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Critical Thinking (Mis)conceptions of First-Year Engineering Students

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Abstract

Critical thinking, an essential skill for engineers, is a cornerstone of effective problem-solving, ethical decision-making, and innovative design. Despite its recognized importance, research on how early undergraduate engineering students perceive and understand critical thinking is limited. This study explores first-year engineering students' conceptualizations of critical thinking at a large Hispanic-Serving Institution with Very High Research Activity. Using an open-ended question embedded in a classroom assessment, this qualitative study analyzes students' definitions of critical thinking through thematic analysis. Preliminary results reveal a spectrum of understanding, ranging from predominately narrow task-oriented views to less common broader evaluative and reflective approaches. The findings underscore the necessity of integrating explicit critical thinking instruction into engineering curricula to address misconceptions and strengthen this vital competency. This study aims to inform engineering educators and administrators of where first-year students are starting with this understanding with the intention to illicit strategies for improvement and contributions to the development of pedagogy to educate engineers who can navigate complex societal and technical challenges.

Introduction

This complete research paper discusses critical thinking in the context of first-year engineering students at a large very-high research activity university. Critical thinking is widely recognized as one of the most crucial elements for the success of an engineer [1-3]. In many ways, it represents the ontological premise upon which the engineering profession, as it exists today, is built [4]. Engineers are responsible for solving complex problems while ensuring that their solutions are reliable, sustainable, ethical, and socially responsible. Success in this field requires a mindset that is systematic, reflective, and saturated with rigor. This directly points to critical thinking, a concept that originated from philosophical and educational disciplines. Over time, it has been adapted and applied to a wide range of fields. In this study, we explore critical thinking specifically within the context of the engineering discipline. At its core, critical thinking involves gathering and analyzing data or information and making sound judgements based on that analysis [5]. In engineering, however, judgement is rarely theoretical or abstract; it often has direct and significant consequences for public health, safety, and ethics. This centrality of judgment underscores the ethical and professional responsibilities engineers bear, reflecting the gravity of their role in society.

Given this pivotal role, developing critical thinking skills should be an essential component of an engineer's education and training. In an era of rapidly evolving technologies and global challenges, such as climate change and cybersecurity, equipping engineers with robust critical thinking skills is not just desirable but essential. These skills enable engineers to navigate ambiguity, innovate sustainably, and respond ethically to societal needs. Faculty in higher education play a critical role in explicitly teaching critical thinking and emphasizing its relevance across diverse contexts and situations. Critical thinking is, without question, an indispensable tool that engineers at all levels should utilize effectively.

While engineering education has made remarkable strides in integrating technical knowledge and problem-solving skills throughout curriculum largely, critical thinking is often assumed to develop naturally over time, rather than being explicitly taught. Currently, no existing literature examines how early undergraduate engineering students understand or conceptualize critical thinking. Although Paul and Elder [1], Paul and Elder [6] and Facione [2], Facione [3] have emphasized the importance of cultivating critical thinking abilities early in educational journeys, few studies focus on engineering students specifically.

Limited research studies from related disciplines suggest that students often struggle to distinguish between critical thinking and routine problem-solving[7]. Additionally, misconceptions about the application of critical thinking have been shown to hinder its development[8]. First year undergraduate studies represent a critical juncture where foundational skills and mindsets are developed. At this early stage, critical thinking remains underexplored. How these students define, apply, and value critical thinking will ultimately determine how they operate as future engineers and leaders of our world. Understanding these perceptions will be vital to designing educational interventions that explicitly foster critical thinking at the beginning of their academic journey. Without such an understanding, efforts to better prepare our future engineering workforce may lack direction. Before implementing changes, it is imperative to first understand students' current conceptions of critical thinking.

This study intends to answer the following questions: 1) how do first-year engineering students conceptualize critical thinking and 2) how do these conceptions align with accepted definitions and academic understandings of critical thinking, particularly in the context of engineering? By answering these questions, we aim to lay the groundwork for future research that measures critical thinking skills in first-year engineering students and informs curricular adjustments. These adjustments would better equip students to engage with critical thinking as a foundational part of their cognitive process, enabling them to design solutions and enact meaningful change in the world.

Background

Critical thinking is widely acknowledged as a crucial competency in higher education and professional domains, including engineering[2, 3, 5, 9-18]. It is broadly defined as "reasonable reflective thinking focused on deciding what to believe or do"[9, 13]. Facione [2] expanded upon this, suggesting that it is a purposeful, self-regulatory process that involves interpretation, analysis, evaluation, inference, and eventually explanation. Halpern (2014) highlights the cognitive and dispositional dimensions of critical thinking, emphasizing metacognition and the importance of fostering critical thinking across all disciplines and contexts.

The context of engineering changes the application of critical thinking to some extent. Problem-solving of complex, real-world scenarios is often tied closely to critical thinking[16, 18]. As engineers operate in their field, they are called upon to employ structured and adaptive solutions. The application of critical thinking to the working lives of engineers enables them to analyze complex systems and synthesize innovative solutions[19], address ethical and societal impacts of engineering decisions[20], and navigate multidisciplinary challenges like sustainability and technological integration[21]. Additionally, ABET accreditation standards and industry feedback on engineering education outcomes underscore critical thinking as a fundamental attribute that is expected from graduates. Even with this understanding of critical thinking's importance in the lives of engineers, significant gaps remain in the integration of critical thinking within curricula throughout engineering[17, 22].

There are significant challenges when defining critical thinking in the context of engineering. The disciplinary variations in understanding the basis of critical thinking often move engineering educators to conflate critical thinking with technical problem-solving, neglecting the broader evaluative and reflective components of a more standard understanding of critical thinking. This dissonance complicates the design of curricula and assessments aimed at succinctly integrating critical thinking as a staple[17]. There is literature indicating the difficulty engineering students face in understanding the abstract aspects of critical thinking, often focusing on more procedural solutions to analyzing complex problems,[19]. This issue is exacerbated by traditional pedagogical approaches prioritizing content mastery over process-oriented thinking[23].

There are pedagogical approaches that support the development of critical thinking, including problem-based learning, interdisciplinary approaches, reflective practices, and simulations/role-playing[15, 18, 20, 24]. Validated assessments for critical thinking such as the California Critical Thinking Skills Test, offering insights into student understanding and application, but may miss subtleties[11, 18]. More nuanced approaches for assessment, such as portfolios and situational judgment tests, have shown some promise in evaluating critical thinking proficiency[2, 3]. The literature surrounding critical thinking in engineering provides significant insight into how curricular design can be applied, although this is outside of this scope of this work[5, 9, 10, 16, 18].

Methods

This study employed a qualitative, open-coding inductive approach to explore the perspectives of first-year engineering students on critical thinking. This qualitative method was chosen to capture the depth and variety of student responses, enabling the identification of nuanced themes and patterns in their conceptions. Using an inductive approach allowed themes to emerge directly from the data, free from the constraints of existing theoretical frameworks. The open-coding process involved systematically analyzing responses to uncover recurring ideas and categorizing them into overarching themes, which were then aligned with established definitions of critical thinking in engineering education literature.

The selection of a qualitative, open coding inductive approach was driven by the exploratory nature of the study. As there is limited existing research on how first-year engineering students conceptualize critical thinking, this method provided a flexible and rigorous framework for uncovering unanticipated insights. Open coding is particularly well-suited to analyzing the open-ended survey question, "In your own words, define critical thinking," which invited participants to articulate their understanding in writing. By avoiding the imposition of predefined categories, this approach ensured that the findings were firmly grounded in the participants' perspectives, offering a rich and authentic representation of their views. Furthermore, the inductive process facilitated the generation of new theoretical insights that can inform future studies and curricular interventions aimed at fostering critical thinking among engineering students[25]. A co-occurrence matrix is also generated with the intention of visualizing the relationship between the various themes in this work.

The process for generating this co-occurrence matrix requires the responses to be analyzed as a matrix of binary values. A one represents alignment of a response with a theme, and a zero represents no alignment. This matrix is then multiplied by its own transpose and represents the frequency with which pairs of codes appear with one another. This is visualized with a weighted network graph where nodes represent the themes, and the edges or lines are the connections between those nodes. The thickness of those connective lines represents the weight of co-occurrence or in other words the strength of alignment. This process follows accepted standards in presenting a rigorous quantitative assessment of qualitative data, appropriate for the context and scope of this study [24, 26, 27].

Setting and Participants

This study was conducted at Texas A&M University; a large, Hispanic-Serving Institution in the southwestern United States, classified as very high research activity by the Carnegie Classification System. The institution is a member of the Association of American Universities (AAU) and a Morrill Act of 1862 Land Grant University, which provides a unique context for examining varied student experiences. Participants were first-year engineering students enrolled in a general engineering program. The survey was distributed through the learning management system of a common first-year course and the course's enhanced learning community Discord server. Of the over 4,000 students in the first-year engineering cohort, 202 students participated in the survey. This sample, while representing approximately 5% of the total cohort, was significant for a qualitative study of this nature [25]. The diversity within the participant group allowed for a broad range of perspectives to be captured and analyzed [25].

Data Collection

Data were collected using a short survey administered through Qualtrics. The survey included two items designed to elicit participants' conceptions of critical thinking. The first question was open-ended, asking students to define critical thinking in their own words: "In your own words, define critical thinking." The second question was a Likert-scale item in which students rated their confidence in their ability to think critically based on their own definition. This dual approach allowed for both qualitative insights and a measure of self-reported confidence. Responses to the open-ended question were analyzed using an open-coding process to identify themes, while the Likert-scale data provided supplementary descriptive statistics. The survey was distributed via the learning management system and the course's Discord server, ensuring accessibility for all participants. Independent coding was conducted by multiple researchers using Microsoft Excel, followed by the development of a consolidated codebook. This codebook was then used to refine the themes and compare them with established definitions of critical thinking in engineering education literature.

Results

Qualitative

Through the inductive open-coding approach, a total of seven distinct themes were determined to capture student conceptions. These themes, detailed in TABLE 1 below and TABLE 2 in the appendix, include the code abbreviation, full code name, approximate percentage of coverage, definition, and inclusion criteria.

TABLE 1
THEMES AND ABBREVIATIONS

Code	Problem Solving Orientation	Multiple Perspectives / Open Mindedness	Evidence-/Logic-Based Reasoning	Creativity /Thinking outside of the box	Application of Prior Knowledge	Systematic/ Analytical Approach	Reflective Judgement/ Metacognition
Abbreviation	PSO	MP	E/L	CO	APK	SAA	RJM

These codes serve to represent the responses of our study collectively and provide interesting insight into which components of an engineering identity early in their education are informing their understanding of critical thinking. It is important to note that percent coverage is related to the total responses associated with that theme relative to all responses, not a proportion of one theme to another. This is due to the nuanced nature of this work where a single response may intersect with multiple themes.

The most prominent theme, Problem-Solving Orientation (PSO), appeared in 85% of the responses. Overwhelmingly students associated critical thinking with problem-solving, emphasizing the integration of critical thinking and problem-solving skills. Representative responses include:

PSO

> *"The skill of thinking uniquely to gain better understanding and create solutions for complex problems."*
>
> *"Having the patience to stop, look at a problem purely as a problem first, then breaking it down to its parts. From there, gradually and systematically solving those broken down problems."*
>
> *"In my own words I would say critical thinking is using the knowledge you have to solve problems/issues without clear guidance or instruction and being able to act on your own and think from multiple different perspectives to find solutions."*

The second most prominent theme, Systematic/Analytical Approach (SAA) appeared in 34% of responses. This theme emphasized a structured process to problem solving. Representative responses include:

SAA

> *"From what I understand, to think critically is to be given a set of information, determine patterns in that information, and apply those patterns to make predictions or solutions regarding that set of information."*
>
> *"Critical thinking is the ability to analytically and rigorously investigate and understand a topic/problem. It includes but is not limited to understanding various viewpoints, connecting associated ideas together, and finding different ways to approach situations."*
>
> *"The ability to discern a problem and its solution quickly and effectively."*
>
> *"Critical Thinking is analyzing a situation before making a decision."*

Application of Prior Knowledge (APK) and Creativity/Thinking Outside the Box (CO) were tied as the third most prominent themes, each covering 25% of the responses. APK captures the use of pre-exiting knowledge to address problems, while CO focuses on novel and creative solutions. Examples include:

APK

> *"Critical thinking is one's ability to absorb new information and apply old knowledge to new problems, both tangible and conceptual."*
>
> *"I think this is when you take a problem and use prior knowledge to figure out an intuitive solution."*
>
> *"Critical thinking is finding solution to a problem on one's own using the knowledge gained or previously attained."*

CO

> *"Critical thinking is the ability to approach and deal with situations by utilizing creativity and problem-solving skills."*
>
> *"the ability to come up with a unique or new solution to a problem that you haven't seen before"*
>
> *"Critical thinking is the ability to construct original ideas and apply them uniquely to new problems. Critical thinking should challenge the learner in ways beyond that extend their current knowledge and force them to adapt in unfamiliar situations."*

Evidence-/Logic-Based Reasoning appeared in 15% of the responses, emphasizing logic and evidence in decision making. Examples include:

E/L

> *"Critical thinking is the ability to think and come to a conclusion using evidence to make reasoned justifications."*
>
> *"Critical thinking is the capability to consider a problem outside of a formulaic approach and utilize one's own logic and understanding of situational context to find a proper solution. This skill can be taught and enhanced through experience, though some people are better at it naturally."*

> *"Critical thinking is how one makes decisions based on logic and past experiences. Many problems require you to think 'outside the box' because you may not have any experience with it. You have to think logically and assess the problems in series of steps."*

The final themes, Reflective Judgement/Metacognition (RJM) and Multiple Perspectives/Open Mindedness (MP), were tied at 11% each. These themes involve self-awareness and consideration of diverse perspectives. Examples include:

RJM

> *"The ability to come up with and consider a wide variety of ideas, ideas which may initially seem counterproductive or impractical. Critical thinking involves constant self-critiquing to improve upon our ideas and discover new approaches and possible solutions."*
>
> *"The ability to think at a deeper level about your actions, the thoughts that drive them, and their consequences"*
>
> *"I would define critical thinking as the process of analyzing, evaluating, and solving problems, complex or not, that don't necessarily have a direct solution. As engineers we must use our own methods of critical thinking to get a solution, resulting in many different solutions to many different problems as engineers all have their own method of critical thinking."*

MP

> *"Critical thinking is breaking down problems and trying to come up with different solutions. These solutions can be based on similar problems or experience, but it's about looking at multiple possible solutions and seeing which one works best!"*
>
> *"Coming up with various solutions from different angles and perspectives."*
>
> *"Think about the problem that I faced in multiple perspectives"*

Quantitative

The 5-point Likert style item assesses respondents' self-reported ability to apply critical thinking based on their own definitions and includes several descriptive statistics. A mean value of 4.03 with a standard deviation of 0.96 indicates a distribution skewed towards the positive end of the scale, suggesting some intrinsic confidence among students in their critical thinking abilities as they understand them.

Fig. *1* showcases the co-occurrence matrix of the qualitative data analyzed. The relationships between these themes reveal an overwhelming biased center of themes surrounding PSO. The strongest relationships are between PSO and other themes, notably, APK, CO, and SAA. This suggests that participants consider problem-solving, prior knowledge application, systematic and analytical approaches, and creative thinking as foundational to critical thinking. While other themes are present, their connections are markedly weaker.

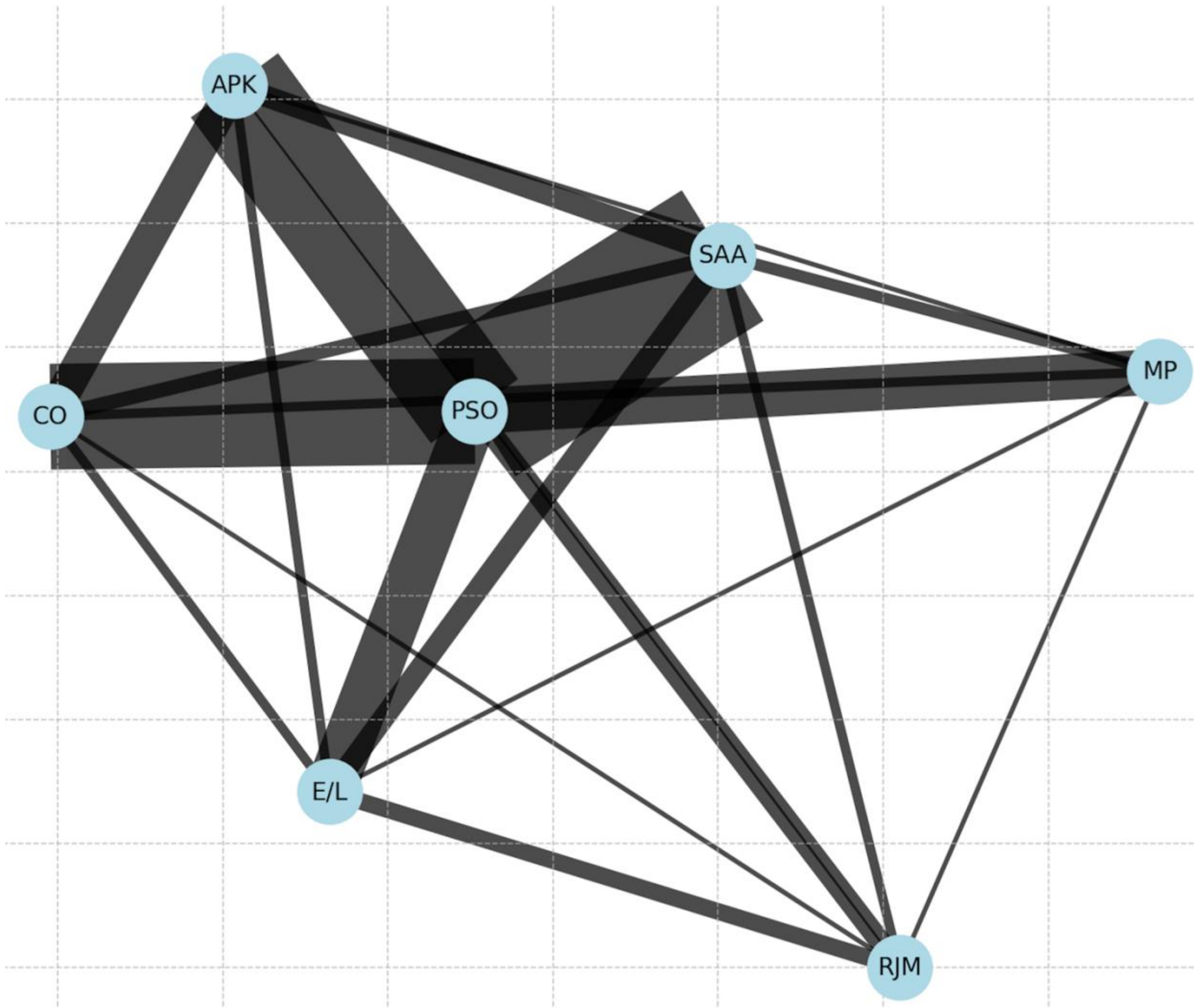

Fig. 1. Co-occurrence map of relevant themes. Connections indicate the frequency for which different codes are present simultaneously, while thickness is related to the weight of those frequencies with a thicker line indicating higher incidence of co-occurrence and thinner lines indicating lower incidence of co-occurrence.

Discussion

The qualitative analysis done in this study revealed significant insights into how first-year engineering students conceptualize critical thinking. From the percent coverage alone, problem solving is by far the most prevalent component of their conceptualization at 85% coverage. Considering the context of the work in engineering education and the institutional context where engineering is the most populous college, it is unsurprising that problem solving is the hub of the network seen in Figure 1. The theme of systematic/analytical approach covers 34% of our data set, enforcing again the engineering flavor of our participants' understanding of critical thinking. The pair of both creative thinking and application of existing knowledge garnering each 25% coverage aligns with this "engineering first" conceptualization of critical thinking, being present, but far from pervasive. Lastly the existence of multiple perspective and reflective practices coming in each at 11% presents the lowered interest in including these processes in a conceptualization of critical thinking at large.

Internal alignment

The strongest alignment between themes is where PSO connects with CO, APK, and SAA. This high level of connection suggests that students in their first year conceptualize these four themes to be interdependent on one another, with problem solving being the central hub of critical thinking.

The strongest connection in this network, between PSO and SAA, suggests an understanding of the importance of structured and goal-oriented methodologies in critical thinking aligning with Facione's [2] foundational work. Facione [2] emphasizes purposeful reasoning in his work and the motivation of students to engage in problem solving and systematic analysis directly supports this emphasis on purposeful reasoning importance.

MP and RJM are seen frequently paired when observed, albeit proportionally low. This connection aligns closely with work by Halpern [15], showcasing the importance of dispositional dimensions. The aspects of inquisitiveness, willingness to entertain diverse ideas and perspectives, and reflect upon internal cognitive processes additionally align with work by Ennis [5], Ennis [10]. Together this showcases an element of adaptability and predisposition for deeper insight when approaching complex problems.

The connection between E/L and SAA represents core cognitive skills necessary for critical thinking. These themes embody the rigorous application of logic, evaluation of evidence, and a structured dissection of arguments where all these skills coalesce into alignment as skills crucial to critical thinking [1]. While the level of coverage suggests that a sizable proportion of students acknowledge these skills as important, there is room for improvement when developing these skills as a suite of critical thinking skills.

CO and APK co-occurrence suggest their understanding of critical thinking involves more than simply structured analysis. This shows there is some level of recognition that integrating past experiences as gained wisdom, along with new fresh creative ideas elevates critical thinking. However, the low level of coverage suggests this is an area that has significant room for improvement. Similarly to how E/L and SAA could be better introduced as part of a suite of critical thinking skills, CO and APK could be framed in ways that closely align with a more holistic framing of critical thinking. This interaction between CO and APK does align with theories describing critical thinking as both divergent and convergent processes, marrying the generative with the evaluative mindsets [28].

This analysis reveals how first-year engineering students primarily conceptualize critical thinking through practical, problem-solving frameworks. This aligns closely with tangible and outcome-oriented processes. PSO and SAA dominate our data coverage reflecting this focus on structured methodologies and procedural approaches to tackling technical challenges. E/L is featured prominently which also indicates a significant emphasis on fact and logic as driving factors for decision making and judgement.

More ethereal themes such as CO and RJM are much less frequently co-occurring with the main procedural themes. This suggests a struggle by students to integrate innovative or reflective practices into their own conceptualization of critical thinking. This may suggest that students are distanced at this point in their studies from an iterative focused mode approach to critical thinking, preferring more linear thinking in their conceptualizations. A potentially narrow inclusion and somewhat concerningly underrepresented theme seen here is MP. Diverse ideas, vantage points, understanding, lived experiences, and ways of thinking are exceptionally beneficial in critical thinking. The relative absence of this is certainly notable and needs to be addressed for first-year students at Texas A&M University.

First-year students' responses to this study align well with the essential skills within engineering, where technical problems dominate curricula and practice [16, 17]. However, a limited emphasis on creativity, reflection, and diverse perspectives presents a significant misalignment. This misalignment is with broader definitions of critical thinking that promote adaptability, innovation, and contextual understanding. This is concerning due to the reality of engineering in practice which contrasts starkly with the prescribed curricula that is present in engineering programs. Engineers in practice navigate ambiguity, poorly defined problems, and diverse stakeholder needs and perspectives, necessitating creative approaches to meet the needs of novel problems. While this is not a nail in the coffin of these young engineers, it is paramount that the importance of these skills are not lost on both faculty educating these students and the students themselves.

A foundational part of both engineering and critical thinking is ethics. No response in this study mentioned ethics or anything tangential to ethics in their responses. This is a major gap in understanding that misaligns with much of the existing literature [2, 3, 15, 20]. Ethics functions as a guiding principle for reasoning, decision making, and problem solving, all of which are deeply integrated into both the internal conceptualization of critical thinking by our participants and accepted definitions of critical thinking. The institutional context of this study likely plays a role in this as currently no explicit ethics course exists in any engineering program. Leadership at Texas A&M University in the college of engineering has instead mandated that ethics be integrated into every course in engineering, although enforcing that mandate is highly challenging in practice and nearly impossible logistically.

Recommendations

This study highlights the critical need for a more comprehensive approach to fostering critical thinking in first-year engineering students. Notably, the findings reveal a significant gap in students' conceptualization of critical thinking, particularly in relation to ethical reasoning. To address this, engineering curricula should incorporate dedicated ethics modules that emphasize the application of ethical frameworks in real-world scenarios. Integrating case studies and role-playing exercises can further enhance students' ability to navigate complex ethical dilemmas, reinforcing the role of ethical decision-making in engineering practice.

Beyond ethical reasoning, fostering an appreciation for different perspectives is essential for developing well-rounded critical thinkers. Structured opportunities for engagement, such as group projects with varied team compositions, cross-disciplinary collaborations, and reflective assignments, can encourage students to consider multiple viewpoints in problem-solving. Additionally, promoting creativity through open-ended design challenges, innovation workshops, and iterative project reviews can cultivate metacognitive skills, allowing students to critically assess and refine their approaches to engineering problems.

Further, connecting critical thinking exercises to real-world challenges through industry partnerships and community-based projects can enhance the relevance and applicability of students' skills. Collaborative efforts, such as sustainability initiatives or local design projects, provide students with authentic problem-solving experiences that reinforce the importance of critical thinking in engineering contexts.

Finally, future iterations of engineering curricula should integrate validated assessment instruments, such as the California Critical Thinking Skills Test or situational judgment tests, to systematically evaluate students' cognitive development. These tools can provide meaningful insights into the longitudinal impact of pedagogical interventions and inform the refinement of instructional strategies. By embedding these targeted approaches within engineering education, institutions can better prepare students to engage in complex, real-world problem-solving with ethical awareness, creativity, and a capacity for critical analysis.

Limitations

The limitations of this study are predominately the lack of assessment of critical thinking skills through accepted means of assessment. Without this measurement there is no understanding of actual proficiency of critical thinking to compare to self-reported proficiencies. Additionally, the proportionally small sample size to the full population of first-year engineering students limits the generalizability of this study, as does the distinct identity of Texas A&M University itself, as a high research activity, Land Grant, HSI, and AUU institution. This identity results in a cross section of college aged students who are disproportionately high achieving in comparison to their peers across the state. Additionally, students participated in this survey at the end of the Fall 2024 semester, after completing much of their coursework. As a result, they were not entirely new freshmen and may have already received some direct instruction from faculty who explicitly teach critical thinking in their courses.

Conclusion

Critical thinking is foundational for engineering, enabling design, innovation, and decision making that have tremendous impacts on society. This study sheds light on the various ways first-year engineering students conceptualize critical thinking. We share both promising insights of greatly aligned understanding for technical application, along with misconceptions that interplay with the way engineers are socialized and educated. Many students equate critical thinking with procedural problem-solving while neglecting the broader evaluative, ethical, and reflective dimensions. These findings highlight the need for engineering educators to create explicit lessons or curricula that define, teach, and assess critical thinking in alignment with the engineering profession's demands. At the same time, educators should recognize and reinforce the stronger components of critical thinking that students are already developing through current teaching practices.

Curricula must integrate critical thinking skills intentionally to better prepare students for initiation into the discipline. These curricula should foster metacognitive awareness, ethical reasoning, and sound judgement while challenging students with loosely structured problems that more accurately represent the real-world environments they will soon enter. Future work will expand on these findings by investigating assessment methods for critical thinking that can be embedded throughout engineering curricula, informing how students develop these skills throughout their undergraduate experience. Qualitative work will accompany these assessment techniques to address the more nuanced elements of developing critical thinking abilities.

The 21st century has brought with it exponentially complex and multi-faceted problems that this and future generations will be responsible for addressing. Preparing students to navigate an increasingly complex world is essential, and critical thinking—an inherently human skill—is a vital part of this preparation, deeply tied to human experience and the human condition.

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Appendix

TABLE 2
THEMES AND RATIONALE

Code	Long-Hand	Percent Coverage	Definition	Indicators
PSO	Problem Solving Orientation	85%	Emphasizes the student's focus on identifying, analyzing, and generating solutions to a problem	Language like "solve", "find an answer", "fix", or "figure out" Centers on outcomes or action steps to address challenges Describing ways or methods to reach solution
MP	Multiple perspectives / Open Mindedness	11%	Highlights the importance of considering various angles, viewpoints, or perspectives when approaching a problem. Often involves being open-minded, acknowledging uncertainty, and/or challenging one's own biases	Phrases like "looking at it from different angles: "Questioning the validity of all perspectives", or "multiple viewpoints" Explicitly discusses need to be flexible, open-minded, or broad in approach
E/L	Evidence -/Logic-Based Reasoning	15%	Involves using logical steps, facts, data, or evidence to support conclusions. May reference Justifications or rational arguments that underpin a proposed solution or viewpoint	References "logic", "reason", "fact-checking", "data", or "evidence" Stresses validity or accuracy of information and conclusions
CO	Creativity/Thinking outside the box	25%	Focuses on original, imaginative, or innovative approaches. Students express a willingness to go beyond conventional or formulaic methods to explore novel solutions.	Uses "thinking outside the box", "innovation", "creative", or "unique/new approach" Emphasis on unconventional or unexplored ideas, lateral thinking, or alternative solutions
APK	Application of Prior Knowledge	25%	Demonstrates how students draw on previously learned material, personal	Using what I already know, past experiences, things we've learned in class

			experiences, or existing knowledge to tackle new or unfamiliar problems	showing a transfer of knowledge between contexts
SAA	Systematic/Analytical approach	34%	Reflects a structured, methodical, or step-by-step way of dissecting and analyzing a problem	break down, step-by-step, analyze, systematic, or methodical Emphasizes logical sequence, organization, or detailed analysis of complex systems or problems
RJM	Reflective Judgement/ Metacognition	11%	Pertains to self-awareness of one's own thinking process, evaluation assumptions or biases, and regulating one's approach to problem-solving	Mention "reflecting on my own thinking", "recognizing assumptions", "fact-checking oneself", or "Challenging my own beliefs" Engages with self-critical questioning, intellectual humility, or self-monitoring, and being ok with being wrong