Research Article

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Students and academicians views on the engineering curriculum and industrial skills requirement for a successful job career

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Abstract: Due to rapid advancement of technology, engineers should have a set of engineering skills. The basic knowledge about engineering skills should be imparted during graduation. In this study, an attempt is made to assess the gap between the present course curriculum that engineering institutions are exposing their engineering students and the skills required by the industries. Views of engineering students and academicians are obtained through questionnaires and analyzed using statistical tools. The results revealed that strong analytical ability, able to adapt and learn new technology, problem-solving within stipulated period or deadlines, and work promotion are the most important factors for a successful future job performance. The study also reveals that a significant gap exists between learning skills like communication, systematic work plan, and furtherance of work done. It is also seen that the use of modern tools and knowledge up-gradation is important to acquire many required industrial skills for a successful job career and the present curriculum is not effective to impart training on these aspects.

Keywords: Engineering curricula; Industry skills; Programme objectives; Employability.

1 Introduction

The employability of engineering graduates depend on several factors. Various skills are required to solve real-world problems. It is therefore, important that an engineering curriculum should be designed accordingly to impart these skills to fulfill the need of the industries. If this is so, engineering education provided during graduation can help and ensure all graduates succeed in work and life in this new era of the global economy (Zaharim et al., 2010). These skills should be integrated with technical and non-technical skills that comply with the requirement of the accreditation body and the employer's needs. The requirement of soft skills, hard skills, and social skills in Industries is growing very fast to meet the day-to-day challenges. To meet the present and future complexities of a project, social requirements, and need-based demands the present engineering curriculum is not sufficient and needs modification. The Centre for Monitoring Indian Economy estimates that unemployment shot up from 8.4% in mid-March, 2020 to 23% in early April 2020 and the urban unemployment rate to 30.9% (Choudhary, 2020). The Bureau for Labor Statistics' May 2020 job report reveals that the unemployment rate was 14.7% (BLS News, 2020). The April 2020 unemployment rate for those with a Bachelor's degree and higher is 8.4% (BLS News, 2020).

Employability is one of the major goals for all professional courses. For a successful job career a set of hard and soft skills including communication, teamwork, management, and other entrepreneurial skills are required. Communication skills are essential for an engineer for a successful job career in the global arena (Jacolbia, 2016) to keep a link between industry and society. Kaushal (2018) highlighted the importance of communication skills in industry and suggested some of the methods for improvement in communication skills and recommended that employability skills can be integrated with engineering education by making pedagogical changes in the teaching of communication skills. de Campos et al. (2020) had discussed different soft skills required for better employment and categorized them into six groups viz Problem Solving, Communication, Team Work, Ethical Perspective, Emotional Intelligence, and

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Creative Thinking. They also suggested how these skills can be included to make fresh-graduate Engineers in line with the market's needs. Providing successful training on these skills should be a part of the engineering curriculum. This leads to many challenges for various engineering institutions and their faculty to balance the different curriculum demands they face as reported by many researchers (Siller et al., 2009; Gilleard & Gilleard, 2002). It is mentioned that the present engineering curriculum is not paying attention to technical/non-technical and soft skills required for industries. Itani and Srour (2016) in their study concluded that the students have shown a significant understanding of the importance of soft skills and the authors recommended that educational institutions need to play a stronger role in strengthening students' non-technical skills in specific areas such as oral communication skills. In past studies, it was emphasized that the engineers should be team players rather than individual contributors (Beder, 1999; Adrian & Fishbein, 2009; Galloway, 2007; Gilleard & Gilleard, 2002; Kirschenman, 2011; Lang et al., 1999; Meier et al., 2000). A study by Zaharim et al. (2009), identified some technical skills and attributes that are required for a successful career. These attributes are the ability to acquire and apply knowledge of engineering fundamentals, having strong theoretical knowledge with the ability of how to apply it in the practical field, in-depth technical competency to solve specific engineering challenges, analysis, interpretation, and presentation of data. Wats (2009) emphasized the soft skill along with suggestions on how to implement it. Cyril et al. (2021) have investigated the development of professional skills by students through their work on in-course or capstone projects. Their findings suggested that project work plays a major role in the development of such skills and suggested integrating projects with traditional classes. Currently, the industries look out for engineers with multi-technical skills to face all challenges in any adverse situation. Zaharim et al. (2009) in their study revealed that 73% of employers require engineers to have all-round technical skills while 85.5% expect engineering graduates to be competent in both application and practical oriented engineering. A huge gap between the skills needed by industry and the skills acquired by engineering graduates is reported by Gerald Ahorbo et al.(2017). Under such situations, many accreditation organizations set specific programme and course outputs that students should acquire after completion of a course or programme of study. Most national and international engineering accreditation bodies (e.g. Accreditation Board for Engineering and Technology (ABET) in the United States, European Network for Accreditation of Engineering Education (ENAE) at the European level, International Engineering Alliance (IEA) at the International level) have included technical skills, and soft skills in their requirements for accrediting engineering programmes (Winberg et al., 2020). However, there are no well-defined soft or professional skills in these requirements. The National Board of Accreditation (NBA) is an autonomous accrediting body in India, which deals with the accreditation of engineering and various technical courses or programmes based on the quality of education being offered. It is an Outcome-based accreditation process and has set some guidelines to assess the status-ante of the performance in a course programme. It helps an institution to know its strengths, weaknesses and opportunities. The National Board of Accreditation (NBA) has defined 12 programme objectives (POs) for the accreditation of any degree programme. Based on engineering skills and attributes for engineering graduates required for accreditation by accrediting institutions, Zaharim et al. (2010) have shown that non-technical skills, such as communication skills, teamwork, lifelong learning, professionalism, and decision-making skills are the employability skills for engineers. Scott (2010) demonstrated that the technical expertise is not sufficient for a successful job career and the curriculum designers should identify these shortcomings and should incorporate the non-technical skills in the curriculum. During the last decade, many institutions have introduced these skills at different levels of the curriculum. In India, efforts have been made to include all 12 programme objectives set by NBA in the course curriculum by designing specialized courses (Mohan et al., 2010). Ramadi et al. (2016) suggested that despite several efforts made at a cross-national level a gap between employers' expectations and the reality of engineering graduates' skill-sets in the 'professional' domain persists. Thus, this study is aimed to identify the gap of skills in engineering course curricula in India, and based on the results, a suggestive plan of action is presented for a successful job career. The study is based on students' and academicians'views from Indian Institutions. It is important to mention that the presented work is not to challenge any course programme offered by any institution or any governing body monitoring or providing accreditation to such programmes. The undergraduate course programmes from different engineering disciplines are used in this investigation. The disciplines included in the study are mechanical engineering, electrical engineering, electronics and computer engineering, and computer science and engineering. These courses are offered by higher educational institutions and technical universities. These institutions are mostly governed by All India Council of Technical Education, India, or Department of Higher Education, India.

2 Problem Statements

In recent years, due to many business challenges and progress in manufacturing diversities, many manufacturing units have changed their usual products to unusual ones. Many industries may like to hire fresh employees who have ideas that are relevant to today's market and would help tackle issues differently at a lower salary than an experienced employee. Day by day this is creating a gap between the curriculum and industry demands. According to the present need, the students are to be trained with blended technology who can give a different perspective to any issue. Despite efforts to align the present engineering graduate curricula by the competent authority, the university and the institutions of higher studies with the requirements of industries, engineering programmes are still being criticized for inappropriate technical hard and soft skills. Gilleard and Gilleard (2002); Siller et al. (2009) in their study mentioned this aspect a decade ago. A major gap between academic perceptions and industry expectations or employability skills has been revealed from the various studies found in the literature (Domal& Trevelyan, 2009; Goh, 2007). Lang et al. (1999) mentioned in their study that most engineering students give higher importance to soft skills. This is also due to the increased demand in software and IT sector in recent years. However, in today's scenario, communication skills, and multidisciplinary skills are the major requirements of many industries. Communication skills include oral communication with managers and peers, presentation skills, business writing skills, and cross-cultural communication abilities (Itani & Issam, 2016). Shukla and Garg (2016) presented the results of the survey of industry executives visiting campuses for placement of graduates, to find out the skills required by the industry so that the curriculum can be revised and the delivery mechanism augmented to prepare students with desired skills.

Manzoor et al. (2018) studied the possible perception gap between fresh engineering graduates and their employers about essential skills required for getting a job in Pakistan. The findings of Manzoor et al. (2018) could be provided to the management of engineering institutions and universities to allow restructuring of the course curriculum and thereby reducing the possible perception gap. Moreover, it highlights the importance of soft skills in a successful job career. Employability skills required in the career field and the way to integrate them into the teaching process was reviewed by Nuryake et al. (2020). Pillutla and Alladi (2013) discussed current educational practices in India, identified the gaps along with the reasons for these gaps and methodology to bridge the gaps. Despite several modifications in the course curricula, a major gap persists due to which the students lack preparedness to face interviews, and hence the course contents should be redesigned to develop more employable skills needed for employment. This aspect is studied through collecting the views from the final year and ex-final year students and these are termed as "students' view". The views from middle and senior faculties are termed as "academicians' view" and both views were gained through a well-defined questionnaire. Four branches of the study included are; Mechanical Engineering (ME), Electrical Engineering (EE), Electronics and Communication Engineering (ECE), and Computer Science and Engineering (CSE). The branches are selected keeping the present demands in core and software/IT sectors. The need for educational reform is addressed in this study. The survey also gave insights on academicians' perceptions about course curriculum and industrial needs. It is required to:

1. Assess the shortcomings in the present engineering curriculum to impart knowledge on employability skills
2. Determine the relationship between the engineering course curricula and skills required by industries
3. Identify the factors required for successful job performance
4. Determine the relationship between the course program objectives (course outcomes) and industry objectives

The objectives of the study is to collect the students' and academicians' views on how engineering course curriculum provides required skills for a successful job career and the gap that exists between curriculum and skills needed.

3 Methodology

Based on a literature review and the present requirements of many industries, an anonymous questionnaire of 4 questions with sub-questions was designed to achieve the study objectives. The questionnaire was designed with four questions which are based on the important factors for successful job performance, suitability of course curriculum for student's preparedness, program objectives and perceptions of technical and non-technical skills, and employability factors. The details are discussed in the subsequent sections of the paper. It used a Likert-type scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). The survey was conducted from August 2020 to December 2020 in India. Two technical institutions and three technical universities were selected from the coastal part, hilly area and plain area of Eastern, and Northern India. A total of 212 students and 32 academicians have participated in the survey. In total, 212 students (65% male and 35% female) have responded to all questions. Views from 32 academicians' responses (92% male) are included in the analysis. The number of responses is sufficient and comparable with the previous studies (Rynes, 1987; Lichtenstein et al., 2009; Gerken, 1993). The majority of the respondents (78%) were in the 22-24 age bracket and the rests were between 25 to 26 years of age. Thirty-two academicians from four branches of study (8 from each branch) had responded to the survey questionnaire. Google form was used to collect the responses. The reliability on the internal consistency of the data was conducted using Cronbach's alpha test (Tavakol & Dennick, 2011). Spearman correlation coefficient and *t*-test were performed to establish the correlation between skill requirement, course curriculum design, and contents, etc. All the analyses were made using Microsoft Excel.

4 Results

Engineering disciplines are designed to understand the needs of society and make life easy by applying the classroom and laboratory knowledge into a feasible technology. To understand the students' perceptions as well as educators on the present education contents and industrial requirement, the mean ratings of different factors were computed and analyzed. Since all rating questions were on a 1-to-5 scale (Likert scale, 1 for strongly disagree and 5 for strongly agree), a criterion is set that any mean above 3.5 was taken as agreed and the mean value below 3.5 as disagree. Similar approach could be seen in the work of Itani and Srour (2016). Conclusions were supported from the results of Spearman correlation, *t*-statistics, *p*-value. Cronbach's alpha test which measures reliability or internal consistency was also conducted.

An industry looks for skills like communication skills, problem-solving, industry skills (soft and hard), pressure management, teamwork, creativity and innovation, leadership and group activity, flexibility and adaptability, etc. In technical skills, design, development and drafting, production planning and monitoring, construction and maintenance, etc. were the priority in earlier years. But due to major developments in computational and IT-related assignments the skills required by industries are changing day by day. These skills are soft skills, knowledge of new technologies, etc. Many industries felt that despite powerful textbook knowledge of fundamentals and theory, the lack of skills needed to apply that knowledge at critical times, indicated the existence of a critical skills gap and a failure to assess and address the day to day problem of society (Mosier & Kristine, 2019; Awonuga, 2019). These skill gaps caused a concern among the industry leaders and the academicians. Hence, it is a challenge for every engineering workforce to figure out how to be effective and impactful, using engineering work remotely and how to train future graduates by the academicians so that they can face such challenges.

4.1 Assessment of skill requirements

For graduate engineers, it is difficult to decide what sectors would flourish in the future and what skill sets would come in handy in tomorrow's world. Some of the emerging fields are IT industries, the healthcare industry, the manufacturing sector, and the construction industry with a focus on CAD Design and automation, Artificial Intelligence, Data Sciences, Machine Learning, and the Internet of Things (IoT). The 'work from home' concept recently adopted due to the pandemic would fuel the demand for IT hardware and software products and forced many manufacturing industries to find alternate technology that can be adopted that supports the work from home concept. The "work from home" for a manufacturing or similar job-oriented industry is difficult but shifting to product design using software, prototyping and 3D printing are a few solutions to working remotely from home. We are in the era of knowledge explosion. It is difficult to figure out any particular skill. Almost 80 percent of the skills trained for in the last 50 years can now be outperformed by machines. The most important skills any student should have to survive and to thrive in any challenging scenario are self-learning and lifelong learning. Berdanier (2014) examined graduate student perceptions of the necessary knowledge, skills, and attributes (KSAs) needed for future engineering careers in industry and found that students and academicians rated their preparedness in the most important categories

Table 1: Views of students and academicianson important factors for future successful job performance.

Sl No	Importance to future successful job performance, (Students)	Mean	Rank	Importance to future successful job performance (Academicians)	Mean	Rank
1	Meet deadlines	4.22	1.0	Solve problems	4.67	1.0
2	Be able to adapt and learn new technologies	4.12	2.0	Meet deadlines	4.62	2.0
3	Solve problems	4.11	3.0	Be able to adapt and learn new technologies	4.55	3.0
4	Possess strong analytical ability	4.08	4.0	Work in teams	4.48	4.5
5	Promote your work	4.00	5.0	Communicate orally	4.48	4.5
6	Break down complex concepts into simple, understandable ideas	3.99	6.0	Possess strong analytical ability	4.36	6.0
7	Motivate others	3.90	7.0	Communicate in writing	4.34	7.5
8	Manage multiple projects	3.70	8.0	Break down complex concepts into simple, understandable ideas	4.34	7.5
9	Communicate orally	3.64	9.0	Approach problems systematically	4.31	9.5
10	Communicate with a variety of audiences	3.59	10.0	Tailor communication to your audience	4.31	9.5
11	Communicate in writing	3.47	11.0	Interface with industry	4.29	11.0
12	Learn independently	3.17	12.0	Give presentations	4.27	12.0
13	Review literature	3.05	13.5	Use multiple tools to solve complex problems	4.15	13.0
14	Bring in outside funding for research	3.05	13.5	Manage multiple projects	4.02	15.0
15	Identify areas of research likely to receive grant funding	2.84	15.0	Write technical reports	4.02	15
16	Work independently	2.47	16.0	Work across disciplines	4.02	15

much lower than the skills required in the industry. This indicated that there is a difference in the skills imparted and required to pursue careers in industry. It is therefore in the present study, the skills required for a successful career in Industries is undertaken. The skills required for industries are listed and views of the students and academicians were collected. The question Q1 as mentioned below was formulated following the findings of Berdanier (2014).

Q1. What factors are important for a successful job performance? Sixteen factors are listed in Table 1.

The mean responses and rank values on 16 factors for future successful job performance obtained from the students and academicians are presented in Table 1. The rank obtained from the mean scores of different attributes in Table 1 was analyzed using the Spearman rank correlation and p at 0.05 level of significance. Spearman Rank correlation coefficient on important factors for future successful job performance is 0.763. The t- statistics and p values are 4.415 and 0.001, respectively.

When asked to rate the degree of truth of several statements about the important factors for future successful job performance, the overall perception of engineering students as well as academicians seemed positive. Based on the Spearman Rank correlation, it can be said that the views of students and academicians on important factors mentioned in Table 1 for future successful job performance is moderately related ($\rho=0.763$). It is seen that there is no difference in opinion on issues like meeting deadlines, solving problems, and adapting and learning new technologies and these are the most important factors for future successful job performance. As per the students, the subsequent important factors are analytical ability and promoting work whereas teamwork and communication skills are the next priorities according to the academicians. Technical report writing or reviewing the existing work, process, technology, work across the multiple disciplines, use of multiple tools to solve complex problems, and interface with industries are the least important factors by the students and academicians. The rank on the communication skill " orally" or "in writing" was found to be 9 and 11 from the students' views whereas communicate "orally" and "in writing" were ranked as 4.5 and 7.5 respectively by the academicians. The technical skills like "able to adapt and learn new technologies" and "possess the strong analytical ability" were ranked 2 and 4 by the students and 3 and 6 by the academicians, respectively. "Approach problems systematically" was ranked 9.5 with a mean value of 4.31 by the academicians whereas students ranked "learn independently" and "work independently" as 12 and 16 with a mean value of 3.17 and 2.47, respectively. Thus the results shown in Table 1 implies that the importance of non-technical qualities like communication skills for successful job performance is less addressed during graduation whereas it is one of the most important factors for a successful career. "Managing multiple projects" with a mean value of 3.7 (ranked 8th) "work independently" (mean M=2.47 andranked 16th) were considered as the least important qualities by the students whereas these are highly required qualities by the industries for a successful career as well as the growth of an industry, and the views of academicians supported it with a mean value higher than 4. The differences in views obtained from the students may be due to less industry-institution interaction during their degree programme. Another possible reason could be improper design of industrial/practical training and may be due to less importance given to the related courses and problem-solving techniques. Hence, the quality of interface with industry is lacking in the present course curriculum of engineering subjects. "Enjoying solving engineering-type problems" should be the key focus in the teaching-learning process. In summary, for students 10 out of 16 statements received a rating of 3.5 or higher, with the lowest being given to "work independently (mean, M=2.47)" and the highest to "meet deadlines (M=4.22)". For academicians, all 16 factors are equally important (M>4.0) with "solve the problem" (M=4.67) and "meet deadlines" (M=4.62) as the most important factors for successful future job performance. The results reveal that views of the students and academiciansonsome issues mentioned here are quite different. It can be concluded that the importance of the factors mentioned in Table 1 should be linked through a well-designed course curriculum. Due to such differences in the opinion between students and academicians, it is a challenge for the institutions and academicians to find a balance on the issues discussed.

4.2 Challenges for Educators

Six "professional" skills, besides "hard" skills, in the undergraduate curriculum emphasized by the Accreditation Board for Engineering and Technology Inc., (ABET) are communication, teamwork, understanding ethics and professionalism, engineering within a global and societal context, lifelong learning, and knowledge of contemporary issues (Shuman et al., 2005). The National Board of Accreditation (NBA) has specified 12 programme outcomes known as graduate attributes based on initial capabilities, competence, skills, etc. Programme Outcomes (POs) are narrow statements that describe what the students are expected to know and would be able to do upon graduation. Graduate Attributes are a set of generic knowledge, skills, and attitude considered essential for all graduate engineers of the 21st century. All graduate engineers are expected to demonstrate these attributes on completion of their degrees. These 12 attributes are engineering knowledge, problem analysis, design/development of solutions, conduct investigations of complex problems, modern tool usage, the engineer and society, environment and sustainability, ethics, communication, project management and finance, and lifelong learning. Most of the engineering institutions have designed the course curriculum according to the recommendations of different governing bodies like AICTE, UGC in India. Many institutions have a common curriculum too. In response to the skills assessment described above, and to address the discrepancy between the preparedness of graduate students, question (Q2) was formulated and the survey was conducted. The views of the students and academicians are presented in Table 2.

Q2. Twelve Programme Objectives (POs) defined by the National Board of Accreditation are listed in the question. How do you rank based on your satisfaction level (1 to 5 scale) that after successful completion of the course programme, you have acquired the Programme Objectives which defines knowledge, skills, and attitude considered essential for all graduate engineers after completion of the degree programme?

The responses obtained from the students on Q2 were analysed and the weighted means were calculated. Based on weighted mean, rank is obtained and Spearman rank correlation coefficient was determined. The results of the Spearman rank correlation are presented in Table 2 and Table 3. The weighted mean and ranks from the students' view are presented in Table 2(a). Table 2(a) shows that out of 12 programme objectives only two programme objectives are able to score greater than 4.0 indicating "agreed". The most important student perception is "engineering

Table 2(a): Students views on the graduate attributes (Programme Objectives) based on the graduate course curriculum covered in the Institution.

	Programme Objectives (Students' views)		
PO	Statement	Mean	Rank
1	Engineering knowledge	4.19	1.0
2	Life-long learning	4.03	2.0
3	Problem analysis	3.90	3.0
4	Design/development of solutions	3.87	4.0
5	Communication	3.80	5.0
6	Conduct investigations of complex problems	3.77	6.5
7	Project management and finance	3.77	6.5
8	Individual and team work	3.71	8.0
9	Environment and sustainability	3.69	9.0
10	The engineer and society	3.65	10.0
11	Ethics	3.62	11.0
12	Modern tool usage	3.60	12.0

Table 2(b): Importance of graduate attributes by the academiciansto successful future job performance.

	Importance to future successful job performance (Academicians' views)		
S. No	Statement	Mean	Rank
1	Solve problems	4.77	1.0
2	Be able to adapt and learn new technologies	4.75	2.0
3	Work in teams	4.68	3.5
4	Communication(Oral & writing)	4.68	3.5
5	Possess strong analytical ability	4.66	5.0
6	Break down complex concepts into simple, understandable ideas	4.64	6.0
7	Approach problems systematically	4.61	7.5
8	Tailor communication to your audience	4.61	7.5
9	Interface with industry	4.59	9.0
10	Use multiple tools to solve complex problems	4.55	10.0
11	Work across disciplines	4.52	11.5
12	Manage multiple projects	4.52	11.5

Table 3: Spearman correlation, *t*stat and *p* values.

D^2 *(square of difference in rank values)*	90.5
n (number of variables)	12
Spearman correlation, ρ	0.684
t-stat	2.962
p	0.014

knowledge" imparted during the engineering graduation with a mean M=4.19 and is rank 1 followed by "lifelong learning" with M=4.03 whereas these attributes are ranked as fifth and second by academicians, respectively in Table 2(b). The "Problem analysis or solve the problem" is the top priority according to academicians whereas students ranked it third based on the course covered. The "problem analysis" is an important technical skill development attribute. This should be related to the analysis of the industry-based problem, design-based problem, or technology/innovative related problem in the class. The maximum difference in opinion by academicians and students was seen for "project management and finance" or "manage multiple projects". This reveals that the management-related courses are to be strengthened and the importance of these courses for successful job career in Industry should be highlighted. If the structure of the course curriculum is examined, it can be seen that management-oriented courses are limited to only 1-2% of the graduation requirement. Hence, additional weightage or credits should be allotted to management courses. The second-highest difference in opinion is seen for "Individual or teamwork". This reveals the shortcoming of the teaching-learning process and the deficiency in practical, project work, and group activities in the curriculum. As per the students' views, the five least addressed attributes during the graduate degree programme in order of highest to lowest are modern tool usage, ethics, the engineer and society, environment and sustainability, and individual and teamwork. The views of the students suggested that interaction with industry and society and solving the industrial and societal problems using modern tools should be apart of the course curriculum. Hence, industry and society need-based projects may be one of the solutions to improve these shortcomings in the course curriculum. Based on the Spearman Rank correlation in Table 3, it can be concluded that the views of students and academicians on different attributes defined by NBA and successful future job performance is moderately related (ρ=0.683). The views of academicians on all 12 statements of Table 2(b) scored M≥4.5. This reveals that all the statements of Table 2(b) are mostly required parameters for future successful job performance by academicians. However, students' views differ significantly and out of 12 statements, 10 statements scored M≤4.0. This clearly shows the lacking course curriculum or training imparted to the students to develop the industry-required skills for better job performance. This is statistically significant as supported by *p* value lower than 5%.

4.3 Engineering Course Curriculum

The contents of different courses, the design of the course curriculum, and teaching-learning process are important to prepare a graduate to face the challenges of the industry. When the results of Table 1 and Table 2 are analysed, it can be said that even the course curriculum is designed based on the 12 programme objectives identified by NBA or any other recommendations by a governing body, but it failed to train the students as per the industry requirement and successful job career. Hence, a detailed analysis of the course curriculum and views of the students on the present course curriculum for a successful job career is required to find out any shortcomings in it.

Strong technical skill and soft skillis required for employment in industries and government sectors. However, some of the key technical skills that students learn during their graduation, including analytic and problem-solving abilities, might be ineffectual unless accompanied by the professional skills necessary to bring them into play (Hissey, 2020; Mohan, 2010). Many professional skills include working in groups, problem-solving, communication and listening, project management, decision making, leadership, multidisciplinary perspective, collaboration with industry, negotiation, goal setting and management, understanding diversity and globalization, and these have been identified as vitally important for successful careers (Chubin, 2008;Lamancusa, 2008; McMasters, 2006) and many more discussed earlier in this work. Hence, it can be said that the engineering curriculum should be able to provide adequate knowledge in these professional skills and prepare students to be competent in multiple domains. Question 3 is framed to know the views about the deficiencies in the present engineering curriculum to impart training in these skills during students' graduation.

Q3. Do you agree that the present curriculum is sufficient to impart knowledge on different skills (attributes) described in Table 4? (Respondents: students from Mechanical Engineering, Electrical Engineering, Electronics & Communication Engineering, and Computer Science and Engineering). Based on the course structure of four branches of Engineering viz Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering and Computer Science and Engineering, all courses are categorized into eight groups. The credit distributions in the percentage of the courses for 8 categories are shown in Figure 1. Data are taken from the model course curriculum of All India Council of Technology Education, India and reputed Indian institutions.

Table 4: Mapping of skills required and engineering course curriculum.

Sl No	**Skill required (attributes)**
1	Communication
2	Engineering Skills/Hard skill
3	Soft skill
4	Project Management
5	Teamwork
6	Creativity
7	Problem-solving
8	Knowledge on Modern tools/Knowledge upgradation
Group No	**Course category**
1	Humanities and Social Sciences
2	Engineering Sciences
3	Basic Sciences
4	Management
5	Program Electives
6	Program Core
7	Internships/Seminars
8	Project(s)

Responses are obtained for the question "How do you rate the present curriculum that it is suitable and well balanced to impart knowledge on different eight skill attributes described in question Q3 on 5-points Likert scale, strongly disagree to strongly agree?". Based on course contents 8 skills are mapped with the broadly classified 8 course groups, Fig. 2. The mean and rank of the responses received from students are presented in Table 5 for Mechanical Engineering Electrical Engineering, Electronics and Communication Engineering, and Computer Science and Engineering, respectively. The internal consistency was checked by evaluating

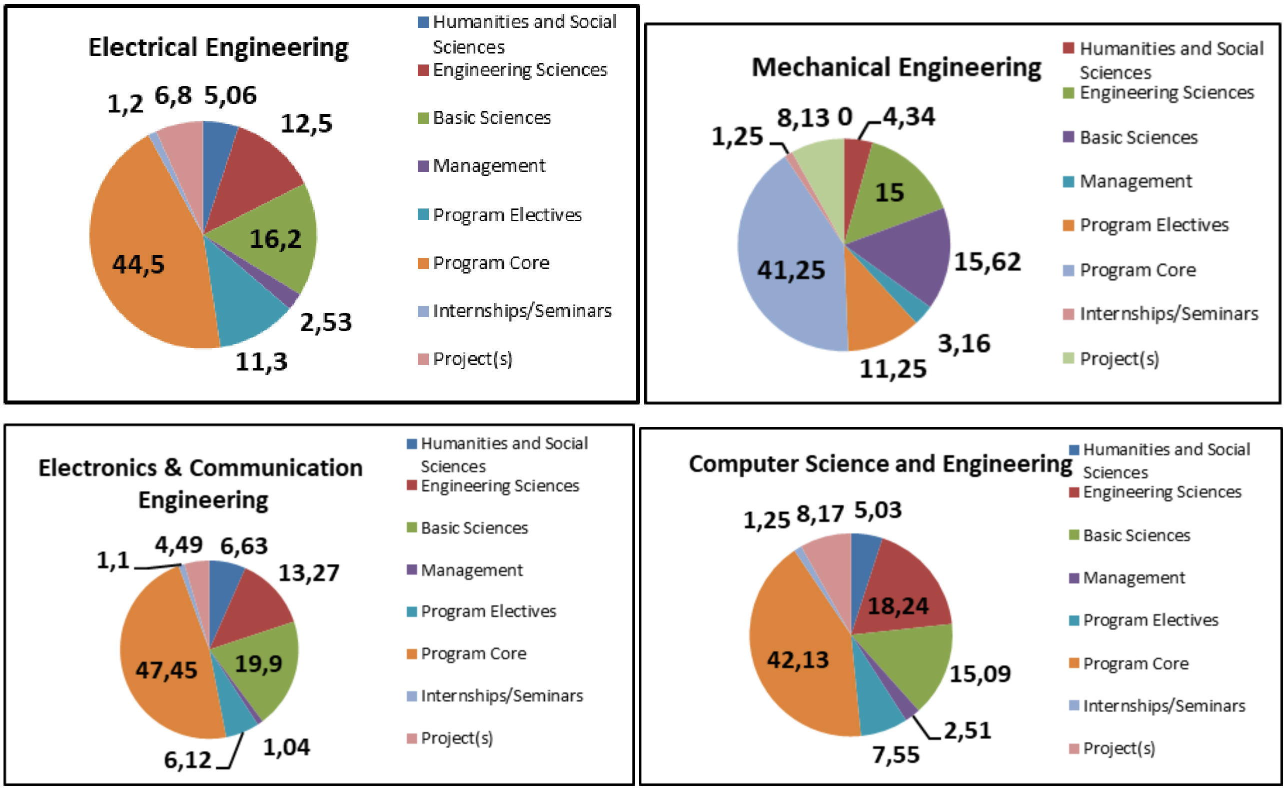

Figure 1: Credit distributions in percentage of the courses for seven categories for different branches of Engineering.

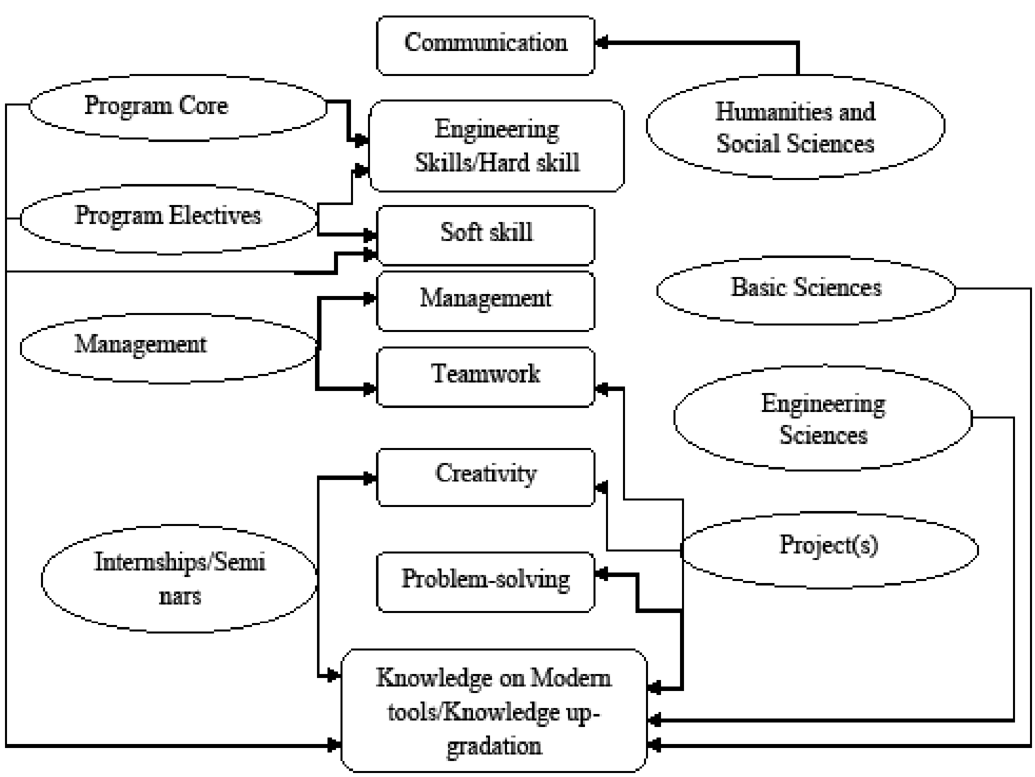

Figure 2: Mapping of engineering courses with skills required for successful job career.

Table 5: Students' responses on "How do you rate that the present curriculum is suitable and sufficient to impart knowledge on different eight skill attributes described in question Q3?"

Sl No.	Skill required	Course helps to develop to develop skill required	Mean				Rank			
			ME	EE	ECE	CSE	ME	EE	ECE	CSE
1	Communication	Humanities and Social Sciences	2.75	3.75	4.125	4.25	15.5	11	7	7
2	Engineering Skills/Hard skill	Program Electives	4.75	4.25	3.875	3.5	3	5	9	11
		Program Core	4.875	4.75	4.25	3.875	1.5	1.5	4	8
3	Soft skill	Program Electives	3.375	4	4.25	4.75	11.5	7.5	4	2.5
		Program Core	2.75	3.875	4.25	4.75	15.5	10	4	2.5
4	Project Management	Management	3.375	3.375	2.375	2.25	11.5	10	16	17
5	Teamwork	Management	4.125	4.125	3.625	3.5	7	7	11	11
		Project(s)	3.375	3.375	3.375	3.375	11.5	13.5	13.5	14
6	Creativity	Internships/Seminars	3.25	3.375	3.375	3.375	14	13.5	13.5	14
		Project(s)	3.625	3.75	3.75	3.75	8	11	10	9
7	Problem-solving	Project(s)	4.375	4.5	4.5	4.5	6	3	1.5	5
8	Knowledge on Modern tools/ Knowledge upgradation	Engineering Sciences	3.375	3	3.125	3	11.5	16	15	16
		Basic Sciences	2.5	1.875	2.125	3.375	17	17	17	14
		Program Electives	4.625	4.125	4.125	4.5	4.5	10	7	5
		Program Core	4.625	4.25	4.125	4.5	4.5	7.5	7	5
		Internships/Seminars	3.5	4.375	3.5	3.5	9	4	12	11
		Project(s)	4.875	4.75	4.5	4.875	1.5	1.5	1.5	1

ME: Mechanical Engineering, EE: Electrical Engineering, ECE: Electronics and Communication Engineering, CSE: Computer Science and Engineering

Cronbach's alpha. The Cronbach's alpha coefficient for all the four branches of engineering is>0.95, suggesting that the items have relatively high internal consistency.

Based on the overall responses from the academicians Spearman coefficients are calculated. The results of the Spearman coefficient along with the square of the difference between rank values are presented in Table 6. The Spearman correlation is 0.4 to 0.7 indicating the existence of a moderate correlation between the academicians and students views on rating present curriculum that helps to develop the skill required for a job and future success. Table 5 reveals that "Project" is the most effective course for knowledge up-gradation, learning about modern tools and software, and working on new technology. Thus, students from all the branches of engineering believe that the industry-required skills can be learned through projects offered at the degree programme. Students also viewed that complex problem-solving techniques can be learned through "project work" and thus this would help them acquire the required confidence and skills to face the industrial challenges. It is also opined that communication skill is less addressed by the courses under "Humanity and Social Science". Figure 2 reveals that the communication skill depends upon the courses developed under "Humanity and Social Science" and its credit contribution is less than 1.5%. The other essential quality "Creativity" is ranked as 8 to 14 and need to be given more attention through regular seminar, workshop and competitive events. The project and programme electives are the most important courses

Table 6: Spearman coefficient of responses on "How do you rate that the present curriculum is suitable and sufficient to impart knowledge on different eight skill attributes described in question Q3?".

		ME	EE	ECE	CSE
		Square of difference in rank			
1	Communication	4.0	2.25	9.0	9.0
2	Engineering Skills/Hard skill	9.0	6.25	0	1.0
3	Soft skill	25.0	1.0	0	1.0
4	Project Management	4.0	0	0	0
5	Teamwork	1.0	0.25	4.0	4.0
6	Creativity	4.0	0	1.0	1.0
7	Problem-solving	0	0.25	1.0	0
8	Knowledge on Modern tools/Knowledge up-gradation	4.0	25.0	16.0	9.0
	D^2	51	35	31	25
	n	8	8	8	8
	Spearman correlation, Roh (ρ)	0.393	0.583	0.631	0.702
	t stat	1.046	1.759	1.992	2.417
	p value	0.336	0.129	0.093	0.052

for the development of technical skills and the average views of these courses are $M \geq 4.5$ indicating the most important to meet the required skills for a successful job career. If branch-wise results are analyzed, soft skill is a major concern for Mechanical Engineering, whereas the use of modern tools in the course curriculum is the biggest concern for all the branches of engineering investigated in this study. The overall view is that most of the courses received a mean $M \leq 3.5$. It reflects that the present course curriculum is insufficient to impart most of the desired skills for a successful job career and better job opportunity.

5 Discussions

Nowadays most industries are moving towards automation and the remote work concept popularly termed as "work from home" seems to be more beneficial in any situation. To fulfill both the requirement, the knowledge of soft skills and the use of modern tools is of utmost importance. The engineers need to take up the challenges and should be able to develop new technologies. Hence, it is essential to acquire knowledge in the field of the state of art technologies during their graduation. If the present situation of industries is analyzed, the industry needs to introduce the concept of remote design, analysis, and monitoring. Some of the new technologies that may help to overcome it are CAD/CAM, artificial intelligence, the use of robotics in different sectors, data science, cybersecurity, Internet of Things, 5G technology, virtual reality, etc. irrespective of any trade of engineering. For example, in the engineering course curriculum bioinformatics, biotechnology, biosensor, healthcare should be a part of the engineering curriculum to address the issues like drug design and selection of drugs, health monitoring, contact tracing, drug delivery, and patient monitoring by use of biosensor, robotics, artificial intelligence, etc. The knowledge of bioinformatics will help to study the genetics of a patient before the selection of a drug. These fields of study shall help the students to prepare themselves to excel in an emergency. With the knowledge of biosensors, an engineer can design a health care jacket using a bio-sensor to monitor health. Also, this will help in genomic analysis of different types of viruses, bacteria, etc. Hence, there is a need of redesigning the course curriculum to overcome such a situation. Hence, it is now essential to include these two aspects in the course curriculum irrespective of branches of engineering. Blending a variety of subjects in the pre-existing learning process will help the students in getting employment. Industry collaborative project and internship or seminar helps in developing the skill like creativity and teamwork. Creativity and career advisement need to be integrated throughout the study, not just at the end of the program so that students build and then can represent relevant skills they have developed and demonstrated. The ability of creativity can be developed through innovative projects, society needs-based mini-project, etc. This will help the students to develop management capability which is one of the major shortcomings seen in this work. Under the present course structure, constituting an interdisciplinary student group right from the first year of graduation and allowing them to implement the theory learned in the classroom may be the right solution and be able to fill the gap between creativity and group work skills. In this way, a student can also learn phase-by-phase manner over some time. This will be more significant than a compressed one-month industrial training and shall enhance the job opportunity. This way the skill of project management and teamwork must be enhanced which are poorly ranked. Proper strategies are required to prepare the engineering education sector for the evolving demand-supply trends across the globe-particularly those related to the global mobility of students and faculty and improving the quality and demand for higher studies in different countries. Further, immediate measures are required to mitigate the effects of any adverse situation like a pandemic on job offers, internship programme, and research projects. As the situation changes, new challenges come to the fore for society. We need to have engineering innovations to face such challenges and be able to generate employment in the society in which entrepreneurship, creativity, and innovation for a student are much required. In present situations, the engineering courses and programmes are to be reconfigured to provide the student with skills needed for competition, as well as making them agile and adaptable for a volatile workplace. All institutions should strengthen in the following area to resolve the issue of employability in the future. **S**oft skills, **S**imulation-based learning, **C**ommunication and **C**reativity, and **C**areer guidance (**S2C2**) are the few solutions for better employability in engineering. In the present scenario, soft skills is as much required as hard skill and one of the most Essential Employability Qualities. A recent NACE survey (NACE, 2020) found that 93% of employers consider soft skills equally as hard skills. These soft skills should be introduced from the beginning of the degree programme and should be mapped with the hard skill or academic skill. This will provide an opportunity to gain industry-oriented skills and improve their employment opportunities. The survey reveals that creativity, problem-solving, and group activity skill can be enhanced through an internship, and hence, the internship is one of the essential requirements of the engineering curriculum which is poorly ranked by the students. Figure 1 reveals that the credit contribution of the internship is 1.2 to 1.25%. It is seen that students prefer to undertake an internship in a reputed organization. But it is difficult to get it as per the student choices. Also due to less weightage of the internship training programme and lack of motivation, the student cannot understand the importance of internship in their career growth. Under such circumstances, Institution-Industry interaction could be the better option to create awareness and importance of such skills in career growth. But, due to many unknown circumstances, it is difficult to organize institution-industry interaction programmes frequently. So these skills were poorly ranked by the students. Alternatively, simulation-based teaching can be an option for an internship. Work-related case studies, simulation studies on a real-life-based problem can be included under this category. Both oral and written communication skills are required as cited by industries (Wolff, 2020), and found in the present study too. Recent research, for example, found that 73% of employers had difficulty hiring qualified applicants with strong communication skills (Kaleigh, 2016; GMAC research team, 2020). Engineering institutions should come up with a well-equipped communication skill development programme. Creativity and career advisement need to be integrated throughout the study, not just at the end of the program so that students build and then can represent relevant skills they have developed and demonstrated. The ability of creativity can be developed through innovative projects, society needs-based mini-projects, etc.

6 Conclusions and Recommendations

In this paper, it is not aimed to challenge the present engineering curriculum or guidelines of any governing body but keeping in mind the skills needed for a successful job career and how the curriculum helps the students for better job career, the views of students and academicians were analysed and recommendations were made.

There is a huge gap between the skills required for successful future job performance and the skills acquired by the engineering graduates and day by day this gap is widening due to change in demand and social requirements. Therefore, the engineering institutions in India have to restructure the course curricula giving equal importance to both technical and non-technical skills and attributes in a well-ordered teaching methodology that emphasizes hands-on training and industrial attachment for the engineering students. The maximum deficiency is observed in the area of “Project management and finance” or “manage multiple projects” followed by “teamwork”.

As per the students' views, the five least addressed attributes during the graduate degree programme in order of highest to lowest are modern tool usage, ethics, the engineer and society, environment and sustainability, individual and teamwork. The course structure should be designed to address these shortcomings. The most important student perception observed in this work is the requirement of sound engineering knowledge with a mean (M) =4.19 followed by lifelong learning with M=4.03. The "Problem analysis or solve the problem" is the top priority according to academicians but students ranked it as third based on course covered related to the analysis of the industry-based problem, design-based, or another engineering-related problem in the class. The maximum difference in opinion by academicians and students is seen for "Project management and finance" or "manage multiple projects". A negligible difference in opinion between the students and academicians is seen for the skills such as "meet deadlines", "solve problems", and "adapt and learn new technologies", and the students do not agree with the opinion on skills "Promote your work /give presentations" and "Communication". Technical report writing or review of the existing work or process or technology, work across the multiple disciplines, use of multiple tools to solve complex problems, and interface with industries are the least important factors according to the students and academicians. Based on the students and academicians views and the correlation between the skills needed by industry and the engineering programme curricula that will be able to train the students, it can be concluded that the observations of the study will be useful to the students, faculty, and management of the engineering institutes in developing the right curriculum, providing the necessary skills and helping the industry in providing the right human resource thus contributing to the economic progress of the country.

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