Student perception on achieved graduate attributes and learning experiences: a study on undergraduate engineering students of India

Meenakshi Sankaran* and Seemita Mohanty

National Institute of Technology, Rourkela – 769008, Odisha, India
Email: mee_kshi@rediffmail.com
Email: seemita@nitrkl.ac.in
*Corresponding author

Abstract: This paper identifies and analyses the graduate attributes that students perceive to have achieved better during their four-year undergraduate engineering studies. It also examines the contribution of engineering learning experiences towards achieving the technical and soft skills aspects of the graduate attributes. To achieve these, a transversal study was conducted for a sample size of 583 undergraduate engineering students of various colleges affiliated to a technical university in India. It was found that the graduate attributes students perceived to have achieved more are, knowledge in mathematics, science and engineering fundamentals. The students also felt confident in working well in multidisciplinary settings, both at the individual and the team level. As perceived by the students, engineering learning experiences such as, project work and seminars play a major role in acquiring better technical skills, co-curricular activities for soft skills, and the internet and seminars for both technical and soft skills.

Keywords: graduate attributes; technical skills; soft skills; learning experiences; engineering students; curriculum; knowledge; ability; engineering; competency.


Biographical notes: Meenakshi Sankaran is a Doctoral student in Engineering Education in the Department of Humanities and Social Sciences at National Institute of Technology, Rourkela. Prior to joining her doctoral study, she has had 14 years of experience in teaching computer science to engineering students. Her current research work focuses on accreditation, pedagogical issues and practices, outcome-based education and engineering graduate attributes. In addition, her research interest includes other areas like mobile ad hoc networks, computer programming languages and system analysis and design.

Seemita Mohanty is an Associate Professor of English in the Department of Humanities and Social Sciences at National Institute of Technology, Rourkela with 20 years of teaching and research experience. Her research interests include English language teaching, cultural studies, and engineering education.
1 Introduction

The prime objective behind the four-year undergraduate education that each engineering student undergoes is to inculcate a rigorous sense of engineering experience onto each student that would culminate in them becoming proficient in experiential learning and practice. This training and experience seek to transform a student from a college goer to a trained professional once he or she moves to the workplace after these four years. Thus it becomes essential for them to recognise and build on their skills and abilities during this period so that they are able to acclimatise to a range of diverse jobs all through their careers. Engineering accreditation bodies and industries across the globe have identified certain graduate attributes and widely emphasise on the engineering institutions to prepare the students to acquire these identified graduate attributes.

1.1 Graduate attributes

Graduate attributes are a cluster of heterogeneous student-learning outcomes which describe expected knowledge, skills, abilities, and competency which an engineering graduate must acquire during his or her engineering education. It is a standard anticipated from the accredited engineering program, to reflect through the student graduates.

Many universities worldwide have adopted graduate attributes, encompassing diverse skills, aptitudes and abilities, as a benchmark for graduates graduating from their universities. Accreditation bodies or agencies on their part have also brought in important regulations that mandate that students achieve certain pre-specified graduate attributes to get their final degree. Likewise, graduate attributes are regarded as significant learning outcomes for the engineering programs in India. They denote a set of wide-ranging outcomes (knowledge and skills) or attributes that engineering students must acquire by the end of their engineering experience or program. Technical skills and soft skills are regarded as the major components of graduate attributes for engineering graduates. Technical skills are the essential domain knowledge ingredients that students must acquire to get a job. Adding to this repertoire of domain knowledge, soft-skills attainment becomes crucial for the graduates as these are skills that are highly rated by employers for successful performance at the workplace. Therefore universities and engineering institutes devise various ways to develop graduate attributes among their students. Successful development of graduate attributes can be achieved by providing better learning experiences to the students. Section 1.2 briefly narrates the relationship between graduate attributes and engineering learning experiences. Further, it discusses how the graduate attributes can be developed among the students with effective contribution to engineering learning experiences.
In India, the professional body responsible for accrediting the engineering programs is the National Board of Accreditation (NBA), which is an autonomous body. An autonomous body "is a self-governing body, independent, and subject to its own laws, having full right to decide its working structure and the way in which it wants to work, but all of this should be within the framework of the constitution, and the law of the land". As cited in NBA (2017), India became a permanent signatory of the Washington Accord on 13 June, 2014, which provides global recognition to Indian engineering degrees that can facilitate the mobility of Indian engineers to other countries for job prospects. NBA recognises and recommends 12 graduate attributes as accreditation parameters for engineering programs (NBA accreditation manual, 2012). Figure 1 illustrates that every attribute may be self-contained, but these attributes are interwoven with each other aimed at generating a trained engineering graduate.

Figure 1  Engineering graduate attributes recommended by NBA, India

1.2 Engineering learning experiences

It is a combination of curriculum components embedded with co-curricular activities such as technical, sports and cultural related events, and other academically related activities such as accessing the internet, library-work, group-study, and experience from internship programs, and learning and acquiring knowledge from value-added courses such as certified courses from external organisations. Students tend to learn and acquire
the necessary technical and soft skills from these experiences during their four years of engineering studies at their universities. Technical skills and soft skills constitute the overall components of graduate attributes. Technical skills are considered as the essential knowledge ingredients which students must acquire to get qualified for the targeted jobs, in addition to developing the soft skills that are highly sought after by prospective employers.

Engineering learning experiences can be characterised as a composite of curricular and co-curricular components, and other related academic activities, like group study, online training etc. These experiences prepare the student to acquire the requisite graduate attributes from the engineering program during their academic stay in campuses.

1.2.1 Curriculum or engineering program study:

The curriculum has to be designed in such a way that it provides the basic learning opportunity for the students to acquire necessary graduate attributes relating to technical skills and soft skills. Engineering institutions are required to submit a brief mapping of graduate attributes with the courses of study to the Accreditation bodies or agencies for getting engineering program accreditation. Therefore extra effort is taken by institutes to ensure that the program curriculum generates appropriate acquisition of graduate attributes by the graduating students.

1.2.2 Co-curricular activities:

Beyond the disciplinary activities, the co-curricular activities (clubs, societies, sports activities and cultural and social events) provide better learning experiences to make the students aware of, and acquire the graduate attributes. For example, students tend to plan, design, organise and manage various institutional events that compel them to communicate, network and collaborate with their peer groups and also the seniors and juniors in addition to other stakeholders like officials, faculty members and other service providers. This enables them to gain experience to develop skills beyond the engineering program.

1.2.3 Other academic activities:

Graduate attributes relating to some other academic activities can also help the students to shape their experiences while studying engineering program, and to develop the necessary skills and knowledge. Group study, learning from online materials and videos, developing skills and knowledge by attending internship training, are some of the activities that come under this category.

The Queen Elizabeth prize for engineering report, Create the Future (2015), p.27 has observed that 80% of young Indians within the age group of 16-17 have shown interest to pursue engineering, which is a much higher response rate compared to countries like UK, USA, China, Japan, Turkey, South Africa, Brazil, Germany and Republic of Korea. Queen Elizabeth Prize for Engineering (QEPrize) is an international engineering prize that rewards and commends engineers for their invention of new things that have been of worldwide benefit to humankind. But with this ever-growing importance of the
engineering profession in India, the questions that arise here are – Are the engineering students able to really acquire the necessary graduate attributes? Does the engineering learning experience prepare the students to understand the importance of graduate attributes such as the technical skills and the soft skills? This study attempts to identify and subsequently analyse students’ responses to queries relating to these issues.

The paper is organised as follows: Section 2 covers the review of literature. Section 3 denotes the study objectives, and Section 4 underlines the study limitations. Section 5 provides the study methodology comprising of the sample, the instrument used during the study, the reliability and the validity aspects, as well as the type of analysis done. Section 6 deals with study findings and is divided into two Sections; 6.1 and 6.2. The first subsection discusses in detail with the graduate attributes acquired by the student participants as perceived by them. The second subsection analyses the contribution of engineering learning experiences towards achieving the two different segments of graduate attributes such as the technical skills and the soft skills. Subsequently, Section 7 highlights the key findings and proposes various suggestions and recommendations to the engineering academic world and policymakers, and finally, the study concludes with closing remarks in Section 8.

2 Review of related literature

Surveys are extensively used as mechanisms to assess engineering programs and for improvement in curricula, by various stakeholders of engineering education (Olds et al., 2005; Puerzer and Rooney, 2002; Rogers and Goktas, 2010). A paper by Martin et al. (2005) highlights the areas of strengths and weaknesses of Chemical Engineering graduates of Cape Town University. The study reveals that the graduates are poor in such skill as management skills, leadership skills and ability to function in teams within multi-disciplinary settings. The utmost aim of all engineering curricula should be to instil within the students the need to possess the necessary engineering knowledge and skills (Lemaitre et al., 2006). To this end “using a student exit survey to assess students’ perceived attribute competencies and program attribute strengths and weaknesses can provide additional insight and data for the graduate attribute assessment process” (Cicek et al., 2013, p.1). In another study, James et al. (2002) have found that that student appraisal plays a noteworthy component towards the attainment of student learning outcomes. Vyas and Chauhan (2013) also speak about the role educational institutes need to play in order to infuse engineering skills among engineering students.

Benjamin Bloom, the well-known American educational Psychologist in his famous book, *Taxonomy of Educational Objectives: The Classification of Educational Goals* (1956) has given certain classifications for learning that aids towards achieving a higher cognition level among learners, and subsequently facilitates in assessing educational outcomes. As per Bloom’s taxonomy, remembering, understanding and applying are lower-order thinking skills, which are pre-requisites for higher-order thinking skills like analysing, evaluating and creating. Students are expected to begin with lower-order thinking skills and at the end of the final course of study, they must have acquired the higher-order thinking skills (Conklin et al., 2005). Employers from various industries have also shown dissatisfaction with fresh engineering recruits for their performances, and they contend that these fresh recruits lack in higher-order thinking skills (Blom and Saeki, 2011; Martin et al., 2005; Ramadi et al., 2016). Blom and Saeki (2011) carried an
extensive survey in the year 2009 across several sectors like Oil and Gas, IT, Mining, Infrastructure, Power, Automobiles, and Other service sectors throughout India to trace the satisfaction rate of employers towards fresh engineering recruits. The finding shows that 64% employers across India are dissatisfied with the quality of engineering graduates.

From these findings, we understand that new engineering recruits do not possess the essential skills required by various industry bodies. Additionally, the above studies also speak on employers’ perceptions of competencies expected of engineering graduates. However, sufficient data could not be accessed on engineering students’ perceptions of their competency level achieved through engineering programs. This study aims at addressing this gap in the existing literature. It is anticipated that the study outcome would contribute to the existing gap in students identifying and assessing the graduate attributes achieved by them, so that they are able to understand the contribution of engineering learning experiences towards achieving the requisite level of competency, during their four years of academic stay in engineering campuses.

3 Key objectives of the study

The following key objectives direct the progress of the study:

- to identify and assess the graduate attributes better achieved by undergraduate engineering students as perceived by them.
- to assess students’ perception on the contribution of engineering learning experiences towards achieving the different aspects of graduate attributes such as the technical skills and soft skills.

4 Limitations of the study

This study focuses on the graduate attributes achieved by engineering students, who pursue their engineering degrees in various colleges affiliated to a particular technical university in India. Engineering institutions across a particular country focus on achieving the same set of graduate attributes prescribed by the national accreditation board. However, curriculum, learning experiences, and delivery of instructional methods may vary from one institution to another and may have an impact on students’ perceived outcomes. Further, the location of the institutes and certain social and cultural aspects exercise their influence where the particular country has a multilingual population. Hence, the study outcomes cannot be generalised as a reflection of outcomes from engineering institutions from other parts of the country.

5 Methodology

The study covered a sample size of 583 engineering students from a technical university in India. The sample constituted of students studying undergraduate engineering from various engineering disciplines. In India, undergraduate engineering is a four-year program comprising of eight semesters. The respondents were all in their eighth semester
and were about to complete the program within one month. The study was conducted in the academic year 2016, during the spring semester. A questionnaire was used as the data-collection tool for this study. The questionnaire was validated by educational experts from the authors’ institute. Measurement of internal consistency is the standard requirement for carrying out a study that involves a questionnaire. Cronbach’s alpha was used to test the inner consistency of the study instrument. The coefficient alpha value of the instrument items used to identify the level to which the graduate attributes have been achieved as perceived by students was 0.87, which confirmed to the accepted level of reliability. Similarly, to what extent engineering learning experiences contribute towards achieving the technical skills as perceived by the students scored the reliability value 0.83, and for soft skills, the score was 0.86, which once again confirmed to the accepted levels of reliability (Pallant, 2005). The sample data has been documented and analysed using the Statistical Package for the Social Sciences (SPSS) Version 22.

The questionnaire comprised of two sections with the first section seeking information on the extent of graduate attributes achieved as perceived by the students. For a better understanding of the questionnaire by the respondents, the 12 graduate attributes were amplified into 20 items or statements (Table 1) using a bipolar Likert scale. The bipolar scale had a neutral point in the middle, and the two ends of the scales were in opposite positions of the opinion. Scale items used were: strongly disagree, disagree, neutral, agree, and strongly agree. Section two included a series of 14 engineering learning experiences such as the curriculum components offered by the chosen technical university, other academic activities such as the internet, library-usage, value added courses, internship and co-curricular activities which students had undertaken during their study period. The respondents were asked to choose how much the particular item contributed towards achieving specific technical and soft skills. The items were ranked using five-point Likert-scale items comprising of none, little, some, much, and very much.

Table 1 Student perception on achieved graduate attributes with mean rate

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engineering knowledge</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 1</strong></td>
<td>I can apply knowledge of mathematics to analyse and solve engineering problems</td>
</tr>
<tr>
<td><strong>Item 2</strong></td>
<td>I can apply knowledge of science to analyse and solve engineering problems</td>
</tr>
<tr>
<td><strong>Item 3</strong></td>
<td>I can apply knowledge of engineering fundamentals to analyse and solve engineering problems</td>
</tr>
<tr>
<td><strong>Problem analysis</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 4</strong></td>
<td>I can apply knowledge of core discipline to analyse and solve engineering problems</td>
</tr>
<tr>
<td><strong>Design and development of solutions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 5</strong></td>
<td>I can apply engineering knowledge to design and develop solutions</td>
</tr>
</tbody>
</table>
### Table 1  
Student perception on achieved graduate attributes with mean rate (continued)

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4  Conducting investigations and finding solution</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 6</strong> I can apply engineering knowledge to investigate complex engineering problems</td>
<td>3.22</td>
</tr>
<tr>
<td><strong>Item 7</strong> I can apply experimental knowledge to synthesise information to reach valid conclusions</td>
<td>3.39</td>
</tr>
<tr>
<td><strong>5  Engineering tools and its limitations</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 8</strong> I can suitably use engineering tools for solving engineering problems</td>
<td>3.03</td>
</tr>
<tr>
<td><strong>Item 9</strong> I have a clear understanding of engineering tools’ limitations</td>
<td>3.02</td>
</tr>
<tr>
<td><strong>6  Engineer and society</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 10</strong> I am suitably informed about the role and responsibility of an engineer and the engineering profession for the betterment of the society (health, safety, cultural and legal factors)</td>
<td>3.31</td>
</tr>
<tr>
<td><strong>7  Environment and sustainability</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 11</strong> I am suitably informed and understand the role and responsibility towards the environment and sustainability issues</td>
<td>3.38</td>
</tr>
<tr>
<td><strong>8  Ethics</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 12</strong> I believe and understand the ethical principles relating to engineering practices</td>
<td>3.58</td>
</tr>
<tr>
<td><strong>9  Individual and teamwork</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 13</strong> I can function effectively as an individual in multidisciplinary settings</td>
<td>3.64</td>
</tr>
<tr>
<td><strong>Item 14</strong> I can function effectively as a team member in diverse teams in multidisciplinary settings</td>
<td>3.68</td>
</tr>
<tr>
<td><strong>Item 15</strong> I can function as a leader in diverse situations in multidisciplinary settings</td>
<td>3.41</td>
</tr>
<tr>
<td><strong>10  Communication</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 16</strong> I can communicate effectively viz. writing reports, designing documents, giving effective presentations – giving and receiving clear instruction to the engineering community</td>
<td>3.45</td>
</tr>
<tr>
<td><strong>Item 17</strong> I can communicate effectively viz. writing reports, designing documents, giving effective presentations – giving and receiving clear instruction to the society at large</td>
<td>3.43</td>
</tr>
<tr>
<td><strong>11  Project management and finance</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 18</strong> I can apply knowledge and understanding of engineering principles to manage projects and finance in a multi-disciplinary environment</td>
<td>3.46</td>
</tr>
<tr>
<td><strong>12  Lifelong learning</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Item 19</strong> I recognise the need for independent and lifelong learning for own development as an engineer</td>
<td>3.56</td>
</tr>
<tr>
<td><strong>Item 20</strong> I think I am well prepared to engage in independent and lifelong learning in a broader technological context</td>
<td>3.24</td>
</tr>
</tbody>
</table>
6 Results and discussion

6.1 Study findings: student perception on achieved graduate attributes

The skills that subsume the technical related graduate attributes are the engineering discipline specified skills such as; problem analysis, complex problem solving and designing solutions, knowledge in basic science and mathematics, basic engineering knowledge, knowledge on discipline-related tools and equipment, and their limitations.

The skills that subsume the soft-skills related graduate attributes are communication skills (both oral and written), lifelong learning, ability to manage projects and finance, knowledge on engineering ethics, knowledge on environment, social and cultural sustainability, and understanding the role of engineers in the society, and ability to work as an individual within a team among different cultural and social backgrounds.

6.1.1 Engineering knowledge

Prior knowledge of Mathematics and Science is integral for students to get into an engineering program. At the same time, students are also taught fundamental engineering subjects that include Maths and Science during the first-year of their engineering studies. Figure 2 clearly indicates that students perceive themselves to be highly competent in Maths in order to be applying that knowledge in analysing and solving engineering problems. The mean rate for this item is 4.02, which is the highest mean rate scored compared with any of the engineering graduate attributes. For items 2 (knowledge in science) and 3 (knowledge in engineering fundamentals) the values scored are 3.99 and 3.96 respectively. The mean rate difference between applying knowledge of mathematics and knowledge of science towards analysing and solving engineering problems is 0.03. Similarly, applying science and engineering fundamentals knowledge also vary with a minor difference of 0.03. Altogether, the findings hold positive indication that students are highly competent in applying the knowledge of mathematics, science and engineering fundamentals in analysing and solving engineering problems. This is no surprise since good knowledge in maths and science is a prerequisite to get into any decent engineering institute in India.

Figure 2  Student perception on achieved graduate attributes (see online version for colours)
6.1.2 Problem analysis

Engineering profession requires engineers to analyse and solve an extensive assortment of technical issues and problems. Problem-solving is integral to the engineering profession. Sometimes, the problems are simple and may require a single solution, but more often the engineers are faced with open challenges that need rigorous analysis and diversified solutions. Applying core-disciplinary knowledge to analyse and solve engineering problems is one of the graduate attributes most sought after by employers. To reach that optimum level the students must possess the fundamental knowledge critical to their respective core disciplines. Thus it is highly essential for them to be competent enough to analyse and solve problems related to their core disciplines. Every engineering domain has its own unique problems, and to find solutions to these problems different methods are also available to approach and analyse the problems. In our study, problem analysis scores the mean rate 3.50, which suggests that students definitely need to develop their knowledge about the methods and techniques involved in problem-solving in their respective engineering disciplines. If students are not aware, or are unable to identify the problems they will not be able to design, develop, and find solutions. It is one of the key attributes expected from students to be successful as engineers later on in their careers. In this context, Sobek II and Jain (2004) observe that students should be frequently exposed to complex engineering problems, and should regularly practice problem-solving activities so that over a period of time generating alternative methods of solutions become second nature to them.

6.1.3 Design and development of solutions to the complex problems

Currently, engineers are expected to face challenges related to designing and redesigning products, and solving complex designing problems, which necessitate extensive knowledge of their core disciplines. Different engineering disciplines have different design and development issues that are unique to that discipline, hence engineering graduates need to be well-versed in solving these problems unique to their disciplines. Designing and developing solutions to the complex problems involve sound technical knowledge with an ability to systematically plan and process the problem. Therefore, students also need to possess contextual thinking and good decision-making skills to successfully apply their technical knowledge in designing and developing solutions to complex problems. Yet, the findings reveal that the student participants have not been trained properly on this attribute as a result of which their competency level on this attribute is a low 3.37, which is one of the lowest achieved attributes as perceived by the students.

6.1.4 Conducting investigation and finding solutions to complex problems

Conducting investigations of complex engineering problems and using experiential knowledge to synthesise information in order to reach valid conclusions is another key attribute for engineering students. This is regarded as the keystone of the engineering profession. Engineers create, design, build and solve complex problems. It is one the foremost skills that lead to creativity and innovation (Cropley and Cropley, 2000). But the results show that as perceived by the students themselves, they have poor competency level in conducting investigations on complex problems (3.22), and in synthesising information to reach valid conclusions (3.39). This shows that the students are not
properly trained to acquire these key graduate attributes. This could be because the students are not being properly introduced to problem-based learning, and there is a great need for improvement in this area. Therefore it is suggested that the faculty members of various departments should practice project-based and problem-based teaching and learning methods for better and appropriate training of the students. This would highly benefit the students to acquire skills that are required to achieve this particular graduate attribute.

6.1.5 Engineering tools and its limitations

Engineering professionals must be cognizant of engineering tools related to their disciplines and must be thoroughly aware of their usage and limitations. Acquiring this attribute is indispensable in order to achieve the optimum skills necessary to understand the potentials and limitations of engineering tools. Sometimes, one’s knowledge of tools or lack of it turns out to be the difference in a life and death situation. Being conversant with the functioning of discipline-related tools helps to gather information and attain profound understanding of the problems that could lead to generating possible alternative solutions to the problems. In this context, we observe that students’ knowledge towards using engineering tools for solving engineering problems has a very low mean score of 3.03. Additionally, understanding of limitations of engineering tools also has a low mean score of 3.02. These are the two least mean scores among all other attributes, which informs us that the students are very poorly informed on these aspects. The academic gurus and masters should, therefore, look into this problem area on an urgent basis. Students must be encouraged to get acquainted with the discipline-related tools. This can be achieved by compulsorily making them visit industries, acquire internship experiences, and attend engineering and technology-related exhibitions and shows.

6.1.6 Engineer and society

The results for this item reveal that the students are not much conversant about the role and responsibility of an engineer as well the engineering profession for the betterment of the society in terms of health, safety, cultural and legal issues. With a mean score of 3.31, both Table 1 and Figure 2 reflect that students possess poor information regarding the role and responsibility of an engineer and the engineering profession towards societal concerns, and how their knowledge and skills can be utilised for the betterment of the society. The results thus suggest that the curriculum must include more subjects related to these aspects so that the students gain an understanding of their roles and responsibilities to the society at large. Including more number of Humanities and Social Science subjects could be a positive step in this direction, in addition to instilling onto them a sense of responsibility for societal well-being, by each and every subject teacher also.

6.1.7 Environment and sustainability

Currently, the world faces crucial issues related to environment and sustainability, such as climate change, irreversible changes in ecosystems, biodiversity loss, water and sanitation issues and similar others. From this perspective, the steps engineers take will have major impact on current and forthcoming generations. Hence, engineering students must acquire sufficient knowledge towards environmental issues and sustainability. The
score of 3.38 suggests that still more needs to be done so that the students are able to acquire better information about the role and responsibility of an engineer towards environment and sustainability issues. For this student sample, their present curriculum offers the subject ‘Environmental engineering’ in the last semester of the engineering program. But our interaction with the teachers and students, while conducting this survey, elicited this information that in most of the engineering colleges the attendance for this course is very poor. Generally, in India, campus placement and recruitment process for engineering students commence during the beginning of the fourth year. Often it has been reported by teachers that final year students remain absent for theory classes due to campus placement and training compulsions, and also remain busy in completing their final year project work. Additionally, it is also reported that after getting placed during the campus recruitment process students lose interest in attending theory classes, and just try to complete the semester obligations in the barest way possible and then move on to their professional life. The ones who are unable to get placed continue to focus on preparing for campus-recruitment. This could be the reason why students responded with a low score on knowledge relating to this particular attribute.

6.1.8 Ethics

Engineers are expected to carry out a standard professional behaviour that needs adhering to the highest principles of ethical conduct. Noble, unprejudiced and impartial behaviour is considered as the most significant qualities of an engineer (Shuman et al., 2005). They must possess this while delivering their services to the society relating to welfare, safety, and public health aspects. Table 1 shows a score of 3.58 towards upholding the ethical principles relating to the engineering practice. It is very much imperative for engineering students to understand engineering ethics so that they are able to take crucial and critical decisions during their professional careers.

6.1.9 Individual and teamwork

A single project can involve several individuals. Thus engineers must have the ability to communicate, collaborate and share, express and receive ideas and exchange views with varied teams and audiences. This study reflects better results by students in achieving this individual and teamwork attribute when compared with other attributes. The results reveal that students are quite competent in functioning productively at an individual level in multidisciplinary settings, with a score of 3.64. Additionally, with a score of 3.68, the findings also tell us that the students can also work effectively within diverse teams in multidisciplinary settings. The present curriculum thus fulfils the need of offering interdisciplinary courses to engineering students. The study participants are from varied regions across the state and also from other states too, from multi-lingual and multicultural backgrounds, which possibly help the students to work, share, and learn within multidisciplinary settings. Yet, interestingly, when it comes to leadership skills, the results are not very encouraging. With a mean score of 3.41, the students have shown less competency level as leaders in diverse situations in multidisciplinary settings. Thus, it is observed that more courses and activities that can hone their leadership skills are the need of the hour.
Possessing good communication skill is an indispensable element in the education of engineering students as they have to make use of this for all their future endeavours. It is one of the most crucial skills identified by industry, and expected from engineering graduates (Nguyen, 1998; Lang et al., 1999; Riemer, 2002; Tong, 2003; Blom and Saeki, 2011). In the engineering profession, engineers have to communicate effectively with the engineering community as well as with the society at large. Communication involves report writing, designing documents, giving effective presentations and giving and receiving clear instructions, in addition to other interpersonal skills. There have been several prior studies that have spoken about engineering graduates’ lack of good communication skills (Illing, 2001; Ashman et al., 2008; Volkwein et al., 2004; Nair et al., 2009; Zaharim et al., 2009; Male et al., 2010; Blom and Saeki, 2011; Ramadi et al., 2016). The findings from this study also complement the previous studies. With a mean score of 3.45 in communication within the engineering community, and 3.43 for communicating with the society at large, the results from the students’ perception are not very encouraging for this important attribute.

For successful professional practice in the global arena, engineers must possess good communication skills and team-work abilities. Even multilingual skills are considered as a prominent component to work effectively in this digital era (Blumenthal and Grothus, 2008). Teachers can play a major role in making the students develop their communication skills and teamwork abilities. These skills can be cultivated among students during teaching learning sessions by incorporating communication skills and teamwork activities as key ingredients of the learning process. These vital skills can be developed among students by assigning more communication-related tasks in classrooms, by encouraging open discussions on problems and by giving assignments that align technical concepts in written, oral and visual forms. We should not forget that good communication skills can only be achieved through continuous practice.

Project management and finance are two important attributes that students are much expected to develop during their study period. Knowledge and understanding of engineering principles to manage projects and finances in a multidisciplinary environment scores a mean rate of 3.46. This conveys that students are not much aware of the engineering principles that are applied to understand the project management concepts. Our interaction with the students tells us that a course Principles of Management is included in their second-year curriculum, but specific courses on project management and finance are not a part of their curriculum. Even then, students can acquire these skills by means of project work and through other co-curricular activities relating to technical, social and cultural and sports, where students have the liberty to plan, organise, manage, maintain and make financial budgets.

A person who recognises and displays lifelong competency is expected to shine in the chosen profession. Further, the engineering profession requires engineers to learn and re-learn throughout their careers (Martin et al., 2005; Shuman et al., 2005; Guest, 2006). Studies by Beston et al. (2001) and Jiusto and DiBiasio (2006) strongly emphasise the
significance of lifelong learning for engineers. It is a self-directing learning skill that students must assimilate. Engineering institutions must play a crucial role by encouraging lifelong learning among students by conducting training and workshops, so that they can provide awareness and insight to the students all throughout their lives. Even with so much of importance being attached to lifelong learning; a mean score of 3.56 reveals that students are relatively less familiar with this attribute of independent and lifelong learning for their development as engineering professionals. In this digital era, we find youths to be highly technology-driven, but preparation to engage in independent and lifelong learning in a broader technological context scores a low 3.24 as per Table 1. This result is surprising in the context that the students perceive themselves to be not well-prepared, lacking in competence, and not motivated enough to update themselves technologically in this world of constant technological changes.

6.2 Study findings: student perception on contribution of engineering learning experiences

6.2.1 Curricular components

Core courses are discipline related courses constituting theory, tutorial, and practical sessions. For the chosen university, as a part of their engineering curriculum, students have to write three internal tests every semester for subjects that are included for that particular semester. The individual institution is responsible for conducting these tests. With scores of 3.84 and 3.21 for technical skills, our study results show that core courses and internal tests yield relatively positive outcomes when compared to free electives, professional electives, and other classroom assignments. Figure 4 clearly shows that none of the curricular components has created any extensive impact on students’ preparedness for soft skills development. All these components score within the mean range of 2.35 to 2.83. Assignments are recognised as the best way to enhance and promote students’ communication skills (McDonald, 1995; Nylen and Pears, 2013). However, the contribution of this component disappoints us with the lowest mean score. Figure 2 above informs us that students are not very competent in communication skills. From Table 2 it is observed that assignment is one of the components that have failed to prepare the students to acquire better communication skills. The curriculum provides the option for students to select subjects from their core discipline, or aligned disciplines as professional electives. However, Figures 3 and 4 clearly indicates that professional electives have not created any major impact on the students in acquiring better technical and soft skills.

Other curricular components such as project work and laboratory experiments play a decisive role in the transformation of theoretical knowledge into practice. Similarly, attending and presenting in seminars plays a decisive role in improving students’ practical knowledge and confidence level within the engineering curriculum. Through these methods students tend to learn and attain higher order skills such as designing, analysing and interpreting data, generating information about safety standards, enhancing creativity, and also getting a chance to work within a team and acquiring better interpersonal skills (Felder et al., 2000; Felder and Brent, 2003; Feisel and Rosa, 2005). With so much of benefits encapsulated into experiential learning, this study observes that
the contribution of laboratory experiments holds an unfavourable result towards technical skills achievement with a score of 3.49, when compared with core courses, seminars and project works. In this context, it is cited from Table 1 above that the graduate attribute items from 4 to 9 show that the students do not possess adequate knowledge in design, development, and understanding of tools and their limitations. This could be because of lack of proper experimental laboratory knowledge.

In India, engineering students undertake project work during their final year of study. As seen in Figure 3, it is the second highest contributor (with a score of 4.03) towards preparedness of technical skills, next to seminars, which has a score of 4.18. Besides, it holds the major contributor for soft skills achievement with a minor variance of 0.34. Table 1 above informs us that students are quite poor in higher-order thinking skills such as problem analysis, design and development of solutions and conduct investigation on complex problems. However, this outcome contradicts with Table 2 results. Project work and seminars play the leading contributors in achievement of technical as well soft skills. Usually, it is observed that students carry out the projects in teams of two or three. Nevertheless, on an individual basis, they feel that they are not competent enough to conduct investigation, design, and develop solutions. Yet interestingly, Table 1 results reflect that the students perceive themselves to be adequately competent enough to work within groups. Table 2 in its entirety reveals that students are much benefited by seminars and project works in acquiring both technical and soft skills. Additionally, they have also placed these two components as among their top learning experiences.

6.2.2 Co-curricular activities

For holistic development of a student there should always be a balance between curricular and co-curricular activities. Classroom activities are projected as fortifying students’ learning and achieving learning outcomes, while outside classroom activities relating to technical, social, cultural and sports, enhance the students’ kinaesthetic, interpersonal, linguistic, and musical intelligences. From Figure 4, with a score of 3.38, it is also acknowledged that these activities play significant roles in students’ learning experiences in acquiring soft skills. This is positioned as the second highest learning experience that prepares students to acquire soft skills.

6.2.3 Other academic activities

General observation tells us that young students tend to learn the most from their peer groups. The study findings also underline the same. Table 2 above informs us that ‘group study’ is placed at sixth (3.91) and fourth (3.72) positions in preparing students to achieve technical and soft skills respectively. The creation and development of the worldwide network is one of the major inventions of man in the 21st century. Our study reveals that internet (Blogs, social media, YouTube, etc.) plays a crucial factor in acquiring technical skills (4.02) and soft skills (4.20) as perceived by the students. Furthermore, it shares the highest mean score among all attributes in the soft skills category. However, this finding contradicts with the outcome of item number 20 from Table 1 where we observe that ‘lifelong learning in technological context’ scores among the least. Yet in Table 2,
M. Sankaran and S. Mohanty

’internet’ scores the highest mean value in soft skills and remains one of the major learning experiences for students in acquiring technical skills. The education system, over the years, has witnessed the positive involvement of libraries as a part of the teaching-learning process, and has always aided the students in independent learning and understanding. Thus, the attribute ‘library’ underlines its contribution in technical skills development with a score of 3.98. A relatively low mean score of 2.74 for soft skills is expected as it is well-known that library access does not leave much scope for soft skills improvement.

Figure 3 Contribution of engineering learning experiences in acquiring technical skills
(see online version for colours)

![Graph](image)

Figure 4 Contribution of engineering learning experiences in acquiring soft skills
(see online version for colours)

![Graph](image)
Table 2
Contribution of engineering learning experiences towards acquiring technical and soft skills

<table>
<thead>
<tr>
<th>Engineering learning experiences items</th>
<th>Technical skills (TS)</th>
<th>Soft skills (SS)</th>
<th>Mean gap differences (TS) – (SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Curricular components</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Core courses</td>
<td>3.84</td>
<td>2.44</td>
<td>1.4</td>
</tr>
<tr>
<td>2. Professional electives</td>
<td>2.83</td>
<td>2.36</td>
<td>0.47</td>
</tr>
<tr>
<td>3. Free electives</td>
<td>3.07</td>
<td>2.62</td>
<td>0.45</td>
</tr>
<tr>
<td>4. Internal tests</td>
<td>3.21</td>
<td>2.35</td>
<td>0.86</td>
</tr>
<tr>
<td>5. Assignments</td>
<td>3.15</td>
<td>2.73</td>
<td>0.42</td>
</tr>
<tr>
<td>6. Laboratory experiments</td>
<td>3.49</td>
<td>3.50</td>
<td>–0.01</td>
</tr>
<tr>
<td>7. Project work</td>
<td>4.03</td>
<td>3.74</td>
<td>0.29</td>
</tr>
<tr>
<td>8. Seminars</td>
<td>4.18</td>
<td>3.84</td>
<td>0.34</td>
</tr>
<tr>
<td>b Co-curricular activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Participation in sports, technical, cultural and society activities</td>
<td>2.83</td>
<td>3.88</td>
<td>–1.05</td>
</tr>
<tr>
<td>c Other academic activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Library</td>
<td>4.02</td>
<td>4.20</td>
<td>–0.18</td>
</tr>
<tr>
<td>11. Internet (Blogs, Social Media, YouTube, etc.)</td>
<td>3.91</td>
<td>3.72</td>
<td>0.19</td>
</tr>
<tr>
<td>12. Group study</td>
<td>3.34</td>
<td>2.43</td>
<td>0.91</td>
</tr>
<tr>
<td>13. Internship experience</td>
<td>3.93</td>
<td>3.03</td>
<td>0.9</td>
</tr>
<tr>
<td>14. Value added courses (VAD)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Internship experience boosts classroom learning by integrating real-world experience, and also by improving job opportunities after graduation. In addition, it provides a platform for students to demonstrate and develop their technical skills and interpersonal skills. An internship experience provides an opportunity for students to view and understand the modern engineering tools used, and technology adapted by the industry. However, the results tell us that students participating in the study are not much aware of the importance of internship experience. It shares its mean rate contribution 3.34 and 2.43 towards technical skills and soft skills. Figure 2 informs us that the present curriculum fails to prepare the students to understand and acquire the ‘engineering tools and its limitations’ graduate attribute. In this study, only 41% of students have internship experience. Thus the failure of perceiving the importance of this attribute probably lies in students’ lack of internship experience. Our interaction with the students revealed that the current curriculum does not offer any credit points to students for undergoing internship experience, and is not mandatory. It is no wonder then that the results for this attribute are low compared to other graduate attributes.

Value added courses are much popular among engineering students and institutions across India. To provide practical and industry certified courses the host institutions collaborate with external organisations and provide these courses to their students. Such courses usually spread over a semester. These courses are primarily intended to enhance employability by giving intensive training to improve communication skills, personality
development, and courses related to a specific technology. Overall, the objective of offering these courses is to bridge the skill gap and make entry-level students readily deployable. Table 2 shows the mean rates of 3.93 and 3.03 for value-added courses towards acquiring better technical skills and soft skills. To some extent, this component fulfils its purpose and benefits the students. From Figure 3, we can see that it is the fifth highest contributor which helps the students to acquire technical skills.

7 Key findings and suggestions

Firstly, the study reveals that the students are competent enough to work in diverse teams and can apply their engineering knowledge to analyse and solve engineering problems. As per the findings, Table 1 shows that the students have not acquired all the necessary graduate attributes required for successfully completing the engineering program. Second, we observe that the university curricular components such as project work and seminars help the students to better possess technical as well as soft skills. Further, as perceived by the students, core courses extend their support in achieving technical skills. Apart from the curricular components, students perceive to acquire better technical and soft skills from the internet. Co-curricular activities also contribute to a large extent in acquiring soft skills by the students.

From Table 1 we find that there is not much difference in the mean values among the attributes such as, design and development, conducting an investigation and finding solutions to complex problems, engineering tools and limitations, ethics, engineer and society, and environment and sustainability. The mean rate score of these attributes is also not very appreciated. On the other side, teamwork, communication, and lifelong learning skills are recognised as crucial components for the modern engineer. However, as revealed in Figure 2, it is indeed a matter of disappointment that the participating students show poor attainment of these essential attributes.

The outcome from Table 2 mirrors the positive contribution of curriculum components such as, project work and seminars, which aid the students to acquire both technical and soft skills. Overall, the outcome of this study leads to multiple suggestions for the parent technical university as well as for other engineering institutions in general and also for engineering educators. Promoting students to possess high-order thinking skills such as analysing, evaluating and synthesising are indispensable for a profession like engineering, where engineers create and implement new ideas. As this study suggests, problem-solving and design and development attributes must be instilled onto the students through project-based and problem-based learning. Students must be frequently encouraged and assigned to solve small open-ended problems that will help and improve them in generating alternative and new ideas for a particular problem. In the context of the study outcomes, auxiliary awareness programs such as role and responsibility of engineers, environmental and socio-economic issues related programs, alumni interaction, awareness camps on the necessity of internship experience must be conducted, and more industry personnel should be invited to discuss and deliver talks so that students are well-informed about their roles for the betterment of society and well-being of individuals.

We strongly believe that project work is one of the best ways to enrich and develop students’ individual abilities, knowledge, and competency. Thus, appropriate selection of projects and their proper processing will undoubtedly construct positive results among
engineering students. They can then share, gather and assimilate the required knowledge, and also learn to work with each other. Therefore we recommend universities to include small projects for each subject in their curriculum. Proper grading of project work is also a necessity for extracting better output from the students. This will motivate and encourage the students to nurture skills relating to problem-solving and designing. It will also compel them to work within teams and learn from peer groups, which will lead the students to understand the importance of life-skills and give them a chance at improving these learning skills. Furthermore, we suggest that students must be encouraged and guided to undertake interdisciplinary and socially relevant projects. Besides, the university must identify and reward the best projects, so that the successive batch of junior students get encouraged to extract the best results out of their project works.

In addition, the engineering faculty must practice problem-based teaching to supplement other pedagogical methods. They have to play a critical role in delivering, conducting, and implementing effective laboratory experiments. The attribute least acquired by the students as perceived by them is engineering tools and limitations. As is well-known, internship experience and laboratory experiments complement each other to improve technical skills. To reinforce their laboratory experiment knowledge, students must visit industrial units so that they can view, observe and understand the tools, devices, and equipment used in their respective domains. Undoubtedly internship experience is the best way students get to know and gain the industry experience. The curriculum should include internship training, and students and institutions should understand and acknowledge the importance of an internship. The gaps that exist between academia and industry can be bridged to a great extent by offering compulsory internship training to the students. Further, universities must pay attention to the range of subjects offered under professional and free electives, and review these at regular intervals.

Engineering institutions also need to employ a practical approach in course delivery and must redesign the curricula as per industry requirements. Engineering educators have an immense role and responsibility to equip themselves with more than a profound knowledge of an academic subject area. The university must assess and measure the effectiveness of teaching and learning processes practised and the learning outcomes achieved during the academic process. They must elucidate the strengths and weaknesses of the curriculum so that the necessary improvements can be made on a timely basis.

8 Concluding remarks

Professional bodies all over the world necessitate engineering programs to deliver graduate attributes and put emphasis on engineering educators to practice various pedagogical approaches, and weighs the institutions’ preparedness, quality, and delivery of student outcomes as described in the handbooks of various accreditation boards.

Engineering educators have their own role in implementing effective teaching and learning practices so that they can produce successful future engineers. Engineering institutions and engineering educators play crucial roles to inculcate the graduate attributes among engineering students during their study period so that they can be well-equipped, and become employable after the completion of their engineering studies. It is highly required for engineering educators to be attentive to the transforming nature of the workplace and of the needs of employing organisations and be more receptive to address these transformations.
Overall, the outcome of this study particularly recommends the designated university to update the curriculum to enhance the educational experience of students, and thereby achieve continuous quality improvement.

Acknowledgements

We wish to thank all the stakeholders from various academic institutions for sharing their views and opinions with us during the duration of the research work. Further, we are thankful to all the final semester engineering students from the participating institutions.

References


**Website**