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Guest Editorial

837

*Tom Dunphy***Impact of Teaching Using Finite Element Modeling on Biomechanics Students' Application Performance and Conceptual Understanding**

838–849

Stepan Hubalovsky and Marie Hubalovska

The aim of this study is to assess the impact of teaching using finite element modeling (FEM) software on the performance and understanding of students in biomechanics education. FEM modeling is perceived as a specific form of interactive teaching, which, according to the ICAP (Interactive–Constructive–Active–Passive) framework, can lead to different levels of cognitive engagement among students. The study, involving 52 undergraduate students divided into two groups, examined differences in application skills and conceptual understanding after the teaching intervention using pre-tests and post-tests. The results show that FEM-based teaching slightly improved application skills; however, without sufficient instructional support, it may lead to a flattening of conceptual understanding. The risks of cognitive overload and the importance of didactic anchoring are discussed. The study provides practical implications for the design of effective interactive teaching in biomechanics education.

Keywords: FEM teaching; conceptual understanding; biomechanics education; learning outcomes; cognitive overload

Creative Life Balance: How Creative Hobbies Support Skill Transfer and Well-being in Graduate Engineering Education

850–863

Autumn R. Deitrick and Catherine G. P. Berdanier

Engineering graduate students are expected to engage in creative research, yet creativity-relevant skills are often undervalued or unsupported within academic environments. While these skills can be developed outside of academia – particularly through creative hobbies – their role in graduate research has not been widely studied. This article explores how engineering graduate students perceive the ways their creative hobbies contribute to their research through transferable skills and enhance their overall graduate experience. Semi-structured interviews were conducted with 15 students from R1 engineering programs across the United States. Thematic analysis revealed that creative hobbies support students' research creativity and improve their well-being. However, most participants reported feeling little support or encouragement for maintaining a creative life balance during graduate school. These findings highlight the need for research group environments to foster a climate that supports, encourages, and values creativity beyond traditional academic boundaries. Advisors can help by recognizing students' creative strengths, encouraging engagement in creative pursuits, and celebrating the transfer of creativity-relevant skills to research.

Keywords: creative hobbies; skill transfer; well-being; engineering; graduate students

Teaching Human Critical Success Factors in a First-Year Software Engineering Module

864–877

Maria Monserrat, Antonio Crespi, Antonia Mas and Antoni-Lluís Mesquida

This research aims to align the academic training of future engineers and project managers with the current needs of the software development industry, benefiting both students and organizations. Motivated by the low success rate of software projects, the study focuses on human factors as key contributors to project success. Two preliminary studies, a Systematic Literature Review and interviews with 30 professionals in the technology sector, were conducted to identify the human Critical Success Factors that influence software project outcomes. Based on these findings, a proposal was developed to integrate the acquisition and training of these competencies into a first-year Software Engineering module. The proposal includes a set of activities designed to enable students to practice essential technical and social skills, such as leadership, communication and negotiation, from the beginning of their academic studies. By embedding these human-centric competencies into the curriculum, the initiative prepares students for future professional roles and equips organizations with graduates capable of contributing immediately to project success. This approach highlights the importance of explicitly addressing human factors in engineering education, offering a structured pathway to improve both student learning and the success rate of software projects in practice.

Keywords: software engineering; engineering profession; professional aspects

Development and Evaluation of an AI-Enhanced Learning System to Bridge Technical and Linguistic Barriers for International Students in Taiwan

878–891

Bo-Siang Chen, Chun-Nan Cheng, Jing-Tang Sie, Wei-Lun Huang, Wei-Sho Ho, Ying-Ju Tseng, Bo-Yuan Tseng, Ching-Yi Lai, De-Shau Huang and Pao-Chung Shin

International students in Taiwanese vocational education, particularly those in the “Southbound Special Class” initiative, often face significant barriers in technical courses due to limited Mandarin proficiency and varied academic backgrounds. To address this challenge, this study developed and evaluated an AI-enhanced auxiliary learning system for an “Automotive Basic Electrical Application and Practice” course. The system, leveraging a fine-tuned Meta LLaMa 3 model and structured around the Zone of Proximal Development (ZPD) and Creative Problem Solving (CPS) frameworks, was implemented with 30 first-year students. Using a pre-test/post-test design, the study found statistically significant improvements across all learning domains: The results demonstrated statistically significant improvements in content knowledge, practical skills, and technical Mandarin proficiency. Students showed marked gains in conceptual understanding, hands-on diagnostic ability, and the use of technical Mandarin for communication, indicating the effectiveness of the AI-enhanced learning system in addressing both technical and linguistic learning barriers. These findings indicate that well-designed, pedagogically-grounded AI systems can serve as an effective tool to overcome learning barriers for linguistically diverse students in technical vocational training. The study provides a model for integrating AI to enhance both subject matter competency and language skills, though further research is needed to confirm these results with larger samples.

Keywords: fine-tuning LLaMa 3; automotive basic electricity; CPS; ZPD

Muhammad Awais, Muhammad Khawar Islam, Muhammad Amin, Ahmad H. Alferidi, Khaled N. Alqahtani and Emad H. Abualsaud

Educational institutions globally encounter substantial challenges in standardizing assessment processes to satisfy the stringent requirements of accreditation bodies such as ABET. The variability in assessment methods across different courses frequently results in inconsistent quality data, complicating efforts to effectively “close the loop” for continuous improvement. This study introduces a standardized computational framework for evaluating student learning outcomes through an innovative matrix-mapping technique. In contrast to traditional average-based calculations, this method quantitatively maps detailed assessment tools directly to high-level Program Student Outcomes (SOs) via weighted linkage matrices. The system was implemented using a MATLAB-based computational engine within the Electrical and Industrial Engineering programs at Taibah University. This approach facilitates the automated calculation of outcome attainment and curriculum emphasis, enabling the precise identification of program weaknesses. The findings illustrate how data-driven insights led to targeted curriculum reforms, particularly in enhancing engineering design competencies, thereby fulfilling the continuous improvement criteria mandated for accreditation.

Keywords: learning outcome; engineering education; program accreditation; data-driven assessment; matrix mapping

Construction and Validation of a Competence Framework for Interdisciplinary Legal Skills in Civil Engineering

904–917

Yan Li, Yu He, Xinying Cao and Yue Teng

Against the backdrop of the deepening reform in emerging engineering education and the advancement of legal governance, the demand for interdisciplinary legal talent (ILT) in the civil engineering discipline has become increasingly urgent. This study employs value co-creation (VCC) theory as the analytical framework to construct a tripartite cultivation model involving universities, industry, and students, and empirically tests its mechanisms using structural equation modeling (SEM) based on 337 valid survey responses. The survey targeted civil engineering students, university faculty, and industry practitioners involved in engineering management and legal affairs. The results indicate that (1) technical competence (TC) and legal compliance competence (LC) exert significant positive effects on communication competence (CC), with path coefficients of 0.72 and 0.32, respectively; (2) TC (0.47), LC (0.74), and CC (0.34) all exert significant positive effects on the cultivation outcomes of ILT, with LC showing the strongest influence, thereby underscoring its central role; and (3) CC serves as an important mediator in the transformation process, effectively facilitating the conversion of TC and LC into integrated professional competence. The findings not only validate the rationality of the TC-LC-CC tri-dimensional competence structure but also provide quantitative evidence and practical pathways for cultivating ILT based on VCC, thereby offering theoretical support and empirical evidence for advancing industry-education collaboration and interdisciplinary integration.

Keywords: emerging engineering education; interdisciplinary legal talent; value co-creation; structural equation modeling

An Approach to Study Associations Between Team Characteristics and Team Outcomes and the Mediating and Moderation Effects of Intermediate Team Outcomes in Two-Semester Senior Design Courses

918–934

Shun Takai, Elizabeth A. DeBartolo, Gregory Barker and Manikanta Guthula

Since products are typically developed by cross-functional teams, engineering students learn teamwork skills through team projects in design courses. Various team effective theories have been reviewed in the past as possible frameworks to enhance teamwork in engineering education. One such team effectiveness theory useful in teaching teamwork is the Input-Process-Output (IPO) framework. In this study, we implemented the IPO framework to investigate the relationships between team characteristics, team processes, and team outcomes in two-semester senior design courses (fall and spring) over three years (a total of 518 students and 158 teams). We analyzed a total of 54 team characteristics derived from various student/team attributes, including team size, student department/major/plan, sex, race/ethnicity, socioeconomic background, cumulative GPA, and course modality. Six team outcomes were constructed from report grades and students' course grades. We analyzed whether (1) the team characteristics (team inputs) are significantly associated with spring team outcomes (“spring outcomes”) (team outputs) and (2) fall team outcomes (“fall outcomes”), which we used as the measures of the team processes, mediates or moderates the relationships between team characteristics and spring outcomes. We found that two team characteristics (the team's average and maximum GPAs) were significantly correlated with four spring outcomes in all three years (report grades and the team's average, maximum, and minimum course grades). We observed mixed results regarding the mediation effects of fall outcomes while there were almost no moderation effects of fall outcomes. In particular, when the course modality was online, team characteristics (such as the team's average and maximum GPAs) may explain spring outcomes as well as or more than fall outcomes.

Keywords: team characteristics; team process; team outcome; input-process-output framework; mediation; moderation

Problem-Centered Design Thinking to Enhance Innovation and Entrepreneurship Competencies among Engineering Undergraduates

935–948

Mao-Yuan Pai, Cheng-Lung Tsai, Sheng-Wen Hsieh and Chih-Chao Chung

This study integrates Problem-Centered Design Thinking to Enhance Innovation and Entrepreneurship Competencies (PC-DTIE) into engineering entrepreneurship education instructional practices, examining its impact on third-year undergraduate engineering students' innovation, entrepreneurship competencies, and problem discovery. Using mixed methods, we conducted experimental teaching with 40 third-year undergraduate engineering students specializing in ‘Innovation and Entrepreneurship’. Our findings indicate that the PC-DTIE approach significantly enhances the feasibility of an integrated curriculum, improves the quality of entrepreneurship projects, and substantially boosts students' entrepreneurship competencies and problem discovery abilities. This research demonstrates PC-DTIE's unique emphasis on cultivating problem discovery skills through inspiring questions within the design thinking process, thereby guiding educators in enhancing the effectiveness of entrepreneurship education and optimizing student learning outcomes and skill development.

Keywords: design thinking; entrepreneurship education; problem-centered; innovation; education reform

Engineering Faculty Views on Essential Engineering Knowledge and Efforts Toward Course Content Relevance

949–957

Berenice A. Cabrera, Lu Zhou, Lisa R. Lattuca, Erika A. Mosykowski, Shanna R. Daly and Joi-Lynn Mondisa

This research investigated engineering faculty perspectives on the skills and knowledge undergraduate mechanical and industrial engineering students should develop in their engineering courses, and, if given the opportunity, what additional skills and knowledge faculty would include in their courses. This work also investigated how faculty strived to make course content relevant to students. Through interviews with 13 engineering faculty members at a research university, we explored their ideas about skills and knowledge students should prioritize and gained insight into their curricular and instructional efforts to enhance content relevance. Our findings suggest that faculty most heavily prioritized helping students develop their technical and foundational knowledge. They also placed emphasis on problem-solving skills and effective technical communication and teamwork dynamics. Conversely, very little emphasis was placed on sociotechnical knowledge. Our characterization of the emphasized competencies and faculty members' content contextualization approaches supports an understanding of the engineering material students are expected to learn, irrespective of its relevance to their future work.

Keywords: faculty; industrial engineering; mechanical engineering; course content; skills and knowledge; engineering work

Hyunkyung Lee, Daeun Jung and Hyungjin Kim

This study examined how students' motivation and learning strategies changed throughout a semester in a flipped laboratory course and how these changes related to learning outcomes and students' perceptions. A flipped learning design was implemented in an electronic engineering laboratory course with 67 undergraduate students, and surveys on learning motivation and strategies were conducted at three stages during the semester. Repeated measures ANOVA results showed significant increases in intrinsic and extrinsic goal orientation, task value, and self-efficacy, while among learning strategies, elaboration increased and peer learning decreased. Regression analyses revealed that increases in task value and self-efficacy significantly predicted the total course score, and changes across all motivational and strategic subscales were positively associated with perceived achievement. The qualitative analysis identified three types of student perceptions – positive, negative, and mixed. Students valued the connection between theory and practice, deeper engagement in experiments, and increased motivation. They also reported challenges such as heavy workload and limited laboratory infrastructure, while perceptions of collaboration reflected both benefits and challenges. These findings suggest that flipped learning serves as an effective instructional strategy for enhancing students' motivation and strategic engagement in laboratory-based engineering education and offer insights that may inform future research and instructional design in experimental learning contexts.

Keywords: flipped learning; flipped laboratory course; laboratory instruction; learning motivation; learning strategies; learning trajectory

The Role of University Educators in Reducing Absenteeism among Engineering Undergraduates

972–990

Elisabet Mas de les Valls, Marcella Castells-Sanabra, Roser Capdevila, Roger Castells-Martínez, Claudia Barahona-Fuentes, Clara Borén, Anna Muijal-Colilles and Vicente Medina

Absenteeism is an increasing concern at public universities, yet reliable figures, context-dependent correlations, and effective strategies to reduce it remain scarce. This study, conducted within a teaching innovation project at a large public engineering university in Spain, investigates how context influences absenteeism, whether specific student profiles are more prone to miss lessons, and the role educators play in mitigating the problem through active learning methodologies. A mixed-methods approach was adopted, combining quantitative and qualitative data collected from multiple stakeholders. Quantitative data were obtained through online surveys administered to 2,069 undergraduate engineering students across three academic semesters, attendance monitoring of 23 courses, and surveys completed by 461 faculty members and 82 industry representatives. Qualitative data were gathered through semi-structured interviews with 25 students identified as frequent absentees, educators' self-reflection reports from 11 courses, and a structured compilation of good teaching practices. Data analysis was conducted in two phases: an initial descriptive analysis followed by the development of explanatory models. Results confirm previous findings that passive teaching methodologies are the primary driver of absenteeism, though nuances such as perceived difficulty and limited personalized support also contribute significantly. The findings highlight that while teachers play a crucial – though not exclusive – role in reducing absenteeism, broader contextual factors must also be addressed. Based on these insights, the study proposes a mitigation plan centred on faculty training to adopt active learning strategies in large classes, with the potential for extrapolation to other institutions facing similar challenges.

Keywords: absenteeism; students' and teachers' perceptions; active learning; evidence-based practice; employability skills

“It's All My Friends Who Know It. It's Not Me:” Engineering Students' Descriptions of Challenges in a First-Year Programming Course

991–1005

Jacqueline Rohde, Carlie Cooper, Kevin Kaufman-Ortiz, Natascha Buswell, Allison Godwin and Linda Deangelo

This article explores students' descriptions of the challenges they experienced during a first-year engineering programming course. Programming and computational thinking are vital skills for engineering students, and these skills are affected by the context surrounding students while they learn. In this study, we allowed students in focus groups to holistically describe the challenges they experienced while learning MATLAB and reflect on the effects they attributed to those challenging experiences during focus groups. The research team conducted six focus groups with 29 students across two institutions with similar first-year engineering programming courses. Emergent thematic coding identified challenges associated with learning MATLAB itself, working in a social environment of peers with different levels of prior experience, navigating course policies and logistics, and, for some, dealing with gendered expectations and experiences. These challenges informed the ways in which students discussed what it meant to succeed and belong in engineering. This work has implications for the messages that are presented to first-year engineering students to help them feel like they can succeed in engineering.

Keywords: undergraduate students; challenges; teaming; belonging; programming

Design and Assessment of a Hybrid Teaching Model for Teaching Internet of Things Hardware Technology

1006–1017

Jiawen Li, Chen Ling, Xinyu Wu, Qiong Nie, Xindi Zhang, Yan Zheng, Huimin Zhao, Jinchang Ren and Rongjun Chen

To achieve high-quality Internet of Things (IoT) education, Asia-Pacific countries have placed greater demands on engineering students' problem-solving abilities and innovative practices. However, the traditional approach has struggled to satisfy the needs of talent training. To this end, this paper proposes a hybrid teaching model that integrates the semi-flipped classroom and Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment, and Summary (BOPPPS) framework. For validation, a quasi-experimental study was conducted with 100 IoT engineering students, who were divided into a control group ($n = 50$) receiving traditional lecture-based instruction and an experimental group ($n = 50$) undergoing the hybrid teaching model. Data were collected through psychometrically validated satisfaction surveys (Cronbach's $\alpha = 0.938$) and pre-test/post-test assessments across ten instructional modules. Quantitative analysis employed independent-samples t-tests and chi-square tests (significance threshold: $p < 0.05$). The evaluation results demonstrate that over 90% of students are satisfied with the teaching method, content design, and equipment resources. Meanwhile, the student approval rating regarding learning interest, professional ability, and classroom participation has exceeded 90%. Furthermore, the comparison of pre-test and post-test accuracy in the experimental group shows an improvement of approximately 20%, with statistically significant differences favoring the experimental group. Such impressive performances reveal that the hybrid teaching model not only enhances students' engineering innovation abilities and learning initiative but also holds significant value for improving the quality of related programs in engineering education.

Keywords: IoT; semi-flipped classroom; BOPPPS; teaching model; hardware technology; engineering education

Willingness for Adaptability of Engineering Faculty in Two Curricular Change Contexts

1018–1034

Hadi Ali, Jennifer Bekki, Rod D. Roscoe and Ann McKenna

Challenges continue to exist for engineering faculty to adopt and scale research-based pedagogies and interventions. Using qualitative research design, we address the question of “How do faculty respond to curricular change, as exhibited in their activities of planning, adjusting, and reflecting during change?” In this work, faculty adaptability is conceptualized as self-regulation during curricular change. Faculty participants were recruited from two divergent curricular change contexts: one that is prescribed with interdependence while the other is emergent with uncertainty. We found that the *willingness* of faculty to adapt during curricular change is nuanced and can be described along six dimensions. Specifically, faculty *willingness for planning* is shown to have different levels of (1) forming an intention to change and (2) allocating time and effort for change. Also, faculty *willingness for*

adjusting is demonstrated as (3) willingness to change one's behavior and (4) the willingness to catalyze efforts for change. In addition, faculty *willingness for reflecting* is characterized as (5) observing one's performance and (6) monitoring task-context relationship. Furthermore, and most importantly, we found that the relationship among these adaptability phases is hierarchical: the more a faculty member is involved in the different phases, the more awareness they are showing for adaptability for change. This work contributes to our understanding of the enablers and barriers for engineering faculty to adapt during curricular change.

Keywords: adaptability; curricular change; faculty roles; self-regulation

Impact of Intelligent Tutoring Systems on Student Engagement and Learning Outcomes in Higher Education:

1035–1055

A Scoping Review of Engineering Education Applications

Yi Li and Chen Hongmei

Intelligent Tutoring Systems (ITS) are increasingly used in higher education to provide adaptive instruction, real-time feedback, and individualized learning support. This scoping review examines how ITS influence student engagement and learning outcomes in engineering education and closely related technical disciplines, and identifies barriers to adoption and ethical concerns. A rigorous search strategy was employed to identify studies on ITS in higher education from databases including Web of Science, Scopus, and IEEE Xplore. Data from relevant studies were extracted and analyzed using thematic analysis. Following the screening process, 31 studies were included in the review. Across these studies, 22 tutoring systems were synthesized (12 ITS and 10 affective tutoring systems). The findings indicate that ITS are most effective in structured, problem-solving-intensive domains such as programming and electrical engineering, where adaptive feedback, mastery progression, and knowledge tracing align with well-defined solution pathways. Affective tutoring systems show consistent benefits for motivation, engagement, and emotional regulation in high-load learning contexts, although performance gains are more variable and depend on task structure and cognitive scaffolding. Key barriers to broader implementation include scalability across disciplines, development and maintenance demands, instructor trust and transparency, and ethical issues related to data privacy and algorithmic bias. Overall, ITS offer strong potential to support engineering learning when integrated as complementary tools that enhance cognitive and affective dimensions of student learning.

Keywords: intelligent tutoring systems; personalized learning; affective tutoring systems (ATS); higher education; engineering education; student engagement; learner performance

New, Relearned, and Lost Information: A Comparison of Returner and Direct Pathway Graduate Engineering Students

1056–1067

Elaine Eggenberger, Diane L. Peters and Elizabeth Gross

Some graduate engineering students, called direct pathway students, go directly into their graduate education after completing their undergraduate degree or complete these degrees alongside one another. Other graduate engineering students, called returners, spend a significant amount of time in industry before returning to school. The focus of this study was to compare and contrast these two demographics in regard to information retention, recovery of lost information, and learning of new information. All students forget similar amounts and types of information. Retention is based in initial mindset, interest in the topic, and frequency of use; fundamental information and concepts also tend to be retained. Twenty direct pathway and twenty-one returner graduate engineering students were interviewed in person. Differences were found in how students learn new information. Returners attempt to fit information in with what they already know, whereas direct pathway students spend more time searching for applications for new information. Returners were also found to have many advantages due to their work experience, whereas direct pathway students were found to have the advantage of more flexible life circumstances.

Keywords: direct pathway; graduate engineering education; returner

A Conceptual Engineering Doctoral Program Accreditation Framework

1068–1077

Faical Mnif

ABET has established a globally recognized framework for assuring the quality of undergraduate and master's programs in engineering, computing, and technology. However, no equivalent accreditation model exists for doctoral programs, despite the increasing importance of research-based education, interdisciplinarity, and societal impact. This paper explores the feasibility and potential framework for extending ABET accreditation to PhD programs in engineering. It analyzes current ABET criteria, contrasts them with existing doctoral-level quality assurance models (e.g., EUR-ACE, QAA, and national qualification frameworks), and proposes a new set of Doctoral Student Outcomes (DSOs) emphasizing originality, ethical research practice, leadership, innovation, and global impact. A conceptual "Doctoral Program Accreditation Framework" (DPAF) is presented, outlining governance, assessment mechanisms, and integration pathways with ABET's continuous improvement model. The paper concludes by discussing challenges, implementation strategies, and implications for global engineering education reform.

Keywords: ABET accreditation; PhD; quality assurance; engineering education; outcome-based framework; research impact

The Development and Practice of Engineering Ethics Education for Master's-Level Engineering Students at a Shanghai University: A Case Study

1078–1089

Fangfang Wang, Xu Li and Guangli Xiu

Engineering ethics education in China has gradually but significantly evolved in response to national policies and the demands of industrialization. This study uses a mixed-methods case study design to investigate a decade-long reform initiative at a university in Shanghai. Enrollment records and course evaluation surveys collected between 2014 and 2024 – encompassing data from approximately 7,500 students and 850 survey responses – were analyzed, and this quantitative analysis was supplemented with qualitative thematic analysis of institutional and pedagogical documents. The transition period of engineering ethics was traced from its beginnings as an elective course to a mandatory general-education course when the key reforms were implemented. Before and after the curriculum reform, questionnaires were administered to students during class sessions to collect feedback. Comparative analysis revealed that students' in-class participation had doubled over the course of the reform. Enrollment figures increased dramatically to more than 1,000 students annually once engineering ethics education became a requirement of the national engineering education standard. Additionally, a faculty pool was established, including both industrial experts and academic faculty, to solve constraints related to teaching resources. The "Shanghai Case" exemplifies a successful model for engineering ethics education that effectively synergizes policy mandates with pedagogical innovation and collaboration between academia and industry. This approach successfully bridged the gap between theory and practice, providing a replicable framework model for engineering ethics education in other countries or regions undergoing rapid development.

Keywords: engineering ethics; education reform; case teaching; policy coordination; industry-education integration

Validating an Instrument to Measure Entrepreneurial Self-Efficacy among Engineering Students

1090–1101

Aturika Bhatnagar and Prateek Shekhar

The presented study validates an engineering-entrepreneurial self-efficacy (E-ESE) instrument among engineering students. Although several survey instruments have been developed to measure entrepreneurship outcomes, they have been developed for and validated with business school students and nascent entrepreneurs, leading to a lack of validated instruments to measure entrepreneurship outcomes in engineering education. The study aims to answer two research questions: First, what is the latent factor structure of an Engineering Entrepreneurial Self-Efficacy (E-ESE) instrument for engineering students? And second, what are the psychometric properties (validity and reliability) of the E-ESE instrument? The analysis was conducted in three phases, with data collected from two institutes in the United States. The first phase involved a review of existing survey instruments and revising the items based on pilot exploratory factor analysis (EFA) results and stakeholder feedback. The second phase includes data

collection at Institute 1 (85 responses) and conducting an EFA to identify the latent factor structure. The third phase includes performing a confirmatory factor analysis using data from two institutes (212 responses) to verify the underlying structure of the five latent variables (searching, planning, marshaling, implementing people, and implementing finance), and evaluating reliability using Cronbach's alpha. The findings reveal a five-factor solution for the E-ESE instrument that is refined for engineering education with psychometric properties (validity and reliability) meeting requisite standards. The study discusses the implications of the results for engineering entrepreneurship education and provides guidance for future work.

Keywords: entrepreneurship education; instrument development; entrepreneurial self-efficacy; engineering education

Developing Managerial Competencies Among Engineering Students: An Experimental Study

1102–1115

Ivana Kužet, Ivana Kovačević, Mateja Manojlović, Jelena Anđelković Labrović and Nikola Petrović

This study investigates the effects of traditional teaching and competency-based teaching on the development of managerial competencies among first-year engineering students, examining if and how those effects are moderated by individual characteristics such as achievement motivation and student engagement. The competencies examined were self-awareness, effective teamwork, leading positive change, and supportive communication. The experimental design included a control group exposed to traditional teaching methods and an experimental to competency-based, with 25 participants in each group. Instruction lasted five weeks and included four structured training sessions, with data collected pre- and post-intervention. Results revealed no significant differences between the two groups, indicating that the teaching method itself did not determine competencies development. However, student engagement showed a significant positive correlation with competencies gains, highlighting its role as a key factor in fostering managerial skill development. The study contributes empirical evidence on the conditions that support the early integration of managerial competencies in engineering education and emphasizes the importance of fostering student engagement as a driver of learning outcomes.

Keywords: engineering education; managerial competencies; competency-based instruction; achievement motivation; student engagement; experimental study

Improving Programming Learning Outcomes for AI-Driven Students using a Digital Assessment Environment

1116–1130

Zhanat Nurbekova, Ainur Sagimbayeva, Gaukhar Ainicheva, Asset Zhaksylykov, Aizhan Nazzyrova and Nurbol Artykbayev

This study investigates the integration of Generative Artificial Intelligence (GenAI) into programming education and its impact on students' learning outcomes, motivation, and algorithmic thinking. The objective is to develop and empirically evaluate a digital assessment framework that supports the responsible use of AI tools while preserving independent cognitive processes. The research is based on a pedagogical experiment involving 365 participants, including students and instructors from higher education institutions. Data were collected through a structured survey and analyzed using descriptive statistical methods and content analysis. The results indicate that a significant proportion of students actively use GenAI tools, with ChatGPT being the most dominant platform. Approximately 63% of students reported a positive impact of AI on their programming skills, while 83.5% expressed high satisfaction with practical tasks implemented in a digital assessment environment. At the same time, the findings reveal concerns regarding overreliance on AI, which may reduce independent problem-solving abilities and weaken algorithmic thinking. The study proposes a pedagogically grounded framework and structured strategies for integrating AI into programming education, balancing technological support with the development of critical and analytical skills. The results contribute to the design of effective digital assessment environments in the era of AI-driven education.

Keywords: GenAI; programming knowledge assessment; algorithmic thinking; feedback; programming knowledge control

Characteristics and Optimization Strategies of Teaching Evaluation Policies of China's Engineering Education

1131–1142

Qiaoli Chang, Xinyu Wang and Dexin Hu

This study examines 25 teaching evaluation policy documents issued by engineering-advantaged universities in China through a two-dimensional analytical framework integrating policy instruments and evaluation elements. The analysis reveals that existing policies are characterized by an overreliance on mandates, an imbalanced alignment of evaluation elements, and a systematic misalignment between policy instruments and evaluation elements. These features indicate a policy design logic predominantly shaped by managerialism, accountability-driven governance, and an emphasis on administrative efficiency. Therefore, the refinement of teaching evaluation policies in China's engineering education should focus on optimizing the structure of policy instruments to better balance faculty teaching autonomy and institutional constraints, improving the scientific design of evaluation elements to promote development-oriented teaching evaluation, and strengthening the alignment between policy instruments and evaluation elements to enhance the effectiveness of teaching evaluation. From a policy perspective, this study contributes to research on teaching evaluation in engineering education and offers empirically grounded insights for improving policy design in support of high-quality engineering education.

Keywords: engineering education; teaching evaluation; policy preferences; China

Mapping the Intellectual Landscape of AI-Driven Innovation in Engineering Education

1143–1154

Yi-rong Tan

The rapid advancement of artificial intelligence (AI) is profoundly reshaping the landscape of engineering education, driving significant transformations in teaching paradigms, disciplinary structures, and competency development. To systematically explore the intellectual structure and evolutionary trends of AI-driven innovation in engineering education, this study conducts a scientometric analysis based on 884 publications retrieved from the Web of Science Core Collection spanning 1998 to 2025. A four-stage analytical framework integrating bibliometric analysis, Latent Dirichlet Allocation (LDA) topic modeling, and regression analysis is employed to reveal the knowledge structure, thematic evolution, and developmental trajectory of the research field. The results demonstrate a marked and accelerating growth in AI-related engineering education research, particularly after 2020, reflecting the growing integration of AI technologies in educational contexts. Bibliometric mapping identifies key contributors, collaborative networks, and influential journals that shape the domain. LDA modeling further uncovers eight major research topics, which are consolidated into three higher-order dimensions: technological innovation in teaching and learning environments, disciplinary reconstruction through interdisciplinary integration, and systemic transformation of educational governance and assessment mechanisms. Regression analysis confirms a statistically significant upward trend in research attention across these thematic clusters. This study not only provides a comprehensive overview of the global research landscape of AI-enabled engineering education, but also offers a structured analytical framework for understanding its evolution. The findings deliver practical insights for educators, curriculum designers, and policymakers seeking to strategically integrate AI into engineering education, supporting the development of future-oriented competencies and resilient educational systems.

Keywords: artificial intelligence; engineering education; scientometric analysis; LDA topic modeling; educational innovation