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Special Issue
How disability is addressed in Engineering Education

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This study aims to present a set of methods to foster the self-regulated learning of engineering students who experience some type of disability that affects their self-determination abilities. The academic community has dedicated effort to providing these students with methods to achieve the learning outcomes in the Science, Technology, Engineering, and Mathematics (STEM) area, which require knowledge of the subject, in addition to soft skills such as teamwork, and assertive communication, among others. To contextualize the study, a literature review was carried out. Results were organized into four categories of methods, including coaching, e-inclusive pedagogy, assistive technology, and immersive learning environments. Each of them was analyzed according to the type of disability it targets. The most optimistic method in self-regulation of learning is coaching since it allows mentors to monitor the development of goal-setting and self-assessment skills. Alternatives are presented, so faculties can evaluate and apply these methods in their contexts so that the student is supported to achieve success in their subject.

Keywords: self-regulation; engineering students; learning disability

The integration of students with intellectual and developmental disabilities into STEAM education presents ongoing challenges, particularly in engineering disciplines where both technical and social competencies are essential. Robotics and active learning methodologies have emerged as promising solutions to address these challenges by offering adaptive, interactive, and student-centered learning environments. This study conducts a systematic literature review to examine how these technologies and methodologies are applied to support students with Intellectual and Developmental Disabilities. A total of 34 high-quality studies published over the past ten years were selected through a rigorous process of database searching, inclusion/exclusion filtering, and quality assessment. The analysis reveals that robotics is particularly effective in fostering academic development, cognitive skills, social-behavioral interaction, and emotional regulation, while active learning promotes social responding, role understanding, and collaborative skills. Together, these approaches not only enhance individual learning outcomes but also facilitate the broader inclusion of students with disabilities within engineering education.

Keywords: robotics; active learning methodologies; intellectual and developmental disabilities; engineering education

Despite the widespread adoption of inclusive education policies worldwide, students on the autism spectrum continue to face significant academic, social, and institutional barriers in higher education, particularly in STEM fields like engineering. While most existing research focuses on English-speaking contexts, inclusive practices remain underexplored in other education systems. This study addresses that gap by analyzing national data from Spain and reviewing international research on barriers and support strategies for autistic students in universities. The article identifies critical challenges – such as sensory sensitivities, social isolation, and limited access to individualized supports – and highlights evidence-based strategies to foster inclusive learning environments. These include the application of pedagogical strategies grounded in Universal Design for Learning (UDL), including insights directly gathered from autistic students themselves. The study advocates a shift toward a holistic support system that integrates strength-based and flexible curricular models, training for educators, peer mentoring, social skills training, counseling services, and parental guidance. Together, these approaches promote equity, well-being, and long-term academic success for autistic students in higher education.

Keywords: ASD; higher education; STEM; peer mentoring; educator training; neurodiversity; strength-based approaches; Universal Design for Learning (UDL)

Section II

Contributions in: Capstone Courses, Makerspace, Internet of Things, Flipped Classroom, PBL, Engineering Ethics, Engineering Design, Self-Efficacy, Entrepreneurship, Motivation, Community of Inquiry, Students Perceptions, AI, Robotics Curriculum, Quantitative Scale, Digital Competencies, Mentoring Styles

Engineering capstone courses provide a culminating experience that integrates knowledge across courses and applies it to real-world design challenges. These courses offer valuable experiential learning but present recurring instructional challenges for students, faculty, and institutions. This study introduces a structured, ABET-aligned framework for capstone course design that integrates ABET standards, engineering design processes, and targeted strategies into a coherent, practice-oriented model. Unlike prior studies that focus on isolated practices or narrow assessment dimensions, the framework offers a holistic and adaptable structure for faculty to enhance course effectiveness. Its practical application is illustrated through a case study supported by student survey data, demonstrating strong student approval and the framework's utility in practice. While empirical evaluation of learning outcomes is beyond the scope of this work, the framework provides a foundation for future research to assess its impact on ABET competencies, teamwork, and long-term professional preparedness.

Keywords: structuring capstone courses; engineering design; ABET; student survey; practice-oriented

Training offerings for undergraduate engineering students vary widely depending on staffing, culture, and associated coursework. Augmented reality (AR) has shown promise in training users for procedural tasks in industry and improving classroom learning. This paper compares the efficacy of an AR training tutorial to a traditional Teaching Assistant (TA)-led demonstration on undergraduate engineering students' learning of makerspace tools. A group of undergraduate mechanical engineering students (n = 47) were trained on the power drill/driver with either a TA-led demonstration or an AR tutorial using a Microsoft HoloLens. Pre- and post-surveys measured students' knowledge of the tools, self-efficacy for tool usage, and perceptions of the tutorial. Both tutorials resulted in a statistically significant increase in student learning as measured by content knowledge and self-efficacy. Students did not exhibit a preference for the AR training compared to the TA training, indicating that either training option is beneficial and equitable for a range of student needs. Considering how different tutorial modalities affect the learning of different

student populations is important when developing inclusive classroom activities. Using AR training in lieu of or in combination with TA-led training could help with staffing and scaling challenges in academic makerspaces and hands-on design courses while accommodating different learning preferences and levels of prior experience.

Keywords: augmented reality (AR); engineering education; makerspace training; hands-on learning; academic makerspaces; design education

This study aims to develop "Precision Health and Maker Education (PHAME)," an innovative high school curriculum model that integrates emerging technologies with hands-on practice, designed to cultivate students' health management knowledge and practical skills. The study utilized the ADDIE instructional design model (Analysis, Design, Development, Implementation, Evaluation) to plan and implement an 18-week experimental teaching program. Adopting a mixed-methods research approach, the study targeted 30 11th-grade students to investigate their learning outcomes, learning attitudes, and the causal relationships within the Technology Acceptance Model (TAM). The research findings indicate that this study successfully constructed a high school PHAME_Course curriculum framework, which includes four main dimensions, 19 sub-dimensions, 49 competency indicators, and corresponding curriculum units. The developed PHAME instructional model, based on the ADDIE framework, is not only suitable for the high school level but also aligns with contemporary educational and industrial trends, effectively connecting with practical industry skills. Furthermore, the experimental teaching of the PHAME_Course demonstrated statistically significant positive effects on students' learning outcomes. The Technology Acceptance Model for PHAME was also validated, with results showing that students' "perceived ease of use" of precision health technology significantly influenced their "perceived usefulness," which in turn positively affected learning intentions and satisfaction. The research team consolidated the study's findings and implementation experiences to provide practical recommendations, with the aim of successfully promoting and integrating this instructional model in high schools.

Keywords: precision health; maker education; wearable devices; ADDIE; Internet of Things

This study investigated English as a Foreign Language (EFL) engineering students' perceptions of flipped instruction in an English-Medium Instruction (EMI) engineering course at a national university in Taiwan. In alignment with the Bilingual Nation 2030 initiative, EMI aims to enhance global competitiveness in Taiwan's high-tech industries. However, implementation remains challenging due to language barriers and the need for pedagogy alignment with students' learning needs. This study explored whether the quality of flipped EMI instructional course design shapes students' course experiences, rather than their extramural English use. A total of 35 junior engineering students participated in a flipped EMI course. Data collected through an online survey comprised three dimensions: students' general views on flipped-classroom instruction, perceived impact on creativity, and challenges encountered. Findings suggest that students appreciated the flexibility and autonomy provided by the flipped model, especially opportunities to review materials and control their learning pace. The results also reveal that students improved their critical thinking and independent learning. However, major challenges included insufficient feedback and difficulties with time management, particularly in EMI settings requiring additional cognitive load. Notably, no statistically significant correlation was found between students' extramural English use and their course perceptions. Overall, the findings highlight that well-structured instructional course design is a more critical factor in shaping students' EMI learning experiences, not their general English exposure. The findings offer practical implications for designing EMI courses which support both technical disciplines and language development, especially in linguistically diverse settings.

Keywords: engineering education; flipped classroom; English-medium instruction (EMI); higher education; sustainable learning

This study examines whether a semester-long scaffolded project-based learning (SPjBL) intervention improves metacognitive awareness among undergraduate electrical engineering students. Using a one-group pre-test and post-test design, N = 44 students in a Malaysian program completed the Metacognitive Awareness Inventory before and after a semester-long project module that integrated authentic engineering tasks with planning supports, milestone reviews, and guided reflections. SPjBL enhanced selected dimensions of metacognition, with clear gains in information management strategies and declarative knowledge, modest change in evaluation and procedural knowledge, little to no change in comprehension monitoring, and a slight decline in debugging.

Keywords: scaffolding project-based learning; metacognition; electrical engineering education; metacognitive awareness inventory

In this paper, we present and evaluate student impressions of two distinct versions of an undergraduate professional ethics course taught in the Electrical and Computer Engineering (ECE) Department at the University of Maryland. One version has been taught by senior electrical engineering professors and follows a "traditional" approach to professional engineering ethics. The other version teaches the course through a Sociotechnical Systems (STS) lens and relies on the use of STS postures (STSP). In an attempt to understand which approach was more effective at transmitting the required knowledge, skills, and abilities (KSAs) to the students, a survey given to students who have taken either version of the course probed students' opinions about the importance of the course overall and about several key concepts. The survey also queried the students' self-efficacy as to whether they had the tools necessary to resolve different situations ethically. The traditional cohort had 64 respondents while the STSP cohort had 31 respondents. Both cohorts recognized the importance of risk analysis and professional codes of ethics, but generally, students in the "traditional" class felt more positive about the focus of the course and about their ability to resolve situations ethically.

Keywords: engineering; professional ethics; higher education

This study investigated the changes in and sustainability of self-efficacy of secondary pre-service science teachers for teaching engineering design before and after engineering design integrated science (EDIS) instruction in a science methods course and after teaching EDIS units in schools. After learning about engineering design and how to integrate it into science instruction in science methods, forty (N = 40) pre-service teachers created and taught EDIS units in schools during student teaching. In the EDIS units, pre-service teachers taught both engineering design and science concepts. Participants completed Teaching Engineering Self-Efficacy Scale (TESS) survey before and after the EDIS instruction in the science methods course, and after teaching EDIS units in schools. The results show that the pre-service teachers' self-efficacy for teaching engineering increased from pre-instruction on EDIS instruction in a science methods course to post-implementation of EDIS units in schools. The linear growth model analysis also revealed that time had a significant positive effect on pre-service teachers' development of self-efficacy for teaching engineering design.

Keywords: engineering design; science; pre-service teacher; self-efficacy

Entrepreneurship education (EE) is increasingly integrated into engineering curricula to develop entrepreneurial mindsets, attitudes, and innovation-oriented competencies among students. However, the mechanisms by which EE influences entrepreneurial intentions (EIs) in engineering contexts remain insufficiently understood. While the Theory of Planned Behavior (TPB) is widely used to explain entrepreneurial intentions, most studies have focused on direct and single mediation paths, and research explicitly examining double mediation effects is notably scarce, particularly in engineering education. This study addresses this gap by introducing and empirically testing a double mediation model in which EE influences EIs through entrepreneurial attitudes (EAs), subjective norms (SNs), and perceived Behavioral control (PBC). Using survey data from 688 students at a Spanish technological university, structural equation modeling reveals that EE affects EIs indirectly through EAs and PBC, with SNs acting as cognitive antecedents. These findings extend existing theory by showing that EE operates through layered psychological mechanisms rather than direct effects alone. The study also finds that higher exposure to EE supports more realistic self-assessment and adjusted entrepreneurial confidence in technical students. By advancing a double mediation framework in an underexplored educational context, this research contributes a novel theoretical perspective to engineering EE. It offers actionable insights for designing effective, context-sensitive EE programs.

Keywords: entrepreneurship education; engineering students; entrepreneurial intention; TPB; double mediation; entrepreneurial learning abilities

Engineering is widely regarded as a demanding career pathway that promises significant professional and societal rewards. This study investigates the motivations and perceptions that influence students' decision to pursue engineering programs in private higher education institutions (HEIs) in Northern Mindanao, Philippines. Adopting a concurrent mixed-methods design, the study utilized a validated 12-item instrument and exploratory factor analysis to identify key motivational dimensions. Results revealed two primary factors: Outcome Expectations (prestige, career advancement, financial security, and societal contributions) and Personal Goals (happiness, employability, and long-term aspirations). Quantitative findings demonstrated that extrinsic motivations, particularly outcome expectations, exert stronger influence than intrinsic motivations. Complementary qualitative analyses highlighted themes of personal interest and passion, anticipated career prospects, and the desire to make a difference in society. These findings confirm a persistent discrepancy between students' idealized perceptions of engineering and the pragmatic realities of academic rigor and professional practice. By clarifying these motivational drivers, this study provides insights that can inform career guidance, curriculum design, and retention strategies in engineering education.

Keywords: engineering education; student motivation; career pathways; perceptions and realities; higher education

In a study on systematic reflection in a flipped fluid mechanics course to drive metacognition, engineering undergraduates were asked to reflect on the impact of the classroom surroundings on their learning. The reflection question described surroundings as the "*conditions and objects*" that surround you. Based on an emergent content analysis, *peers* were mentioned as positive classroom "surroundings" in 46% of the reflections in the fall 2021 and fall 2022 semesters upon return to campus after the COVID-19 pandemic. We had expected reflections related to physical classroom surroundings, such as layout, size, furniture, temperature, or infrastructure. Although students identified the classroom's physical features as "surroundings" with both positive and negative influences, they more frequently identified *peers*, the *instructor,* and/or *in-person instruction* as their positive "surroundings." To situate and understand this unexpected result, we applied the Community of Inquiry (CoI) theoretical framework. This framework has been applied in multiple contexts with its three interdependent presences that drive learning—cognitive, social, and teaching. Interestingly, when students identified their CoI as part of their positive "surroundings," they less-frequently mentioned non-supportive physical classroom features. Our results suggest that an interactive classroom with notable social presence can have a positive impact on perceptions of the classroom "surroundings" that influence learning. Students' identification of the CoI with their classroom surroundings suggests the importance of community in higher education, particularly during times of disturbance to educational practices.

Keywords: Community of Inquiry; CoI; classroom surroundings; flipped classroom; peers; COVID-19

This study aimed to investigate the perceptions, usage patterns, and attitudes of engineering students towards artificial intelligence (AI) at a major university in Saudi Arabia. A key objective was to identify gaps in AI education and understand the challenges students face in utilizing AI tools.

A cross-sectional survey was conducted among undergraduate and graduate engineering students at King Saud University. A 24-item questionnaire was used to collect data on students' AI knowledge, sources of learning, applications in academic work, perceived benefits, challenges, and career aspirations related to AI.

The findings revealed a high adoption of AI tools for academic purposes among students. However, students predominantly rated their formal AI knowledge as moderate, with self-learning being the primary source of understanding. Key challenges reported included the high cost of AI tools, limited access to resources, and ethical concerns such as plagiarism. No significant differences in attitudes were found based on academic level, GPA, or socio-economic status.

The study concludes that while engineering students actively use and value AI, a significant disparity exists between its practical application and formal education. The results underscore the necessity for integrating structured AI training, including fundamentals, applications, and ethics, into the engineering curriculum to equip future engineers with the necessary competencies.

Keywords: Artificial intelligence; AI; attitudes; benefits; challenges; engineering; gaps; graduate; knowledge; perceptions; Saudi Arabia; survey; undergraduate

One of the fundamental principles of the latest industrial revolution is the development of intelligent systems capable of autonomous decision-making through the integration of advanced technologies. In this context, the convergence of cloud computing, the Internet of Things (IoT), and robotics represents an innovative approach to ensuring secure data storage and transmission, real-time monitoring and control, and the scalability of intelligent applications. This study explores the transformation of educational curricula through the integration of cloud-based and IoT-enabled robotics, introducing the foundational principles of the Internet of Robotic Things (IoRT) into the educational content. The transformed curriculum was structured around the IoRT framework and implemented via the Arduino IoT Cloud platform. The instructional design was grounded in Fink's taxonomy, which has demonstrated its efficacy in engineering education, and incorporated student-centered and project-based learning strategies. The revised robotics course was piloted in Kazakhstani universities within master's degree programs for future computer science educators.

Keywords: transformed robotics curriculum; education; cloud computing; IoT; IoRT concept; integration

Quantitative measures are important tools in engineering education research that often lack an ongoing and robust process of validation. Researchers may take a scale from one study and use it in another because it has been published as "validated" without gathering evidence for its use in the new context. Validation is particularly important when attempting to develop measures of abstract constructs. The purpose of this study is to illustrate the process and challenges of adapting quantitative scales into an engineering education context by presenting a case exploring the process of adapting a scale to measure engineering epistemic constructs. We explicitly map our work to *The Standards for Educational and Psychological Testing* with the goal of supporting other engineering education researchers as they use these standards. A sample of 3,711 responses from first-year engineering students from institutions across the United States was used to demonstrate a multistep, validation process, which included exploratory and confirmatory factor analysis. Our process provides an example of how to use the *Standards* while also demonstrating that a robust validation process does not automatically result in a trusted scale. The outcomes of this study provide a basis for better understanding the challenges associated with scale adaptation and validation. This work also adds to knowledge around quantitatively measuring epistemic constructs in engineering and encourages our field to critically consider its value.

Keywords: instrument development; validation; epistemology

The digital transformation of the agri-food sector demands new competencies from professionals in agronomic and environmental fields. This study presents the implementation and evaluation of an educational framework designed to develop digital competences among postgraduate students, using IoT technologies in a course on Precision Agriculture. The course was structured around the DigComp 2.2 framework, targeting specific competences such as information management, technical problem-solving, and identification of technological solutions. 21 students participated in a project-based learning experience involving Arduino and ESP32 microcontrollers, sensors, actuators, and cloud platforms for data monitoring and control. A 16-item DigComp 2.2-based questionnaire was used to assess competence acquisition. Results showed significant improvements in students' confidence and abilities, particularly in hardware integration and applied problem-solving. However, lower confidence levels in cloud platform usage revealed a need for more sustained training in digital environments. The findings highlight the effectiveness of hands-on, interdisciplinary methodologies in fostering relevant digital skills in agricultural education. The pro-posed framework aligns academic training with sectoral demands, enhancing students' employability, innovation capacity, and readiness for smart farming systems.

Keywords: precision agriculture; digital competences; DigComp 2.2; Internet of Things; Arduino; ESP32; Higher education

This study uses the Managerial Grid Theory and Big Five Personality Model to explore how supervisors' mentoring styles affect engineering graduate students' academic achievement and anxiety. Via questionnaire surveys and data analysis of 643 graduates, it finds mentoring styles significantly influence the two factors, with students of different personalities adapting differently. Relevant mentoring strategies can boost academic performance and reduce anxiety, providing theoretical and practical guidance for optimizing mentoring and improving graduate education quality.

Keywords: supervisor's mentoring style; managerial grid theory; big five personality model; academic achievement; anxiety level