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Assessing the Competencies of Engineering Students in Generic Skills: Insights from India

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Abstract: Development of generic skills is a primary focus for educational policies and accreditation bodies, there has been insufficient exploration into engineering students' perceptions of these skills and their motivation to develop them. Typically, the promotion of such competencies relies on conventional methods rather than well-organized curriculum frameworks. In addition, the absence of a unified definition and interpretation of generic skills across various disciplines complicates curriculum design. This study seeks to evaluate the competencies of engineering students in generic skills by employing an innovative decision-making approach. The proposed method assesses students' skills within a structured framework by combining the Analytic Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). AHP method is utilized to determine the weights of different competency criteria, whereas the TOPSIS method is employed to rank criteria according to their proficiency in these skills. The approach taken in this study demonstrates the efficacy of addressing decision-making challenges and underscores its practical utility and dependability in evaluating the development of generic skills. Finally, this study's findings determined the importance set of generic skills in the context of the Indian higher education system.

Keywords: Engineering students, Generic skills, Higher education, AHP, TOPSIS, India

1. Introduction

Engineering education has been considered to be focused on emphasising technical and disciplinary skill neglecting social aspects (Chan *et al.,* 2017) further; National Academy of Engineering (NAE) has revised the skills needed for Engineer of 2020. However that target deadline is reached, the fundamental principles and issues highlighted remain relevant, and the challenges have only intensified. This complexity arises from increased societal interdependence, the rapid advancement of technologies, the necessity for accountability and stakeholder engagement, a significant level of uncertainty, and a commitment to lifelong learning to adapt to ongoing changes (Chan and Fong, 2018). As a result, there is a growing need for new competencies related to creativity, communication, management, leadership, agility, and resilience. Furthermore, they are competencies that are transferable across vocational and contextual boundaries and that have gained traction in the globalized knowledge economy.

Moreover, the role of engineers extends far beyond technical expertise in today's rapidly evolving global economy. Besides, the rising intricacies of business challenges and social issues necessitate engineers to possess a broad range of competencies (Huang *et al.,* 2022). These competencies referred to as "generic skills" encompass a variety of abilities such as academic and problem-solving, interpersonal skills, community and citizenship knowledge, leadership, professional effectiveness, information and communication literacy, critical thinking, and self-management skills (Chan *et al.*, 2017; Chan and Fong, 2018). Imbibing these skills enable engineering students adapt to varied work environments and make meaningful contribution towards their profession and society (Wheebox, 2024).

Employers prefer engineers who are not just technically proficient but also capable of coping with complex work environments, working across disciplines, and responding to the rapid rate of change in 21st-century workplace demands (Hirudayaraj *et al.*, 2021; Islam, 2022). To meet the industry's growing needs for interdisciplinary and technological roles, engineering education must provide students with a wide array of generic skills embedded within the curriculum along with technical skills (Cruz *et al.*, 2021; Wheebox, 2024). Earlier researchers attempted to highlight key skills in different contexts. Notably, Yap & Tan, (2022) examined the association of students' competencies in lifelong learning and professional success and Hirudayaraj *et al.* (2021) focused on employers expectations of soft skills and communication skills from entry-level engineers. In a similar context, Fleming *et al.* (2024) study highlighted the need for problem-solving and technical skills. In addition, recent studies emphasize the need for global competency learning to ensure graduates meet globalized labor standards (Richter and Kjellgren, 2024), prosper in the current digital age, and are competent enough in the workplace (Impagliazzo and Xu, 2024). Furthermore, key stakeholders of engineering education emphasized fostering normative, strategic, and systematic thinking competencies in engineering students to ensure the attainment of Sustainable Development Goals (SDGs) by addressing varied future social and environmental problems (Beagon *et al.,* 2023).

From the previous studies the present study found research gap in two ways. Primarily, earlier studies considered the employers' perspectives and industry requirements in evaluating competencies for engineering students (Fleming *et al.*, 2024; Hirudayaraj *et al.*, 2021) discarding students perceptions and their preparedness in acquiring required skill set. Recent studies tried to address this gap by capturing the students perceptions for example Picard *et al.,* (2022) studies focused on skills acquired through team-based projects, and Richter and Kjellgren, (2024) studies focused on course specific global competencies required for engineering students. Similarly, Josa and Aguado (2024) study focused on skills acquired by civil engineering students through social sciences courses. All these attempts lack a holistic understanding of competencies needed. On the other hand, due to the interconnected nature of skills and diverse industry environment engineering skills need to be examined collectively. Therefore, this research gap underlines the need for a comprehensive investigation to assess the competency of engineering students in generic skills holistically.

Secondly, while generic skills are widely recognized as essential, there is still a significant need to prioritize them based on students' perceptions. Prioritization of generic skills supports students to identify areas for improvement and plan their academic and career goals. Facilitates educators in designing effective curricula and developing teaching methods and assessment strategies. Recent studies successfully applied various methods like Multi-Criteria Decision-Making (MCDM) for prioritization of generic skills in different contexts. Despite significant scholarly attention to measuring specific aspects of competencies and their associated skill set, there remains a gap in understanding the holistic skillset needed to prepare engineering students for diverse and evolving changes. In addition, there is a need for a comprehensive structural approach in evaluating and prioritizing multiple conflicting criteria to arrive at the best decision along with a mathematical approach to handle uncertainty and imprecision in prioritizing competency in generic skills of engineering students. Therefore, this research gap motivated us to take up this study. Hence, this study investigates the competency of engineering students in generic skills and prioritizes them according to students' perceptions using the AHP-TOPSIS method. The rational for deploying this method is that, AHP-TOPSIS method is effectively utilized in higher education context in determining the criteria weights and prioritize them through ranking the alternatives for optimal decision making (Bhattacherjee *et al.,* 2024; Wang *et al.,* 2022). Subsequently, the findings of this study are used to develop implications for stakeholders and draw conclusions.

Accordingly, the objectives of the study are as follows:

1 Identify the critical generic skills required for engineering students by literature review.

2 Develop a robust evaluation to assess competencies with consideration for uncertainty on generic skills and to rank generic skills based on engineering students' perceptions' by integrating the AHP-TOPSIS.

The structure of the paper is compiled as follows: The next Section 2 reviews the current literature to establish theoretical foundations and understand the current state of knowledge, trends, and significant findings. In the subsequent Section 3, the research design of the present study is detailed followed by Section 4, disclosure of results produced through statistical analysis. Then, Section 5 discusses the results. Section 6 details the implications for stakeholders. Finally, Section 7 concludes the study.

2. Literature review

Early scholars extensively researched the association of general skills with various dimensions such as student learning, performance, instructional methods, and evaluation. Hence, a literature review is conducted to understand the major trends and findings and form a complete picture. This results in recognizing the gap and creating the necessity for the current research.

2.1 Role of generic skills for engineering students

The emphasis on learning generic skills has accelerated at a high pace in the last ten years, particularly in engineering education. In addition, there is changing preference on the part of stakeholders such as students, instructors, governing authorities, and employers towards generic skills along with the fundamental technical skills from engineering education. Moreover, because of the nature of dynamic work environments that are complex and interdisciplinary, employers anticipate that engineering education includes generic skills in the curriculum (Fleming *et al.,* 2024; Hirudayaraj *et al.,* 2021). Generic skills are also referred to as 'soft skills' or 'transferable skills' that include communication, teamwork, critical thinking, and problem-solving, lifelong learning, etc. Past research has highlighted the significance of such skills in various contexts. For example, Chan *et al.* (2017) developed and tested a scale for engineering students' measurement of generic skills competencies that are inherent in the development of well-rounded engineers. Cruz *et al.* (2021) also showed in another study that engineering students who underwent training with these skills feel that they are more prepared for an effective workforce. As identified by Bennett *et al.* (2014), engineering graduates can graduate with technical competence yet without full knowledge of soft skills that are required in engineering professions. An identical view was supported by Islam (2022) research, which established the mismatch between the skills required by employers and those acquired in the academic environment and applauded the requirement for coupling engineering courses with general skills including communication and teamwork.

Additionally, professional accreditation criteria like the Accreditation Board for Engineering and Technology (ABET) also stress the importance of generic skills in engineering students (Larry *et al.,* 2005). Furthermore, the literature also concentrated on skills that are critical for coping with changing technology and uncertain environments. Under lifelong learning, Yap and Tan (2022) observed that curiosity and love for new experiences are essential for students' willingness to practice continuous learning. This is seen during the COVID-19 pandemic, with the sudden transition to online learning forcing students to cope with e-learning platforms and to learn the skills necessary to adjust to the new normal (Jacques *et al.,* 2020; Nalluri *et al.,* 2023). Furthermore, Hernandez-de-Menendez et al. (2020) highlighted that it is crucial to enhance the lifelong learning skills of engineering students in Industry 4.0 and the artificial intelligence age. Thus, with the evolving nature of the engineering jobs, the need for creating generic skills is heavily asserted by both the literature available and the collective stakeholders. Thus, the given scenario stresses the importance of generic skills in shaping future engineers to manage disruptions and transition.

2.2 Generic skills and student learning performance

Generic skills have a strong positive correlation with engineering students' academic performance. Communication, teamwork, problem-solving, and flexibility are the essential generic skills that lead to academic achievement, and overall performance. Moreover, developing these skills makes them ready for working in their professional career (Arumugam *et al.*, 2023; Yap and Tan, 2022). Encinas and Chauca (2020) noted that emotional intelligence of students is a critical generic skill that develops problem-solving skills which, in turn, leads to enhanced performance in academics. Within a problem-based learning environment, Du *et al.* (2020) noted that student groups that used group-based approaches effectively enhanced their learning outcomes. Thus, displaying team spirit during such group work allowed students to share ideas, combine resources, and address intricate problems. Here, communication skills promote group cohesion and enable students to interact with peers and teachers further, this skill enhances academic success and serves as a base for further professional positions (Saleh *et al.,* 2019). Similarly, flexibility is an important skill, which allows students to move quickly in an ever-changing environment and be resilient. Yap and Tan (2022) emphasized that students with adaptability capabilities can switch to online learning and maintain their learning performance in spite of the COVID-19 disruption. Therefore, generic skills facilitate students to overcome learning problems and enhance their academic performance in spite of uncertainties.

2.3 Impact of teaching methods on generic skills development

The approaches utilized within the curriculum have a significant impact on generic skills development. For instance, Problem-Based Learning (PBL) is an approach that builds teamwork, critical thinking, and flexibility. Particularly in the case of Information and Communication Technology (ICT) courses, PBL nudges students towards autonomy and supports independent learning that is very much a key to success in the ever-changing engineering field (Brilingaitė *et al.,* 2018). Likewise, project work by students under group settings enhances teamwork and exhibits greater self-regulated strategies that are essential skills required in all areas of engineering (Chen *et al.,* 2021). Team-Based Learning (TBL) is also another instructional technique that encourages leadership, teamwork, and strong communication at the individual and group levels. Implementation of TBL strategies among engineering students allows students to achieve industry standards thus preparing them for collaborative work on graduation (Zhang *et al.,* 2018). Hence, effective teaching practices assist in developing generic skills that ultimately enhance learning and academic achievement. In addition, teachers need to identify and implement such teaching practices addressing students' required skills and discipline needs.

2.4 Outcome based education and skill competencies

Specifically in Indian higher education context, teaching, learning and assessment are connected with Outcome Based Education (OBE) which emphasizes teaching methods to learner-centric approaches that prioritizes defined learning outcomes, competencies, and graduate attributes. For instance, Graduate Attribute (PO-9): "*Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.*" explicates team based learning environments were students engage in group projects, peer discussions, and team-based assessments. Through team interactions students develop leadership, time management, and communication skills that are crucial for modern engineering practice. Further, OBE model ensures ethical behaviour is not only taught but also measured as learning outcome (Pradhan, 2021; Saravanan *et al.,* 2024).

2.5 Challenges in developing generic skills

In spite of the acknowledged value and industry need, engineering curricula justify technical content over the promotion of generic skills among engineering students owing to the possible impediments. For example, differences in the disciplines influence the student view regarding generic skills and a greater focus on technical skills makes the students undervalue and view generic skills as subordinate (Chan and Fong, 2018). Second, students' heterogeneity and learning styles present potential challenges to evaluating and cultivating generic skills properly. Moreover, a lack of institutional resources introduces more obstacles to implementing generic skills. Özgen *et al.* (2013) identified that variation in students' interpersonal skills and cultural background imposes more pressure on the students while improving these skills and similarly Chan and Fong (2018) also expressed the perception differences between engineering and business management students while selecting the nature of skill requirements. Additionally, engineering students' preference is not uniform for all the generic skills. For example, Saleh *et al.* (2019) discovered that civil engineering students value teamwork and communication more than other skills. Conversely, teaching approaches and curriculum design also affect students while embracing certain generic skills (Durandt *et al.,* 2022). Specifically, the acquisition of critical generic skills such as ethical reasoning and behavior, the curriculum and co-curriculum activities play an essential role in putting these skill (Finelli *et al.,* 2012). Moreover, in the face of the COVID-19 pandemic. Yap and Tan (2022) concluded that attributes such as curiosity and openness to learning are essential in obtaining lifelong learning skills. Thus, students and teachers need to recognize those correlated factors which have an effective impact on the formation of generic skills. Thus, these complex issues constraint the formation of generic skills among engineering students.

Earlier research provided suggestions for overcoming such difficulties. Teachers need to train students in generic skills and encourage them to identify the contribution of these skills toward improved learning performance and career advancement. Additionally, students from all the streams of engineering might not view and like all generic skills equally. Hence, teachers need to implement discipline-specific strategies for developing generic skills during curriculum construction (Chan and Fong, 2018). Technical communication skills are the most important for engineering students particularly when conveying technical information to non-technical people (Nalluri *et al.,* 2023). Therefore, Saleh *et al.* (2019) stressed the inclusion of communication training within engineering courses.

Problem-solving and critical thinking are other critical skills to be imbibe and acquire by utilizing PBL approaches (Chen *et al.,* 2021). As a result of the broad focus on ethical thinking and behavior across academia, co-curricular and curricular reforms assist in the development of these skills (Finelli *et al.,* 2012). In addition, lifelong learning is becoming more widely identified as a vital capability higher education must undertake steps to enhance the likelihood of instilling these skills particularly to navigate and cope with unforeseen situations such as COVID-19 (Yap & Tan, 2022).

2.6 Methods of assessing generic skills in engineering education

Evaluating generic skills in engineering education is problematic in that these skills are frequently intangible compared to technical knowledge. An evaluation suite of methods is used ranging from self-assessment surveys and rubrics to observational tests and standardized tools. Tobajas *et al.* (2019) investigated the use of scoring rubrics in assessing competencies in chemical engineering classes and concluded that rubrics ensured the standardization of assessment criteria for varying faculty members and provided increased transparency. Not only did this method enable consistent assessment, but it also provided students with clear feedback for their performance, which is important in developing skills. Saleh *et al.* (2019) carried out a quantitative study on the communication skills of engineering students, with specific reference to teamwork and oral presentation. Their study emphasized the need for embedding communication training in core engineering courses, as students valued such communication skills highly for their own professional growth. They employed structured observation and surveys to collect data, stressing that an effective assessment of these skills should involve both self-reporting and assessments by peers or educators. Cruz *et al.* (2021) validated a self-report instrument that aimed to assess the perceptions of engineering students on their competence in a set of generic skills. A challenge that stands out with regard to the assessment of generic skills is ensuring that the measures accurately capture students' capacities in actual contexts. As Chen *et al.* (2021) depicted in their research on PBL, assessment methodologies must factor in the collaborative and sometimes unpredictable aspects of professional engineering work. There is an increasing focus on mixed-method designs that integrate quantitative measures with qualitative findings to allow for an integrative understanding of student capabilities.

Hence, the construction and evaluation of generic skills in engineering education is an intricate and many-sided issue. It demands sound consideration of the needs of the discipline, creative teaching methods, and sound assessment practices. With the ongoing evolution of the profession of engineering, the value of these transferable skills is predicted to grow, calling for continued research as well as curriculum development work. In doing this, previous research primarily addressed the employer, industry concerns in quantifying the skill demands of engineering graduates and novice engineers (Fleming *et al.,* 2024; Hirudayaraj *et al.*, 2021), and the findings of these researches emphasize occupational skills and do not have collective skill assessment. Chan *et al.* (2017) constructed and validated the generic skills perception questionnaire for examining engineering students' understanding of their levels of competency in most generic skills (see Table 1). Their research identified generic skills and established the reliability and validity of the tool for comprehending engineering students' generic skills.

Engineering students as the important stakeholders, their own perceptions of what they have, and their priorities remain unexplored so far by the current researchers. Therefore, the current study tries to rank generic skills with the perceptions of the students using the AHP-TOPSIS technique. Consequently, this study constructs implications for stakeholders from the research results and contributes to the current literature.

Table 1 Generic skills perception questionnaire

Criteria (competency)	Sub-criteria code	Sub-criteria (Generic skills)	Operational definition	Empirical support
Academic and problem-solving skills	SC1	Design and conduct experiments	The ability to apply knowledge to solve complex engineering problems, including skills in mathematics, science, and engineering fundamentals.	Chan *et al*. (2017)
	SC2	Analyze and interpret data from experiments		
	SC3	Identify and solve engineering problems		
	SC4	Possess IT skills		
	SC5	Apply knowledge of mathematics, science, and engineering		
	SC6	Use engineering equipment		
	SC7	Design a system, component, or process		
Interpersonal skills	SC8	Be flexible	The ability to communicate effectively, work collaboratively in teams, and interact professionally with diverse groups.	Cruz *et al.* (2021)
	SC9	Be open minded		
	SC10	Offer support and ideas to others		
	SC11	Negotiate to reach a decision		
	SC12	Work together and listen to others' opinions		
	SC13	Handle conflicts		
	SC14	Persuade others		
	SC15	Build and maintain working relationships		
Community and citizenship knowledge	SC16	Be aware of political issues	Understanding of professional, ethical, and social responsibilities in engineering practice, including global and societal contexts.	Larry *et al.* (2005)
	SC17	Be aware of social issues		
	SC18	Be aware of economic and environmental issues		
Leadership skills	SC19	Motivate an supervise others	The ability to lead teams, manage projects, and make decisions in engineering contexts.	Özgen et al. (2013)
	SC20	Coordinate and plan tasks		
	SC21	Build team cohesion		
Professional effectiveness	SC22	Understand roles and responsibilities	The ability to function effectively in professional engineering	*Hirudayaraj et al.* (2021);

	SC23	Understand professional and ethical responsibility	environments, including project management and adherence to industry standards.	Huang *et al.*, (2022)
	SC24	Understand and respect other professionals		
Information and communication literacy	SC25	Research information	Proficiency in using modern engineering tools, information technology, and technical communication skills.	Brilingaitė *et al.* (2018)
	SC26	Identify relevant information		
	SC27	Express and receive ideas clearly		
	SC28	Write concisely		
Critical thinking	SC29	Generate new ideas	The ability to analyze complex problems, evaluate information from multiple sources, and make sound engineering judgments.	Encinas and Chauca (2020)
	SC30	Think critically		
	SC31	Think and act independently		
Self-management skills	SC32	Organize things effectively	The ability to engage in lifelong learning, manage time effectively, and adapt to changing technologies and environments.	Yap and Tan, (2022)
	SC33	Self-reflection		
	SC34	Manage time and meet deadlines		
	SC35	Be punctual to classes or meetings		

3. Research Design

This study proposed a group decision-making approach for generic skills assessment by applying a combination of AHP and TOPSIS techniques. To match the terminology of the method applied, the word competency is termed as criteria and the generic skill set associated with it is termed as sub-criteria. In the first phase, the criteria and its basic sub-criteria are identified through a systematic literature review on generic skills assessment. In the second phase, the AHP method is used to specify the weight of all criteria using the teacher's opinions. Finally, the TOPSIS method is applied to rank all sub-criteria. Figure 1. Shows the flow chart of this research.

3.1 AHP-TOPSIS

Despite the growing importance of generic skills such as communication, teamwork, problem-solving, and adaptability in today's rapidly evolving job market, there remains a notable gap in systematically assessing these competencies among engineering students in India. While technical proficiency continues to dominate engineering curricula and evaluation systems, generic skills, often equally crucial for employability are rarely measured with the same rigor. Existing research in the Indian context is fragmented, focusing largely on curriculum design or employer expectations, with little empirical evidence assessing students' actual competency levels or identifying critical skill gaps. This leaves educational institutions without clear data to design targeted improvements. The use of structured multi-criteria decision-making methods like AHP can help address this gap by systematically prioritizing the most important generic skills through expert input and stakeholder comparisons, generating meaningful weightings for each skill area. Moreover, while international studies have proposed various assessment frameworks, their applicability to India's diverse educational and socio-economic context remains underexplored. Cultural and institutional factors specific to India may influence how generic skills are developed, requiring assessment tools tailored to local conditions. Here, integrating TOPSIS can help rank the competency levels of students or institutions by comparing them against ideal benchmarks, thus identifying areas of strength and weakness. Despite the potential of combining AHP to prioritize skills and TOPSIS to rank performance levels, few studies have applied these tools in Indian engineering education.

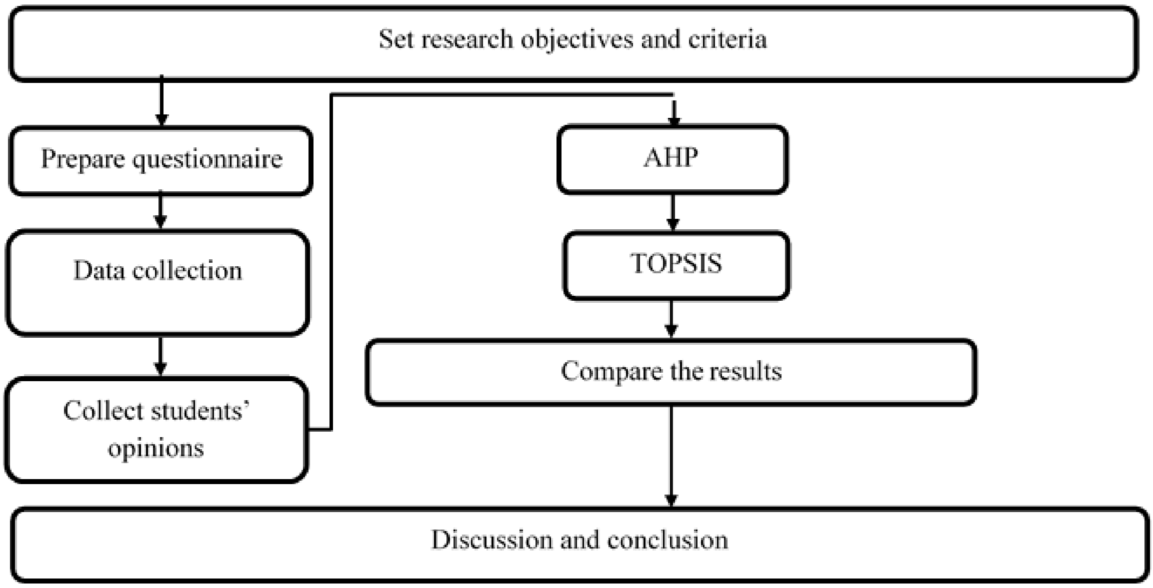

Figure 1. Research flow chart.

Compared to other MCDM methods such as PROMETHEE (which relies on outranking relations and preference functions) and VIKOR (which emphasizes compromise solutions), the AHP-TOPSIS combination offers a balanced approach by integrating subjective judgments (via AHP) with objective performance evaluation (via TOPSIS). This makes it particularly suitable for complex problems involving both qualitative and quantitative criteria, as in the present study (Bhattacherjee *et al.*, 2024; Wang *et al.*, 2022). Addressing this methodological and contextual gap is critical for improving educational practices, strengthening students' employability, and aligning engineering education outcomes with India's national development goals.

4. Result of this study

4.1 Criteria finalization

This study adopted the Generic Skills Perception Questionnaire (GSPQ) from Chan *et al.* (2017) studies, to determine engineering students' perceived level of competencies in generic skills. The GSPQ scale originally contained 35 generic skills categorized as sub-criteria under 8 main criteria scales/competencies (see table 1). For the present study, the scale finalization and data collection are performed in three phases spanning three months from June to August 2024. The expert opinion method was used to finalize the relevant and important sub-criteria within the generic skills scale (Hee Lee & Shvetsova, 2019). Therefore, in the first phase, structured brainstorming sessions were conducted with three experts, one being a professor in education and the other in the Engineering domain, and the third expert is from Industry working as HR team lead for an MNC company. All the experts possess sufficient expertise in the education domain. These experts evaluated the original sub-criteria based on their practical applicability, importance, and prevailing educational practices. Then, experts were asked to assign scores on a scale of 1 to 10 (1 - being less and 10 - being the most important), and their average weights were computed, and ranks were assigned. Subsequently, the top 20 sub-criteria were deemed relevant from the GSSPC scale (see Table 2), ensuring their efficacy and suitability to the present study's objective.

4.2 Data collection and respondents' profile

In the second phase, the finalized criteria were used to conduct an online survey of engineering students pursuing various streams in different universities across India. The survey employed a convenience sampling method, and the responses were gathered using Google Forms through online platforms. Out of 53 responses received, inconsistent and semi-filled responses were excluded and finally, 45 responses were deemed valid for the AHP ranking analysis.

Subsequently, in the third phase, 54 total responses were collected, erratic and semi-filled responses were excluded and finally, 47 responses were deemed valid for the TOPSIS analysis. We have calculated the Consistency Ratio (CR) for each matrix. All CR values were found to be ≤ 0.1, indicating an acceptable level of consistency. The demographics of the respondents are presented in Table 3. Reliability and validity tests are performed, and the results ensure internal consistency and trustworthiness of the data collected during the survey. Therefore, these results provide access to perform data analysis.

Table 2. Finalization of sub-criteria (expert method).

Sub-criteria	Expert 1 (Teacher in education domain)	Expert 2 (Teacher in engineering domain)	Expert 3 (Industry/company representative person)	Average weight of competency	Ranking
SC1	9	10	9	9.33	1*
SC2	4	2	2	2.67	15
SC3	8	7	9	8.00	5*
SC4	7	10	6	7.67	6*
SC5	1	6	1	2.67	15
SC6	8	10	9	9.00	2*
SC7	3	7	5	5.00	11
SC8	9	7	9	8.33	4*
SC9	8	10	6	8.00	5*
SC10	4	6	3	4.33	12
SC11	5	5	1	3.67	13
SC12	3	7	1	3.67	13
SC13	9	6	7	7.33	7*
SC14	5	4	8	5.67	9
SC15	10	9	9	9.33	1*
SC16	4	3	6	4.33	12
SC17	10	6	9	8.33	4*
SC18	9	8	7	8.00	5*
SC19	8	7	1	5.33	10
SC20	10	6	9	8.33	4*
SC21	8	7	8	7.67	6*
SC22	5	2	4	3.67	13
SC23	7	9	10	8.67	3*
SC24	8	8	9	8.33	4*
SC25	6	8	8	7.33	7*
SC26	8	9	9	8.67	3*
SC27	5	4	1	3.33	14
SC28	4	4	5	4.33	12
SC29	8	7	7	7.33	7*
SC30	1	1	6	2.67	15
SC31	8	7	8	7.67	6*

SC32	8	7	9	8.00	5*
SC33	2	3	1	2.00	16
SC34	6	9	10	8.33	4*
SC35	5	5	8	6.00	8

Note: authors' elaboration. *Sub-criteria selected by experts through brainstorming sessions for finalizing the survey scale.

Table 3. Demographic characteristics of the respondents.

Demographics	**Category**	**AHP Method (N=45)**		**TOPSIS Method (N=47)**	
		Frequency	Percent	Frequency	Percent
Gender	Female	25	55.6	22	46.8
	Male	20	44.4	25	53.2
Age	<=18 years	12	26.7	16	34.0
	19 to 21 years	31	68.9	28	59.6
	>=22 years	2	4.4	3	6.4
Engineering Stream	Bioinformatics	2	4.4	9	19.1
	Bio-Medical	6	13.3	2	4.3
	Biotechnology	1	2.2	1	2.1
	Computer science	14	31.1	12	25.5
	Electronics and communication	7	15.6	7	14.9
	Electronic and Electrical	5	11.1	4	8.5
	Food Technology	4	8.9	4	8.5
	Information Technology	1	2.2	3	6.4
	Mechanical	5	11.1	5	10.6
Year of Study	2nd Year	18	40.0	19	40.4
	3rd Year	19	42.2	24	51.1
	4th Year	8	17.8	4	8.5
CGPA in the recent semester	<= 7.0	7	15.6	13	27.66
	7.1 - 7.6	12	26.7	18	38.30
	7.7 - 8.1	12	26.7	9	19.15
	8.2+	14	31.1	7	14.89

4.3 AHP analysis

The weights of the criteria are obtained using the AHP approach. All criteria are considered as beneficial and carried out all calculations. As shows in Table 2, the linguistic terms used to collect the students opinions on the all criteria. Then, the student's opinions are used to assess the importance of each criteria level. For each pairwise comparison matrix $A = [a_{ij}]$, the priority vector (weights) w_i was derived using the eigenvalue method as follows: $A \cdot w = \lambda max \cdot w$

Where: A is the pairwise comparison matrix,

W is the normalized eigenvector (priority vector), λmax is the principal eigenvalue of A.

The local and global weights of the main and sub-criteria are calculated and shows in Table 4, and similar procedures are performed inside the sub-criteria.

Table 4. Local and global weights the criteria.

Criteria	Sub-criteria	Local weight	Global weight
C1 (0.202)	SC1	0.354	0.81
	SC3	0.577	0.151
	SC4	0.561	0.142
	SC6	0.375	0.092
C2 (0.404)	SC8	0.270	0.008
	SC9	0.749	0.174
	SC13	0.333	0.076
	SC15	0.698	0.177
C3 (0.064)	SC17	0.404	0.144
	SC18	0.322	0.048
C4 (0.200)	SC20	0.287	0.023
	SC21	0.471	0.146
C5 (0.261)	SC23	0.184	0.011
	SC24	0.6	0.162
C6 (0.387)	SC25	0.396	0.089
	SC26	0.707	0.189
C7 (0.108)	SC29	0.501	0.139
	SC31	0.54	0.151
C8 (0.341)	SC32	0.401	0.152
	SC34	0.656	0.16

4.4 TOPSIS analysis

The TOPSIS approach is performed by using the weights derived by AHP to identify the optimal sub-criteria. The sub-criteria were assessed by the students using linguistic phrases. Since the respondents' assessments differ, the student evaluations were combined. Then, the TOPSIS analysis determined the decision matrix, followed by calculated NIS and PIS values. Finally, the closeness coefficients values are determined as shows in Table 5. SC9 is the most significant sub-criteria among the generic skills sub-criteria, which are ranked in priority order as SC9, SC26, SC34, SC3, and SC15.

Table 5. The distances of SC to positive/negative ideal solutions, the related closeness coefficients, and the ranking

Sub-criteria	d+	d-	d+ + d-	pi	Group rank	Overall rank
SC1	0.037	0.033	0.07	0.471	2	13
SC3	0.021	0.045	0.066	0.682	1	4

SC4	0.063	0.039	0.102	0.382	4	19
SC6	0.063	0.055	0.118	0.466	3	15
SC8	0.037	0.044	0.081	0.543	3	8
SC9	0.060	0.41	0.47	0.872	1	1
SC13	0.054	0.041	0.095	0.432	4	18
SC15	0.038	0.051	0.089	0.573	2	5
SC17	0.062	0.051	0.113	0.451	2	17
SC18	0.035	0.039	0.074	0.527	1	9
SC20	0.041	0.041	0.082	0.500	2	10
SC21	0.038	0.047	0.085	0.553	1	7
SC23	0.036	0.036	0.072	0.500	1	10
SC24	0.051	0.042	0.093	0.452	2	16
SC25	0.036	0.047	0.083	0.566	2	6
SC26	0.012	0.044	0.056	0.786	1	2
SC29	0.062	0.055	0.117	0.470	2	14
SC31	0.061	0.055	0.116	0.474	1	12
SC32	0.033	0.031	0.064	0.484	2	11
SC34	0.021	0.046	0.067	0.687	1	3

5. Discussion on Findings

This section discusses the findings of this study and draws comparisons with the prior studies by addressing the research objectives. Reverting to our research objective 1, an extensive review of the literature is performed, and the crucial findings are as follows: Problem-solving and critical thinking is essential generic attributes for engineers. In a problem-based learning (PBL) and Team-based learning (TBL) context students are supposed to exhibit and apply problem-solving and critical thinking to cope-up in collaborative environments. Moreover, Key stakeholders of engineering education insist on nurturing normative, strategic, and systematic thinking competencies in engineering students to ensure the attainment of sustainable development goals (SDGs) by addressing varied future social and environmental problems.

Proficiency in using modern engineering tools, information technology, and technical communication skills are core skills obviously demanded from an engineering student, honing communication skills allows students to communicate technical information specifically to a non-technical audience. As students cultivate skills like critical thinking and effective communication, they become more adept at processing complex information and articulating their understanding, for instance, problem and project-based learning (PBL) have been effective in fostering collaboration, critical thinking, and adaptability.

The ability to engage in lifelong learning, manage time effectively, and adapt to changing technologies and environments leads to the attainment of self-management skills.

Assessing generic skills within engineering education presents unique challenges, as these competencies are often less tangible than technical knowledge. Further, a major obstacle is the tendency for engineering curricula to prioritize technical content at the expense of soft skills. This disconnection between employer expectations and educational outcomes suggests a need for curricular reforms that place greater emphasis on these competencies.

To conclude, existing research strongly recommends that honing generic skills ensures engineering students' readiness for professional challenges and their effective adaptation to collaborative work environments. As the demand for well-rounded professionals increases, proficiency in technical skills alone would not fulfill the needs of industry and society. Equipping technical and generic skills provides engineering students with a superior edge and makes them competent enough in the global arenas.

Reverting to objective 2, the prime objective of this study is to understand what engineering students perceive and prioritize generic skills. Therefore, this study investigates the competency of engineering students in generic skills, adopted from Chan *et al.* (2017) study, and prioritizes them according to students' perceptions using the AHP-TOPSIS method. The data analysis revealed the three most important competencies/criteria: interpersonal skills, informational and communication literacy, and self-management skills. Within them, the students strongly preferred 'interpersonal skills', such as empathy for others, listening capacity, taking feedback, and empathizing. As part of the course, students undergo group-based projects and work on assignments collectively making them draw technical and moral support, explore competencies with each other, and brainstorm for unique ideas. Hence, students perceived interpersonal skills as being most important among the generic skills, therefore students aspiring for leadership roles must acquire these skills and these results are consistent with previous studies such as Özgen *et al.,* (2013). Overall, interpersonal skills play a crucial role in building groups and ensure cohesiveness.

The second priority competency perceived is 'information and communication literacy'. It is no surprise that engineering students prioritize it as an important competency. Proficiency in using modern engineering tools, information technology, and technical communication skills makes students solve engineering problems, adapt to future technologies, and increase efficiency in the tasks performed. The significance of this competency is widely accepted by previous researchers like Brilingaitė *et al.* (2018) and Saleh *et al.* (2019), therefore our results are consistent with them. The third preferred competency in priority is self-management skills. Were, engineering students are often involved in coursework, projects, and extracurricular activities self-management skills help them prioritize tasks and meet deadlines effectively. Literature insists on the significance of self-management skills, particularly in an interdisciplinary engineering education system (Chan & Fong, 2018; Ming *et al.,* 2024) and our results are closely aligned with previous studies.

Now looking into results on sub-criteria, the top 5 sub-criteria / generic skills that are perceived as important by engineering students are 1) Be open-minded, 2) Identify relevant information, 3) Manage time and meet deadlines, 4) Identify and solve engineering problems, and 5) Build and maintain working relationships. Among the top 5, 'be open-minded' is considered the most important because working in diverse groups, students are supposed to adapt readiness to accept diverse perspectives, ideas, and approaches leading to a collaborative mindset and lifelong learning. Chan and Fong (2018), engineering students perceive 'being open-mindedness' as a crucial competency. Richter and Kjellgren (2024) also highlights the role of 'open-mindedness' as an important skill in acquiring global competencies by engineering students. The second priority perceived is 'identifying relevant information', this enables engineering students to focus on the most critical data for their academic and professional development. Further, the most pertinent information such as concepts, theories, and methodologies allows students to develop critical thinking and fosters innovation. This is evident from previous research. For instance, Hirudayaraj *et al.* (2021) mentioned that relevant information enables proficiency in solving complex engineering problems. Chan and Fong (2018) found that research information is one of the crucial generic skills. Therefore, the present study results share commonality and are consistent with the literature.

The generic skill perceived as third in priority is 'manage time and meet deadlines'. Chan and Fong, (2018) and Picard *et al.* (2022) in two different contexts, highlights the role of 'manage time and meet deadlines' and this tops the priority list in their research. Therefore, our findings highly correlate with the existing literature. The generic skill perceived as fourth in priority is 'identify and solve engineering problems'. In solving complex engineering problems students are supposed to apply analytical and creative thinking on this note students rightly identified and prioritized this skill. Research on competencies for Industry 4.0 by Hernandez-de-Menendez *et al.* (2020), also underscores that the industry most expects problem-solving skills. In addition, problem-solving skills are also found to be associated with developing adaptable learning strategies leading to lifelong learning (Yap & Tan, 2022). Hence, our findings match the outcomes of the previous studies. The respondents perceive the generic skill 'build and maintain working relationships' as their fifth priority. It is the most critical skill for students and significantly influences their academic and professional development. In a study by Chan and Fong (2018) in the context of skills needed for future careers, engineering students perceived that acquiring this skill was their priority. Módné Takács and Pogátsnik (2024) on Generation Z students also recommended the significance of this skill for their prospects in cybersecurity roles.

6. Implications of this study

This study's findings offer implications in two folds: firstly, the proposed method in this study with the combination AHP-TOPSIS can express uncertainty and ambiguity in the respondent's opinions, especially, this is a novel approach for this educational research area. Secondly, practical implications are as follows:

Our findings about engineering students' perspectives on generic skills can contribute to students, educators, and governing bodies in several respects. Students provided with generic skills can differentiate themselves from peers who focus solely on technical competencies. Therefore, this study attempts to stimulate students to think beyond their domain-specific skills. Further, students involved in prioritizing generic skills facilitate students to introspect and plan their academic and career goals.

Educators and curriculum designers should consider integrating project-based learning (PBL) modules across core and elective courses to address and enhance skills ranked "very important" but "least attained". For example, capstone design projects, case-based ethics discussions, and collaborative industry-linked assignments can be embedded in the curriculum to reinforce teamwork, communication, and ethical reasoning. Moreover, an alignment between academia and industry is a pressing need so, engage industry experts in curriculum design. This association could be further extended by organizing guest lectures, and collaborative projects to connect academic and professional environments. Thereby, students and industry experts exchange thoughts and understand each other's requirements. Train educators on methods that inculcate generic skills such as collaborative assignments, role-play, and problem-based learning.

Concerning implications for governing bodies, the insights of this study assist them in several ways. This study elucidates the significance of generic skills that are perceived as a priority by engineering students. These findings assist governing bodies in policy formulation towards integrating generic skill assessment into national education frameworks. Governing bodies must refine their assessment criteria by including stakeholder feedback, measuring student skill accomplishment, and infrastructure availability while accrediting an institution and the gaps identified could be fulfilled by the institution in time. Furthermore, governing bodies must financially support institutions to develop infrastructure, innovation hubs, and resources for training and assessing generic skills. Develop policies to promote lifelong learning through continuous reskilling and allow credit-based professional certification to make students adapt to evolving industry demands.

7. Conclusion

This study aims to investigate how engineering students perceive generic skills and their motivation to acquire them. Many methods are presented to identify the set of generic skills. AHP-TOPSIS useful technique for illustrating the ambiguity of MCDM issues in recent years. MCDM methods can better handle the uncertainty and ambiguity in the decision-maker's opinions, and better capable of addressing the uncertainty of real-life issues.

For this reason, this study is a new method for ranking generic skills from students' perspective. This study's findings highlighted that interpersonal skills, information and communication literacy, and self-management skills are important for engineering students to improve their learning ability and job skills. Coming to this study contribution, this study proposed a novel approach to assess the generic skills and their importance for engineering students by AHP-TOPSIS approach. Besides contribution, there are a few limitations for this study as follows: first, this study's analysis was carried out by adopting the criteria from Çalık (2021) and tested it in the context of the engineering domain in the Indian education system. In future studies, the different criteria that affect student learning performance can be included, and this study's methodology can be expanded and also can be applied to domains in the education system and other sectors. Secondly, this study's findings are generated based on student groups, so there is a chance for subjectivity in these findings. Therefore, we are unable to generalize or apply those findings to other domains in the Indian education system and other countries. Thirdly, this study investigated how engineering students perceive generic skills and their motivation to acquire them. Further studies may investigate in the context of other perspectives (such as teachers or professors, decision-makers at a department level or organizational level, and policymakers). In addition, if further studies will conduct multi-perspective analysis and apply sensitivity analysis with a large sample size to improve the accuracy of the findings is a further recommendation.

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Author Contribution Statement

Sai Manideep Appana: Conceptualization, methodology, investigation, writing—original draft preparation. Hari Babu Bathini: Conceptualization, methodology. Ch. Paramaiah: formal analysis, validation. Raghuveer Katragadda: validation, writing—review and editing. B.K. Surya Prakasha Rao: project administration. Ravi Sankar Pasupuleti: writing - review & editing. All the authors read and approved the final version of the manuscript.

Does this article screen for similarity?

Yes

Informed Consent

Consent was obtained before commencing the survey.

Electronic Supplementary Information

Generic Skills Perception Questionnaire (GSPQ).

Conflict of Interest

The authors have no conflicts of interest to declare. There is also no financial interest to report. The author certifies that the submission is original work and is not under review at any other publication.

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