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Contents

Contributions in: Nontraditional Students, Generative AI, Resilience, Online Learning, Large Language Models, Competency Indicator, First-Year Students, Entrepreneurial Mindset Teacher-Student Inteaction, First Generation Students, Engineering Identity, PBL, Autonomy, Diversity, Innovation, Virtual Mentorship, Industry-Academia, Human-AI Collaboration, Entrepreneurial Readiness, Learning Style, Accreditation, Conceptual Understanding, Outcome-Based Education, Underrepresented Groups, Blended Learning, CNC Machining, Environmental Engineering, Manufacturing Engineering, IC Design, Engineering Programing, Biomedical Engineering, Software Testing, Thermodynamics, Image Processing, Mechanical Design

The number of nontraditional students in engineering (NTSE) is growing across the United States. By definition, NTSE do not go through a standard four-year degree program straight from high school to a residential campus. These nontraditional students typically work full-time jobs, have family, or other responsibilities that traditional students do not encounter. Still, few prior works on engineering education have investigated how universities and educators can support NTSE. Therefore, this work intends to investigate NTSEs' experiences in order to inform universities, educators, and policymakers on how to better support this student population. Semi-structured interviews were collected and analyzed using thematic analysis to investigate prominent themes. Our results indicate that three main themes play a significant role in impacting NTSEs' experiences: relationships, time, and money. This work highlights these experiences and discusses how universities and educators can address those experiences.

Keywords: nontraditional students; engineering; student support; co-curricular; thematic analysis

Engineering education increasingly requires students to address sustainability in authentic design contexts. At the same time, generative artificial intelligence (AI) is changing how students retrieve information, generate ideas, evaluate solutions, and refine designs. However, there is still limited evidence on how different collaboration forms shape AI-supported design processes and outcomes. This study compared three types of two-person teams – design-only, engineering-only, and cross-disciplinary design and engineering teams (N = 90 students, 45 teams) – in a sustainable campus waste management project with unrestricted AI use. The study examined sustainability awareness, AI acceptance, AI-supported process behaviors, and design outcomes. All three groups showed significant gains in sustainability awareness and AI acceptance, with no significant between-group differences in post-test scores. Clear group differences emerged in process behavior. The Design group relied more on idea generation, the Engineering group relied most on information retrieval and showed the lowest adoption of AI-generated ideas, and the cross-disciplinary group showed a more balanced use of information retrieval and evaluation/optimization. In terms of outcomes, the Design group achieved the highest novelty ratings, whereas the Engineering group achieved the highest feasibility ratings. These findings indicate that collaboration form shapes how AI is adopted during design work and leads to different process configurations and learning outcomes in engineering education.

Keywords: engineering education; generative artificial intelligence; collaboration forms; double diamond; sustainable design; technology acceptance

This research examines the impact of a resilience-enhanced training model on psychological preparedness and precision performance among CNC machining trainees in Taiwan. As modern manufacturing environments increasingly demand high accuracy under conditions such as time constraints, elevated noise levels, and complex toolpath decisions, psychological resilience has become an essential but frequently neglected element of engineering capability. Utilizing the Connor Davidson Resilience Scale (CD-RISC) as its theoretical framework, this study defines resilience as a dynamic and developable quality that enables individuals to sustain stable performance, adapt effectively to unforeseen machining challenges, and recover swiftly from errors in high-pressure technical settings. The investigation employed a quasi-experimental design with 29 participants allocated to either a resilience-focused intervention group or a control group. During the ten-week program, those in the intervention group completed targeted resilience training, which encompassed cognitive reframing strategies, structured stress exposure exercises, and task-related mental imagery techniques embedded within CNC machining activities. The study assessed three principal outcomes: psychological resilience, state anxiety related to machining, and a composite score reflecting machining precision – including dimensional accuracy, surface integrity, and consistent time-performance. The data indicates that trainees participating in resilience-based training experienced significant enhancements in psychological readiness and machining precision, as well as marked reductions in anxiety during complex machining tasks. These findings underscore the value of incorporating resilience-oriented pedagogical strategies into engineering and technical-vocational education curricula. Such methodologies contribute to improved emotional regulation and decision-making under pressure, while advancing the development of dependable, versatile, and industry-ready CNC machining professionals.

Keywords: psychological resilience; CNC machining training; precision performance; engineering education

The delivery of higher education through online learning has evolved as a primary mode worldwide; however, few studies have integrated instructional, technological, design, feedback, and assessment elements into a comprehensive model that explains competence for best practice in the online environment. The present study proposes and tests a multidimensional higher-order model, Perceived Competence of Best Practices (PCB) consisting of Perceived Capability of Design (PCD), Perceived Clarity of Instruction (PCI), Perceived Acceptability of Technology (PAT), Perceived Fairness of Assessment (PFA), and Perceived Convenience of Feedback (PCF). Data collected from 4,034 engineering undergraduate students were analysed through PLS-SEM to determine reliability, validity, and predictive associations. All constructs have sound psychometric properties (CR = 0.848–0.884; AVE = 0.583–0.781). Structural findings indicated that PFA was the significant predictor of PCB (β = 0.394, $p < 0.05$) and PAT, PCI, and PCD ($P<0.05$), whereas PCF exhibited no influence. The model accounted for a significant 29.8% of the variance in PCB, providing a unique theoretical contribution by demonstrating that students' perceived best practices in online learning are most strongly motivated through fairness considerations for assessment. The refined model provides a transferable means for enhancing quality control and curriculum development in international higher education.

Keywords: online learning; best practice competence; assessment fairness; technology acceptance; instructional clarity; engineering education; PLS-SEM

This study investigates the integration of Large Language Models (LLMs) into undergraduate Environmental Engineering education at Jilin University. We propose a "Diagnose-Reconstruct-Critique" (DRC) framework, implemented across a multi-tiered system encompassing foundational AI literacy training, theoretical concept reconstruction, and field practice enhancement. Using a mixed-methods approach with surveys (N = 109) and detailed case studies, results revealed a significant competency gap: while 71.76% of students were familiar with LLM concepts, only 11.90% possessed API integration skills essential for advanced applications. Post-intervention, 35.3% of students gained conceptual resilience, becoming capable of deriving complex formulas independently. Qualitative findings confirmed that the DRC framework effectively shifted students from passive content receivers to active critical evaluators of AI-generated outputs, leading to awards in national competitions and student-authored publications. This study argues for empowering educators as "Critical AI Mediators" who leverage AI as a cognitive partner to foster deep conceptual understanding and lifelong learning competencies.

Keywords: engineering education reform; large language models (LLMs); multi-modal models; critical AI literacy; diagnose-reconstruct-critique (DRC); environmental monitoring; field practice

As semiconductor manufacturing advances toward Industry 4.0, a disconnect persists between engineering education and the technical competencies required for IC packaging operations. This study develops a structured pedagogical framework for training maintenance technicians in this domain. A mixed-methods approach was adopted, combining a multi-round Delphi process with 15 industry experts to identify 29 competency indicators, followed by the Analytic Hierarchy Process (AHP) to determine their relative importance. The validated framework organizes competencies into five domains: Basic Technical Knowledge, Professional Literacy, Equipment Operations, Safety/Regulatory Perception, and Advanced Problem-Solving. Results show that while foundational knowledge remains essential, safety awareness and fault diagnosis are critical higher-order skills that are insufficiently emphasized in current vocational training. By formalizing tacit industry knowledge into a hierarchical model, this study offers a practical reference for curriculum design. It further recommends integrating these competencies into project-based learning and industry–academia collaboration to better align graduate capabilities with the reliability and sustainability demands of the semiconductor and battery industries.

Keywords: sustainable manufacturing; competency indicator; IC packaging; downtime reduction; Delphi technique

Personality type and student performance have shown significant correlation in both science and engineering. Certain personalities seem better suited to these types of programs. These same personalities are prevalent among science and engineering instructors. However, there is little research into the correlation between student and instructor personality type and its effect on student performance. We determined the personality types of first-year engineering technology students in three programs. We also studied student personality and performance across a range of subjects. Our unique purpose in this study was to also examine correlations between instructor personality type, student personality type, and student performance. We measured student personality type using the True Colors® Collegiate Assessment, and we summarized student performance and personality type by subject. We identified correlations between student and instructor personalities and student performance using a method we developed for defining a student as having the same or different personality from their instructor. Our students had an overrepresentation of both Orange and Green personality types. Orange students performed significantly below the mean, while Green and Gold students performed significantly above the mean. Instructors were characterized by Green and Gold personality types. We found a strong correlation between the alignment/misalignment of instructor and student personalities, and student performance. The overabundance of Green and Gold personalities among instructors made it difficult to separate the effects of instructor/student personality alignment from the general tendency for these personalities to perform well. Our method of analysis lays the groundwork for further studies.

Keywords: engineering education; personality type; True Colors®; MBTI; academic performance; first-year students

Entrepreneurship education has been gaining momentum in both curricular and co-curricular undergraduate programs across the United States. The focus within engineering has been on promoting students' ideation skills, teamwork, and design of solutions for real-life problems. Embedded in the engineering design process are opportunities for students to develop the skills, attitudes, and knowledge commonly associated with an entrepreneurial mindset (EM). The exact definition of EM continues to be formalized by scholars and educators within engineering and business. This study explores how one proposed EM framework centered on the concepts of curiosity, creating value, and connections (the "3Cs") is conceptualized and interpreted. This framework was selected because of its growing use within the Kern Entrepreneurial Engineering Network (KEEN). Participants from academia (including faculty, graduate students, postdoctoral researchers, and administrators) engaged in multiple workshops where they evaluated

performance was compared with a baseline GPT-4 model using 24 expert-curated I2C questions, and the results indicate stronger domain accuracy and contextual relevance for hdlGPT, while also revealing limitations in abstract reasoning and multi-step problem solving. The findings suggest that generative AI can supplement electronics education by providing scalable, context-aware mentoring, provided that future work expands evaluation to include student usability, learning outcomes, and qualitative learner perspectives.

Keywords: engineering education; instructional scaffolding; virtual mentorship; industry-academia gap; hardware verification; competency-based learning

Human-AI Collaboration as a Pedagogical Tool for An Introductory Engineering Programming Course 1317–1328

Mehran Andalibi, Angelynn Alvarez, Cameron Williams, Oyku Eren Ozsoy, Luis Felipe Zapata-Rivera and Sameer Abufardeh

Generative Artificial Intelligence (Gen-AI) tools are reshaping expectations for engineering graduates, requiring instructional models that help students collaborate effectively with such systems. This study examines the effects of structured AI instruction, where "AI" denotes generative AI tools, such as ChatGPT on the programming, AI literacy, problem-solving, and creative-thinking skills of first-year engineering students. Twenty-six freshmen worked in small teams to design interactive standalone MATLAB applications for teaching abstract calculus topics, using AI tools where desired, while mathematics faculty served as customers and judges to approximate real-world engineering workflows. Throughout the semester, core MATLAB concepts and programming practices were taught and assessed through rigorous, non-AI-mediated activities, with AI framed as optional support rather than a replacement for learning to program. Students completed pre- and post-project surveys consisting of 29 Likert-scale items and 3 descriptive questions capturing skill development and authentic patterns of AI use. Paired t-tests and effect size analyses showed significant increases in self-reported ratings on 27 of 29 items, with largely large or very large Cohen's d values; these improvements are associated with the instructional intervention but cannot be attributed to it causally given the study design. Descriptive responses indicated that most students used AI extensively, yet a substantial portion of AI-generated code required debugging or refinement, underscoring the ongoing need for foundational programming fluency. Overall, the findings support integrating transparent and ethically guided AI use into engineering curricula and highlight the value of teaching students not only to apply AI tools but also to critically evaluate and improve AI-generated solutions.

Keywords: generative AI; programming education; AI literacy; problem solving; creative thinking; human-AI collaboration

Bridging the Innovation Gap: Analysis of Biomedical Engineering Entrepreneurial Readiness in a Low-Resource Ecosystem 1329–1340

Linda Essilfie, Precious Obinna, Peter Prempeh, Wendy Bagonluri and Hephzi Tagoe

Graduate unemployment in Ghana has intensified national interest in entrepreneurship as a strategic pathway for economic transformation and healthcare resilience. Biomedical Engineering (BME) holds transformative potential for addressing context-specific health challenges, yet a significant gap exists between academic training and successful venture creation. This mixed-methods study investigates entrepreneurial readiness among 56 undergraduate BME students across seven Ghanaian universities. Guided by the Theory of Planned Behaviour (TPB) and the Entrepreneurial Event Model (EEM), the research integrates quantitative indicators of interest and confidence with qualitative analysis of systemic barriers. Findings reveal high entrepreneurial desirability (45.5% reporting maximum interest) driven by a desire to solve local health problems. However, perceived behavioural control is suppressed by significant skill gaps in business model development (82%), intellectual property management (73%), and regulatory navigation (68%). Structural constraints, including a 71.4% lack of specialised mentorship and 64.3% curriculum misalignment, further diminish perceived feasibility. As one of the first empirical studies examining BME entrepreneurial readiness in an African context, this pilot investigation provides early evidence to guide curriculum and policy reform. The study proposes a conceptual framework for strengthening the BME innovation pipeline in emerging ecosystems, emphasising that technical proficiency must be paired with discipline-specific entrepreneurial scaffolding. These insights inform national policy initiatives, such as Ghana's National Entrepreneurship and Innovation Programme (NEIP), and offer a scalable model for BME curriculum reform across Low- and Middle-Income Countries (LMICs).

Keywords: biomedical engineering education; STEM entrepreneurship; entrepreneurial readiness; emerging innovation ecosystems; theory of planned behavior

A Community-Developed Framework for Entrepreneurial Mindset in First-Year Engineering 1341–1349

Kaitlin Mallouk, Krista M. Kecskemety, J. Blake Hylton and Jack Bringardner

In 2024, a gathering of 24 first-year engineering educators and thought-leaders was led in the development of a framework for first-year engineering program content which holistically incorporates elements of the entrepreneurial mindset, as popularized by the Kern Entrepreneurial Engineering Network (KEEN) and others. This framework, coined the EMIFY Framework, was refined and enhanced by the development of an online repository of exemplar classroom activities, mapped onto the framework, as well as a heuristic to be used in development or modification of classroom activities built with the framework as a foundation. This paper discusses the need for and development of the framework and surrounding ecosystem of tools, as well as how the framework and tools have thus far been used for first-year engineering faculty development.

Keywords: entrepreneurial mindset; first-year engineering; taxonomy; introduction to engineering; faculty development

Student Expectations and Learning Styles in a Bilingual Materials Science and Engineering Course: Cognitive Profiles and Language-Mediated Learning 1350–1360

Ivan D. Arellano-Ramirez, Enrique D. Arias Castaño and Nancy J. Castillo Rodriguez

This study presents the results of the cognitive diversity and learning styles of undergraduate students enrolled in a Materials Science and Engineering course taught with alternating English–Spanish instruction, without translation, as the instructor switched naturally between languages, within the Engineering Physics Program at the Universidad Tecnológica de Pereira, Colombia.. Using Gardié's adaptation of the Herrmann Brain Dominance Instrument (HBDI), the thinking preferences of 28 students were analyzed alongside qualitative data from focus-group interviews. Results show a strong predominance of Left-Cortical (A) dominance, associated with analytical, logical, and structured thinking, while additional profiles in the Left-Limbic (B), Right-Limbic (C), and Right-Cortical (D) quadrants demonstrate meaningful cognitive variability. By integrating linguistic and behavioral indicators observed during the semester, the study identifies how distinct thinking styles manifest in learners' expectations, problem-solving approaches, and engagement with bilingual instruction. Analysis of quadrant combinations revealed that most students align with a realistic thinking model (A + B), followed by pragmatic (A + D) and idealistic (C + D) orientations. The bilingual learning environment appeared to strengthen cognitive flexibility and metacognitive awareness. The study concludes with pedagogical recommendations for designing linguistically and cognitively inclusive learning experiences, emphasizing the value of aligning instructional strategies with diverse thinking profiles to enhance learning outcomes in engineering education.

Keywords: Herrmann brain dominance; bilingual education; learning style; thinking style; materials science

Development and Effectiveness Evaluation of an Online Experimental Teaching System for Software Testing 1361–1371

Zhiyan Zhang

Engineering education accreditation emphasizes the cultivation of students' engineering practice abilities. In light of the requirements of engineering education accreditation, this paper analyzes the shortcomings in current Software Testing course instruction and develops an online experimental teaching system to address these issues. Students can engage in hands-on practice

of software testing-related operations through various modules offered by the system. The system adopts a Browser/Server (B/S) architecture and is developed based on node.js technology (an open-source, cross-platform JavaScript runtime environment that allows developers to execute JavaScript code outside of a web browser). To validate the effectiveness of the system, a sample of 244 students (experimental and control groups) was used. The practical application results of the online experimental teaching system indicate that it played a positive role in the achievement of course objectives. A strong correlation exists between the improvement in students' academic performance and the use of the system. The questionnaire results also further validated the above viewpoints. Application results demonstrate that the online experimental teaching system not only significantly improves students' performance in the Software Testing course but also cultivates their practical engineering competencies in multiple aspects.

Keywords: online experimental teaching system; engineering education accreditation; software testing course; practical engineering competencies; teaching reform

Conceptual understanding of thermodynamics remains a persistent challenge in undergraduate engineering education. This study analyzes 317 student responses to a problem involving isothermal, isochoric, and isobaric processes to identify the nature and origins of conceptual errors. Using a mixed-methods approach, 23 recurring errors were classified by their conceptual characteristics, cognitive sources, and score patterns. Results show that over 75% of students failed to represent at least two processes correctly, often due to confusion between state variables and process constraints, incorrect assumptions about phase behavior, or misidentification of system boundaries. Errors were especially concentrated among students with intermediate performance scores (5.0–7.5/10), who tended to demonstrate structured but incorrect reasoning. The findings suggest that many difficulties are systemic rather than isolated misconceptions. To address these challenges, instruction should emphasize integrated reasoning skills – combining symbolic, visual, and conceptual dimensions – to improve students' ability to model thermodynamic systems and accurately interpret states and processes.

Keywords: thermodynamics; engineering education; student misconceptions; conceptual understanding; problem solving

Traditional computer engineering instruction often struggles to connect theoretical learning with industrial practice and emerging human-AI collaboration requirements. To address this problem, this study proposes an Outcome-Driven Project-Based Participatory Learning (ODPPL) model. Grounded in the principles of Outcome-Based Education (OBE) and the Conceive-Design-Implement-Operate (CDIO) framework, the proposed model operates through a three-phase process comprising backward design, forward implementation, and closed-loop improvement. Here, backward design refers to identifying the expected learning outcomes and industry-oriented competency requirements first, and then designing project tasks, learning activities, and assessment criteria accordingly. Authentic enterprise projects are transformed into progressive learning tasks, an intelligent learning platform is employed to facilitate human-AI collaboration, and a multi-dimensional evaluation system is adopted to support continuous improvement of teaching effectiveness. The model was implemented in a digital image processing course involving 100 undergraduate students. Compared with the control group, the experimental group achieved a 21.5-point improvement in the average final score and a 50.0% increase in the proportion of excellent project outcomes. In addition, the course satisfaction rate of the experimental group reached 95.8%. Further assessments indicate significant improvements in key abilities, including algorithm implementation, system optimization, human-AI collaboration, teamwork, and innovative thinking. These findings suggest that the ODPPL model offers a feasible instructional approach to improve academic performance, project quality, the learning experience, and practical competency development in image processing education.

Keywords: Outcome-Based Education (OBE); Computer Engineering; Project-Based Learning; Conceive-Design-Implement-Operate (CDIO); Human-AI Collaboration

Despite substantial attention and effort to broaden participation within Engineering, the number of Black adults earning a bachelor's degree in engineering still lags far behind that of White students. This negatively impacts both the life chances of Black adults as individuals and families, and also the broader society because research suggests that minorities in STEM fields may innovate at higher rates than their majority (white, male) counterparts. This paper reports on a concurrent mixed-methods research design (N = 24) used to investigate the ways in which a five-week intensive design-based summer program impacted the engineering self-efficacy, values, and identities of African American engineering students at a Historically Black College and University (HBCU). The results suggests that (1) students' engineering self-efficacy significantly increased over the course of the workshop, (2) they entered the program with a high level of engineering values which were sustained over the course of the workshop, and (3) their engineering identities were impacted in notable ways with some students' internalizing stronger engineering identities, while others instead were able to see more clearly the path forward required for them to become an engineer.

Keywords: engineering design, engineering identity, engineering self-efficacy, engineering values, underrepresented groups

In recent years, there has been a growing emphasis on blended learning within the field of education. Mechanical engineering experimental teaching relies heavily on hands-on practice. However, traditional Mechanical Design courses face significant challenges in visualizing complex spatial relationships, guiding students through hands-on experiments, and managing equipment costs. To address this gap, this study developed a VR-based assembly teaching platform (VATP) based on Unity3D, focusing on two progressively complex types of mechanical equipment: gear pumps and gear reducers. The platform integrates a blended learning framework combining experimental preview, experimental operation and exam evaluation modules, supporting dual practice modes (automatic/manual) and cross-platform deployment on VR glasses and Android for adaptive skill training. A controlled teaching experiment involving 70 engineering students (35 experimental, 35 control) was conducted to evaluate the platform's effectiveness. Results show that the blended learning group using the VATP achieved a significantly higher average score (81.17) compared to the traditional teaching group (77.26), with 63% of students scoring above 80. Questionnaire feedback further indicated high user satisfaction regarding interface usability, operational realism, and learning engagement. This study demonstrates that VATP can effectively complement traditional laboratory training, enhance practical understanding, and improve learning outcomes. It thus provides an immersive and cost-effective solution for reforming practice-oriented instruction in mechanical design.

Keywords: virtual reality; engineering education; blended learning; mechanical design; experiential learning; educational technology