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Engineering Education in the 21st Century: Understanding Curricular Aspects and Teaching-Learning Practices

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Abstract

As a whole, compared to the global trends, there is little or less innovation in engineering education with meagre revision in curricula and practice of traditional teaching-learning strategies in India for a long period (even though there are a few exception). Today, strong controversies are going on around regarding how should Engineering curricula be restructured, in what ways teaching should be organized to attain the desired learning objectives, who should teach and what should be their qualifications, and how to make teachers of engineering better prepared to teach. These are stronger questions that are to be addressed. The need to ponder the overall instruction, structure, transaction and assessment of the Engineering education in its essence is at most significant. Recently, achieving a competency-based curriculum in technical education yields to the adoption of outcome-based education. Engineering disciplines demand innovative curriculum development and new arrangements in the teaching-learning process on a regular basis to meet the global standards and benchmarks in quality teaching-learning. In this context, this article discusses various approaches, curricular innovations and teaching methods in view of attaining quality engineering education.

Keywords: *Engineering Education, Teaching Strategies, Curriculum, Learning Aspects, Outcome-Based Education*

1. Introduction

Need for a 21st Century Engineering Curriculum

The need for a twenty-first-century engineering curriculum demands a profound change in upbringing the knowledge and skills, but inappropriately the curricula fail to meet the gap between syllabus and industry requirements. It influences the world globally, technically, socio-economically and digitally in many ways. Overall, these have a greater impact in the lacunae behind preparedness of students with skills, need for strengthening curricula, the necessity of enhancing faculty performance, providing additional academic support and failure to ensure holistic development and absence of pedagogical innovativeness. Engineering by profession needs to be understood within the milieu of its role in society as it proposes to prepare 'industry-ready' graduates with innovation into the career. Beyond technical acquaintance, it requires profound creativity, employability, professionalism, codes of ethics and so on (Lawlor, 2016).

Similarly, Rugarcia et al., (2000) discuss many thoughtful concerns and trends affecting the 'future of engineering education'. The most prominent view was that the traditional instructional methods not alone equip the engineering graduates to acquire the required knowledge, attitudes and skills rather, the new vision demands more alternative methods to have a long-term impact. The critical changes that would push engineering education to an advanced level require (a) thorough revisions in the engineering curriculum and course structure from time to time, (b) implementation of alternative

teaching methods and real assessments, (c) initiating instructional development programs both for students and faculties, (d) adopting reward mechanisms for raising faculty improvement and advancing teaching. Establishing alternative pedagogical techniques like co-operative (team-based) learning, inductive/discovery learning, triggering the chance for open-ended discussions, practical problem-solving exposures and other approaches would overthrow traditional teaching methods such as lectures, readings, note-taking, and the rest.

Moreover, the engineering education should put forth graduate competencies such as synthesizing knowledge, professional skill development, problem-solving, curriculum design and instructions, summative and formative feedback to cope with 21st-century technical education (Engineering Education Graduate Competencies, 2005). Engineers require newer competencies, capabilities and professional skills to compete for local, national and global challenges. There are numerous gaps in preparing the engineers with adequate skills that satisfy society's demands, failure to develop innovative curricula, and enriching learning experiences. Often it is not easy to find qualified professionals (Morell, 2010).

In addition to this, Kapranos, (2013) seeks answers in resolving fundamental questions that addresses' engineers of the 21st Century, the skills they need to possess and envisioning teaching-learning in the context of engineering education'. The 21st-century engineering should inculcate the skills, scientific, economic, social and practical knowledge which can at the same time be understood concerning other disciplines as well.

2. Curricular Aspects

The curriculum generally refers to the students' knowledge and skills during their entire course of study. It relies on several factors, including meeting the course's learning objectives, methods of teaching-learning strategies adopted, successful completion of attributed assignments and projects, methods of evaluation, assessments, and tests to estimate student learning. Unlike other subjects, Engineering curriculum plays a pivotal role in determining the quality of technical education and the technical know-how and capabilities students gained throughout their graduation. Further, it benefits graduates in entering the workforce successfully even after graduation.

It is evident that the central feature of engineering curriculum centres around the acquisition of Design skills and Problem-solving skills and it is demanded by the society by and large. It should be in accordance with the changes and technological advancement happening around the global scenario. Mostly the world-class curriculum is designed in par excellence with outcome-based. Most of the curriculum is designed in due significance with the courses' nature and content (Idachaba, 2018).

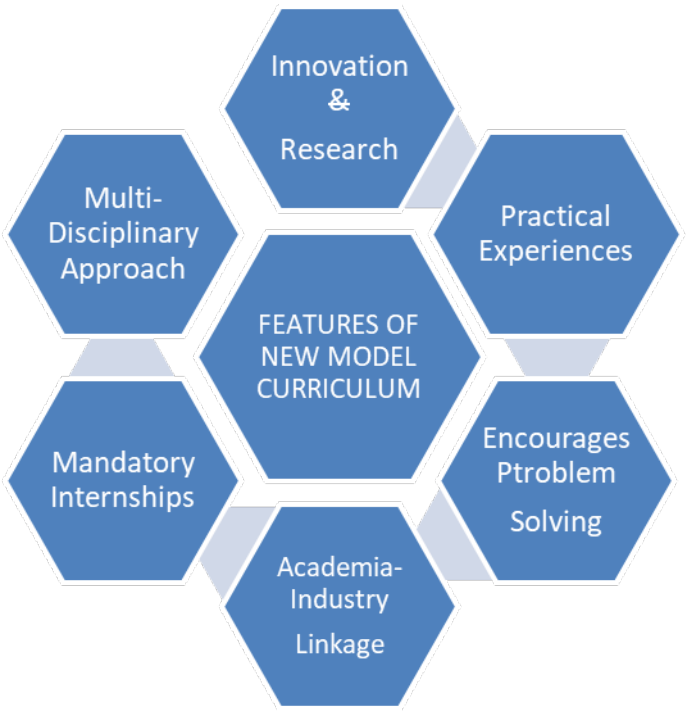

Figure 1. New Curriculum Model:

Source: Formulation based on AICTE Guidelines

As we k ow, in realizing the need to improve technical education quality, AICTE has re-vitalized a few quality initiatives like conducting mandatory induction programs, periodic curricular-revision, examination reforms, compulsory accreditation, and the rest. Furthermore, the broader perspective plans for providing outcome-based education. It has paved the way to the revision and update of the Under and Post Graduate curriculum of engineering education, which offers improved engineering discipline flexibility. The new model curriculum's salient feature envisages flexibility in different engineering disciplines, thereby encouraging innovation and research for linking institutions and industry, providing better hands-on experience and enduring opportunities for internships.

Besides, the stipulated activity programme recommends 1000 hrs training, 600-700 hrs obligatory internships and set aside 300-400 hrs. for community and other services for each technical graduate.

3. Towards Outcome-Based Education

The outcome-based education commonly termed as OBE is implemented recently in engineering education in India, which is assessed based upon evaluating different categories of parameters consisting of programme outcomes (PO), Course outcomes (CO), Program Educational Objectives (PEOs), Graduate Attributes (GA) and is structured in a manner based on measuring the outcomes in terms of understanding, evaluating and analyzing the skill level required by students in their whole educational process. Adopting OBE into the curricula has relied on content delivery (CD) and assessment methodology (AM). It elaborates students' graduation attributes to acquire the skill and required learning objectives (Ravindran & Lenin). Let us explain some of the strategies and elements of teaching-learning further.

4. Teaching- Learning Strategies

Engineering education is facing many deep-rooted challenges in terms of employing decent teaching and knowledge deployment. Besides conventional teaching methods, technical education requires contemporary and up-to-date teaching strategies and learning approaches. The shift in teaching-learning standard from purely teacher-centric to learner-centric overlook new approaches to engineering pedagogy. Undoubtedly, the quality of teaching primarily depends on the qualifications and competencies of the teaching faculties. Hence, the educators' quality and knowledge and introduction of effective teaching strategies tend to imbibe students with critical thinking, in-depth understanding, self-analyze, apply concepts and outstands to achieve academic success. Teachers should become expert in adopting a wide variety of teaching strategies to support students in moving beyond mere memorization. Simultaneously, this kind of teaching models in the form of questioning, structuring the lessons, proper communication, and feedback will enhance students' understanding.

Previous research evidenced that the major requisite like content, pedagogical and learners knowledge are vital in teaching engineering education (Kipper & Ruutmann, 2013; Eggen & Kauchak, 2006). Teachers' attitude and skills, followed by adopting precise teaching strategies for better-promoting students understanding, were also significant. Following innovative strategies like Inductive or Integrative Models, the Model of Direct Instruction proves high results of improving students' academic achievement and ensuring meaningful outcomes. Engineering educators must obtain knowledge in each of the concerned areas to make their instructions systematic and competent (Prince & Felder, 2006: Eggen & Kauchak,2006: Paik,2003: Lang & Evans,2006: Melezinek,1999).

Likewise, Chaubey et al., (2018) indicate that engineering education challenges in enabling good teaching are enormous since new teaching and learning approaches must be advanced in technical disciplines. It is crucial that the adoption of effective teaching methods would necessitate quality enhancement and highly advents students' academic performance. Still, major research gaps endure as a barrier to effective teaching in the modern era, particularly in the engineering field. Muchmore attributes were to be taken into consideration as a strategy for evaluating effective teaching. It would consist of imparting persuasive training programs, viable assessment models and intense feedbacks to evaluate teaching practices and learning.

Figure 2. Attributions of teaching

Source: Adapted from Chaubey et al., 2018

Further, teachers' interest and awareness about learning, effective interaction within the classroom, and assigning daily activities, experience-based evaluation techniques, and feedback mechanisms promote good teaching. Innovative practices in teaching-learning can enhance educational practices in engineering education and stimulate the quality of higher education. Failure of academic institutions in providing quality education and lesser adoption of innovative pedagogical practices limits student performance. Enabling precise best practices such as peer-to-peer learning, collaborative learning, participative and technology-enhanced learning widely helps improve teaching-learning quality and produce outstanding engineering graduates (Kumar et al., 2018).

Motivation, active learning, engagement and assessment drives the learning process. Rather than lecturing, encouragement of active learning methods is better effective, Similarly, promoting group or teamwork within the engineering learning system before entering into employment would improve results. Ensuring the learners' active participation or whole-hearted engagement would greatly enhance the learning process, and technical assistance in engineering education would significantly support the teaching-learning process.

What do we infer then? A class comprising of passive learners learn less effectively since they were neither active experimenters nor reflective observers which is true in engineering education. Felder, (2002) in his study' Learning and Teaching Styles in Engineering Education' indicated that students' learning styles and teacher's teaching styles in most technical institutes were incompatible in various aspects. The teaching-learning process in most of these institutes relied only on auditory, abstract, and intuitive-based, passive and sequential, leading to students' poor academic performances. At the same time, the quality of learning can be enhanced by changing professors teaching techniques to incorporate approaches that pave attention to motivate learners, provide in-class activity, use of pictures, graphs, sketches that elaborate with ease, taking assistance of ICT-enabled technologies, giving timely intervals to refresh and recollect the taught matters, appreciate creativity and encourage learning styles to make teaching worth enough.

Even though the central Government has launched few programs like Quality Improvement Programs (QIP) and Technical Teachers Training Programs as well as setting up of Technical Teacher Training Institutes (TTTIs), and Academic Staff Colleges (ASCs) in its earlier outset, it was not acquiescent towards improving the teaching skills. Comprehensive Training Policy for Technical teachers put forth by AICTE, 2018 foresee reducing this lacuna and envisage to improve the quality of teaching-learning process in technical education by enhancing educators' professional skills and imbibe values, encourages student-teacher interactions, proper mentoring and make them well informed with latest developments.

5. Alternative Suggestions for curricular revival

Eventually, the curriculum lags the connection between the fundamental application and the teaching methodologies adopted. Students are not covered with understanding the actual world industry demands, unfamiliar with the tools and applications of modern types of machinery and receive less hands-on experience of projects. The quality and content of the engineering programs should be periodically evaluated by academia, and subsequent intervention to monitor institutions' educational best practices will be an added advantage. Encouraging both students and faculties with highly-priced rewards and appreciation may also add academic benefits. Several of the issues can be addressed by propounding interdisciplinary/ cross-domain degrees by which students get the advantage of it.

Another limiting factor is that of the failure in offering high-quality course content that exemplifies global standards. The effective enrollment of undergraduate engineering students in courses like Massive Open Online Courses (MOOC), SWAYAM will also mandate curriculum needs. The prerequisite of incorporating Summer- bridge programs would aid students to increase their knowledge and skills.

6. Conclusion:

Besides, to the formal classroom training and learning, encouraging collaborative project works, active participation in team activities and involvement in co-operative learning programs across multiple-semesters paves the way to prepare engineering graduates for employability better and enter the workforce. Encouraging active, group, and peer learning would well reflect upon student success. Productive internships with reputed industrial firms may enable students to associate with experienced engineers who will also have massive outcomes. Conducting skill-based empowering workshops within institutional settings, campus engagements, peer-pairing programs, academic and career support services enhance the curricula and educational programs. Proactively the need for new approaches such as 'Evidence-based'/'Competency-based' approaches add value to teaching- learning and curriculum in engineering education. Innovation- like adoptions, blending and fusion-are the need of the hour in the curriculum of engineering education.

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