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A Survey on Critical Thinking Perception among Engineering Education Students

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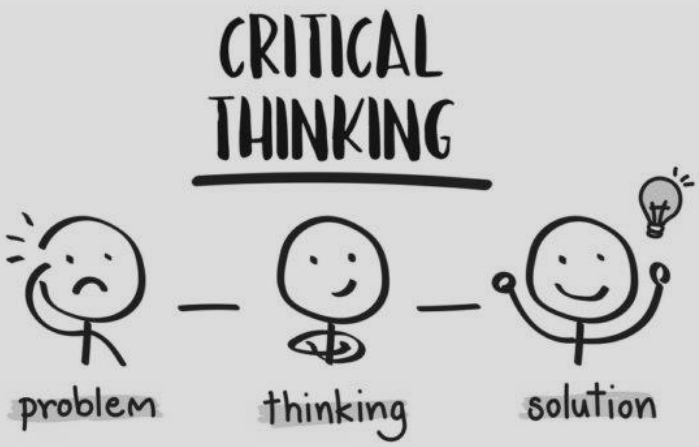
Abstract: This paper discuss about the critical thinking which is known as a key skill and a primary goal of engineering education. Existing trends in technology and work place need engineers equipped with critical thinking skills such as solving problems, making decisions and understanding of technical and engineering skills for successful future like Artificial intelligence. Though, surprisingly there is little research on critical thinking in engineering education. This paper describes quantitative survey carried out on engineering students for identifying students' perception regarding critical thinking skills for problem solving and decision making. Validity and reliability were proved through pilot study and experts of the field. One hundred twenty undergrad engineering students participated from civil, electrical and mechanical engineering departments. The results illustrated that engineering students have high perception on critical thinking skills in all four sub-dimensions analysis, evaluation, induction and deduction.

Graphical Abstract:



Keywords: Critical Thinking, Quantitative Survey, Engineering Education

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1. Introduction

Over the past few years, there is an increasing demand for engineering education providers to produce engineers who are more holistic in their attributes. To be a successful engineer; graduates need to have multiple competencies which encompass intellectual, technical and academic competencies [1]. Existing trends in technology and work place need engineers equipped with critical thinking skills such as solve problems, taking decisions and understanding of engineering as a broader way for successful future [2]. Educational and industrial sectors agreed that several engineering learners are graduated deprived of having critical thinking skills. Industries criticize that technically engineers are competent but deficiency in critical thinking skills like problem solving and taking unexpected decisions [3]. Therefore, engineering students need the critical thinking skills in their courses. In a class room educators focus on memorizing the content knowledge provided in curriculum rather than to evaluate and synthesize the particular significance of knowledge [4]. The lacking of critical thinking skills is unfortunately due to the non-updated curriculum are taught with the old tools and procedures, which have been practiced fifty years before. The traditional teaching methods do not produce engineers having multiple capabilities including critical thinking ability [5]. The critical thinking skills allows engineers to logically measure their own mental skills and experiences and apply those skills to create new ideas [6]. Critical thinking skills enables the capacity to examine information, to define the significance of information collected and interpret that information in problem solving and decision making. As a result, critical thinking skill has become more prominent factor of engineering education [7]. Thus, to achieve the critical thinking standards, institutes are continually challenged to improve and reflect on the success of teaching approaches that may boost the development of learners' critical thinking skills.

Adopting modern techniques of teaching to support student learning is an essential part of ensuring that the learners involve positively with subject and improve their learning skills and intellectual skills [8]. Educators of engineering institutes have the challenge to assure that strategies of teaching reflect the various nature of learners and make students of engineering with the understanding to be competent, and critical thinker who can face future challenges of modern world [9]. Critical thinking allows students to explore and observe ideas, then process it which leads to problem solving and decision making. Problem solving is a thoughtful process that supports students to changing condition, unify thinking abilities, manage gaps in information, produce ideas, make better decisions and is important to enhance intellectual capabilities of students [10]. It is mental process that includes discovering, analyzing and resolving difficulties is problem-solving skill as well as to reduce obstacles and discover a solution that solve the issue. Students observe and solve gap among a present situation and preferred goal through the way to the objective blocked by identified or unidentified obstacles [11].

In addition, Problem solving is sometimes perceived as take out something that is not required or as finding an error and correct it to right. Similarly, decision making a mental process that is concerned with the process of choosing a reasonable choice from the obtainable alternatives. One or more possible solutions are chosen in a selection procedure to reach a wanted goal is known as decision making process [12]. Decision making is mainly problematic where it comprises of dissimilar values, the considering of dissimilar attributes and measuring uncertainties. And there are many conditions where decision making is affected by uncertainty and doubt [13]. Mostly repetitive and well-defined problems learners face in class and in repetitive way they solve those problems and take decisions

about them problem solving and decision making involve mixing previous knowledge and experience together to solve a problem whose result is unknown with use of mental skills [14]. There are certain obstacles in problem solving and decision making which block the approach to reaching an objective. If the obstacle can be understood it may be thinkable to eliminate it, or discover a method about it. Some are well described and the technique of solve those problems is clearly organized. For example, a designed system is installed, it works well but suddenly breakdowns. For a technical engineer, these are routine problems discover the error and repairs it [15]. Thus, for this kind of problems, it may be appropriate to adapt techniques they already used successfully in solving problems. Consequently, enhancing thinking skills and experience can contribute to solve problem and take decisions successfully. The age, professional background, technical background, knowledge of problem finding techniques, and knowledge of content and context of problem these are experience factors. Analytical ability, holistic thinking, logic and reasoning, intuition, imagination synthesizing ability, and memory these are mental factors [16]. There are three stages of problem solving and decision making, the first stage is understanding the problem then generating solutions and finally choosing the best solution, first and second steps come under problem solving and last one is decision making [17]. Hence, these stages show that both variables are related to each other. These steps generally include analysis, evaluation, deduction and induction. Thus, critical thinking assists understanding the notion of problem solving and decision making through thoughtful method which increases learners' mental capabilities [18].

In the contemporary technological environment rapidly varying progresses and insistently growing awareness, professional engineers need to improve critical thinking skills that will deliver them with expertise in problem solving and decision making. In engineering education, mostly repetitive and well-defined problems learners face in class and in repetitive way they solve those problems and take decisions [19]. Therefore, the assessment of critical thinking is often carried on students in engineering education. Tailoring the instructive process based on a specific learning process may effect student critical thinking ability. It is assumed that learning preferences may have impact on learner's critical thinking ability.

2. Problem Statement

The learning procedure is a communication between learners, educators, and teaching resources. Looking into engineering education perspective, most engineering academic courses demand critical thinking skills. Although theory supports the notion that the critical thinking skills in engineering is highly valued and required to enhance the achievement of cognitive learning goals in engineering education. In general, however, there has been relatively little research and isn't well studied in undergraduate in achieving cognitive learning goals particularly in engineering education. Ignoring the role of critical thinking skills has resulted in developing a perception among engineering students as undervaluing the significance of critical thinking skills [20]. Even professors reported valuing critical thinking skills, but not seeing it in their students which may be a reason on how to integrate critical thinking skills into learning styles especially in engineering education.

3. Objective of Study

This study focus on determining engineering students' critical thinking skills perception based on following critical thinking dimension. These are analysis, induction, evaluation and deduction.

4. Methodology

In this study survey research approach has been adopted, because this approach provides better accuracy and reliability of research findings. A survey is an empirical method which explores and provides potential information regarding the targeted population and to collect data from individuals about their knowledge, feelings, ideas, social, financial, and educational backgrounds. In addition, survey is an attempt to obtain data from participants to determine the current status of that population with respect to one or more variables [22]. The critical thinking questionnaire was used in this study. Validity and reliability were proved by through pilot study and experts of the field. Critical thinking instrument contains twenty eight items each questions were divided according to four sub-skills of critical thinking skills analysis, evaluation, induction and deduction.

5. Participants

There were 120 engineering students from mechanical, electrical and civil voluntarily participated in this study from Quaid-e-Awam University of engineering, science & technology Nawabshah, Sindh, Pakistan

6. Results and Analysis

I used quantitative survey methodology with 120 participants from mechanical, electrical, and civil engineering disciplines to investigate the perception of critical thinking among engineering education students. The results of this study showed that a majority of engineering education students recognize the importance of critical thinking in their field. They acknowledge that critical thinking not only helps them excel in their studies but also prepares them for future careers and enhances their employability. Overall, the research indicates that there is a strong awareness and recognition among engineering education students about the significance of critical thinking in their field. The integration of critical thinking skills in engineering education is crucial for students to succeed academically and thrive in their future careers. By embracing modern technology and cultivating a culture of critical thinking, engineering education can better prepare students to navigate the complexities of the future engineering landscape and become truly impactful professionals in their field. The research findings suggest that engineering education students recognize the importance of critical thinking in their field and acknowledge its role in their academic success and future careers. The research findings indicate that engineering education students are aware of the significance of critical thinking in their field and understand its role in both their academic success and future careers. This awareness is crucial for creating a learning environment that fosters the development of critical thinking skills. The analysis has been carried out for identifying critical thinking perception among engineering students by computing mean score of four sub-skills of critical thinking analysis, evaluation, induction and deduction. Table 2 summarizes the critical thinking sub-skills represented by overall mean score. The description in table 1 shows that engineering students have high perception in all sub-skills of critical thinking. As it is shown in table 1 the range of low, moderate and high range of mean score interval adopted from [23].

Table. 1 - Interpretation and Level of the Mean Score Interval

Mean Score Interval	*Interpretation*	*Level*
1.00-2.49	Do not agree	Low
2.50-3.49	Not totally agree	Moderate
3.50-5.00	Agree	High

The table 1 categorizes mean score intervals into three levels of agreement: low (1.00-2.49), moderate (2.50-3.49), and high (3.50-5.00). If the mean score falls within the low range, it indicates a predominant disagreement or negative sentiment among respondents. The moderate range suggests a mixed or neutral sentiment, where respondents are neither fully agreeing nor completely disagreeing, indicating partial agreement or reservations. The high range reflects a positive sentiment, with the majority of respondents agreeing with the statement, indicating strong agreement. This categorization helps to interpret the overall sentiment of survey responses effectively.

Table. 2 - Critical thinking sub-skills mean score result

N	*Analysis*	*Induction*
120	The overall mean score of item1 to item7 3.9551	The overall mean score item15 to item21 3.8226
	Evaluation	*Deduction*
	The overall mean score item8 to item14 3.7321	The overall mean score item22 to item28 3.7726

Table 2 presents the mean scores for critical thinking sub-skills, derived from the responses of 120 participants. The sub-skills are divided into Analysis, Evaluation, Induction, and Deduction. The overall mean score for Analysis, based on items 1 to 7, is 3.9551, indicating a high level of agreement among respondents regarding their analytical abilities. Induction, assessed through items 15 to 21, has a mean score of 3.8226, also reflecting a high level of agreement. Evaluation, encompassing items 8 to 14, shows a mean score of 3.7321, suggesting a positive but slightly lower agreement compared to Analysis and Induction. Finally, Deduction, evaluated through items 22 to 28, has a mean score of 3.7726, indicating a high level of agreement, similar to Induction. Overall, all sub-skills show high mean scores, indicating strong agreement on the proficiency in these critical thinking sub-skills among the respondents.

Figure 1 provided chart is a donut chart representing the mean scores of different critical thinking sub-skills among 120 respondents. The sub-skills are divided into Analysis, Induction, Evaluation, and Deduction. Each segment of the donut chart is labeled with its corresponding sub-skill and the percentage it represents out of the total, showing how each sub-skill's mean score compares proportionally. Analysis, with a mean score of items 1 to 7, occupies 26% of the chart, indicating the highest level of agreement among the sub-skills. Induction, with a mean score of items 15 to 21, and Deduction, with a mean score of items 22 to 28, each account for 25% of the chart, reflecting similarly high levels of agreement. Evaluation, with a mean score of items 8 to 14, represents 24% of the chart, slightly lower than the others.

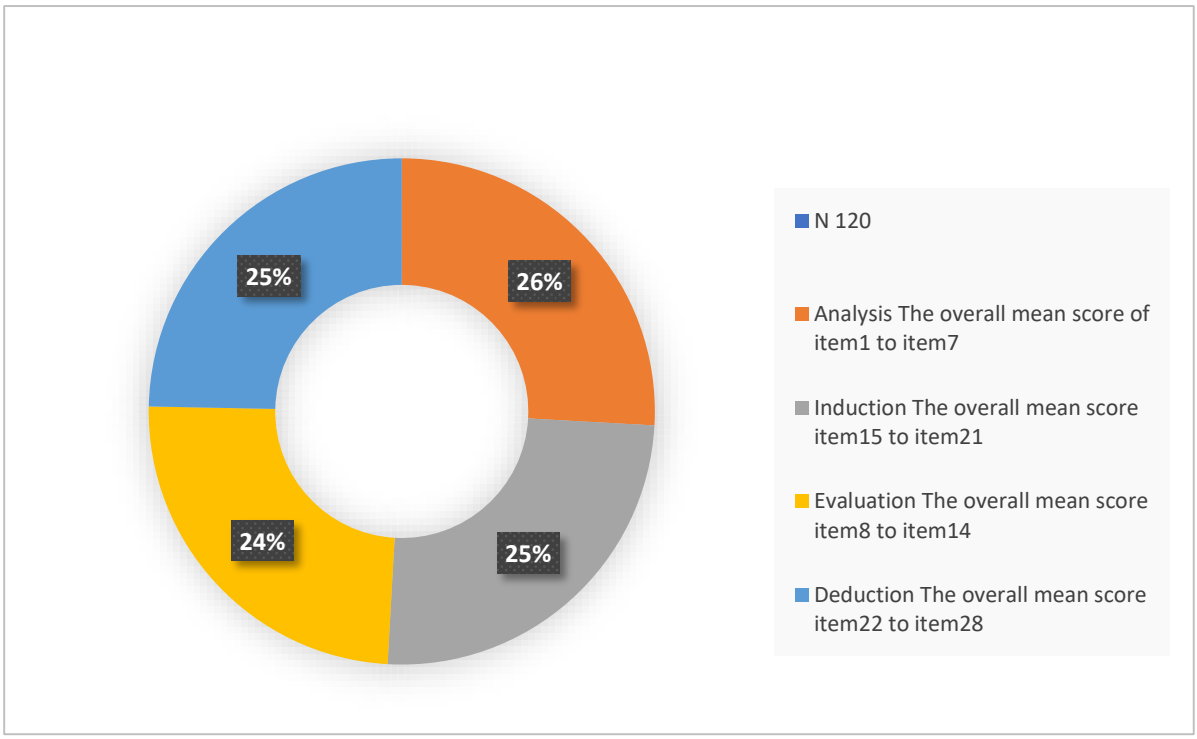

Fig. 1 – Critical thinking sub-skills mean score graphical representation

Overall, the chart visually demonstrates that all four critical thinking sub-skills have high mean scores, suggesting strong agreement on the proficiency in these areas among the respondents. The slight variations in the percentages highlight the relative strengths of each sub-skill, with Analysis being slightly more prominent, followed by Induction and Deduction, and then Evaluation. This visual representation effectively communicates the distribution of mean scores across the different sub-skills, emphasizing the overall strong critical thinking capabilities of the respondents.

7. Discussion

In conclusion, the integration of critical thinking skills in engineering education is vital for preparing students to excel academically and thrive in their future careers. The recognition of the importance of critical thinking among engineering education students emphasizes the need for educational institutions to continue emphasizing and enhancing these skills within their programs. As the engineering landscape continues to evolve with technological advancements, fostering a culture of critical thinking will enable students to adapt to the changing demands of the field and make meaningful contributions to the engineering profession. Educators in the classroom often focus on identifying the most effective ways in which students learn. Understanding learners' perceptions of critical thinking can greatly enhance the quality of both teaching and learning [11]. This study seeks to gain insight into students' perspectives on critical thinking. The findings indicate that engineering students exhibit a strong understanding of critical thinking skills. Recognizing these perceptions is key to improving the learning and teaching processes in the classroom, as it enables teachers to tailor their approaches to accommodate students' learning styles and needs. Additionally, fostering critical thinking abilities can help students overcome challenges in their academic pursuits. Critical thinking skills are not only essential for engineers in their professional endeavors, but also imperative for engineering students as they prepare for future careers and strive to excel academically. This study

suggests that educators should prioritize the development of critical thinking skills in their instructional methods and incorporate engaging activities in the classroom to stimulate students' cognitive processes [21]. Furthermore, educational institutions should actively promote critical thinking activities among students to ensure their success both academically and in the workforce. The insights derived from this research have significant implications for learners, educators, and institutions, particularly within the context of public universities in Pakistan. Firstly, this study demonstrates the extent to which critical thinking can be integrated into the classroom environment. Secondly, educators can refine their teaching approaches to cultivate critical thinking skills, while higher education institutions can identify and address any gaps in the incorporation of critical thinking skills into the undergraduate curriculum.

8. Conclusion

In conclusion, it is evident that educational strategies aimed at cultivating critical thinking skills should be prioritized within the engineering education curriculum. Emphasizing critical thinking will not only enhance students' analytical abilities but also prepare them for complex problem-solving in real-world scenarios. To achieve this, it is recommended to integrate critical thinking exercises into the curriculum, provide real-world problem-solving opportunities, and encourage reflective practice and feedback. Additionally, developing assessment tools to measure critical thinking skills and fostering a culture that values critical thinking and creativity are essential steps. These recommendations will ensure that future engineers are equipped with the necessary skills to innovate and excel in their professional careers.

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