heavy forging of the components for tanks. When they operate one forging machine, there were very vibrations and sometimes resonance will occur. They could not operate more than one machine at a time. The reason was the soil dynamics under heavy forging machines were not investigated, The foundation engineer did not study the machine foundation. There is need for a course on the machine foundation for all foundation engineers. Again, the problem of shortage of attributes raise due to poor planning of the curriculum.

Case -3

A postgraduate civil engineer carried out a site plan for a two-acre plot. Later, local people approached the court and stopped the building construction. The problem was the civil engineers never studied development control rules, Town and Construction Acts, etc. Again, this is proof of incomplete attributes.

Case-4

An Agricultural Engineering Graduate could not design drip irrigation for a 10-acre planation. He can't prepare a layout, specify the required materials and estimate.

Case-5

An Automobile Engineer couldn't diagnose the starting trouble of SUV. All five cases center around the desired attributes of the graduate engineers.

These cases show the need for appropriate curriculum development, assessment of skills, planning, design, and implementation of cutting-edge programs for each cadre of the graduates. Many institutes don't plan the curriculum based on the needs-assessment. The faculty development programs should be based on professional needs. Many faculty development institutes suffer from increasing vacancies in the faculty and a shortage of modern resources. Further, many interdisciplinary postgraduate and doctoral programs are not available for the teachers. All these problems in faculty development have to be investigated and acceptable suggestions are to be made so that the graduates fully possess the needed attributes.

Objectives

The Objectives of this research are as follows:

- Identify the type of curriculum for various cadres of Engineering Education that will enhance the quality and attributes of engineering graduates.
- Suggest the establishment of various competency specific student development programs focused on the attributes and market-ready engineering graduates in the knowledge-based economy.
- Recommend engineering students to prepare portfolios indicating a list of development programs needed based on the advances of engineering, technology, management of higher education, communication technology, and the needs specified attributes of the industry to meet the career vision of the graduates.
- Suggest to review of the improved performance of the alumni and identify further student attribute development programs so that the graduates reach excellent careers.

Research Methodology

The research methodology is based on qualitative research using a naturalistic process.

Research Questions

The research work centers around the answers to the following research questions:

- What are the skills and attributes/ competencies that are required for the engineering graduates at various cadres that will enable them to develop industry-ready engineering graduates?

- Who is offering needed student development programs centered around the attributes in India by focusing on needed human capital?
- What are the benefits of acquiring skills and competencies that are earned by the engineering faculty members and that would be passed on to the engineering graduates?
- Is there any standardized list of abilities/attributes at various cadres for developing the needed human and knowledge capitals?
- What are the strengths/attributes of the graduates of engineering colleges to implement jobs and tasks in Industry-4.0?
- What are the weaknesses of the graduates and the engineering education subsystem which will pull down them in an industry?
- What are the new global opportunities available for the engineering graduates in the knowledge-based Indian economy?
- What are the threats that Indian Engineering Institutes face which would affect the performance and attributes of the engineering graduates?
- Whether the engineering graduates prepare any future-focused portfolio?
- How will the faculty members acquire needed skills and competencies in Engineering Education which can assist the graduates?
- Whether the faculty members can plan needed student development courses based on their portfolio?
- How will senior Engineering faculty members facilitate the growth of knowledge capital and human capital?
- How will the CEO assess the impact of engineering faculty development on the performance of the graduates?
- How will the engineering institutes get more return on the investments (RoI) made on the faculty training, modernization of the workshops, computers, and laboratories due to the performance of the graduates?

Literature Survey

Without any proper faculty development, industry-relevant curricula, instructional design, and delivery, there CAN'T be high-quality graduates with desirable attributes.

Khedkar (2012) emphasized the need for faculty development to facilitate the university for international collaboration in engineering education.

Francois Cilliers and Ara Teklan (2015) have created the following 11 key considerations and actions for an effective faculty development program in an institutional context (Table-1):

Table-1 Key Considerations and Interventions (Cilliers and Ara Teklan, 2015)

Focus	Interventions
Considerations	1. Relate faculty development to job requirements and balance the institutional need and individual aspiration. 2. Relate faculty development to the context of industrial practice. 3. Provide opportunities to practice with peers in a safe environment. 4. Make the path to change clear and feasible. 5. Anticipate challenges in transferring learning to practice. 6. Reward participants for implementing what has been learned.
Participants	7. Consider the participants' personal

	capacity to implement what is learned. 8. Provide resources for goal setting, follow-up, and feedback on performance.
Implem entation	9. Allow participants to apply learning in the workplace. 10. Anticipate how the context can influence implementation. 11. Design the program to enhance accountability for implementation.

They have concluded that the goal of any faculty development program is for the participants to utilize new knowledge, regardless of the context or motives for their participation. Focus on the enabling environment in which participants can translate the learning into practice and improve the attributes of the graduates.

NAE Grand Challenges (2006)

Engineering educators must embark on a worldwide transition to a more holistic approach to engineering. This requires i) a major paradigm shift from control of nature to participation with nature; ii) awareness of ecosystems, ecosystem services, and the preservation and restoration of natural capital; and iii) a new mindset of mutual enhancement of nature and humans that embraces the principles of sustainable development, renewable resources management, appropriate technology, natural capitalism (Hawken et al, 1999). Engineering educators must take a closer look at how engineering students are being prepared to enter the 'real world'. Engineers of the future must be trained to make intelligent decisions that protect and enhance the quality of life on earth rather than endangering it. Prepare engineers to become facilitators of sustainable development, appropriate technology, and social and economic changes is one of the greatest challenges faced by the engineering profession today.

Veronica Diaz et al. (2009) suggested appropriate faculty development for the 21st Century. According to them, the faculty need support in keeping up with an increasingly technological workplace, developing ways to further integrate technology into an instructional experience, and assessing student learning in a variety of instructional delivery modes.

Mona Holmquist (2016) stated that a lack of qualified teachers is a global challenge for future knowledge development. She suggested bridging the gap between practice and theory to enhance teaching quality as well as the importance of practice-based professional development to maintain teachers to work as teachers in a long-run perspective and recommended to use of designed modules.

Daniel Druhora (2017) observed that students are turning to engineer diplomacy to solve 21st Century Grand Challenges. Engineering Diplomacy students have to confront the global challenges from day one of class. Topics should range from water diplomacy to virtual reality and artificial intelligence, to weapons of mass destruction, nonproliferation, counterterrorism, nuclear energy, climate change, oceans and the high seas, food security, conflict resolution, and emergency response to a coastal-disasters.

Gerardo Gonzalez (2017) stated that faculty members play a massive role in the delivery of a world-class student experience. According to him, faculty ought to be aware of forces that are shaping their future roles and must maintain a voice on how their role ensures that any transitions align with professional standards for high-quality scholarship, teaching, and service.

Bilal, Salman, and Songsheeng (2019) have stated that faculty vitality is the main ingredient to enhance professional education and competence. Enriching the faculty vitality in key domains of teaching,

assessing, research, professionalism, and administration is perceived to improve the educational environment significantly and enhances the academic performance of learners. Faculty Development Program (FDP) has been considered as a stand-alone educational pedagogy in fostering the knowledge and professional skills of faculty.

Synthesis of Literature

- Focus on outstanding faculty development to create desired needed course outcomes/attributes of the engineering graduates;
- Creation of human capital to support the industries and knowledge-based Indian economy.
- Development of knowledge capital to support the leadership of the Indian industries;
- Institutional development through the high performing graduate engineers to undertake complex projects under International Development Agencies (IDAs);
- Establishing in-house faculty development programs based on the needs;
- Improve the return on investment (RoI) through outcome-based graduate programs, consultancy projects, research, and development to create innovative products and services.

Suggestions from the National Educational Policy (NEP 2020) [17]

- **The objective of Professional Education**
  "Build a holistic approach to the preparation of professionals, by ensuring broad-based competencies and 21st-Century skills, and understanding of the social-human context, and a strong ethical compass, in addition to the highest-quality professional capacities".
- Professional Education must seek to develop individuals with the capacity to combine a strong foundation of theoretical knowledge and specific competencies; the ability to connect theory to practice; an understanding of how their profession impacts and is impacted by society; generic competencies such as decision making, critical thinking, problem-solving and communication; and an ethical compass and disposition to be constructive, contributing citizens. Achieving such a goal necessitates that professional education is integrated with liberal education.
- Teacher education programs in professional education, at the college and university level, tend to have a wide scope of objectives. These need to be focused and teachers need to be educated to specialize in teaching subjects.
- Collaborative and experiential learning methods and an awareness of professional ethics need to be brought in systematically through improved education.
- India must take the lead in preparing professionals in cutting fast edge-growing prominence such as Artificial Intelligence, 3-D Machining, Big Data Analysis, and Machine Learning among others in technical education.
- Teacher Preparation and Continuous Professional Development (CPD): A very large effort towards the CPD of teachers will be needed to successfully implement the National Policy.

Inferences

The National Education Policy 2020 emphasizes on the 21st-century skills, social-human context, and the desired abilities of the graduates and teacher education.

Lessons Learned from the Tracer Studies [32]

NITTTR conducted several tracer studies to get authentic feedback from the alumni on the quality of curriculum, implementation, industry visits, and knowledge on the current industrial practices. It is learned that the courses are to be very much focused on the key skills required by the employers. The instructional delivery is to be focused on solving the industrial problems faced by the graduates.

SWOT Analysis

Strength, Weakness, Opportunity, Threat (SWOT) analysis has been done to identify the strength of the graduate engineers, their weaknesses, new opportunities for the students and faculty members, and the possible threats for the system and presented in Table-2.

Table-2. SWOT Analysis of Indian Engineering Education Subsystem

Strengths	Weaknesses
Motivated and high performing young students. Focus on high-level academic/industry careers. Have a goal for acquiring postgraduate degrees and doctoral degrees even many colleges are NOT offering and supporting. Wish to contribute to knowledge capital. Goal to become professional engineers in the short run. Committed to lifelong learning in the workplace. Capable of maintaining life balance. The best students are selected through national engineering entrance tests. They are all willing to excel.	Poorly designed curricula cause all types of failures. Poor instructional planning leads to poor quality graduates. Also, the growth opportunities for the graduates in the branch of specialization due to the absence of industrial exposure. The teachers were not exposed to the attributes expected from the students. The students never had any mentors to guide them. Not exposed to current technology and industrial applications. No research is work based on the needs of MSMEs. Most of the programs are outdated due to poor planning of the curriculum without any focus on the fast-growing technology.
Opportunities	**Threats**
Fast-growing industries due to global value chain (GVC) in the state. New industrial development is due to a globalized economy and global value chains (GVCs). A fast-growing economy demands sufficient human capital with desired attributes. More career development opportunities for highly qualified graduates are there. They can also become entrepreneurs.	If the students are NOT getting appropriate jobs, colleges will be closed due to a poor number of students who opt for engineering programs in that college. Due to a shortage of trained human resources and infrastructure and multinational companies would be preferring other fast-developing countries in Asia like Indonesia, Malaysia, Vietnam, Cambodia, Thailand. GDP growth will be lowered.

Analysis of Skills at Entry Level and Methods of Acquiring Competencies and Abilities

Table-3. Skills and Competencies and Method of Acquiring

No.	Skills and Competencies	Method of Acquiring	Resources and Facilitating Factors	References.
1	Industry-specific Instructi-onal Design	Courses offered by NITTTRs, Human Resource Development Units, ISTE Summer Schools, In-house	Well-designed course planning, Library, Internet Facilities, Planning for the cognitive skills to be acquired, etc.	2, 25, 26, 35, 36, 37, 38, 39, 40, 41.

		Faculty Development Courses, Webinars, Workshops, etc.	Assignments, tests, case studies, industry-specific project works.	
2	Curriculum Evaluation, Needs Analysis, Development, Formative Evaluation, etc.	Courses are to be offered as stated above, Project-based learning, synthesis of the outcome of tracer studies/ longitudinal studies, through the seminars on the industrial needs, and a focus on Industry-4.0 needs.	As stated above. Project-based learning, In house teams, Just in time learning, Industrial visits, and Collaboration with the industries for internships.	5, 13 6, 9,
3	Preparing Measuring Tools	As stated above, workshops, and self-study.	Commitment to quality outcomes and learner accomplishment.	Textbooks on Educational Measurement and Evaluation.
4	Laboratory Instruction	Focus on learning theories, use of the results for design, manufact-uring, etc.	Operation manuals, Calibration of equipment.	Workshops on quality testing.
5	Design	As stated above, Content updating, and Work Specific Software Applications.	Software and hardware, Industrial standards, Collaboration and cooperation with industries.	
6	Engineering Drawing	AutoCAD etc.	Software, Hardware and printers, Advanced Textbooks, and Reports.	Web-based learning materials
7	Estimation	Based on the current industrial practices, value analysis, etc.	Industrial standards, current market rates	Cost accounting.

8	Project Proposal	Participating in the project development meetings and preparing a proposal for the development of the department.	Needs analysis, vision, and mission, assessing the industrial needs, comparative analysis of global initiatives.	Government policies, assessment of human capital needs of the industry.
9	Counseling	Short courses on educational psychology.	Human relations, interpersonal development skills, and human resource dynamics.	
10	Coaching	Short courses on coaching	Do	
11	Mentoring	Courses on educational management and administration.	Do	
12	Publication of Instructional Materials	Courses on instructional design and publication of materials through reputed publishers	Publishing through reputed publishers.	
13	Instructional Leadership	Advanced courses on interpersonal relationships and leadership. Instructional system technology	Advances in institutional development, diverse global participants, growth strategies.	20, 32, 33, 34.
14	Accreditation through approved standards.	Quality, Effectiveness, Efficiency, Outcomes, Program educational objectives, and human capital development.	Global standards, instructional resources, management support, strategic planning, etc.	Global standards
15	Cooperation with the Local Companies	Industry-Institute-Government-Society-	Identify the technology used by the companies in the region	,

		Partnership, Creation of linkages with the industries.	and create an active link with them.	
16	Content Updating in Engineering, Mathematics, and Science Courses.	Advanced courses, finishing school courses, MOOCs offered by Coursera, EdX, World Bank Institute, etc.	Identify the advances in various subjects and the institutes which offer these courses. Apply for undergoing these courses through the institutes.	,
17	Interdisciplinary Research Methodology in Engineering Education.	Identify the institutes which offer interdisciplinary research programs and prepare a proposal and apply them through the college.	If selected, undergo the program. Also, try to identify the organizations which offer MOOCs in this area and apply them.	,
18	Undertaking Action Research	Identify the organizations which offer	DO	
	Projects (ACP)	ACP and select.		
19	Planning Industry Relevant Curriculum in Engineering Courses to meet the needs of Industry-4.	Identify the organizations which offer this type of course and apply.	Many research articles are available on GOOGLE. Try to select and download them.	
20	Planning industrial training courses for the students	Identify the industries in the region and link with them Send a list of students' applications and negotiate for admission.	Check through alumni and get the list of possible courses.	

Continuous Professional Development (CPD) for Heads of Institutions and others in Leadership Roles [17]

- There shall be CPD opportunities made available for those in leadership positions. New leaders must be fully supported through formal and informal mentoring. Post appointment professional conferences/seminars with other colleagues in similar positions, professional training programs, or a formal advanced degree must be made

available. To all those in leadership positions.

- The process of appointment should consider outstanding achievers and similar internal candidates who have been developed within the institution.

Senior Level Faculty Members

Fully qualified faculty members with more than 25 years of experience and planning for CEO posts. The accomplishments should be outstanding. The vision for growth is essential. Leadership should be outstanding. Try to plan outstanding new postgraduate and doctoral programs to create human capital. Assess global developments and plan new programs. The skills in institutional development should be foremost. Desired skills are presented in Table-5.

Table- 5. Analysis of Skills at Senior Level and Methods of Acquiring Competencies and Abilities

No.	Skills and Competencies	Method of Acquiring	Resources and Facilitating Factors	References
1	Developing Industry-Specific Postgraduate Programs: Now there is a demand for interdisciplinary postgraduate programs that are also industry-specific.	Conduct a comparative assessment of programs of global research universities and develop validated innovative programs.	Planning based on the qualifications fixed by industries, advances in the technology, & trends in new innovative product design. Involve alumni.	2,4
2	Planning and Conducting National Conferences for Disseminating the Advances in Cutting Edge Technologies.	Consult national and professional associations/ societies and plan national conferences.	Conduct planning meetings with research universities and leading industries to plan the conference.	8,18
3	Planning and Conducting International Conferences to Synthesize Innovations.	Form a multidisciplinary global team of experts.	Generate funds from industrial sponsors and companies who are marketing new products. Get the support of governments.	
4	Industry-Institute-Government-Society-Partnership to undertake product development and executive	Strat a partnership by involving all departments. Focus on consultancy and product development.	A dedicated Senior Professor, a website for providing the information on the innovations, products, and projects,	

	training.		completed.	
5	Networking with Global Research Universities and Organizations.	Utilize new opportunities like Indo-USA 21st Century Knowledge Initiative, SPARK, etc.	Develop multidisciplinary postgraduate and doctoral programs. Conduct diverse global faculty development.	
6	Protecting Intellectual Capital and Transfer to Industries through Agreements.	Register your innovations and apply for patents.	Validate the utility and fix a price/ royalty for utilization.	
7	Entrepreneurship development, Startups, Incubation, etc.	Focus on entrepreneurship-based programs. Mentor the participants through alumni.	Get funds from Angel investors. Assist in incubation. Assist in getting patents.	
8	Creating Research Parks and Innovation Centers.	Establish Research Parks through outstanding and multidisciplinary faculty.	Support the global bidding for projects. Create corpus funds.	
9	Creating a Learning	Conduct academic audits every	Have an open discussion. Create	
	Organization.	year. Learn the success and failure factors.	a problem-solving voluntary groups (Quality Circles). Synthesize the results and incorporate them into the policies.	
10	Planning new educational business models based on the National Education Policy.	Sale of Publications, Teaching-learning aids, video programs, MMLPs, Training materials, Contract Manufacturing, Lease of Halls, Rooms, Income through Executive development programs, etc.	Modern labs and workshop facilities, Physical space, Software, Auditorium, Classrooms, Playground, Transport facilities, trained staff members, outstanding faculty members, intellectual properties patented, etc.	,
11	Develop a Research Cluster for underta	A group of institutes joined to form a consortium of	Bid for research and development projects under	

	king complex research projects.	research institutes, extension centers, satellite institutes, etc.	MNCs, IDAs, etc. Provide training in preparing a technical proposal and financial proposal, writing agreements, etc.	
12	Transformation in Indian Engineering Education through Academic Autonomy to High Performing Faculty Teams.	Educational Leadership models, Administrative processes, etc.	Processing of offering academic autonomy, project-based administrative, and financial autonomy.	
13	Intrapreneurship and Innovation in Engineering Education.	Encourage the outstanding faculty to bid for the projects	Follow the MoE formula for sharing the project gains.	
14	Global Convergence to Improve the Internal Quality Assurance for Engineering	Academic Council, Academic Audit, Appreciative Appraisal, Quality in	Comparative studies on educational programs, internal quality maintena	
	Programs from Certificate to Postdoctoral Programs.	Academic Activities, etc.	nce, recruitment processes.	
15	Developing Massive Open Online Courses.	The methodology of developing self-instructional modules.	Online posting, Internet facilities, Trained instructional designers, self-evaluation tools	
16	Establish an in-house Faculty Development Center.	Planning training and development materials based on the faculty needs' analysis.	Support from the administrators, funds, planning, and implementation process.	
17	Reward the High Faculty Teams.	A policy of sharing the gains, MoE guidelines, sharing the gains in the consultancy works and projects	Norms approved by the Board of Governors.	
18	Create Project Specific Multidisciplinary Faculty Teams	Identify feasible projects based on in-house expertise and	Train the team members in planning and developing	

	and Nurture.	resources.	solutions. Follow the 3M Principles.	
19	Conduct Open House for Collaboration.	Inform the industry executives and society.	Prepare a list of outcomes due to research and accomplishments.	
20	Establish Publication Center.	Book, lab manual, drawing manual production principles, printing, and publication.	Expert writers, editors, proofreaders, draughtsman, DTP software, etc.	

Developing A Portfolio

Students have to prepare portfolios and plan to acquire needed abilities and the underlying competencies. This will assist them to develop the department through new graduate and postgraduate programs based the industrial needs. In the long run, they can't be left behind. The graduates outstanding accomplishments and contributions would facilitate the faster growth of the economy and a high return on tinvestment (ROI).

Desired Radical Innovations in Engineering Education

The senior faculty members must focus on the industry-specific curriculum development process. The graduates have to be developed through industry participation. The whole growth of the graduates' center around the vision and mission of the faculty members guided by the accrediting standards. Innovative graduates would improve their return on investment. Ultimately the competitiveness of the region would increase.

Radical and Innovative Self-directed Faculty Development Programs which need the Administrative Support

Many outstanding faculty members are selected to undergo international workshops, conferences, and internships based on their performances. Many CEOs refuse to forward the applications. The following cases are presented for the positive support of the CEOs (Table-7.).

Table. 7. Self-directed Faculty Development Programs

No.	Type of Self-directed Faculty Development Programs	Administrative Support
1.	The internship offered by a foreign university is based on the performance in an international workshop for one semester where no expenditure is involved by the parent institute.	Should provide nomination by availing the leave at credit.
2	Selection to undergo a training program in a foreign university under a bilateral agreement with the Indian government and the application was sent through proper channel.	The faculty has to be relieved to make travel plans and join the university programs.
3	The research papers have been accepted and the faculty have been awarded a travel grant for attending the international conference.	The chief executive officer has to grant permission to the faculty member to attend the conference since no expenditure is involved.
4.	A faculty has been selected initially to participate in a technical working group planned by	The faculty member's application has to be dispatched within the deadline.

	an international development agency	

Methods Adopted to Improve the Attributes of Postgraduate Engineering Students of HRD.

1. Offering interdisciplinary courses in Industrial Psychology, Sociology, Human Resource Development and Management, Human Resource Development, Multimedia, etc.
2. Involving the students in executive development programs.
3. Identifying dissertation topics from MSMEs, Government Engineering Departments, and Large-scale companies.
4. Encouraging them to participate in national conferences.
5. Attend the diverse global faculty development programs, forming small groups for case study analysis.
6. Providing to prepare bids for projects under IDAs.
7. Industrial exposures
8. Encouraging participation in the meetings of the Indian Society for Training and Development, Indian Society for Technical Education, & Institution of Engineers (India).
9. Case studies on real-life problems
10. Arranging guest lectures from industries.
11. Arranging visits to industrial exhibitions.
12. Arranging to participate in international seminars and conferences.
13. Providing real-life cases based on the topics to solve.
14. Exposure to maintenance activities.
15. Planning houses based on client needs.

All the above courses focused on industry-specific attributes. All the students are employed within three months after completing the program.

Faculty Development Programs with a focus on the Industrial Problems and Graduates Attributes

1. Cooperative Programs in the Irrigation Management and Training Institute, Trichy, Tamil Nadu
2. Planned Ground Water Engineering Program in Collaboration with Ground Water Engineering Section of the Irrigation Engineering department.
3. Transportation Engineering Program in collaboration with Airport Engineering Department, Highways, and Port Trust.
4. Developing Automobile Body Building Textbook in Collaboration with Ashok Leyland Ltd.
5. Developing Curriculum in Building Technology in collaboration with the Builders Society of Tamil Nadu.
6. Management Development Program in collaboration with Management Development in Government, Kerala.
7. Development of Film Technology Program in collaboration with the Institute of Film Technology.
8. Development of Diploma Program in Footwear Technology in Collaboration with Central Leather Research Institute.
9. Development of Wood Technology Program in collaboration with the Industries in Kerala.
10. Developing M.Sc. (Forestry) in collaboration with Tamil Nadu Forestry Department.

All these faculty development programs assisted the teachers to focus on the attributes required by the graduates.

A Course on Building Failures for the Teacher Trainees

A course on Building Failures was introduced to the Dip. T.T. trainees and B. Tech. Ed trainees. It is a tree credit course. Many textbooks are available. The objectives of this course are:

- To investigate the causes for failures.
- To identify the attributes that are required to prevent such failures.
- Develop utmost precautions in planning, designing, and constructing a building in complex soil conditions, earthquake quack zones, extreme wind forces etc.

- Introduce the safety concepts to the students.

The Outcome of this Course: The teachers' trainees learned the causes due to poor soil investigation, poor design, poor drafting, poor construction, and poor maintenance. They developed a positive attitude to improve the attributes of the students,

CONCLUSIONS

In a knowledge-based economy, the engineering graduates should possess industry-relevant advanced skills and competencies to critically analyze the complex industry problems in product analysis, design, prototype development, manufacturing, and maintenance. The engineering graduates must prepare their skill-based portfolios and they should plan to acquire outstanding abilities and attributes in learning industry-relevant courses, interdisciplinary research programs, and innovative startups, incubation, etc. The engineering students have to achieve the portfolios over a fixed period. The Boards of Governors must ensure that highly qualified faculty members are selected and offered needed faculty development programs that facilitate high-quality graduates who can bring innovations in product design, testing, manufacturing, and maintenance. The training and development organizations must prepare needed competency-based development programs for all cadres of the faculty members and heads of institutions. Such efforts are to be validated periodically and new courses are to be prepared. The CEOs have to relieve the faculty members to undergo foreign university training, present papers, and participate in the technical working committee meetings when their primary application has been sent through the proper channel. Self-planned engineering faculty development has to be supported that will lead to excellence in engineering education. The engineering students are to be guided to undertake dissertations from the MSMEs. They also are exposed to the failures of buildings, systems, machines, and projects so that they are forewarned about the causes. This approach would improve the attributes of the graduates. Annual feedback from the alumni on the key attributes will assist the faculty to inculcate the industry needs. It is suggested to plan maintenance workshops as one of the skill development activities for all engineering programs which will close the skill gap and improve the attributes of the graduates.

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