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Importance versus Achieved: A Cross-Sectional Study on Engineering Students' Perception on Generic Attributes

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Abstract: The objective of the present study is two-fold. First is to explore engineering students' perceptions on the importance of generic attributes required to become a successful engineer, and, second is to assess the extent to which the students possess these generic attributes. To achieve the objectives a cross-sectional study was conducted among final year engineering students pursing various engineering programmes under a state technical university in Odisha, India, during the academic session of spring 2016. Making use of the survey method, data were collected from the respondents with the help of a questionnaire. The results indicate that there is a serious mismatch between the students' perception on the importance of the generic attributes,and the attributes possessed by them. In addition, the findings reveal that students possess very less knowledge on discipline-specific technology and tools. The social and business contexts of practicing engineering is also not much known to them, in addition to possessing inadequate problem-solving and leadership skills. Further, they are not able to manage the stress in their lives even though they are very well aware of its importance in a person's general well-being.

Keywords: Generic attributes, Engineering students, Engineering education, Knowledge, Skills, Academia

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1. Prelude

Transitioning from academic environment to workplace environment certainly puts pressure on engineering graduates. With globalisation, today's job scenario has changed drastically and what are required of an engineering professional are not simply domain knowledge but also certain other skills and expertise that move beyond technical knowledge. During their academic stay students must recognize the attributes necessary for success in the workplace and must work hard toward acquiring them. Today,employers expect additional skills and knowledge from engineering graduates. Those engineers who possess better generic attributes skills are more likely to be successful in their profession. Various studies indicate that employers around the world are not satisfied with the skills possessed by fresh engineering graduates (Passow, 2012); Alpay and Jones (2012); Nair et al., (2009); Martin et al., (2005); Blom, Andreas and Hiroshi Saeki's (2011)).Many suggestions and recommendations have been proposed to impart more employability and professional skills among engineering students(Balaji and Somashekhar, 2009); Alpay and Jones (2012); Lemaitre et al., (2006); Holsapple et al., (2012); Danielewicz-Betz and Kawaguchi (2014). Several studies have identified the engineering graduates' weak area of competencies from industry point of view. There have been numerous voices to broaden the quality of engineering programmes and its deliverables (Lee, 2003); Passow (2012); Maleetal., (2010); Ramadiet al.,(2015); Martin et al., (2005);

Blom, Andreas and Hiroshi Saeki's (2011); Danielewicz-Betz and Kawaguchi (2014);Barrie (2004)).Engineering education has to address the changing paradigms and must be ready to adapt the transformation from traditional mode of delivery into a more modern approach. Both engineering education and profession are confronted with various challenges across the globe. Engineering graduates are expected to possess an assortment of skill sets to address the worldwide problems. This study varies from previous studies in its identification and analysis of the importance of generic attributes from engineering students' point of view.

2. Literature Study

As per Bath et al., (2004), graduate attributes are influenced by three factors - measurement of quality education, preparinggraduates to be employable, from the point of view of education as a lifelong development. Barrie (2004) points out that for a number of decades universities around the globe have voiced the need for a diverse collection of graduate attributes. Radcliffe (2005) emphasises that engineering students must prepare and acquire the knowledge in specific technology to get employed in the industry. Patil (2005) also holds the same views as Radcliffe. According to Wellington et al., (2002) and Radcliffe (2005),discrepancy exists between skills acquired by students during the course of study and skills expected in the workplace.

Kruger (2006) claims communication skills and information skills are parts of functional skills, but, Zubaidah et al.,(2006) argue that creative thinking, problem solving, leadership skills and organizational skills, along with communication skills are part of functional skills. Blom, Andreas and Hiroshi Saeki's (2011) policy research working paper underlines the fact that Indian engineering graduates do not possess high order thinking skill sets.

3. Cross-Sectional Study

A. Purpose of the study

The core objective of this study is to shed light on the generic attributes obtained by engineering students and identifying the students' perception on the importance of those generic attributes. It is highly anticipated that the outcome of this study will provide the relevant information about the students' perceptions and their own assessment of generic attributes to the parent university and the engineering educators.

B. The Constraints of the Study

· The outcome of the study cannot be generalized to the engineering students from other universities, since different curricula and teaching and learning methods may influence the outcome.

· It is the reflection of the participating university students only. The study does not focus on any particular engineering discipline.

C. Research Methodology

The sample comprised of 583 final semester engineering students from various engineering disciplines from a state technical university in the Indian state of Odisha. The university offers 22 engineering programmes under various disciplines. The university has 110 colleges both affiliated and constituent. In the study, 26% participants were from Government engineering colleges and 74% from private engineering colleges. The percentage of private college students was more because more than hundred 100 engineering colleges are owned by private stakeholders. The percentage of male students was pretty higher (64%) than female participants (36%). The students from seven (7)disciplines have participated in the study. The participants discipline were Computer Science & Engineering, Information Technology, Mechanical Engineering, Electronics & Communication Engineering, Electrical & Electronics Engineering, Electrical Engineering and Electronics & Instrumentation Engineering.

Twenty one generic attributes was designed to accomplish the study goals. The generic attributes were derived from the identified graduate attributes of various sources such as the National Board of Accreditation (NBA), National Academy of Engineering (NAE), and Accreditation Board for Engineering and Technology(ABET).A questionnaire was used as the tool to collect the related data to fulfil the objective of the study. The questionnaire comprised of 21 generic attributes covering the domains of knowledge, skills and abilities. The questionnaire was framed using a five-point Likert scale ranging from 'not important' to 'very important' and was divided into two parts. The first part asked the participants their perception on the importance of

generic attributes.The second part of the instrument records the students' own assessment of the listed generic attributes corresponding to their agreement or disagreement, with the scale ranging from Strongly Disagree to Strongly Agree.

Data collection process was initiated by visiting the engineering colleges across Odisha. After seeking permission from the respective colleges the study was undertaken. The participating students were explained in detail about the list of 21 generic attributes. The questionnaire was validated by senior faculty members from the researcher' sown institute. The data was analysed using Statistical Package for the Social Sciences (SPSS) 22. Descriptive statistics was used to summarize the outcomes of the study. Further, Cronbach alpha (α) was used to check the reliability of the questionnaire. The reliability value for students' perception was 0.81 and students' own assessment was 0.83. As stated by Pallant (2013), if the instrument value is greater than 0.8 it can be considered as good and reliable. Our questionnaire reflects and confirms to the said standards.

D. Findings

Table 1. Students' Perception on the Importance of Generic Attributes vs Students' Own Assessment on Achieving of Generic Attributes with Gap Analysis

Generic Attributes	Students' perception on Important attributes (a)	Students' own assessment on achieved attributes (b)	Gap (a-b)
Adaptability	3.98	4.15	-0.17
Commitment to work	4.32	4.35	-0.03
Creativity	4.23	3.94	0.29
Decision making ability	4.15	4.05	0.1
Knowledge in discipline specific technology and tools	3.96	3.02	0.94
Discipline specific knowledge	3.93	3.96	-0.03
Ethical issues	3.69	3.65	0.04
Leadership	3.74	3.41	0.33
Lifelong Learning	4.02	4.09	-0.07
Oral communication	4.24	4.11	0.13
Practical knowledge	4.38	3.59	0.79
Presentation skills	4.12	3.91	0.21
Problem analysis	4.34	3.57	0.77
Problemsolving	4.31	3.39	0.92
Programming knowledge	3.88	3.52	0.36
Science and mathematics	3.78	4	-0.22
Social and business context	3.58	3.46	0.12
Stress management	4.18	3.55	0.63
Team work	4.37	3.68	0.69
Written communication	3.83	3.61	0.22
Logical thinking	4.14	3.97	0.17

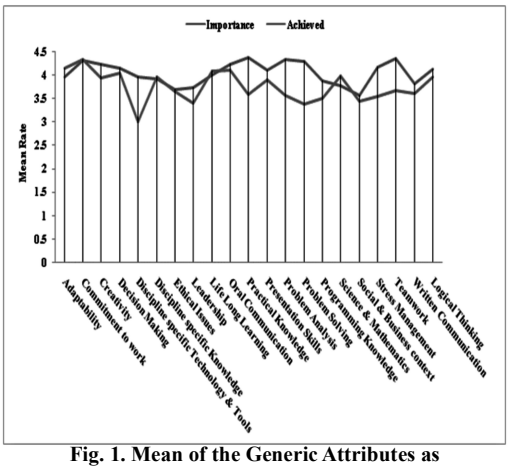

Fig. 1. Mean of the Generic Attributes as Perceived by the Students: Importance and Achieved

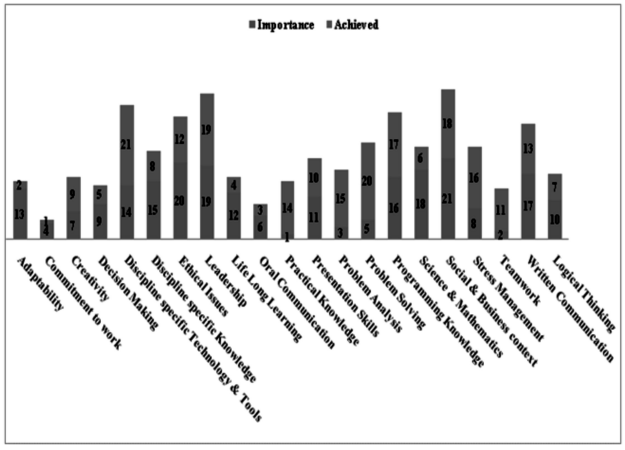

Fig. 2 Ranking of the Generic Attributes as Perceived by the Students: Importance and Achieved

E. Discussion and Suggestions

Fig. 1 illustrates the mean rate of importance of attributes in students' view, and attributes possessed by them. Fig. 2 shows the ranking of the attributes as per their importance and achieved, as perceived by the students. The five generic attributes that have been rated most important by the students are practical knowledge, team-work, problem-analysis, commitment to work, and problem-solving.

Social and business context, ethical issues, leadership, knowledge in science and mathematics and written communication are the five attributes that are rated in the least importance category from the students' point of view. Similarly, they rated their own assessment of top five perceived generic attributes, as commitment to work, adaptability, oral communication, lifelong-learning, and decision-making ability. Knowledge in discipline specific technology and tools, problem-solving, leadership, social and business context and programming knowledge are the least five attributes possessed by students.

The findings as analysed from Table 1, Fig. 1 and Fig. 2 are summarised herewith. Table1 indicates the mean rate scored by each generic attribute and the gap existing between the perceived importance of the attributes with the levels of achievement among the students. From Table1 we clearly understand that gap exists between important versus obtained ratings that range from 0.1 to 0.94.

The gaps existing between adaptability, commitment to work, discipline-specific knowledge, lifelong-learning and knowledge in science and mathematics fall under negative gap value -0.22 to -0.03, which indicates that attributes achieved by the students are more than their perceived importance about these attributes. This negative gap shows that students possess more capability than what they perceive to be important relating to certain attributes.

Problem analysis involves recognizing the prevailing problems and ascertaining the causes and effects relating to the problem. Problem analysis is perceived to be quite important by the students with a score of 4.34, and a third rank, but students own assessment of their achieved score for problem solving capabilities has the mean rate 3.57 with a rank of 15. This result shows that students are not very confident of their problem solving skills. Students must therefore be taught various approaches through which they can better analysed a problem. Hands-on experiments requiring problem solving skills must be routinely practiced by the students to develop their problem solving abilities which is an integral part of an engineer's array of skills. Problems can be analysed with the help of appropriate engineering tools as well with specific technology involved within it. From Fig.1 we also understand that students possess very poor knowledge of engineering tools and discipline-specific technology. This could be the reason why students are not competent enough on analysing problems. Problem-based learning and project-based learning are certain teaching methods by which students can better understand problems and come up with multiple solutions.

In today's complex world every profession and organisation faces multiple ethical issues. Accordingly the engineering profession should take the lead in addressing the ethical issues during problem-solving and implementation of projects. Ethical issues involvethe professional code of ethics, as well the engineer being aware about the social and cultural codes of ethics. Ethical issues are considered to be vital knowledge for an engineer to possess. This study results shows that students are not much aware of its importance and gave a score of 3.69. Ironically, with a mean score of 3.65, they also perceive that they have adequate informationrequired to be designated as ethically aware.

For an engineer working in teamsis inevitable as it creates human synergy that results in quality output and superior productivity. Teamwork plays a vital factor in a project's success. Basically, engineering students tend to learn working in teams during project work and participating and conducting co-curricular activities, Team work is an effective factor for the students to share, learn and experience all the known and unknown knowledge and skills. Students understand that team work is a very important skill to possess (4.37) which has given it the second highest rank among the importance of attributes. Even though they understand the importance of team work (4.37), they perceivethey have very less achievement in team work skills (3.68) as compared to its importance. Yet, it still holdsits position within top 15 attributes in importance rank (2nd) and the achieved rank(11^{th}).

Similarly, students have well understood the importance of possessing practical knowledge (4.38) which scored the highest mean rate as well holding 1^{st}

rank among all the attributes. But, students do not have adequate experience in practical knowledge, and its mean rate of 3.59 gives it the 14th rank. It is well understood that students will gain practical knowledge once they begin their industry experience. Still, it is the responsibility of the academia to prepare them to acquire basic practical knowledge. Students must acquire more practical knowledge while they are in the academic environment, so that they are able to equip themselves properly, and subsequently apply their fundamental knowledge in the industry. Students can gain practical knowledge from various sources such as from, internship experience, industrial visit, and conducting laboratory experiments and project works.

Problem-solving is one of the main tasks an engineer is expected to undergo during design, development and investigation of complex problems. This attribute is assigned with the 5th rank with the mean rate of 4.31 for importance, while students' own assessment of their problem solving capability is assigned a lowly 20thrank with the mean rate of 3.39. Thegap existing between the two is observed to be the highest (0.92) for this particular attribute. Problem analysis, problem solving along with practical knowledge, commitment to work and team work are the most important generic attributes as indicated by the results of the study.

Development of lifelong-learning is crucial for an engineer in the contemporary world where a huge part of economic growth and employment is the outcome of knowledge intensive activities. Lifelong-learning is one of the graduate attributes included in programme outcome in engineering programme which necessitates engineers to understand the responsibility of their own development as an individual as well as an engineer. Engineering institutions play a major role in elevating lifelong learning by providing training to engineering educators so that they learn and understand the importance of this attribute. As a result of which they can serve as examples that can subsequently encourage and motivate the students to keep on learning all through their lives for their own development, both personal and professional. If students do not understand the importance of lifelong learning, and institutes fail to make them aware of this, or inculcate this attribute among students, then ultimately it becomes a loss to the engineering profession and to the nation in general. The importance score of lifelong learning is 4.02 and students own assessment on this skill is 4.09. Lifelong learning is all about creating and maintaining a positive attitude to learn throughout the life for own development. This result shows that students hold a strong belief about both the importance and possession of this particular generic attribute.

Stress is another factor that scores quite high in the importance scale. Common knowledge suggests that young students face lot of stress in their lives relating to social, cultural, environmental, peer and academic pressures. High level of stress can ruin the life of students. Generally, stress occurs when pressure surpasses beyond its perceived ability to cope. Stress management has a mean score of 4.18 in the importance scale, but students admit that they are not able to manage the stress in their lives which is reflected in the 3.55 score in the achieved scale. University must include stress management courses in curriculum so that students would be able to better understand their stress levels and thus manage the problems that lead to their stress. Further, it is suggested that institutions must incorporate studentmentorship programmes, and faculty members must also be assigned a group of students to mentor and act as faculty advisors. Additionally, counselling services should be provided at the institutional level for the benefit of the students.

Another area where the students reveal to have not much awareness is the importance of discipline-specific technology and tools. As a result the mean score for this attribute is 3.96 and students perceived level of achievement for this is quite low when compared with other attributes (3.02). This is one of the attributes perceived as least important by the students and comes towards the lower end in the hierarchy. In this context, this knowledge can be imparted to the students through industrial visits, and by visiting technology related shows and exhibitions. Institutions must pay attention behind the reason for the poor score in this attribute.

Social and business context is viewed by the students as another least important attribute with the mean score 3.58 and achieved score of 3.46. This score conveys that students are not well-informed about the importance of this attribute and as a result they believe they do not possess good social and business contexts information.

Decision-making ability ranks within 1 to 10, both

in importance and achieved scales. It ranks 9 in importance and 5 in achieved. This suggests that students have a strong belief that they possess strong decision-making abilities. Similarly, logical thinking has mean scores of 4.14 and 3.97 for importance and achieved respectively. On the hierarchy it scores10thfor importance and 7th for achieved respectively.

Articulating thoughts and ideas into a written form is one of the essential communication skills students are highly expected to possess. Engineers are frequently required to write reports about projects and its progress among the peer groups as well with the higher officials. Yet, written communication scored less mean rate in both importance and achieved scales and holds the 17th and 13th respectively. Students need to improve their written communication skills and they can be well trained by the faculty through regular written assignments, and by writing short technical papers and also through workshops and training programmes.

Good presentation skills are also an important attribute to be achieved by engineering students. Presentation skill holds the 11th rankfor importance and 10th for achieved. Correspondingly, the mean scores are 4.12 and 3.91 respectively. Through regular seminar presentations students can improve their presentations skills. Good oral communication means expressing ideas clearly and articulating properly with diverse audiences. The mean score of its importance is 4.24 and the achieved score 4.11 as per students' perception. This result brings good news that students feel that they are competent in oral communication.

Science and mathematics scores for importance is 3.78 and for achieved is 4, which suggests that students possess strong knowledge in science and mathematics which are the foundation courses for engineering students.

Intellectual development of an individual is based on innovation and creativity. It gives a shape to an individual's imaginative ideas, bringing it into reality. In the contemporary competitive environment industries expect creative thinking engineers. Students are aware about the importance of creativity and hence have rated it 4.23,yet at the same time they perceive that they do not possess adequate creativity (3.94).Creativity holds 7th and 9th ranksin importance and achieved respectively, with a gap of 0.29. The mean score of 3.94 clearly indicates students' lack of creative ideas, and teachers can certainly enhance students' creativity via brainstorming and mind-mapping methods.

Leadership is one of the crucial skills highly expected by employers from the engineering graduates (Farr, J.V. and Brazil, D.M., (2009); Kumar, S. and Hsiao, J.K.,(2007);Robledo et al., (2012)). It is all about influencing and directing others for a positive outcome. Leadership and team work are related entities where an individual with strong leadership skills can lead a team towards better productivity and also subsequently towards betterment of the society. Yet with all these positive aspects associated with leadership, Table1 and Fig.1 reveal a sorry state of affairs with respect to its importance and achieved levels among the students. The results show a mean score of 3.74 for importance and 3.41 for own achievement and holds 19th rank for both categories.

Institutions can invite leaders from industry who can interact and share their experiences with students which can influence young minds to acquire and possess leadership skills. Elective courses on leadership can also be included in the syllabus which can impart new and contemporary ideas to the students.

Programming knowledge is one of the important skills for students across any domain area. Every domain uses software and simulation which requires programme coding. Yet the results show that students do not perceive it to be too important by giving a mean score of 3.88, while the achieved score stands at 3.52. The ranks for both aspects are also quite low at 16th and 17th respectively.

Adaptability is one of the important issues of human resources in engineering. In particular, adaptability is highly significant as the Indian Information Technology (IT) sector is primarily a service-oriented sector where engineers are expected to move around the world to undertake projects. Further, students must be well-prepared to adapt to work in multi-disciplinary settings in different geographic areas. In the adaptability factor the students perceive that they are adaptable to various situations, and hence achieved adaptability attribute has a mean score of 4.15, which is higher than its importance mean score of 3.98. The result thus states that students are well-prepared in adapting to diverse

settings. This illustrates that students have learnt from the multi-set academic environments which comprises of teachers, staff and students from diverse social and cultural backgrounds.

The importance given by students on discipline-specific knowledge is 3.93, which presumably is because of the fact that irrespective of the disciplines to which the students be long to, a majority of them get placed in the IT sector. As per the 2015 The National Association of Software and Services Company (NASSCOM) report IT companies are the biggest recruiters of engineering students during the campus recruitment process.

4. Conclusion

The mission of technical institutions must not only be to put emphasis on technical related attributes, but must also extend to incorporate attributes related to core discipline employability and professional development. Various pedagogical approaches can be adapted to instil these skills among students during their academic stay. Exposing the students to the given attributes and facilitating them towards acquiring the attributes is very much essential for the students for their own development as well for their professional development. Curriculum must be designed in a way that the students get an opportunity to acquire all the required attributes to meet the global challenges.

If academia fails to prepare the engineering students to meet the global challenges, then it results in immense disservice to the society. A professional degree like engineering requires longer duration of study to complete, in addition to being entwined with higher expectations from parents and society. It is the duty of the academia to ensure that students possess the necessary skills to get into the right job.

This would ultimately result in bringing success to students and the academic institutions.

Finally, as the study aids the students in understanding their own strengths and weaknesses vis-à-vis the generic attributes required to be successful engineers, we believe that it will help the students to prepare themselves better to be successful engineers for the country. The engineering institutions can certainly act as able facilitators in the whole process.

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