AI-SUPPORTED LEARNING: SELF-ASSESSMENT OF ENGINEERING STUDENTS

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ABSTRACT

Assessment and feedback are foundational components of CDIO-based engineering education, and an expanding body of research has investigated the role of artificial intelligence (AI) in enhancing teaching and learning processes. As AI tools become increasingly embedded in academic and professional environments, it is necessary to examine how their use influences students' learning experiences, particularly within engineering programs that emphasize problem-solving, active learning, and continuous improvement. This study investigates AI-supported learning through engineering students' self-assessment of their learning experiences when using Google Gemini as a learning tool. Drawing on existing research on AI in education and technology acceptance, the study examines changes in students' perceptions across twelve dimensions, including intrinsic motivation, learning readiness, self-efficacy, anxiety, interaction, perceived usefulness, and learning achievement. The study sample comprised 136 students from the University of Engineering and Technology, of whom 78 engineering students participated in AI-supported instruction, while the remaining 58 received traditional instruction without AI support. The analysis focuses on how AI influences students' motivation, confidence, engagement, and perceived learning success, which are directly related to CDIO Standard 8 (Active Learning) and CDIO Standard 11 (Learning Assessment). The results indicate that students experience both benefits and challenges when using AI-based learning tools; however, strong patterns of positive engagement, high self-efficacy, and low anxiety were observed. The findings provide empirical insight into how AI can support professional competence development and learning effectiveness in CDIO-oriented engineering education based on self-assessment data from engineering students in Mongolia.

KEYWORDS

Self-assessment, AI-supported learning, engineering education, student perspectives, CDIO Standards: 8, 11

INTRODUCTION

The rapid expansion of artificial intelligence (AI) across all sectors in Mongolia has produced significant transformations in educational systems, particularly in the ways learning content is delivered, accessed, assessed, and managed. In higher education, AI technologies are reshaping conventional pedagogical methods by supporting personalized and adaptive instruction, enhancing interactive learning experiences, and enabling data-driven approaches to teaching and learning (Sharples, M. 2025; Ash, A. M., 2026; Burns et al., 2026). International organizations and policymakers increasingly recognize AI as a strategic driver of educational innovation (Krstić, Aleksić, & Krstić, 2022). According to UNESCO's Guidance for Generative AI in Education and Research (2023), AI can contribute to learning effectiveness when it supports three core competencies: cognitive competence, reflective thinking, and learning competence. These competencies provide a conceptual foundation for integrating AI into teaching and learning in a way that promotes deeper understanding, self-regulation, and continuous improvement.

AI tools such as Google Gemini and Microsoft Copilot now provide learners and educators with advanced capabilities for content generation, problem-solving, adaptive feedback, and instructional design. These tools support engineering education by enabling learners to explore complex problems, receive immediate feedback, and engage in iterative learning cycles that reflect professional engineering practice. In Mongolia, the integration of digital and AI-based learning is supported by a national legal and policy framework, including the Electronic Signature Law (2021), Personal Data Protection Law (2021), Cybersecurity Law (2021), and Intellectual Property Law (2020), as well as the Mongolian Education Sector Digital Transition Implementation Plan (2023). Together, these regulations establish a secure and ethically grounded environment for digital transformation in education.

In practice, AI has been applied to enhance distance learning, personalized instruction, automated assessment, teacher support, and student engagement. Platforms such as Khan Academy and other intelligent tutoring systems demonstrate how AI can provide individualized feedback, scaffold learning, and promote learner autonomy. UNESCO (2023) emphasizes that generative AI should function as a complement to human teaching rather than a replacement, reinforcing the role of educators as facilitators of learning. This perspective aligns closely with the CDIO framework, particularly Standard 8 (Active Learning), which emphasizes student engagement and experiential learning, and Standard 11 (Learning Assessment), which focuses on meaningful feedback and continuous improvement. Through these standards, CDIO encourages learning environments that are interactive, reflective, and aligned with real-world engineering practice.

Within this context, the present study examines how engineering students experience AI-supported learning through the use of Google Gemini. Specifically, it investigates how students' learning-related perceptions change across twelve dimensions: intrinsic motivation, learning readiness, self-efficacy, anxiety, user interface, content, interaction, perceived usefulness, perceived ease of use, attitude, behavioral intention, and learning achievement. By analyzing students' self-assessments, this study contributes empirical evidence on how AI can support CDIO-aligned engineering education.

BACKGROUND AND THEORY

Student learning is influenced by a complex interaction of individual and environmental factors, and these factors were selected because they align with the constructs measured in this study.

Individual factors include cognitive ability, motivation, effort, self-confidence, learning strategies, and physical and psychological well-being, while external factors include family support, teacher guidance, institutional environment, socioeconomic conditions, and cultural context. A holistic understanding of these factors is essential for supporting academic success, as learners must be able to recognize their strengths, limitations, and learning opportunities. AI-based instructional systems are designed to address these complexities by integrating multiple learner attributes into adaptive and personalized learning environments.

AI-supported personalized learning systems can assess learners' cognitive abilities and provide content that matches their proficiency levels. This allows advanced students to engage with more challenging material while offering additional support to those who struggle, thereby reducing learning disparities and promoting equitable learning outcomes (Luckin et al., 2018). By continuously analyzing learner performance, AI systems can adapt instructional pathways and recommend targeted resources that enhance understanding and retention.

Motivation and persistence are strongly associated with academic achievement. AI-based environments that include interactive features, conversational agents, and gamified elements can stimulate learners' intrinsic motivation and increase engagement. However, some research cautions that excessive reliance on reward-based AI systems may weaken intrinsic motivation by shifting learners toward extrinsic incentives (Zawacki-Richter et al., 2019). AI can also support persistence by monitoring engagement patterns and delivering motivational feedback or adaptive challenges (Roll & Wylie, 2016).

Self-confidence and assessment accuracy play a crucial role in effective learning. AI can provide rapid and individualized feedback that helps learners evaluate their knowledge and skills, potentially increasing self-confidence and metacognitive awareness. At the same time, poorly designed systems or excessive automation may lead to overconfidence or inaccurate self-evaluation (Chen et al., 2020). Therefore, AI systems must be carefully aligned with pedagogical goals to ensure that feedback supports authentic learning.

Learning strategies and metacognitive skills directly affect how students process information and regulate their learning. AI can detect learning patterns and suggest strategies for planning, monitoring, and evaluating progress, thereby strengthening metacognitive development (Holmes et al., 2021). Additionally, AI-based systems can monitor attention and workload to support learners' well-being, although excessive dependence on digital tools may introduce risks related to stress or digital fatigue.

AI also influences the broader learning environment. In families, AI can provide insights into learners' progress, while in classrooms, teachers increasingly take on the role of facilitators who guide students' interaction with intelligent systems. These shifts highlight the importance of aligning AI integration with educational frameworks such as CDIO, which emphasize experiential learning, reflection, and continuous assessment.

METHODS

This study employed an experimental design involving an experimental group and a control group. Both groups completed pre-test and post-test assessments to measure changes in learning performance. Prior to instruction, all participants completed a pre-test to establish baseline levels. Following instruction, a post-test was administered to evaluate learning outcomes.

A total of 136 students from the University of Engineering and Technology participated in the study. Of these, 78 engineering students were assigned to the experimental group and engaged in 32 hours of instruction supported by Google Gemini. The remaining 58 students formed the control group and received traditional instruction without AI support. The experimental group used Google Gemini as a learning assistant during course activities, including problem-solving, information retrieval, and concept clarification.

The study employed a validated survey instrument to measure twelve dimensions related to AI acceptance and learning outcomes. All items were rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The measurement instrument encompassed 12 variables, each grounded in the literature reviewed in this paper.

RESULTS AND ANALYSIS

To ensure that the results were not influenced by initial differences in student ability or motivation, Baseline Equivalence of groups was established using pre-test measures. An independent samples t-test indicated no statistically significant differences ($p>.05$) between the experimental ($n=78$) and control ($n=58$) groups across all twelve dimensions at the outset of the study. This ensures a level playing field for the intervention.

Table 1. Pre-Test Baseline Equivalence (Experimental vs. Control)

№	VARIABLE	EXP. (M)	CTRL. (M)
1	Internal Motivation	3.78	3.80
2	Readiness	3.45	3.48
3	Confidence	3.52	3.55
4	Anxiety	2.95	2.92
5	User Interface	3.10	3.12
6	Content	3.25	3.28
7	Interactivity	3.40	3.38
8	Perceived Usefulness	3.60	3.62
9	Perceived Ease of Use	3.55	3.58
10	Attitude	3.65	3.68
11	Behavioral Intention	3.70	3.72
12	Academic Performance	69.91	69.93

The primary objective of the study was to assess the impact of AI-supported instruction on academic performance. Post-test results indicate a statistically significant difference between the two groups:

- Experimental Group Mean: 86.92 ($SD=6.5$)
- Control Group Mean: 82.34 ($SD=7.0$)

- Statistical Significance: $t=5.78$, $p<.001$

The observed mean difference of 4.58 points reflects a meaningful academic performance for students in the experimental group in AI-supported instruction (M = 86.92) over the control group (M = 82.34), which hasn't received AI-supported instruction. Although both groups demonstrated improvement from the baseline, the experimental group's higher "minimum" score (72.00 vs. 61.00) suggests that AI-supported scaffolding may have contributed to reducing performance variability by supporting lower-achieving students and effectively raising the performance floor.

In addition to overall academic performance, the experimental group demonstrated statistically significant advantages in several key dimensions, including Internal Motivation ($p=.003$), Interactivity ($p=.003$), and Perceived Usefulness ($p<.001$).

Further analysis was conducted within the experimental group to better understand students' perceptions of the AI-supported learning environment, revealing consistently high mean scores across most variables, ranging between 4.0 and 4.5. Behavioral intention (M = 4.53), self-efficacy (M = 4.51), and interaction (M = 4.49) were particularly high, suggesting that students were confident in using AI and intended to continue doing so.

Standard deviations ranged from 0.45 to 0.78, indicating low variability and high agreement among students. Anxiety had a low mean (M = 1.62) and low standard deviation (SD = 0.35), demonstrating that most students experienced minimal anxiety when using AI. Learning achievement averaged 82.60, indicating strong academic performance.

These results provide evidence that AI-supported learning positively influenced motivation, confidence, interaction, and perceived learning effectiveness while maintaining low psychological stress.

DISCUSSION

This study examined how engineering students perceive AI-supported learning across multiple cognitive, motivational, and technological dimensions. Rather than viewing these constructs in isolation, the findings reveal a coherent learning ecosystem in which motivation, readiness, self-efficacy, and technological affordances interact to shape students' engagement and achievement in an AI-mediated learning environment.

Intrinsic Motivation and Learning Engagement

A strong level of intrinsic motivation was evident across the sample. Specifically, 66.67% of students rated their intrinsic motivation at the highest level (5), while an additional 26.92% rated it as 4, meaning that over 93% of students reported high or very high intrinsic motivation when learning with Google Gemini. Only 1.28% of students reported a neutral level of motivation, and none reported low motivation. This distribution indicates that the AI-supported learning environment effectively stimulated students' internal interest, curiosity, and willingness to engage with learning tasks.

Readiness to Engage in AI-Supported Learning

Students also demonstrated a high level of readiness to learn in an AI-supported environment. 44.88% of students rated their readiness as 5, and 21.79% rated it as 4, meaning that approximately 67% of students perceived themselves as highly prepared to use AI for learning.

Only 3.84% of students rated their readiness at the neutral level, indicating that lack of preparedness was rare.

Self-Efficacy in Using AI for Learning

Students' self-efficacy was particularly strong. A total of 59.0% of students rated their self-efficacy at the highest level (5), while more than 40% rated it as 4, meaning that nearly 100% of students expressed high confidence in their ability to use AI effectively for learning. Very few students reported lower levels of self-efficacy. This pattern indicates that the AI-based learning environment not only provided functional support but also strengthened students' beliefs in their own competence. High self-efficacy is known to promote persistence, problem-solving, and resilience—qualities that are essential for engineering education and professional practice.

Anxiety and Psychological Comfort

An important finding is the relatively low level of anxiety associated with AI use. 62.82% of students reported low to moderate anxiety, while only 17.66% fell into the high-anxiety category. This suggests that most students felt psychologically comfortable interacting with the AI system. Given that new technologies often introduce uncertainty and cognitive stress, this result indicates that Google Gemini functioned as a supportive learning tool rather than a source of intimidation.

User Interface and Learning Environment Design

The quality of the AI system's interface also influenced students' experiences. 42.31% of students rated the interface at levels 4–5, indicating that nearly half of the students perceived it as easy to use, well structured, and visually supportive of learning. However, approximately 20% of students rated the interface at 3 or below, suggesting that some learners encountered usability challenges. While the overall perception was positive, these results indicate that improvements in interface clarity, navigation, and responsiveness could further enhance learning efficiency and user satisfaction.

Content Quality

The instructional content delivered through the AI tool was evaluated positively by most students. More than 60% rated content quality at 4–5, indicating that the material was generally perceived as clear, relevant, and aligned with learning objectives. Approximately 15% rated the content at 3, suggesting that some students found it insufficiently detailed or in need of deeper explanation. These results suggest that while AI-generated or AI-mediated content is broadly effective, its pedagogical value can be further enhanced through improved contextualization and alignment with course objectives.

Interaction and Active Learning

Learning interaction received some of the strongest evaluations. The predominance of high ratings indicates that the AI-supported environment successfully facilitated student–AI, student–content, and student–teacher interaction. This confirms that the AI tool enabled real-time feedback, continuous questioning, and iterative learning processes, thereby supporting the active learning principles of CDIO Standard 8. The interactive structure encouraged students to engage cognitively rather than passively consume information.

Perceived Usefulness

Students overwhelmingly perceived the AI tool as beneficial. More than 75% of students rated usefulness at 4 or 5, with 34.62% assigning the highest rating. Only 2.56% rated usefulness at levels 2 or 3. This indicates that students strongly believed that AI improved their learning efficiency, academic performance, and engagement. These results align with the technology acceptance model, confirming that perceived usefulness is a major driver of adoption and sustained use.

Perceived Ease of Use

Ease of use was also rated highly. Approximately 60% of students rated ease of use as 5, and an additional group rated it as 4, meaning that the vast majority experienced the system as intuitive and user-friendly. Only a very small percentage (1.28–2.56%) reported moderate difficulty. This reinforces the conclusion that the technical accessibility of the AI system played a key role in enabling learning rather than obstructing it.

Attitude and Behavioral Intention

Students' attitudes toward AI were more moderate than their functional evaluations. About 28% of students reported relatively low attitudes (level 2), while most clustered around levels 3–4, and only 6–10% reported very strong positive attitudes (level 5). Despite this, behavioral intention was high, indicating that students planned to continue using AI even if emotional acceptance was still developing. This suggests that functional benefits currently outweigh affective reservations, and that attitudes may improve with more refined pedagogical integration.

Learning Achievement

Learning achievement showed moderate to high performance overall, with some students demonstrating particularly strong results. These differences suggest that achievement depends not only on the availability of AI but also on individual readiness, engagement, and learning strategies. However, the overall performance supports the conclusion that AI-supported instruction can enhance academic outcomes when properly implemented.

CONCLUSION

The primary aim of this study was to systematically examine the educational potential of an AI-supported learning environment using Google Gemini within an engineering education context. A total of 136 students were divided into experimental and control groups, and instruction was organized according to a structured pre-class, in-class, and post-class learning model. This design enabled a direct comparison of learning processes and outcomes between AI-supported and traditional instructional approaches.

The empirical results demonstrate that students in the experimental group consistently outperformed the control group across key learning dimensions, including intrinsic motivation, self-efficacy, learning readiness, technological understanding, learning attitude, and academic achievement. These findings provide strong evidence that AI-supported learning environments can meaningfully enhance both effective and cognitive components of learning, which are essential for effective engineering education.

During the intervention, students actively used Google Gemini, which supported the development of logical reasoning, analytical thinking, and independent learning skills, which are core outcomes emphasized by the CDIO framework.

CDIO Standard 8 (Active learning) focused on student engagement in the learning process, which this study utilized through AI-supported instruction. This promotes active learning by asking questions, filtering and analyzing information, interpreting results, and engaging in discussion with both peers and instructors. Rather than passively receiving information, students engaged in iterative inquiry and problem-solving, reflecting authentic engineering learning processes.

CDIO Standard 11 (Learning Assessment) focused on measuring the achievement of intended outcomes, which shows that the student performances were evaluated through pre- and post-test aligned with course learning outcomes.

In addition to personal learning factors, environmental characteristics, including content quality, interface design, and interactive functionality, were shown to have both direct and indirect effects on students' technology acceptance, learning engagement, and academic performance. This confirms that effective AI integration depends not only on the tool itself but also on how it is embedded within instructional design and learning activities.

Overall, the findings indicate that an AI-based learning environment using Google Gemini:

- Enhances cognitive engagement, analytical thinking, and logical reasoning
- Strengthens intrinsic motivation, learning readiness, and self-confidence
- Demonstrates the importance of interface design, content quality, and interaction in technology-supported learning
- Provides a reliable and theoretically grounded foundation for digital and AI-supported engineering education

Consequently, this study confirms that AI-supported learning, when aligned with CDIO principles, offers a student-centered, interactive, and analytically rich educational model that effectively supports both learning quality and professional skill development in modern engineering education.

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