CURRENT STATUS OF GLOBAL ENGINEERING EDUCATION: MINI REVIEW

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Abstract

This mini review addresses global engineering education, its diversity, its challenges, and its geographical disparities. Engineering education is essential to sustainable development. The review stresses the need for interdisciplinary engineering that considers social, economic, and environmental concerns. Specialised engineering education packages are increasingly emphasising sustainability. This combination gives engineers the knowledge and abilities to create solutions that meet present needs while preserving resources and future generations. Despite its importance, this brief study highlights global engineering education challenges. Access to high-quality education is unequal, favouring pupils with strong math and science backgrounds. The lack of academic and student diversity may limit perspectives and innovation. Curriculum should also adapt to rapid technological change and industry needs. Internationalising engineering education is complicated by varied standards and teaching methods in different nations, making global comparison and collaboration difficult. The review compares educational systems in India, Malaysia, the US, the UK, China, Australia, Germany, and Indonesia. Regional variances are monitored by certification authorities to ensure compliance with local industry standards. The study emphasises the need for a flexible, well-planned curriculum. Optimal curriculum should align educational goals with industry-specific competencies, be flexible to meet technological developments, and be interdisciplinary. This aims not only meet student educational and career goals but also ensure a workforce with the skills and knowledge to address today's important concerns, particularly sustainability.

Keywords: Engineering Education; Sustainable Development; Curriculum Design; Global Perspectives; Regional Differences.

I. Introduction: What is engineering education

Engineering education encompasses the comprehensive examination of the fundamental principles and practical aspects of engineering. This field focuses on the utilisation of scientific knowledge, technological advancements, and mathematical principles to facilitate the development, creation, and functioning of various systems, machinery, and structures [1, 2]. Engineering education commonly encompasses a curriculum that incorporates a range of subjects, including...
mathematics, physics, chemistry, and other natural sciences. Additionally, it incorporates specialised engineering disciplines such as electrical engineering, mechanical engineering, civil engineering, and computer science [3-5].

Engineering education encompasses the cultivation of practical aptitudes and experiential learning, facilitated through laboratory experimentation, design undertakings, and professional placements. The primary objective of engineering education is to cultivate graduates who possess a comprehensive understanding, innovative thinking abilities, and adeptness in the practical implementation of engineering principles and methodologies to address tangible challenges encountered in the real world.

Engineering education is commonly provided at both the undergraduate and graduate levels, resulting in the attainment of degrees such as a Bachelor of Science in Engineering (BSE), Master of Science in Engineering (MSE), or Doctor of Philosophy in Engineering (PhD). Individuals who have successfully fulfilled the requirements of a professional engineering programme and have demonstrated their competence by passing a licencing examination are commonly recognised as professional engineers (PEs) [6, 7].

II. Challenges in engineering education

Engineering education encounters various problems, which encompass:

The accessibility and diversity of engineering education are sometimes seen as limited to students who possess a solid foundation in mathematics and science. Additionally, there exists a dearth of diversity among both students and instructors within numerous engineering programmes [7, 8]. The presence of this barrier might provide challenges for students belonging to underrepresented groups who aspire to pursue careers in engineering. Moreover, it can impede the inclusion of diverse perspectives and approaches in addressing engineering challenges.

The field of engineering education is subject to continuous evolution due to the emergence of new technologies and methodologies. Educators sometimes have difficulties in staying abreast of these changes and integrating them into their courses [9, 10]. Furthermore, it might be argued that conventional teaching approaches that rely heavily on lectures may not be optimally suited to effectively include students in the intricate and practical aspects of engineering.

The practical applicability of engineering: It is imperative for engineers to possess adequate readiness in addressing real-world challenges. However, a disparity sometimes arises between the curriculum taught in engineering programmes and the demands of the industry [11, 12]. This phenomenon can provide challenges for recent graduates in their pursuit of work opportunities, as well as for businesses in their search for people who possess the requisite qualifications and skills that align with their specific requirements.

Internationalisation: The field of engineering education operates on a global scale, attracting students and faculty members from many countries [13, 14]. Nevertheless, it is worth noting that engineering education varies among nations, leading to challenges in the comparison and evaluation of programmes, as well as hindering international collaboration on projects.
The provision of funding and resources poses a significant difficulty for universities and colleges in the realm of engineering education [15, 16]. This is mostly due to the requirement of costly laboratory equipment, software, and other essential resources. The aforementioned circumstance may impose constraints on the variety of courses and experiences accessible to students, hence posing challenges for instructors to remain abreast of contemporary technology and methodologies.

III. Engineering education for sustainable development

Engineering Education for Sustainable Development (ESD) represents an evolving paradigm within engineering education that emphasizes the integration of principles and methodologies geared towards fostering a more sustainable future. This form of educational approach prioritizes the incorporation of scientific knowledge and technological innovation into the development and management of various systems. The overarching aim of ESD is to arm current generation engineers with the requisite skills and knowledge, enabling them to address present-day challenges without prejudicing the well-being or opportunities for coming generations.

The urgency to transition to a low-carbon and resource-efficient economy is an eminent challenge that confronts the global community. Engineers stand at the forefront of this transition, burdened with the responsibility to design and implement systems that not only fulfill the needs of diverse sectors, but also prioritize environmental conservation. In light of such circumstances, a strong case exists for reorienting engineering education to absorb sustainable development principles. This could involve exposure to a variety of industry perspectives and an emphasis on experiential learning approaches. Within this pedagogical framework, students engage in hands-on experiences through methods like project-based learning and internships, affording them the aptitude to handle real-world challenges effectively.

A focus on ESD prepares students to actively partake in shaping a future that aligns with sustainability goals. This includes the ability to design and build energy-efficient systems and environmentally benign technologies, while simultaneously engaging in analytical thinking about their societal, economic, and environmental impacts. Engineers educated under this approach acquire the skills to address complex socio-economic and environmental issues, and possess the ability to collaborate in efforts aimed to nurture a globally sustainable and resource-equitable society.

In summary, the inclusion of ESD principles into engineering education is widely considered a crucial enabler in hastening the move towards a sustainable global future. The goal here is to adequately prepare a new cohort of engineers who are competent and skilled in developing and deploying sustainable technologies and systems. This approach aims to respond effectively to our ever-changing environmental sustainability needs and achieve long-term objectives, thereby contributing to a more robust global environment for future engineering generations.

IV. Engineering education in several region

Education in engineering is a competitive area in India. There are a huge number of students pursuing degrees in engineering, and there are many educational institution
that provide various engineering degree programmes. Engineering education is mostly pursued at the undergraduate level, awarded as a Bachelor of Technology (B.Tech) or Bachelor of Engineering (B.E.) degree. Also, there are a variety of postgraduate programmes in engineering that can be pursued in India. These include programmes leading to a Master of Technology (M.Tech) or Master of Engineering (M.E.), as well as doctoral programmes that can be completed to earn a PhD in Engineering. These programmes are often more specialised and focused on a specific area of engineering.

Education in engineering can be obtained from a wide variety of educational establishments, such as universities, colleges, and technical institutes. These institutions are often associated with one of the technical boards or councils that are responsible for the administration of engineering education in India. Some examples of these boards and councils include the All India Council for Technical Education (AICTE) and the University Grants Commission (UGC). There are also a number of private universities in India that provide engineering education. These institutions may be more expensive, but they may also provide more adaptable and specialised course options. Overall, engineering education in India is a popular and competitive field, with a wide variety of programmes and institutions available to match the demand for competent engineers in the country. This is because India has a large population of people who are interested in becoming engineers.

Education in engineering can be obtained from a wide range of establishments in China, including universities, colleges, and technical institutes. These educational establishments are often associated with one of the technical boards or councils that are in charge of engineering education in China. Some examples of these boards and councils are the China Association for Science and Technology (CAST) as well as the Ministry of Education (MOE).

Education in the field of engineering can be obtained from a number of different establishments in Malaysia, including universities, colleges, and technical institutes. The Malaysian Qualifications Agency (MQA) or the Ministry of Higher Education (MOHE) are two of the technical boards or councils that are in charge of engineering education in Malaysia. Generally speaking, these institutions are associated with one of these boards or councils.

Education in the field of engineering can be obtained from a number of different establishments in Indonesia, including universities, colleges, and technical institutes. These educational establishments are often associated with one of the technical boards or councils that are in charge of engineering education in Indonesia. Some examples of these boards and councils include the Indonesian Directorate General of Higher Education (DIKTI) and the Indonesian Association of Engineers (IAE).

Education in the field of engineering can be obtained at a number of different establishments in the United States, including universities, colleges, and technical schools. Typically, one of the engineering accrediting agencies, such as the accrediting Board for Engineering and Technology (ABET), is the body that bestows accreditation onto these educational establishments.

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Education in the field of engineering can be obtained from a wide range of establishments in Germany, including universities, colleges, and technical institutes. The accrediting Council for Engineering and Science (ACES) and the German Engineers Association (VDI) are two of the engineering accrediting agencies that commonly accredit these types of universities.

Education in engineering can be obtained at a number of different establishments in Australia, including universities, colleges, and technical institutes. Usually, one of the engineering certification authorities, such as the Institution of Engineers Australia (IEAust) or the Australian Council of Professional Engineers (ACPE), grants accreditation to these schools so that their programmes can be taught to students.

V. Engineering education requirements

The prerequisites for an engineering education might vary significantly from one programme and school to the next, as well as according to the level of education being pursued (bachelor’s, master’s, or doctoral). On the other hand, most engineering programmes adhere to a standard set of prerequisites and other requirements.

At the undergraduate level, the majority of engineering programmes require students to have completed certain courses in mathematics (such as algebra, geometry, and calculus), as well as certain courses in science (such as physics and chemistry). Additionally, students must have a high school certificate or an equivalent degree. It’s possible that some programmes will require you to have specific knowledge in other fields as well, such engineering design or computer science.

Students applying to graduate engineering programmes are often required to hold a bachelor’s degree in engineering or a field that is closely linked to engineering, and they must have maintained a minimum grade point average (GPA) during their time spent pursuing their undergraduate degrees. Additionally, the submission of test scores (such as those from the Graduate Record Examination, or GRE) and letters of recommendation may be necessary for admission to certain programmes.

Students applying to engineering doctoral programmes are normally required to hold a master’s degree in engineering or a field that is closely linked to engineering, as well as a good grade point average (GPA) from their time spent studying at the graduate level. In addition to exam results, letters of recommendation, and a research proposal, they may demand that applicants submit these items.

In general, a solid foundation in mathematics and physics as well as a documented track record of academic accomplishment are required to pursue an education in engineering. However, the criteria for engineering education might vary greatly depending on the particular programme and school.

VI. Curriculum design for engineering education

Crafting a curriculum for engineering education involves structuring a methodical study program geared towards grooming students for engineering professions. This usually calls for the
inclusion of courses and experiences that furnish students with a strong grasp of mathematics, science, and engineering basics, along with the capability to apply these essentials to real-world situations.

When shaping a curriculum for engineering education, several crucial aspects are weighed, such as:

1. Program Objectives: A curriculum in engineering education ought to be custom-fitted to fulfill the unique goals and objectives of the specific program. These can range from preparing students for a particular engineering field to making them eligible for professional certifications.

2. Program Level: Whether it’s an undergraduate, graduate, or PhD course, the curriculum design should fit the program’s level, encompassing the depth and breadth of topics accordingly.

3. Student Needs: The curriculum has to be attuned to meet the necessities and interests of the students. It should equip them with the knowledge and skills needed for both academic success and career advancement.

4. Industry Requirements: The coursework should be constructed with an eye towards meeting the industrial needs of the engineering sector. That implies instilling in students the in-demand skills and knowledge that employers are looking for.

Generally speaking, crafting a curriculum for engineering education requires setting up a well-ordered study program. It should not only root students in the fundamentals of math, science, and engineering but also capacitate them to utilize these basics to tackle real-world challenges.

VII. Conclusion

Educational pursuits in engineering encompass multifaceted and international dimensions, having substantial implications on societal issues as well as endorsing sustainability for the long term. Curriculum development is but one aspect of this extensive endeavor. Students embarking on engineering studies have to traverse a diverse range of subjects, from mathematics and natural sciences to specialized engineering disciplines. It’s noteworthy that although engineering is a universally practiced discipline, its academic programs are remarkably region-specific, reflecting local emphases and arrangements. This localization is chiefly mediated by distinct regional accreditation bodies.

However, engineering education is also constrained by multiple challenges which impede its evolution. The impediments range from, but are not confined to, lack of diversity among students and faculty, rapid technological changes, industry-relevance obligations, the necessity for global reach, and limitations rooted in resource scarcity.

Given these multifarious issues, prioritizing curriculum design is of critical importance to align the educational outcomes with the demands of the corporate sector and broader societal expectations. Consistent reevaluation of academic programs is not just essential but imperative to ensure that graduates are aptly conditioned for the challenges they will face in the professional world. Such reevaluations should make provision for the integration of emergent technologies and instructional methodologies. Moreover, interdisciplinary education ought to be front
and center in the instructional strategies, offering students ample opportunities for skill enhancement necessary for tackling complex real-world problems.

Promotion of sustainability is another critical facet that needs to be woven into engineering education. Future engineers should not just be technically proficient but also possess the necessary acumen to contribute to a future that is equitable as well as sustainably responsible. To effectuate this, a tripartite collaboration among educators, governmental agencies and industry is absolutely crucial. Their continual engagement will ensure that engineering education remains pertinent, inclusive and attuned with the global sustainability goals.

VIII. Future research recommendations

The prevailing state of engineering education possesses room for enhancement, yet a more rigorous investigation is needed for grasping the challenges at hand and capitalizing on existing opportunities. As directions for future research activities, these themes may be considered:

1. Underrepresentation in Engineering Programs: A comprehensive study is required to unveil the root causes contributing to the lack of diversity in engineering programs. Research could look into numerous methods for ameliorating inclusiveness, focusing especially on the recruitment and retention of underrepresented demographics.

2. Curriculum Relevance: Given the rapid speed of technological advancement, longitudinal studies assessing the efficacy of existing curriculums in meeting industrial needs are essential. Such studies would facilitate timely revisions to educational frameworks, keeping them aligned with ever-changing industry expectations.

3. Interdisciplinary Approach: The need exists for case studies that delve into the effectiveness of interdisciplinary engineering programs. Research of this kind would shed light on efficient ways to incorporate disciplines like environmental science, public policy, and social sciences into engineering education. The U.S. could be a focal point for these studies.

4. Global Standardization: Employing comparative studies across various nations may serve as a tool for inching towards global standardization of engineering education. Such steps could ease the recognition of engineering credentials across borders, thus enhancing international mobility for professionals.

5. Resource Allocation: Research into how limited resources impact the quality of engineering education is especially relevant for institutions in less-developed countries. Insights from such studies could guide more effective resource allocation models.

6. Sustainability Metrics: Investigative work is necessary to develop metrics for assessing how engineering programs are incorporating sustainability concepts. The findings could be standardized into accreditation procedures.

7. Faculty Development: As curriculum changes, so must teaching methodologies. Research into effective faculty development programs could offer educators the tools they need for adapting to
changes, thereby elevating the overall quality of engineering education.

8. Industry-Academia Collaborations: Studies examining successful examples of such partnerships could yield valuable insights into best practices. This could encompass a wide array of activities, such as research projects, internships, and co-op programs.

9. Longitudinal Studies on Graduates: Tracking engineering graduates over a prolonged period can provide nuanced understandings of their career trajectories, job satisfaction levels, and contributions towards sustainability. Such investigations enrich our perception of the real-world impact of engineering education.

10. Online Education: Given the surge of online educational platforms, particularly post-pandemic, research into their effectiveness, inclusivity, and educational outcomes is timely and pertinent.

By bridging these research gaps, educators, policy-makers, and industry stakeholders could gain crucial insights. This will enable data-driven decisions that could shape the future of engineering education, making it more inclusive, relevant, and aligned with sustainability goals.

IX. References


