Engineering Education Review

RESEARCH

Learning through cognitive, affective, and psychomotor domains: Understanding undergraduate engineering students' perspectives in the United States

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ABSTRACT

This study explores engineering students' perceptions of their learning experiences across the cognitive, affective, and psychomotor domains, as defined by Bloom's Taxonomy. Despite extensive research on the cognitive, affective, and psychomotor domains of learning, there remains a gap in understanding how engineering students perceive their abilities within these learning frameworks, particularly in relation to teaching methodologies. The research aims to address the following questions: How do engineering students perceive their learning in the cognitive, affective, and psychomotor domains? A survey instrument was developed, consisting of 18 items across the three learning domains. The survey was administered to engineering students who had experience as teaching assistants, and exploratory factor analysis (EFA) was conducted to examine the factor structure of the instrument. Data were collected from 115 participants after cleaning. Skewness and kurtosis checks confirmed the assumption of normality, and Bartlett's test of sphericity, along with the Kaiser-Meyer-Olkin (KMO) test, confirmed the appropriateness of factor analysis. Three distinct factors emerged from the EFA: the cognitive, affective, and psychomotor domains. Internal consistency was evaluated using Cronbach's alpha, with values ranging from 0.63 to 0.73, indicating good reliability. The findings suggest that students report higher confidence in applying knowledge in new situations, receiving knowledge, and valuing their own learning outcomes. This study contributes to the field by providing a deeper understanding of how students perceive their learning across different domains, paving the way for more targeted and effective educational strategies in engineering programs.

Key words: affective domain, cognitive domain, engineering education, learning domains, psychomotor domain

INTRODUCTION

The process of learning is a multifaceted and dynamic experience, deeply embedded in our daily lives. Learning not only encompasses the acquisition of knowledge but also the development of emotional responses and physical skills. Bloom's Taxonomy of Learning Domains provides a comprehensive framework for categorizing learning into three key domains: cognitive, affective, and psychomotor (Bloom *et al.*, 1956). Each domain represents distinct but interrelated aspects of learning, from intellectual understanding to emotional development and motor skill proficiency. These domains have been instrumental in shaping educational practices and instructional design across various disciplines (Krathwohl, 2002).

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The cognitive domain, which focuses on mental processes such as reasoning, problem-solving, and knowledge application, has traditionally been the primary focus of education (Anderson & Krathwohl, 2001). The affective domain, which deals with emotional responses and attitudes, plays an equally important role in shaping students' engagement and motivation, though it has historically received less attention in educational settings (Lozzi, 1989). Lastly, the psychomotor domain emphasizes physical skill development, crucial in fields that require hands-on proficiency, such as engineering, medicine, and the arts (Nicholls *et al.*, 2016).

Despite extensive research on these domains, there remains a critical gap in understanding how students—particularly those in engineering—perceive their learning experiences across these domains. Engineering education, with its emphasis on both theoretical knowledge and practical application, demands a balanced focus on cognitive, affective, and psychomotor development (Borrego *et al.*, 2014). However, current educational practices often prioritize cognitive development, potentially neglecting the emotional and physical components of learning that are essential for holistic educational outcomes (Gottipati & Shankararaman, 2018).

This study seeks to explore engineering students' perceptions of their learning within the cognitive, affective, and psychomotor domains. By examining how students rate their confidence in these areas, we aim to generate insights that can inform the development of more effective, comprehensive educational strategies. The research addresses the following key questions: How do engineering students perceive their learning in each of the three domains? This study aims to explore students' views on the cognitive, affective, and psychomotor domains in their education, with the ultimate objective of generating insights that can inform the development of more effective educational practices.

LITERATURE REVIEW

Extensive research has been conducted on the learning domains, particularly in relation to students' perceptions. However, there is a notable gap when it comes to undergraduate engineering education. Furthermore, most studies on student perceptions are not generalizable due to limited sample sizes or lack of diversity within the sample population (Hoque, 2016; Hussain *et al.*, 2016). Many studies focus on the application of learning domains in education without considering students' perspectives (Ken, 2008; Olatunji, 2014). Other research areas include the development of instruments to assess the conduciveness of learning environments to specific domains or improvements in teaching methodologies within one or multiple domains (Gottipati & Shankararaman, 2018; Olatunji, 2014; Violante *et al.*, 2020).

Despite the breadth of research, there has been little investigation into how students perceive the learning domains in the context of their educational experiences. A relevant study by Vezzani, Vettori, and Pinto (2018) examined environmental factors influencing students' views on learning, such as socio-economic status, race, and gender. While understanding the complexity of these external influences is crucial, so too is understanding students' perceptions of the learning process itself. This study aims to bridge that gap by evaluating students' views of the cognitive, affective, and psychomotor domains in engineering education.

The cognitive domain

The cognitive domain has been categorized into six levels. These levels and their descriptions are provided in Table 1. The cognitive domain has been the cornerstone of education for decades, focusing on the mental processes involved in acquiring, processing, and applying knowledge (Anderson & Krathwohl, 2001). This domain is structured hierarchically, progressing from basic tasks like remembering and understanding to more complex processes such as analyzing, evaluating, and creating. In engineering education, the cognitive domain is paramount as it encompasses skills such as critical thinking, problem-solving, and the ability to apply theoretical knowledge in practical situations (Borrego *et al.*, 2014).

Table 1: Levels of cognitive domain (Hoque, 2016)

Levels	Description
Evaluation	The ability to delineate concepts by importance.
Synthesis	The ability to create a new meaning from previous notions and or from varying subjects.
Analysis	The ability to separate opinion and fact.
Application	The ability to use knowledge in different environments and scenarios.
Comprehension	The ability to understand the meaning of said knowledge.
Knowledge	The ability to remember information.

Recent studies have emphasized the importance of fostering higher-order cognitive skills in engineering students to prepare them for the complexities of real-world problem-solving (Borrego & Henderson, 2014). However, research also highlights a gap between students' and instructors' perceptions of cognitive demands. For example, a study conducted in Indonesian universities revealed that while professors perceived their lectures to require lower cognitive effort, students reported higher cognitive demands (Fitriani *et al.*, 2021). This disconnect underscores the need for a deeper understanding of how students perceive cognitive challenges in their education and the necessity for aligning teaching practices with these perceptions. The study by Coffman and Kittur (2024a) explored undergraduate engineering students' understanding and perceptions of the cognitive domain of learning, as outlined in Bloom's Taxonomy. Their findings indicate that students generally possess a strong understanding of higher-order cognitive skills such as applying and evaluating knowledge. However, the study also revealed discrepancies between students' self-perceptions and actual abilities in these areas, suggesting a need for enhanced instructional strategies that better align with students' perceived and real cognitive demands. Additionally, the research emphasizes the importance of fostering critical thinking and problem-solving skills in engineering education.

The affective domain

The affective domain has a total of five levels, and these levels and their descriptions are provided in Table 2. The affective domain, which encompasses emotional development, attitudes, and values, is often overlooked in higher education, particularly in technical fields like engineering (Olatunji, 2014). This domain is essential because it influences students' motivation, engagement, and ability to persist in the face of challenges (Hoque, 2016). The affective domain is structured into five levels of increasing complexity: receiving, responding, valuing, organizing, and characterizing by value (Krathwohl *et al.*, 1973). At the highest level, students internalize values that influence their behavior and decision-making.

Table 2: Levels of affective domain (Hoque, 2016)

Levels	Description
Characterization (by value)	Being able to guide their actions with their values
Organizing	The ability to rank values.
Valuing	Being able to see the merit or worth of something and being able to express it.
Responding	Engagement, or active participation
Receiving	Being cognizant of feelings or emotions and being able to use selective attention.

Recent research underscores the significance of affective learning in promoting student success. For instance, studies show that students who develop positive emotional responses to learning are more likely to engage deeply with the material and persist through difficult tasks (Abbasi *et al.*, 2023; Violante *et al.*, 2020). However, there is limited research on how engineering students perceive the affective domain within their education. Olatunji (2014) notes that higher education institutions tend to treat affective learning as a secondary outcome of cognitive learning, rather than as an integral part of the learning process. This study seeks to address this gap by examining engineering students' perceptions of affective learning and how it impacts their overall educational experience. The study by Coffman and Kittur (2024c) investigated undergraduate engineering students' understanding and perceptions of the affective domain of learning, which focuses on emotional responses, attitudes, and values. The findings indicate that while students recognize the importance of emotional engagement and motivation in their learning, the affective domain often receives less emphasis in the classroom compared to cognitive learning. Students expressed that greater attention to emotional factors, such as valuing learning outcomes and actively participating in knowledge transfer, could improve both their motivation and overall learning experiences in engineering education.

The psychomotor domain

The psychomotor domain is classified into seven levels as presented in Table 3. The psychomotor domain, which focuses on physical skills and coordination, is particularly relevant in disciplines that require hands-on learning, such as engineering and the medical sciences (Nicholls *et al.*, 2016). This domain progresses from basic physical tasks, such as perception and guided response, to more complex actions like adaptation and origination (Hoque, 2016). In engineering, the psychomotor domain is critical for tasks that involve manual dexterity, precision, and the use of tools and equipment.

Table 3: Levels of psychomotor domain (Hoque, 2016)

Levels	Description
Origination	Creating new original patterns of movement for a certain scenario.
Adaptation	The ability to alter learned skills according to the situation.
Complex Overt Response	The ability to conduct patterns actions with increased complexity.
Mechanism	The ability to turn a learned response into a habit.
Guided Response	The ability to produce a behavior after seeing it displayed.
Set	Having the preparedness or motivation to act.
Perception	The ability to let your senses dictate your actions.

While the cognitive domain has been extensively studied, the psychomotor domain remains underexplored, especially in engineering education (McNett, 2012). Most research on the psychomotor domain focuses on medical education, where skill acquisition is vital for tasks like surgery or nursing (Nicholls *et al.*, 2016). In engineering, however, psychomotor skills are often relegated to laboratory settings or extracurricular activities, leaving their development less integrated into the core curriculum (Coffman & Kittur, 2024b). This lack of integration may contribute to a disconnection between students' perceptions of their abilities in this domain and their actual skill development.

Few studies have examined students' perceptions of psychomotor learning in engineering. The limited research that does exist suggests that students often undervalue their psychomotor skills in relation to their cognitive abilities, despite the importance of both in professional engineering practice (Abbasi *et al.*, 2023). This study aims to fill this gap by exploring how engineering students perceive their development in the psychomotor domain, particularly in relation to the practical demands of their field.

Perceptions of learning domains in engineering education

While research on the cognitive, affective, and psychomotor domains is extensive, there is a noticeable lack of studies that explore how engineering students perceive their own learning across these domains. Most existing studies focus on specific aspects of learning, such as the effectiveness of instructional methods or the development of particular skills, without considering students' subjective experiences (Gottipati & Shankararaman, 2018). However, understanding students' perceptions is critical for developing teaching strategies that address their needs holistically.

The closest related study to this research was conducted by Vezzani, Vettori, and Pinto (2018), who explored how environmental factors, such as socio-economic status and race, influence students' views on learning. While this study offered valuable insights, it did not focus on engineering students, or the specific domains of learning outlined in Bloom's Taxonomy. This research seeks to build on that work by providing a comprehensive analysis of how engineering students perceive their learning across all three domains, with the goal of informing more effective and integrated educational practices.

Given the complexity of engineering education, understanding how students perceive their learning in the cognitive, affective, and psychomotor domains is essential for creating more effective instructional strategies. By exploring these perceptions, this study aims to contribute to the development of a more holistic approach to engineering education, one that equally prioritizes intellectual, emotional, and physical skill development. This research will provide valuable insights into how educators can better align their teaching practices with students' experiences, ultimately enhancing learning outcomes in engineering programs.

Recent empirical evidence from engineering education

Cognitive domain

Several studies examined undergraduate engineering students participating in problem-based learning environments and found significant improvements in critical thinking and decision-making abilities compared to traditional lecture formats (Shen *et al.*, 2024; Tursynkulova *et al.*, 2023; Wilson *et al.*, 2020). A meta-analysis reported that problem-based approaches consistently enhance higher-order thinking skills in STEM disciplines (Nanda *et al.*, 2023).

Affective domain

A study showed that instructor emotional support and sense of belonging significantly predicted engineering students' academic engagement, with instructor immediacy playing a key mediating role (Burk & Pearson, 2022). Research has further demonstrated that fostering peer and faculty interactions bolsters students' emotional engagement and resilience in engineering courses.

Psychomotor domain

A 2023 study highlighted the impact of VR-supported fabrication training on engineering students' psychomotor competence, reporting increased precision and task performance in simulation *vs.* traditional lab settings. Findings from engineering makerspace initiatives indicate that scaffolded hands-on design activities significantly enhance physical skill development and creative thinking (Greene *et al.*, 2025).

METHODS

Development of the survey instrument

The survey instrument was developed during the spring of 2024 and comprises three scales measuring the cognitive, affective, and psychomotor domains of learning. This study was approved by the Institutional Review Board (IRB #17058; approval date: March 27, 2024), and participating students provided informed consent. Refer to Table 4 for the definitions and example items for each scale. These scales, along with their respective items, were constructed based on insights from existing literature (Hoque, 2016). Participants were asked to evaluate their perceptions using a 5-point Likert-type scale, where they rated their confidence in their abilities on each item. The survey consisted of 18 questions, distributed across the three learning domains. The Likert scale ranged from (5) strongly agree, (4) agree, (3) neither agree nor disagree, (2) disagree, to (1) strongly disagree. Additionally, the survey included a section gathering demographic information from the participants.

Evidence of content and face validity

To ensure content and face validity, feedback was

Table 4: Overview of Scales within the Instrument

Scale (# of items)	Definition	Example Items
Cognitive Domain of Learning (6)	The cognitive domain involves mental skills and the acquisition of knowledge. It is primarily concerned with the development of intellectual abilities and understanding.	- *Understand*: explain the meaning of what I already know - *Evaluate*: come up with judgments about importance of different concepts or solutions based on criterion
Affective Domain of Learning (5)	The affective domain deals with emotions, attitudes, values, and feelings. It involves how individuals interact emotionally and their ability to empathize with others.	- *Respond*: actively participate to engage myself in knowledge transfer - *Characterize*: control the value of my learning outcome through my behavior
Psychomotor Domain of Learning (7)	The psychomotor domain involves physical movement, coordination, and the use of motor skills. Development in this domain is measured in terms of speed, precision, distance, and techniques in the execution of physical activities.	- *Guided Response*: learn through trial and error by practicing through imitation - Adaptation: modify my learned skills/experiences required in new situations

gathered from experts in survey design as well as potential participants. Three experts evaluated the survey instrument, offering insights on the relevance and appropriateness of the items in relation to the scales and overall study. Additionally, three potential participants reviewed the survey to provide feedback on the clarity and wording of the questions. Revisions were made to the survey instrument based on the feedback received from both the experts and participants.

Exploratory factor analysis (EFA)

Procedure

EFA was employed to assess the factor structure of the developed survey instrument (McCoach *et al.*, 2013; Seltman, 2013). Data collection for this study occurred in early spring 2024. Program chairs' contact information was obtained through university websites, and emails were sent requesting them to distribute the survey to students who had served or were currently serving as teaching assistants in engineering courses. The first reminder email was sent after one week, followed by a second reminder after two weeks. Additionally, the survey questions were randomized using Qualtrics' randomization feature. The participants of this study were students enrolled in Accreditation Board for Engineering and Technology (ABET) accredited engineering programs who were currently enrolled in an ongoing engineering course in the United States.

Analytical approach

The statistical analysis was conducted using the SPSS software package. To confirm the assumption of univariate normality, skewness and kurtosis were examined for all 18 survey items prior to conducting the EFA (Shen *et al.*, 2024). The suitability of the data for factor analysis was then evaluated using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity. The KMO test assessed the shared variance between items, with values of 0.8 or higher indicating the presence of a factor structure. Bartlett's test of sphericity, which examines the item correlation matrix, yielded a result of $p < 0.05$, suggesting that the data were appropriate for factor analysis. To assess the suitability of the dataset for EFA, two standard diagnostic tests were employed: the KMO measure of sampling adequacy and Bartlett's test of sphericity (Kittur, 2023; McCoach *et al.*, 2013). The KMO test determines whether the partial correlations among variables are small, which indicates that the patterns of correlations are compact and that factor analysis is likely to yield reliable factors. A KMO value of 0.8 or higher is considered meritorious, supporting the presence of latent constructs. Bartlett's test of sphericity evaluates whether the correlation matrix is significantly different from an identity matrix. A statistically significant result ($p < 0.05$) confirms that the variables exhibit sufficient intercorrelation to justify the use of factor analysis. Together, these tests are widely recognized as essential preconditions for conducting EFA, ensuring that the underlying assumptions of factorability are met (Kittur, 2023; McCoach *et al.*, 2013).

Principal axis factoring (PAF) was utilized to extract the factors, as it accounts for potential measurement errors associated with self-report surveys (McCoach *et al.*, 2013). Given the anticipated correlations between the survey factors, the Promax rotation method with Kaiser normalization and a standard *kappa* value of 4 was applied.

After verifying the factorability of the data, Kaiser's criterion, parallel analysis, and a scree plot were employed to determine the appropriate number of factors (Kittur, 2023; McCoach *et al.*, 2013). Survey items with factor loadings below 0.4 or items loading on more than two factors with loadings of 0.3 or higher were excluded (Kittur, 2023; McCoach *et al.*, 2013; Sullivan *et al.*, 2003). Once the factor structure was established, Cronbach's alpha (α) was calculated to evaluate the internal consistency reliability of each scale. A Cronbach's alpha above 0.6 was considered acceptable, while values exceeding 0.8 were preferred. This entire EFA was conducted using SPSS software.

RESULTS

Participants

A total of 170 participants completed the survey instrument. The participants' demographic information is shown in Table 5. Following data cleaning and pre-processing, 115 responses were retained for analysis. These 115 responses fit in the recommended items per respondent: 5 to 10 (Hair *et al.*, 2010). Responses that were excluded were either largely incomplete or had identical answers selected for every question. Missing data were addressed using the group mean substitution method. The sample consisted of over 65 percent male participants. In terms of race and ethnicity, participants identified as White (56.52%), Asian (21.74%), Black or Hispanic/Latinx (17.4%), African American (14.8%), American Indian or Alaska Native (9.57%), and Native Hawaiian or Other Pacific Islander (1.74%). Please note that the total percentage of race and ethnicity is greater than 100% as some participants identified they belong to multiple race and ethnicity. Graduate students made up 75 percent of the sample, and participants represented ten different engineering majors across various academic standings.

Table 5: Participants' Demographic Information

Category	n	%
Gender Identity		
Male	67	58.26
Others	48	41.74
Race/Ethnicity		
White	65	56.52
Asian	25	21.74
Black or African American	17	14.78
Hispanic or LatinX	20	17.39
American Indian or Alaska Native	11	9.57
Native Hawaiian or Other Pacific Islander	2	1.74
Academic Department		
Computer Science	23	20.00
Mechanical Engineering	18	15.65
Biomedical Engineering	17	14.78
Electrical and Computer Engineering	14	12.17
Chemical Engineering	12	10.43
Aeronautical Engineering	12	10.43
Civil Engineering	11	9.57
Industrial and Systems Engineering	5	4.35
Engineering Physics	2	1.74
Architectural Engineering	1	0.87
Class Standing		
Freshmen	21	18.26
Sophomore	43	37.39
Junior	40	34.78
Senior	11	9.57

EFA

According to Seltman (2013), each survey item must exhibit absolute skewness and kurtosis values below 3.0 to be considered within acceptable limits for representing a normal distribution (Table 6). Several aspects that students rated highly based on average response scores (greater than 4 out of 5) include: "Apply" (apply knowledge in new situations, item #3, mean = 4.03), "Receive" (receive knowledge, item #7, mean = 4.36), "Value" (find value in learning, item #9, mean = 4.24), "Characterize" (control learning outcomes through behavior, item #11, mean = 4.1), "Perception" (use sensory cues to guide motor activity, item #12, mean = 4.02), "Set" (act mentally and physically when required, item #13, mean = 4.27), "Guided Response" (learn through imitation and practice, item #14, mean = 4.34), and "Complex Overt Response (Expert)" (skillfully perform patterns of action, item #16, mean = 4.16).

Bartlett's test of sphericity confirmed that the data were suitable for factor analysis ($p < 0.001$), and the KMO measure of sampling adequacy (KMO = 0.79) supported the extraction of factors to explain meaningful variance (McCoach *et al.*, 2013). Additionally, Kaiser's criterion, parallel analysis, and the scree plot suggested that the data contained three, three, and two factors, respectively. Based on these results, three factors were chosen for further analysis, aligning with the initial hypothesis. Due to the high correlations between the factors ($p > 0.33$), the Promax rotation method was employed (McCoach *et al.*, 2013).

None of the items cross-loaded, meaning no items had factor loadings greater than 0.3 on more than one factor (Fitriani *et al.*, 2021; Kittur, 2023; Sullivan *et al.*, 2003). Six items, which had factor loadings below 0.4, were excluded from the final analysis (Seltman, 2013). These items were: "Remember" (recall data/information, item #1), "Analyze" (break down information for relationships, item #4), "Receive" (receive knowledge, item #7), "Value" (find value in learning, item #9), "Perception" (use sensory cues for motor activity, item #12), and "Guided Response" (learn through imitation, item #14).

The EFA resulted in three distinct factors: the cognitive domain of learning, the affective domain of learning, and the psychomotor domain of learning. The factor loadings of the final factor structure are shown in Table 7. Factor loadings for the first factor (F1) ranged between 0.52 and 0.83, for the second factor (F2) from 0.57 to 0.75, and for the third factor (F3) from 0.43 to 0.54. The internal consistency reliability, measured by Cronbach's alpha, ranged from 0.63 to 0.73 across the three factors, indicating good reliability.

IMPLICATIONS FOR CURRICULUM DESIGN: COGNITIVE, AFFECTIVE, AND PSYCHOMOTOR DOMAINS OF LEARNING

The results of this study suggest that while engineering

Table 6: Descriptive statistics of survey items

#	Measure	Mean	Standard Deviation	Skew	Kurtosis
	Cognitive Domain of Learning				
1	Remember: recall data/information	3.97	0.77	-0.53	0.18
2	Understand: explain the meaning of what I already know	3.97	0.71	-0.55	0.63
3	Apply: apply my knowledge in new situations	4.03	0.76	-0.91	1.94
4	Analyze: breakdown information to look at relationships	3.99	0.72	-0.57	0.62
5	Evaluate: come up with judgments about importance of different concepts or solutions based on criterion	3.97	0.73	-0.37	0.02
6	Create: synthesize information to generate new ideas or solutions	3.90	0.83	-0.65	0.16
	Affective Domain of Learning				
7	Receive: receive knowledge	4.36	0.65	-0.52	-0.73
8	Respond: actively participate to engage myself in knowledge transfer	3.84	0.91	-0.74	0.25
9	Value: find value/worth in my own learning	4.24	0.72	-0.40	-0.98
10	Organize: organize concept/topic values according to their priorities	3.91	0.81	-0.75	0.98
11	Characterize: control the value of my learning outcome through my behavior	4.10	0.80	-0.72	0.27
	Psychomotor Domain of Learning				
12	Perception: make use of my sensory cues to guide motor activity	4.02	0.79	-0.67	0.35
13	Set: act physically and mentally when required	4.27	0.70	-0.58	-0.20
14	Guided Response: learn through trial and error by practicing through imitation	4.34	0.67	-0.52	-0.73
15	Mechanism (basic proficiency): convert the learned skills/experiences into habitual (regularly or repeatedly) actions	3.94	0.78	-0.45	-0.07
16	Complex overt response (Expert): skillfully perform patterns of action	4.16	0.78	-1.08	2.07
17	Adaptation: modify my learned skills/experiences required in new situations	3.92	0.79	-0.82	1.84
18	Origination: create new procedures or solutions to solve problems	3.59	1.00	-0.32	-0.50

Table 7: Factor loadings of the survey item structure

#	Measure	F1	F2	F3
	Cognitive Domain of Learning (Cronbach's α= 0.73)			
2	Understand: explain the meaning of what I already know	0.52		
3	Apply: apply my knowledge in new situations	0.83		
5	Evaluate: come up with judgments about importance of different concepts or solutions based on criterion	0.61		
6	Create: synthesize information to generate new ideas or solutions	0.57		
	Affective Domain of Learning (Cronbach's α = 0.63)			
8	Respond: actively participate to engage myself in knowledge transfer		0.75	
10	Organize: organize concept/topic values according to their priorities		0.57	
11	Characterize: control the value of my learning outcome through my behavior		0.56	
	Psychomotor Domain of Learning (Cronbach's α = 0.64)			
13	Set: act physically and mentally when required			0.46
15	Mechanism (basic proficiency): convert the learned skills/experiences into habitual (regularly or repeatedly) actions			0.48
16	Complex overt response (Expert): skillfully perform patterns of action			0.43
17	Adaptation: modify my learned skills/experiences required in new situations			0.52
18	Origination: create new procedures or solutions to solve problems			0.54

Note. F1 = Cognitive Domain of Learning, F2 = Affective Domain of Learning, F3 = Psychomotor Domain of Learning.

students show confidence in applying knowledge within the cognitive domain, there is a need to foster greater engagement in both the affective and psychomotor domains. To improve holistic learning outcomes, curriculum design must focus on integrating these domains, aligning with Bloom's Taxonomy, which advocates for a balance across cognitive, affective, and psychomotor skills (Bloom *et al.*, 1956; Krathwohl, 2002). Below is specific curriculum recommendations grounded in recent and relevant literature.

Cognitive domain: Promoting higher-order thinking skills

The cognitive domain has traditionally dominated engineering education, focusing on problem-solving, reasoning, and knowledge application (Anderson & Krathwohl, 2001). Recent studies emphasize the importance of developing higher-order thinking skills such as evaluation and creation, which are crucial for real-world engineering challenges (Fitriani *et al.*, 2021).

Active learning approaches

Research shows that active learning strategies significantly enhance students' cognitive abilities, encouraging deeper engagement with content (Freeman *et al.*, 2014). Methods such as problem-based learning (PBL) and case studies challenge students to apply theoretical knowledge in new and complex scenarios, promoting critical thinking, analysis, and synthesis.

Assessment reforms

Rather than relying solely on traditional exams, assessments should incorporate project-based tasks that evaluate students' ability to create and innovate (Lavado-Anguera *et al.*, 2024; Mathias, 2023; Zhang & Ma, 2023). Projects that require students to design, prototype, and present solutions to engineering problems foster cognitive development across Bloom's hierarchy.

Scaffolding cognitive challenges

According to Violante *et al.* (2020), aligning the difficulty of instructional tasks with students' cognitive development is essential. Engineering curricula should progressively increase task complexity to help students develop higher-order cognitive skills while providing adequate support through formative feedback.

Affective domain: Enhancing emotional engagement and motivation

The affective domain, involving emotions, attitudes, and values, has often been overlooked in engineering education (Lozzi, 1989; Olatunji, 2014). However, recent research highlights the importance of emotional engagement for student success, particularly in fostering motivation and resilience (Abbasi *et al.*, 2023). Developing students' emotional intelligence can also enhance their ability to collaborate, empathize, and persist in challenging tasks.

Reflection and self-assessment

Reflection exercises and self-assessment tools can enhance students' emotional engagement with learning (Borrego & Henderson, 2014). Incorporating reflective journals or self-evaluation rubrics allows students to assess their emotional responses to learning tasks, improving their ability to regulate emotions and stay motivated.

Creating supportive learning environments

Affective learning is closely linked to students' sense of belonging and support (Borrego & Henderson, 2014). Engineering programs should emphasize peer support, mentoring, and emotional resilience training to help students navigate the emotional challenges of rigorous academic environments.

Team-based learning and collaboration

Collaborative learning strategies, such as team projects and peer-to-peer instruction, can enhance students' emotional engagement by fostering a sense of community and shared responsibility (Hussain *et al.*, 2016). In team settings, students can practice empathy, leadership, and conflict resolution—skills central to the affective domain.

Psychomotor domain: Strengthening hands-on skill development

Despite the centrality of psychomotor skills to many engineering tasks, this domain is often underrepresented in the curriculum, particularly in theoretical courses (Nicholls *et al.*, 2016). Psychomotor learning involves the development of physical skills and coordination, which are essential in lab work, prototyping, and field engineering tasks.

Laboratory and field-based learning

Psychomotor skills are best developed through hands-on experiences that allow students to apply their learning in practical settings (McNett, 2012). Engineering curricula should prioritize lab courses, fieldwork, and hands-on design projects where students can practice and refine their motor skills in real-world scenarios.

Use of simulations and virtual reality (VR)

Emerging technologies such as VR and engineering simulations provide a unique opportunity to develop psychomotor skills in a controlled, risk-free environment (Violante *et al.*, 2020). These tools allow students to interact with virtual models, improving their hand-eye coordination, tool handling, and technical proficiency without the need for physical materials.

Performance-based assessments

Psychomotor learning should be assessed through performance-based methods that evaluate students' ability to carry out specific engineering tasks (Abbasi *et al.*, 2023). For example, evaluations of students' ability to fabricate, assemble, or operate technical equipment provide valuable insights into their psychomotor development. Capstone projects and engineering competitions also serve as high-impact opportunities to assess these skills.

Integrated learning experiences: A holistic approach

The integration of cognitive, affective, and psychomotor domains can significantly enhance the effectiveness of engineering education. Research by Hussain *et al.* (2016) supports the view that holistic educational strategies lead to better learning outcomes. For instance, combining lab-based work (psychomotor) with reflective assessments (affective) and problem-solving tasks (cognitive) can provide students with a more comprehensive learning experience. Integrated learning approaches, such as capstone projects, should be central to the curriculum, requiring students to demonstrate skills across all three domains. This holistic approach not only prepares students to tackle technical problems but also equips them with the emotional intelligence and physical dexterity required in professional practice.

To better prepare engineering students for the complexities of the field, curriculum designers must adopt a holistic approach that integrates cognitive, affective, and psychomotor learning. The evidence from recent research highlights the importance of this multidimensional approach for fostering well-rounded graduates who are intellectually capable, emotionally resilient, and physically skilled. By reimagining the structure of engineering programs to address all three domains, educators can create more engaging, relevant, and effective learning experiences, ensuring that future engineers are equipped to meet the demands of both industry and society.

Implications for teaching practices

To translate these findings into actionable strategies for educators, the following practices are recommended:

Cognitive domain

(a) Design scaffolding frameworks that align instructional activities with progressive levels of Bloom's Taxonomy.

(b) Incorporate metacognitive strategies such as concept mapping and think-aloud protocols to help students monitor their own cognitive growth.

(c) Use frequent low-stakes quizzes and peer instruction to reinforce retrieval practice and application of knowledge.

Affective domain

(a) Embed structured opportunities for emotional reflection, such as guided prompts following challenging assignments or peer feedback activities.

(b) Train faculty to recognize signs of emotional disengagement and use inclusive pedagogy to foster psychological safety in the classroom.

(c) Integrate value-based discussions (*e.g.*, ethics in engineering, sustainability) to connect course content with students' personal and professional identities.

Psychomotor domain

(a) Ensure equitable access to physical resources, including laboratory tools and makerspaces, especially for remote or under-resourced learners.

(b) Provide structured rubrics for hands-on tasks to ensure transparent expectations and feedback loops on physical skill performance.

(c) Incorporate brief psychomotor warm-ups or tool demonstrations in lecture-based classes to maintain kinesthetic awareness.

Directions for future research

This study also opens several avenues for future investigation:

Cross-institutional comparisons

Future studies could examine how curriculum designs vary across institutions in integrating the three learning domains, providing comparative insights and best practices.

Longitudinal studies

Tracking students across academic years would help determine how domain-specific learning evolves over time and which interventions are most impactful at different stages.

Quantifying affective and psychomotor gains

Unlike cognitive learning, affective and psychomotor development remains difficult to measure. Future research should focus on developing valid, reliable instruments to capture growth in these domains.

Technology integration research

Given the rise of VR, AR, and AI in education, further work is needed to evaluate how these tools support domain integration and student engagement across learning styles.

Faculty readiness and training

Additional studies could explore how prepared instructors are to implement integrated learning strategies and what professional development is needed to support them.

CONCLUSION

This study provides valuable insights into how engineering students perceive their learning experiences across the cognitive, affective, and psychomotor domains. Using Bloom's Taxonomy as a framework, we explored students' self-assessed abilities and confidence in each of these domains, which are critical for a holistic educational experience. Our findings highlight that while students report high confidence in cognitive tasks such as applying and evaluating knowledge, they also demonstrate strong engagement in the affective and psychomotor domains, particularly in valuing learning outcomes and performing complex motor skills.

The results suggest that engineering students are not only focused on cognitive learning but also place significant importance on emotional engagement and hands-on learning. These findings underscore the necessity for educators to adopt a more integrated teaching approach that balances intellectual, emotional, and physical skill development. Engineering curricula that emphasize cognitive growth while neglecting the affective and psychomotor domains may miss the opportunity to fully prepare students for the practical and emotional demands of real-world engineering challenges.

By acknowledging and addressing the multidimensional nature of learning, educators can enhance both student motivation and skill acquisition, ultimately improving learning outcomes. Future research should continue to investigate how these domains interact and contribute to the overall learning process, particularly in the context of engineering education, where both theoretical knowledge and practical application are vital. Additionally, this study was conducted with engineering students enrolled in programs within the United States. As such, the findings may be influenced by the specific educational, cultural, and institutional characteristics of the U.S. context. Caution should be exercised in generalizing these results to engineering students in other countries. Future research should aim to replicate and validate the findings across diverse geographical and cultural contexts to assess their broader applicability.

In conclusion, this study contributes to the growing body of research on educational strategies by emphasizing the need for a comprehensive approach that nurtures all aspects of student development. By understanding and incorporating students' perspectives on cognitive, affective, and psychomotor learning, educators can create more effective, engaging, and well-rounded engineering programs.

DECLARATIONS

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Author contributions

Mukherjee played a leading role in the research, actively participating in every stage of the project, including manuscript writing and subsequent revisions. Kittur offered valuable feedback throughout the process, from the initial concept development to the final edits. The authors read and approved the final manuscript. All authors have read and approved the final version of the manuscript.

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Ethical approval

This study was approved by the Institutional Review Board at the University of Oklahoma (IRB #17058; approval date: March 27, 2024).

Informed consent

The participants provided their consent to participate in the study at the start of the survey.

Conflict of interest

The authors declare no competing interest.

Use of large language models, AI and machine learning tools

During the preparation of this work the authors used ChatGPT 4o to improve the language and readability. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Data availability statement

Not applicable.

REFERENCES

Abbasi, M., Shirazi, M., Torkmandi, H., Homayoon, S., & Abdi, M. (2023). Impact of teaching, learning, and assessment of medical law on cognitive, affective and psychomotor skills of medical students: a systematic review. *BMC Medical Education*, *23*(1), 703. https://doi.org/10.1186/s12909-023-04695-2

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. (1956). *Taxonomy of educational objectives: the classification of educational goals, handbook I: cognitive domain*. Longman.

Borrego, M., & Henderson, C. (2014). Increasing the use of evidence-based teaching in STEM higher education: a comparison of eight change strategies. *Journal of Engineering Education*, *103*(2), 220-252. https://doi.org/10.1002/jee.20040

Borrego, M., Foster, M. J., & Froyd, J. E. (2014). Systematic literature reviews in engineering education and other developing interdisciplinary fields. *Journal of Engineering Education*, *103*(1), 45-76. https://doi.org/10.1002/

jee.20038

Burk, N., & Pearson, A. (2022). Encouraging student sense of belonging through instructor face support. *Journal of Communication Pedagogy*, *6*, 214-230. https://doi.org/10.31446/jcp.2022.1.16

Coffman, A., & Kittur, J. (2024a). Cognitive domain of learning: exploring undergraduate engineering students' understanding and perceptions. In *2024 ASEE Annual Conference & Exposition Proceedings*. https://doi.org/10.18260/1-2-47705

Coffman, A. L., & Kittur, J. (2024b). Engineering students' perceptions of psychomotor domain of learning: a qualitative investigation. In *2024 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)* (pp. 1-8). https://doi.org/10.1109/TALE62452.2024.10834385

Coffman, A. L., & Kittur, J. (2024c). *Investigating Undergraduate Engineering Students' Understanding and Perceptions of Affective Domain of Learning*. In *2024 ASEE Annual Conference & Exposition*. https://doi.org/10.18260/1-2-47705

Fitriani, S. S., Yusuf, Y. Q., & Zumara, A. (2021). The use of cognitive domain in questions: the perception of students and lecturers of public universities in Aceh. *Journal of Language and Linguistic Studies*, *17*(1), 122-138. https://doi.org/10.17263/jlls.903359

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(23), 8410-8415. https://doi.org/10.1073/pnas.1319030111

Gottipati, S., & Shankararaman, V. (2018). Competency analytics tool: analyzing curriculum using course competencies. *Education and Information Technologies*, *23*(1), 41-60. https://doi.org/10.1007/s10639-017-9584-3

Greene, M. L., Coley, B. C., & Maitra, D. (2025). Academic makerspaces in context: an exploratory study of the experiences of black men. *Studies in Engineering Education*, *6*(1), 48-69. https://doi.org/10.21061/see.95

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). *Multivariate Data Analysis* (7th ed.). Pearson Prentice Hall.

Hoque, M. E. (2016). Three domains of learning: Cognitive, affective, and psychomotor. *The Journal of EFL Education and Research, 2*(2), 45-52.

Hussain, W., & Mak, F. K., & Addas, M. F. (2016). Engineering Program Evaluations Based on Automated Measurement of Performance Indicators Data Classified into Cognitive, Affective, and Psychomotor Learning Domains of the Revised Bloom's Taxonomy. In *2016 ASEE Annual Conference & Exposition*. https://doi.org/10.18260/p.27299

Lozzi, L. A. (1989). What research says to the educator. *The Journal of Environmental Education*, *20*(4), 6-13. https://doi.org/10.1080/00958964.1989.9943033

Ken, H. (2008). Teaching within all three domains to maximize student learning. *Strategies*, *21*(6), 9-13. https://doi.org/10.1080/08924562.2008.10590794

Kittur, J. (2023). Conducting quantitative research study: a step-by-step process. *Journal of Engineering Education Transformations*, *36*(4), 100-112. https://doi.org/10.16920/jeet/2023/v36i4/23120

Krathwohl, D. R. (2002). A revision of bloom's taxonomy: an overview. *Theory Into Practice*, *41*(4), 212-218. https://doi.org/10.1207/s15430421tip4104_2

Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1973). *Taxonomy of educational objectives: The classification of educational goals. Handbook II: Affective domain.* David McKay.

Lavado-Anguera, S., Velasco-Quintana, P. J., & Terrón-López, M. J. (2024). Project-based learning (PBL) as an experiential pedagogical methodology in engineering education: a review of the literature. *Education Sciences*, *14*(6), 617. https://doi.org/10.3390/educsci14060617

McCoach, D. B., Gable, R. K., & Madura, J. P. (2013). *Instrument development in the affective domain: School and corporate applications*. Springer.

McNett, S. (2012). Teaching nursing psychomotor skills in a fundamentals laboratory: a literature review. *Nursing Education Perspectives*, *33*(5), 328-333. https://doi.org/10.5480/1536-5026-33.5.328

Nanda, A. D., Hasan, R., Sukri, A., Lukitasari, M., & Rivera, A. T. (2023). Reinforcement analyze and evaluate of higher-order thinking skills using problem-based learning in ecosystem material. *Journal of Biological Education Indonesia*, *9*(3), 492-499. https://doi.org/10.22219/jpbi.v9i3.28604

Nicholls, D., Sweet, L., Muller, A., & Hyett, J. (2016). Teaching psychomotor skills in the twenty-first century: revisiting and reviewing instructional approaches through the lens of contemporary literature. *Medical Teacher*, *38*(10), 1056-1063. https://doi.org/10.3109/0142159X.2016.1150984

Mathias, B. (2023, May 22). The assessment of students' creative and critical thinking skills through project-based approaches. Organization for Economic Co-operation and Development. Retrieved Jul. 7, 2025, from https://one.oecd.org/document/EDU/WKP(2023)8/en/pdf

Olatunji, M. (2014). The affective domain of assessment in colleges and universities: issues and implications. *International Journal of Progressive Education, 10*(1), 101-116.

Seltman, H. J. (2013). Experimental design and analysis. Carnegie Mellon University. Retrieved Jul. 7, 2025, from http://www.stat.cmu.edu/~hseltman/309/Book/

Shen, S., Tang, T., Pu, L., Mao, Y., Wang, Z., & Wang, S. (2024). Teacher emotional support facilitates academic engagement through positive academic emotions and mastery-approach goals among college students. *Sage Open*, *14*(2), 21582440241245369. https://doi.org/10.1177/21582440241245369

Sullivan, J., Pett, M., & Lackey, N. (2003). *Making sense of factor analysis: the use of factor analysis for instrument development in health care research.* Sage Publications.

Tursynkulova, E., Madiyarov, N., Sultanbek, T., & Duysebayeva, P. (2023). The effect of problem-based learning on cognitive skills in solving geometric construction problems: a case study in Kazakhstan. *Frontiers in Education*, *8*, 1284305. https://doi.org/10.3389/feduc.2023.1284305

Vezzani, V., Vettori, G., & Pinto, G. (2018). Students' perceptions of learning: The role of socio-economic status, race, and educational environment. *Educational Research Review, 24*, 180-196.

Violante, M. G., Moos, S., & Vezzetti, E. (2020). A methodology for supporting the design of a learning outcomes-based formative assessment: the engineering drawing case study. *European Journal of Engineering Education*, *45*(2), 305-327. https://doi.org/10.1080/03043797.2019.1622653

Wilson, D. M., Summers, L., & Wright, J. (2020). Faculty support and student engagement in undergraduate engineering. *Journal of Research in Innovative Teaching & Learning*, *13*(1), 83-101. https://doi.org/10.1108/jrit-02-2020-0011

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis. *Frontiers in Psychology*, *14*, 1202728. https://doi.org/10.3389/fpsyg.2023.1202728