Journal of Engineering Education Transformations,
Volume No 36, January 2023, Special issue, eISSN 2394-1707

10.16920/jeet/2023/v36is2/23053

A novel way to designing the undergraduate mechanical engineering curriculum using active stakeholder participation

Sachin B. Khot, Sachin K. Patil, Sushma S. Kulkarni
Department of Mechanical Engineering, Rajarambapu Institute of Technology, Rajaramnagar, Maharashtra, India

***Abstract*— Curriculums that are adaptable to the demands of the communities they serve are the most effective. Whether you intend to modify an existing curriculum or develop one from scratch, you must first undertake an evaluation. This article outlines the creative method utilised to develop the new curriculum in accordance with AICTE requirements. The first stage in formulating a plan is to determine the industries where graduates will find work and the skill sets they will require to be successful in those professions. The strategy emphasizes the need of including important stakeholders in curriculum development at an early stage. According to the findings of a survey given to a diverse group of stakeholders, there are issues with the current curriculum as it is assessed. This paper presents a case study of the development of the mechanical engineering curriculum at Tier-I institution from western Maharashtra for undergraduate (UG) students.**

***Keywords*— Curriculum Design; stakeholders' involvement; active participation; Mechanical Engineering.**

***JEET Category*— Practice paper**

I. INTRODUCTION

CONCERNS have been raised all over the globe about the market potential of graduates from educational programmes in technical fields like engineering. According to the findings of a study conducted in 2021 on the subject of talent shortages the countries with the most severe talent shortages are Taiwan (88%) and Portugal (85%). Near to 90% of the companies polled in Singapore (84%), china (83) India (83%), said that talent shortages restrict them from recruiting candidates with the required expertise. This issue is pervasive across Asia Pacific. Global average of talent shortage is about 75% [1].

Today's industrial workplace is characterised by a high-performance work ethic, intense competition, a greater emphasis on quality or value addition, a greater range of products and services, and an increase in automation. The business world demands college grads who are job-ready, meaning they have the necessary skills and are able to immediately begin working on whatever projects or responsibilities have been delegated to them. Not only are technical knowledge and abilities included on the list of anticipated competences for graduates, but also the capacity to collaborate effectively in groups, leadership, interpersonal skills, communication, creative thinking, and flexibility. Due to the shortage of professionally trained people in the industry, businesses will need to invest time, money, and resources into training workers so that they are ready to work. Due to the situation, there must be more contact and collaboration between the different engineering institutes and the industry. Even if a lot of subcomponents of the technical education system require improvement, the curriculum and teaching techniques are the two subcomponents that require immediate attention in order to produce graduates who are industry-ready [3].

A crucial part of every curriculum is ensuring that student learning is directly applicable to real-world contexts. The primary issue with curriculum is that it eventually becomes irrelevant and cannot fulfill external demand. The distractions will make it hard for students to learn. A lack of motivation to learn will slow a student's progress. Not doing so is not in the student's best interest.

To address this issue, the curriculum must be evaluated on a regular basis. The faculty has a unique opportunity to keep track of the curriculum he/she is presenting and give adjustment ideas as he/she goes. Thus, an attempt was made for design and development of UG mechanical engineering curriculum at tier-I institution of western Maharashtra with an innovative approach. Section 2 contains the details about the methodology adopted. Section 3 describes the implementation of proposed methodology and procedure of involvement of various stakeholder in curriculum design & development. Section 4 discusses the result and analysis of feedback survey from stakeholders.

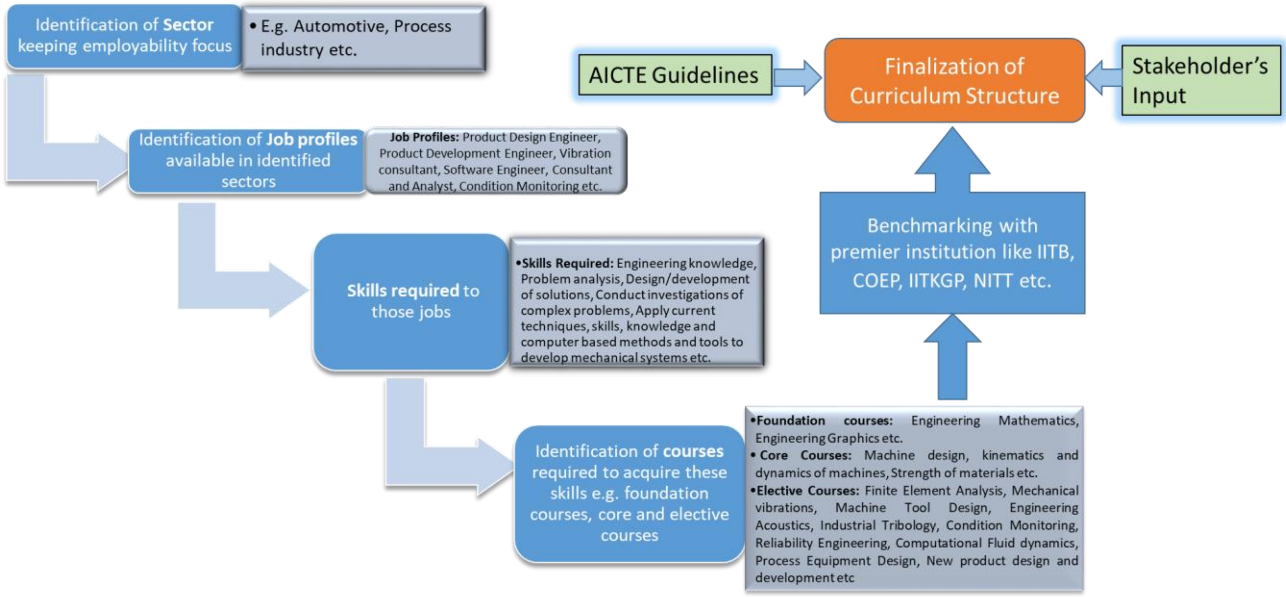

Fig. 1 Methodology adopted for the curriculum structure design and development

II. METHODOLOGY

The terms curriculum and syllabus are interchangeable. The course is the component of the teaching and learning system that is considered to be the most important. There will be a connection made between the learning and teaching objectives that are specific to each curriculum. Certain learning outcomes are predicted to occur once instruction on a topic has been completed. Therefore, the curriculum serves as the primary motivating factor for everyone. In particular, intellectual activities carried out in the classroom to be considered high-quality, a curriculum needs to be able to adapt its instructional activities and services to the shifting demands of today's society. In this particular scenario, Industry refers to the place in which the student will find employment when he has finished his graduation. The manufacturing sector is fundamentally dynamic. Ability in areas such as technology, interpersonal relationships, and communication are becoming increasingly important in various industrial sectors. Students must be provided with an overview of the outside environment and its expectations as part of the curriculum that is given in the classroom. Students' skills should match industrial needs. Curriculums become obsolete and can't fulfil industrial needs. Hence, there is need to identify the skills graduates need.

In this paper, the industries where mechanical engineering graduates will work are selected initially. The skills required by these industries are then mentioned. Furthermore, the courses that must be added to the curriculum in order to obtain these competencies are indicated. This task is performed over several days. A one-day workshop was organised to determine the final courses required for the mechanical engineering curriculum for undergraduates. Figure 1 depicts the methods utilised to identify the courses.

Formation of faculty teams is the starting point in the curriculum design procedure. These faculty teams are formed according to their area of study and competence, based on their post-graduate education and professional experience. In addition, a one-day workshop was organised to debate the motivation for this work. During this one-day training, faculty teams were tasked with identifying several industries in their respective areas where recent graduates find employment. In addition, professors were requested to determine what capabilities these graduates must acquire in order to become employable. Faculty teams were tasked with brainstorming and identifying the courses that students would need to take in order to obtain the finalised skill sets. Then, a tentative curriculum framework is developed in accordance with the AICTE requirements and compared to the curriculum of leading institutions. This document is then distributed to multiple stakeholders, including employers, alumni, faculty from other universities, parents, etc. A survey questionnaire was developed to collect the opinions of stakeholders about the proposed curriculum.

III. IMPLEMENTATION

The technique described in section 2 was implemented using the following steps: A one-day workshop was scheduled to carry out the tasks.

Step 1: Formation of faculty teams as per the job sectors

Faculty teams are formed according to the various industries in which graduates of mechanical engineering might find employment, such as Automotive/Aerospace, Energy, Automation and Robotics, IT & Software development, Manufacturing, Business Management and Finance, etc. Each of these groups were assigned a chairman to maintain team discipline and guide the conversation in the appropriate direction.

Step 2: Identification of relevant subsectors keeping employability focus

Group leaders were tasked with identifying the relevant industrial subsectors where graduates of mechanical engineering find employment. The information on faculty teams and sectors and subsectors is provided in Table 1.

Team No	Sector	Sub sectors / relevant sectors	Faculty teams (Abbr.)
1	Automotive / Aerospace	R&D / Marine industry / Rail / Defence / NPDD	SSG, MBM RGD*, SRP, GLS, RVP, SAL
2	Energy	Power Generation / Nuclear / Non-Conventional Energy	SMS, SDP*, SVK, PVG, ASP, ABC, KPP
3	Automation and Robotics	Mechatronics / Robotics / Artificial Intelligence / Precision Engineering / 3D Printing	MVK, AMM*, RVZ, RAP
4	IT & Software development	CAD / CAM / CAE/ Software development / technology consulting / PLM	SNJ, UMN*, MMM, LRP, SNS, RAM, SSM
5	Manufacturing	Advanced manufacturing/ Green and Sustainable manufacturing / Remanufacturing / Food Processing / Pharmaceuticals / maintenance and reliability engineering / advanced materials and mining engineering	BRJ, CAW, MVP*, PSJ, SAD, SSS
6	Business Management and finance	Business analytics/ engineering economics/ business ethics/ Project management/ Decision Making	SKP, MLD*, PMJ, SBK, ABP, PAP

TABLE I
Details of faculty teams

Note: Faculty names are mentioned as abbreviations of their names. *indicates the group leader.

Step 3: Identification of job profiles in the above sectors

After identifying the sectors and subsectors, faculty teams were involved in finding the skills and competencies graduates must master over their four years of study. The specifics of one sector, its subsector, and the appropriate skills graduates should acquire are shown in Table 2.

TABLE II
Details of first team showing identification of subsectors and job profiles available in sectors

Sector	Subsector	Identification of job profiles in identified sectors
Automotive	Automobile Marine Aerospace	1.Work with design, hardware and software engineers in an R&D 2.Product Design Engineer
Process Industry	Power Industry Chemical Industry Textile Engineering Food Processing	3.Product Development Engineer 4.Consultant and Analyst for Noise and Reliability
Agricultural Engineering	Agro Equipment's	5.Condition Monitoring 6.Vibration consultant 7.Software Engineer 8.Maintenance Engineer

Other groups had also established the suitable job profiles in a recognized industrial sector using similar approach. Six faculty teams have completed this task for their respective group.

Step 4: Identification of skills required by the industries in selected industrial sectors

In addition, teams were instructed to discuss and compile a list of the abilities necessary to obtain employment in the specified industrial sectors. Table 3 outlines the skill sets that design graduates must acquire during their four-year degree programme. Each faculty team engaged in a similar task for their particular industrial sector.

TABLE III
Skills that graduate should possess from design domain

Sr. No.	Skills that graduates must possess
1.	Fundamental Engineering knowledge
2.	Problem analysis
3.	Design / development of solutions
4.	Conduct investigations of complex problems
5.	Apply current techniques, skills, knowledge and computer based methods and tools to develop mechanical systems
6.	Apply knowledge of contemporary issues to investigate and solve problems
7.	Pursue lifelong learning as a means to enhance knowledge and skills.

Step 5: Identification of courses to acquire the skills

In this stage, teams compiled a list of the courses that students must take as part of their UG programme in order to obtain the necessary skills for a certain industrial sector. The curriculum includes both theoretical and lab courses. The team was tasked with categorising the courses into the following four groups:

a. Foundation courses
b. Core courses
c. Electives or major courses
d. Open electives or interdisciplinary courses

Table 4 depicts the list of courses identified by design faculty team. Similarly, other teams also identified the courses for their respective domains.

Figure 2 highlights the glimpse of one-day workshop in which these activities are conducted.

Fig. 2. Glimpses of one-day workshop and team discussions

TABLE IV
List of courses identified by design faculty team

Foundation courses	Core courses	Electives or minors	Interdisciplinary/ open electives
1. Engineering Mechanics 2. Engineering Graphics 3. Engineering Mathematics 4. Basic Mechanical Engineering Practical 1. EG Lab 2. BME Lab	1. Kinematics of Machinery :S.Y.-I 2. Strength of Materials: : S.Y.-I 3. Numerical Methods: S. Y.-II 4. Design of Machine Elements: S. Y.-II 5. Dynamics of Machinery_ T. Y.-I 6. Machine Design: T.Y.-I 7. Mechanical System Design :T.Y.-II Practical 1. KOML: SY-I 2. DOML: TY-I 3. Numerical Method Lab: TY-I 4. Machine drawing Lab: SY-I 5. CAD Lab: SY-II	1. Finite Element Analysis 2. Design of Mechanisms 3. Mechanical vibrations 4. Machine Tool Design 5. Engineering Acoustics 6. Rotor Dynamics 7. Biomechanics 8. Industrial Tribology 9. Condition Monitoring 10. Vehicle Dynamics 11. Reliability Engineering 12. Computational Fluid Dynamics 13. Nonlinear Vibrations and Chaos 14. Fracture and Fatigue 15. Experimental Mechanics 16. Aerodynamics 17. Process Equipment Design 18. Aircraft Conceptual Design Practical 1. FEA Lab: Final Y. B.T-I 2. Vibration Lab: Final Y. B.T-I 3. Advanced Testing Lab: Final Year B. T.-II 4. EM Lab: Final Y. B. T.-I	1. Linear Control Systems 2. Optimization Techniques 3. Composite and Smart Materials 4. Industrial Pollution Control 5. Robust Design 6. Nanotechnology 7. Reverse Engineering and Benchmarking 8. Aircraft Systems

Step: 5 Finalization of Curriculum structure and benchmarking the same with AICTE guidelines and reputed institutions

After all teams have identified the courses within their respective disciplines, a basic curriculum structure has been developed. This curriculum outline was developed in accordance with AICTE guidelines. In addition, curricular structures of reputable universities are compared. After benchmarking and faculty brainstorming, the department has developed a final version of curriculum structure.

Step 6: Inputs from the stakeholders on draft curriculum through survey

Following that, a proposed curriculum framework is sent to stakeholders such as alumni, parents, faculty, and employers, along with a survey questionnaire. To include stakeholders in the survey, a Google form was created. It was distributed to over 200 people via email and Whatsapp groups. The Google form received responses from 28 alumni, 19 employers, 29 faculty members, and 3 parents. Only parents with an engineering background or experience were chosen for the survey. The questions posed in the survey are as follows:

1. The syllabus structure is fulling industry need, sufficient to bridge the gap between the industry standards and academics.

2.The current Syllabus covers all fundamental courses of mechanical engineering.

3.The Current Syllabus structure covers sufficient courses related to contemporary topics, global/emerging issues and trends in mechanical engineering.

4.The Current Syllabus structure provides sufficient programme elective to acquire domain specific knowledge.

5.The Current Syllabus structure provides sufficient open elective courses to acquire multidisciplinary knowledge

6.Syllabus structure fulfils the need of providing the hands on experience through laboratories, projects, internships etc.

7.The Specified contact hours are sufficient to complete the coverage of the course syllabus.

8.The current curriculum structure meets the expectations in terms of learning values, innovation, attitude, analytical abilities, practical orientation to the real life situation.

9.The Evaluation methods mentioned in syllabus structure are sufficient for providing proper assessment.

10.The current syllabus tries to build opportunities in terms of employability such as Jobs, Services and entrepreneurial attitude amongst students.

Responses from stakeholders were collected on five-point scale as per table 5.

TABLE V
Five-point scale

Scale	**Interpretation**
1	Strongly disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly agree

IV. DISCUSSIONS

The opinions of individuals affected by the proposed curricular framework are gathered by analyzing the replies of the various stakeholders. Due to their extensive experience of the industry, Alumni and Employers' opinions were given the highest importance in the study. Figures 3a and 3b exhibit a graphical representation of the survey results collected from graduates and employers, respectively. It shows the total number of respondents for each question and for each five-point scale.

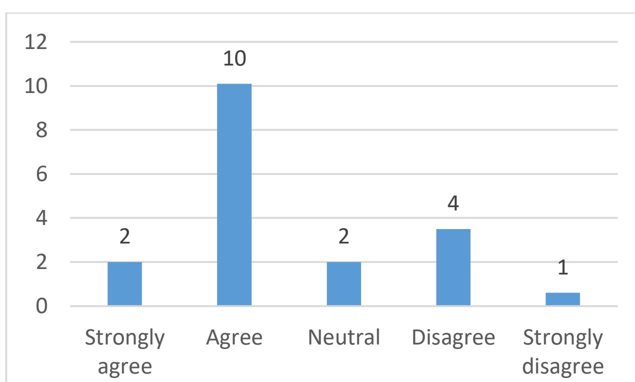

Fig. 3a Employer responses

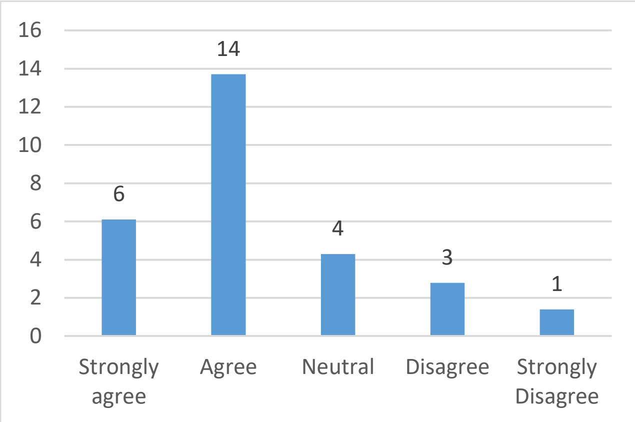

Fig. 3b Alumni responses

It is noticeable from the responses that the majority of alumni and employers support the proposed curriculum. Some employers and alumni are still dissatisfied with the proposed curriculum format. In addition, these stakeholders' opinion is solicited using Google forms for any curriculum-specific requirements. These requirements are then included into the new curriculum through discussions with faculty teams and members of the board of studies. Some comments suggested that industry internships and trendy topics such as python programming, MATLAB, hybrid/electric vehicles, artificial intelligence and machine learning, data science for engineers, and so on be included. These comments were taken into account positively during the review process, and the curriculum framework was subsequently modified accordingly by adding these courses. In the eighth semester, a choice-based three-track system was implemented, which included a six-month Industry Internship, Undergraduate Research Experience, and Entrepreneurship Development Program. The final curriculum framework is then accepted by the institute's academic council.

V. Conclusion

Curriculum should be viewed as dynamic, with modifications occurring on a regular basis. It should be more so in the technical education system, because technological advances and the resulting shifting needs from industry are considerably more rapid. This article stresses the need of active engagement from stakeholders in the process of curriculum design and development. Based on the findings of this research, a novel approach was suggested, which included determining market sectors and job profiles as well as developing the appropriate skill sets in students via the curriculum design. In addition to this, it includes the participation of industrial stakeholders such as alumni and employers in order to make the curriculum relevant to the requirements of the industry. This study contributes to the research's future directions by identifying substantial gaps in the curriculum-update process, such as a lack of competency and a limited number of resources to teach students about emerging technologies.

References

Manpower Group (2021), Talent Shortage Survey: research Results', www.manpower.com

AICTE, (2018), AICTE Model curriculum for Undergraduate programs', New Delhi: *All India Council for Technical Education.*

PK Tulsi. (2015), Expectations of industry from technical graduates: Implications for curriculum and instructional processes. *Journal of Engineering Education Transformations, 28(4)*.