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Special Issue

Sustainable Development Goals in Engineering Education

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Integrating Computer Vision and Deep Learning for Sustainable Development in Engineering Education: A Case Study in Electronics and Circuits Laboratories 564–576
Shih-Yeh Chen, Ying-Hsun Lai, Wei-Cheng Chen, Patrick C.K. Hung and Chin-Feng Lai

With the promotion of global educational equity and quality education under the United Nations Sustainable Development Goals (SDGs), technology-assisted instruction has become a critical pillar in engineering education. This study aims to apply computer vision and deep learning technologies to electronics circuit lab teaching, enhancing learners' efficiency and addressing fairness issues in experimental assessment. Traditional assessment methods for electronics experiments focus on experiment success or failure, which may fail to accurately reflect the efforts of some students. To address this, the study developed an intelligent experimental assessment system based on computer vision, capable of accurately identifying the number and position of components amidst environmental noise. Combined with deep learning for experiment classification, the system provides dynamic scoring and subsequent operational suggestions based on the recognition results, thereby improving learners' understanding and interest in electronics experiments. The system leverages image processing to filter external noise and accurately extract key experimental features. To enhance adaptability and versatility, the system supports automated recognition and scoring across various experimental scenarios. Experimental results demonstrate that this system not only reduces the workload of educators but also significantly increases learner engagement and learning outcomes. The study contributes to integrating technological innovation into engineering education, achieving the SDGs' vision of educational equity and quality education.

Keywords: technology-assisted engineering education; computer vision in experimental assessment; deep learning for fair scoring; sustainable development in education

Sustainable Development Goals In Engineering Education: a Low-Carbon-Oriented Practical Teaching Framework 577–589
Wenfang Zhang, Ligang Wang and Hangyang Li

The integration of Sustainable Development Goals (SDGs) into engineering education has garnered widespread attention, yet there is a lack of actionable teaching frameworks and empirical support. This study develops and evaluates a low-carbon-oriented practical teaching approach to create an efficient design learning environment for engineering courses, aiming to enhance students' sustainability consciousness, design skills, and systematic thinking. The approach was applied in a real-world classroom setting with 313 undergraduates in mechanical engineering. The teaching process is structured in four phases: topic selection and grouping, design simulation, life cycle assessment (LCA), and design optimisation. Its innovation lies in incorporating LCA into the conventional design process, providing students with a comprehensive experience of low-carbon-oriented design. Sustainability consciousness assessments, design skill evaluations, and course reflection reports were used as instruments to investigate students' learning experiences. The sustainability consciousness assessment indicate a significant improvement of 25.62%. Compared to the control group using conventional teaching methods, participants in the experimental group demonstrated an 11.95% advantage in design skill assessment scores. The reflection analysis revealed that students generally held a positive attitude towards the teaching approach. The enhancement in sustainability consciousness, design skills, and systematic thinking was significantly correlated with the teaching design elements, with correlation coefficients ranging from 0.52 to 0.89.

Keywords: engineering education; sustainable development goals (SDGs); low-carbon; product design; teaching approach

The Process of Aligning Engineering Instructors' Values to Content, Assessment, and Pedagogy (VaCAP) 590–606
Jorge Cristancho Rodríguez, Leonardo Pollettini Marcos, Héctor E. Rodríguez-Simmonds, Eugene L. D. Mahmoud and Angel G Enríquez Mujica

Engineering instructors' values influence how they teach, yet these values are rarely intentionally aligned with course content, assessment, and pedagogy (CAP). This self-study of teaching practice explores how three engineering instructors intentionally reflect on and align their values with their content, assessment, and pedagogy (VaCAP). Using semi-structured interviews, focus groups, and reflective activities guided by the Mycorrhiza framework, we explored instructors' awareness of the impacts of their values on themselves, their students, peers, institutions, and Nature. Results reveal how instructors navigate fears of misinterpretation and institutional repercussions, external limitations such as rigid curricula, institutional priorities, and limited time and energy. To address these challenges, instructors reported realizations and strategies to align values to teaching practices, including adapting communication, exercising vulnerability, ritualizing reminders, engaging with supportive communities, and using tools such as the Sustainable Development Goals and the Online Ethics Center. This paper proposes the VaCAP process to guide instructors through intentionally aligning their Values with Content, Assessment, and Pedagogy. VaCAP emphasizes dialogue, reflection, rituals, and community support for sustaining value-aligned teaching practices. Based on our findings, we offer four pillars for reflective teaching practice: reflect in community, embrace reflection as an ongoing practice, maintain a living document, and reflect on power and responsibility.

Keywords: engineering education; instructor values; content; assessment; pedagogy; liberatory pedagogy; teaching community

Sustainable Development Goals in Vehicle Engineering: Utilizing the Technology Acceptance Model to Analyze Tesla Owners 607–612
Hsueh-Kuei Fan, Pao-Nan Chou and Yu-Hsin Christine Chou

This paper presents an example of how the concept of sustainable development goals can be incorporated into vehicle engineering. This study examined the use behavior of electric vehicles' owners by using the technology acceptance model (TAM). A survey design focusing on Tesla vehicle owners in Taiwan was adopted. Self-developed TAM questionnaires were randomly distributed at Tesla service centers and charging stations. A total of 200 valid questionnaires were collected. The evaluation of the survey items indicated that the questionnaire had high reliability and validity. Kruskal–Wallis analysis revealed that an owner's income influenced their willingness to repurchase a Tesla electric vehicle. In addition, structural equation modeling indicated that all TAM constructs accurately predicted the use behavior of Tesla vehicle owners.

Keywords: electric vehicles; technology acceptance model; Tesla; survey design; vehicle engineering

Sustainability Aspects of Core Engineering Programs in View of Increasing Demand for Computer Science Related Programs 613–625
Rayapati Subbarao

Engineering education in India and across the globe had a very impressive growth in the last few decades of the 20th century. In those days, engineering, medicine and law were the most sought-after as career option. Because of the increased computer applications, stake holders of the engineering institutes have started looking towards computer science related programs. For the last couple of years, it has changed so dramatically that the existence of core engineering programs has become questionable. In such a scenario, the present work discusses the sustainability aspects of core engineering programs. Initially, admissions in overall engineering education are analyzed, in Indian context. Scenario of admissions in under graduate engineering programs of different states and various engineering institutes is particularized. Admissions are 30–40% lesser than the sanctioned number of seats. Also, out of the students graduating, only 50% are getting jobs. Later, daily needs of human beings are identified and the need of versus engineering equipment is detailed. Based on the equipment/non-equipment used by the human beings, industries of relevance and core branches of engineering are confirmed. Study finds that there is greater relevance and requirement of such engineers, which is closely related to the existence of associated engineering programs. After identifying the importance of core engineering programs, ways for their improvement are also elaborated. Implementation of OBE, continuous assessment, innovative teaching practices and training of faculty, embedding the skills required are the few measures, which are detailed here. Implementable plans for conducting core engineering programs and the courses effectively are also incorporated. Analysis done in this study and suggested measures would pave the way for the sustainability of the core engineering programs and the complete engineering education.

Keywords: sustainability; core engineering programs; computer science engineering; engineering education; information technology

Engineering in K-12: Micro:bit Projects with SDGs 626–632
Sheng-Yi Wu and Hong-Jhe Lin

Against the backdrop of global emphasis on engineering literacy and Sustainable Development Goals (SDGs) in education, the international “Do Your Bit” competition integrates Micro:bit technology with SDGs to provide students with a practical platform for solving societal problems through engineering design. However, research on the integration and effectiveness of engineering education and SDGs at the K-12 level remains limited. This study conducted a content analysis of 144 award-winning projects from Taiwan between 2021 and 2024 to explore the societal issues students focused on, the characteristics of their engineering designs, the linkage to SDGs, participant demographics, and the creativity and social impact of the projects. Using a structured coding scheme based on SDG categories and engineering design features, the findings revealed that students generally addressed concrete and urgent societal issues in their daily lives. The predominant engineering domain was electronics, with increasing integration of mechanical elements and sensor modules over the years, forming interactive loops of sensing-processing-action, showcasing students' growing systems design capabilities. Among the SDGs, SDG 3 (Good Health and Well-being) appeared most frequently, followed by SDGs 13, 12, and 11. Participants were mainly aged 8 to 14, including upper elementary and junior high students, with diverse gender representation and a notable number of female-led or mixed-gender teams. In terms of creativity and social impact, the projects demonstrated increasing innovation and application scope over time, reflecting a progression from learners of technology to problem-solvers and socially engaged participants. Recommendations based on the findings are provided.

Keywords: engineering education; Do Your Bit; SDGs; Micro:bit; STEM education

Contemporary Research on AI Integration for Sustainability Education within STEM and Engineering Curricula: A Systematic Mapping Review 633–645
Ai-Jou Pan and W. G. Will Zhao

This study presents a Systematic Mapping Review of 56 peer-reviewed articles (2021–2025) to examine how Artificial Intelligence (AI) is integrated into Engineering Education for Sustainable Development (ESD). Guided by a newly proposed AI-Enabled ESD Competency Development Framework, the research maps the intersection of sustainability mandates, technological enablers, and pedagogical actions. Findings reveal an acceleration in research since 2024, driven by Generative AI and LLMs as scaffolds for critical reflection and ethical decision-making regarding the UN SDGs. While Asia and Europe emerge as primary research hubs, the field remains limited by technological determinism and a lack of longitudinal evidence on behavioral shifts. This study contributes a strategic roadmap for transitioning toward ethically governed, value-centered, and globally inclusive engineering education. Future research must shift from short-term adoption toward longitudinal frameworks that integrate sustainability ethics and inclusive AI models to ensure permanent competency retention and global equity.

Keywords: sustainability education; STEM; engineering education; Artificial Intelligence (AI); systematic mapping review

Section II

Contributions in: Curriculum Assessment, Motivation, Behavioral Engagement, Self Efficacy, Belonging, Design Thinking, Engineering Judgment, PBL, First Year Engineering, Student Success, Entrepreneurial Characteristics, Teaching Effectiveness, Postgraduate Education, Civil Engineering, Mechanical Engineering, Technology Fairs, Differential Instructions, AI-Based Learning Tools, Learning Strategies, STEM, Teaching with Stories

Impact of Two Decades of Continuous Development on Advancing a Civil Engineering Graduate Program with a Global Vision

646–659

Aman Mwafy and Bilal El-Ariss

Although case studies of engineering programs that have implemented various curriculum development approaches are available in the literature, there is a scarcity of studies focusing on the evolving experiences and cumulative modifications made to redesign civil engineering graduate curricula following periodic reviews, particularly detailed case histories over extended timeframes. Following several assessment cycles, including two comprehensive reviews conducted by international evaluators, the structure and curriculum of a civil engineering master's program offered at the United Arab Emirates University over the past two decades have been revised to improve students' competencies and the program's quality. This paper summarizes this development journey, highlighting the challenges faced and the changes made based on lessons learned over the past years. The curriculum revisions involved removing required and elective courses, reclassifying specific required courses as electives, increasing the credit hours for the research thesis, and adding new courses with research and technical components. These transformative changes were made after thorough program reviews, incorporating recommendations from external evaluators and benchmarking that confirmed the restructured curriculum aligns with those of several well-recognized universities. The adopted developments enhanced the curriculum and enriched the program, enabling students to enroll in courses related to their interests and dedicate more time to research. The summarized journey in this paper has been more than just academic; it has driven advancements evident in the students' competencies and the program's effectiveness. The curriculum redesign model and process are shared with other educational institutions, aiming to meet society's need for qualified professionals.

Keywords: curriculum assessment; master's program; engineering; benchmarking; effectiveness

Impact of Major Switching Intention of Engineering Students on their Behavioral Engagement

660–675

Shaoyan Wu, Miao Xue and Juanlan Liang

When students encounter issues of disciplinary fit during their studies, they often develop an intention to switch majors. This intention may affect their academic performance and hinder the achievement of disciplinary training objectives. Based on self-determination theory (SDT) and social cognitive theory (SCT), this study constructs a theoretical model and employs structural equation modeling (SEM) to explore the mechanism linking major switching intention to behavioral engagement. Based on questionnaire surveys and empirical analysis of 271 students majoring in Engineering Management and Engineering Cost, the study finds that intrinsic motivation plays a partial mediating role in the aforementioned relationship. The research also reveals multi-level moderating effects, the moderating role of self-efficacy varies across different contexts, while teacher support exerts a dual moderating effect. Specifically, teacher support can both buffer the negative impact of major switching intention and strengthen the positive pathway from intrinsic motivation to behavioral engagement. Theoretically, this study extends the explanatory scope of SDT in the context of higher education and reveals the interactive mechanisms between psychological motivational factors and teaching environmental factors. Practically, the findings provide intervention strategies for university administrators and teachers to enhance students' behavioral engagement.

Keywords: major switching intention; behavioral engagement; intrinsic motivation; self-efficacy; teacher support

Programming Self-Efficacy is Moderated by an Ecological Belonging Intervention, Race/Ethnicity, and Gender

676–690

Matthew Bahnson, Allison Godwin and Linda DeAnglo

STEM environments are often “unwelcoming” and impact students' sense of belonging, particularly in fields with long-standing underrepresentation of women, Black, Latiné, and Indigenous students. Belonging interventions have shown promise in addressing these issues to improve outcomes. A new variation is an ecological belonging intervention that has been contextualized to a specific course within a predominantly White institution (PWI) suggests that struggle in the course is a normal and surmountable experience, and that struggle does not signal a lack of belonging. In-class, students participated in peer-to-peer and faculty-led discussions of overcoming struggle through self-reflection and shared experiences with past struggle. This quasi-experimental study of 1110 students enrolled in a 1st year engineering programming course examines impacts on programming self-efficacy. The study used a quasi-experimental design with some treatment and control sections of the programming course. With PROCESS in SPSS, the moderation of programming self-efficacy by intervention condition from pre-test to post-test was tested. In addition, the moderation of intervention effect by race/ethnicity (Black, Latiné, white, and Asian), and gender (women and men) was tested. The moderated moderation analyses showed significant interactions for Black (condition by Black $\beta = -2.00$, $p = 0.009$; PSE by condition by Black $\beta = 0.81$, $p = 0.003$), White (condition by White $\beta = 0.59$, $p = 0.04$), and gender (PSE by condition by gender $\beta = 0.27$, $p = 0.005$) models such that the intervention supported student post-programming self-efficacy. The ecological belonging intervention supports students in developing programming self-efficacy as part of an introductory programming course.

Keywords: intervention; programming; self-efficacy; race/ethnicity; gender

Using Cardboard Blocks to Investigate Elementary Students' Engineering Design Thinking Strategies

691–698

Sheng-Yi Wu and Pao-Nan Chou

This study investigated elementary students' engineering design strategies through the implementation of a newly developed cardboard block kit. A survey research design incorporating both quantitative and qualitative components was employed to investigate (a) the types of engineering design thinking strategies adopted by students, (b) the relationships among these strategies, and (c) students' perceptions of the entire learning experience. A total of 89 fifth-grade students from a public elementary school in Taiwan participated in two engineering-focused project modules: Traffic Light Support Structure and Creative Engineering Structure. The results indicated that the students most frequently employed collaborative and division of labor, planning, and exploratory strategies, which highlights the importance of teamwork, pre-task planning, and hands-on experimentation in engineering design learning. Correlation analysis revealed that planning was strongly associated with decomposition and integration, reflecting a sequential cognitive process in structural problem-solving. Qualitative analysis further revealed that the students exhibited multilayered strategic behaviors, including ideation, exploration, collaboration, reflection, adaptation, and decomposition, with relatively limited use of creative strategies, which may be related to the structured nature of the assigned tasks.

Keywords: engineering design thinking; elementary engineering education; cardboard block construction; survey research; strategic behavior

Renee M. Clark and Samuel J. Dickerson

It is important to ensure the development of engineering judgment for today's aspiring engineers. The Accreditation Board for Engineering and Technology (ABET) requires assessment of this crucial competency for undergraduates. Although there have been some empirical assessments of engineering judgment, this has been an understudied and underassessed area, possibly due to the lack of a consensus-based definition for engineering judgment. The present study contributes to empirical assessment of engineering judgment and is part of a larger exploratory study to define and assess this critical competency. We previously developed an emergent consensus-driven definition for engineering judgment using a Delphi study and subsequently implemented associated educational materials in the spring 2025 semester in two contextually different undergraduate courses. An end-of-course survey question prompted students to reflect on how they had used or not used engineering judgment in their final course project. The responses underwent a content analysis using the emergent definition as the coding scheme, revealing evidence of the use of engineering judgment as well as differences in the two course cohorts. The responses from the cohort that had more open-ended projects were richer in terms of the frequency of various aspects of engineering judgment that were discussed. Although these empirical results are preliminary, they have potential implications for educating students about engineering judgment for their project work in accordance with ABET accreditation requirements.

Keywords: engineering judgment; ABET; project-based instruction

Academic Performance of First-Year Engineering Students: A Systematic Literature Review

709–727

Ana Aparicio Colino, Jose Luis Arroyo-Barrigüete and Carmen Sánchez Ávila

The academic performance of first-year engineering students is a critical topic, given its relevance for understanding and improving retention, identifying at-risk students and fostering success in engineering education. This study employs the PRISMA methodology to conduct a rigorous and systematic literature review of research on the academic performance of first-year engineering students published between 2014 and 2024. Through an exhaustive search and selection process, 36 articles were identified and analyzed.

The review shows that academic achievement is a multifaceted construct measured through a wide range of indicators, including first-year or semester grades, performance in key subjects such as mathematics or introductory engineering courses, retention and graduation rates, and students' self-reported outcomes. The lack of standardization in these metrics underscores the complexity of the field and complicates cross-study comparisons. Two main approaches to measuring performance in the first year emerge: overall course averages based on large, multi-subject datasets, and subject-specific assessments that enable more controlled analyses.

Across studies, cognitive factors such as high school grade point average, university entrance scores and prior mathematics preparation consistently appear as strong predictors of first-year performance. Mathematics plays a central role as both a foundational knowledge base and a powerful predictor of subsequent success. At the same time, non-cognitive variables, including self-efficacy and motivation, also show robust associations with achievement. Finally, the review highlights the diversity of analytical strategies, from classical statistical models to machine learning techniques, and points to the value of mixed methodological approaches for capturing the complex interaction between cognitive, non-cognitive and contextual factors shaping first-year engineering performance.

Keywords: first-year engineering students; academic performance; PRISMA methodology; educational interventions; higher education; student success

Comparative Analysis of Entrepreneurial Characteristics between Engineering and Engineering Technology Students

728–743

Oai Ha and Vivek Singhal

This study examines how engineering (ENG) and engineering technology (ENT) students perceive and engage with entrepreneurship education, revealing both shared patterns and discipline-specific distinctions in entrepreneurial characteristics. Quantitative analyses found no statistically significant differences in entrepreneurial self-efficacy, creative self-efficacy, or risk propensity; however, ENT students consistently demonstrated higher mean ranks across most items, suggesting stronger entrepreneurial characteristics that may be influenced by greater exposure to business – and management-oriented coursework. Qualitative findings indicated that ENG students viewed entrepreneurship as a complementary capability best embedded within project-based and industry-engaged experiences that reinforce technical learning, whereas ENT students regarded entrepreneurship as a core component of professional preparation and expressed strong interest in dedicated coursework related to business formation, finance, and commercialization. Gender differences were largely non-significant, though female ENT students exhibited higher creative and risk-taking tendencies, potentially reflecting the influence of inclusive learning environments and faculty role models. Consistent with prior research, students across both groups reported interest in entrepreneurship while preferring initial employment in established firms, reflecting a pragmatic “employee-first, then entrepreneur” career orientation. Despite limitations related to sample size, institutional context, and self-reported data, the findings underscore the importance of aligning entrepreneurship education with disciplinary contexts to support the development of entrepreneurial characteristics among engineering graduates.

Keywords: engineering education; engineering technology; entrepreneurial characteristics; self-efficacy; gender differences; curriculum changes

Relationship Between Research Productivity and Teaching Effectiveness in Engineering Education: A Qualitative Study in Taiwan

744–754

Pao-Nan Chou

This study examined the relationship between research productivity and teaching effectiveness among engineering professors through a qualitative research approach. In-depth interviews served as the primary data collection method. A total of 12 engineering professors participated in the study, representing three distinct categories: those excelling in teaching, those excelling in research, and those excelling in both teaching and research. The qualitative analysis revealed distinct themes across these categories. Faculty members who excelled exclusively in either teaching or research perceived a negative correlation between the two domains. In contrast, those who excelled in both areas attributed the positive correlation to their competitive personality traits and effective time management skills.

Keywords: research productivity; teaching effectiveness; qualitative study; phenomenological approach

Comparing Postgraduate Education Models in Civil Engineering: A Case Study of China and Singapore

755–769

Weijing Yao, Hao Zhang and Qinghe Zhang

Amid China's ongoing promotion of the new engineering initiative, the education of postgraduate students in civil engineering holds strong demonstrative significance and plays a leading role in talent development. This study conducts a comprehensive investigation into the postgraduate education model at the National University of Singapore (NUS), focusing on key elements such as selection methods, educational objectives, educational processes, scholarships and financial aid, extracurricular activities, graduation requirements, and the distribution of faculty and students. Based on this investigation, a comparative analysis is made between China and Singapore in terms of educational philosophy, teaching methods and curriculum design, supervisory systems, and research environments. Finally, several constructive recommendations are proposed, including optimizing curricula and instructional strategies, enhancing students' practical, innovative, and collaborative competencies, and strengthening diversified and internationalized education. These insights aim to inform the reform of postgraduate education in China and improve both education quality and international competitiveness. These insights may also be useful for institutions worldwide seeking to refine postgraduate engineering education policies and programme design.

Keywords: National University of Singapore (NUS); civil engineering; postgraduate education; cultivation process; comparative analysis

Feng-Ming Ou

This study implements a scalable two-stage project that bridges Morphological Analysis (MA) to Taguchi Design of Experiments (DOE) within an extended Kolb cycle, using a modular spring-powered vehicle as a common platform. Stage 1 targeted configuration selection for mean performance; Stage 2 targeted variance control under noise factors, e.g., payload. Across 168 students organized into 44 teams, evidence shows clear gains in systematic exploration and data-driven experimentation. Formative evidence from staged assignments indicated that the pathway functioned as intended: most teams discriminated performance-critical factors in Stage 1 (best-worst S/N gaps > 5 dB in 31 teams), and a subset achieved variation reduction in Stage 2 (travel-distance standard deviation reduced by 37.5%). In summative trials with random payloads, 33/44 teams reached accuracy rate $\geq 90\%$ (median 95.8%), and 34 teams recorded zero lateral offset. Pre/post analysis of the course-feedback survey showed significant gains (nonparametric tests, $p < 0.001$; medium effects) in students' self-efficacy for systematic configuration concept generation and evaluation and for data-driven experimental optimization, alongside improvements in holistic systems thinking and evidence-based reflection, while motivation remained stable over the six-week cycle. Contributions are threefold: (1) an explicit MA \times DOE framework that operationalizes Kolb's cycle for novices; (2) a short, large-enrollment pathway that yields accurate and stable performance while cultivating systematic experimentation; and (3) a reusable, low-cost kit and artifacts. The pathway appears replicable. Brief Stage 2 variance checkpoints and paired pre/post measures may further enhance variance control and evaluation fidelity.

Keywords: first-year mechanical engineering education; experiential learning; project-based learning; morphological analysis; Taguchi method; design of experiments

The Impact of Environmental Research and Technology Fairs on Students Academic Outcomes: A Pre- and Post- Pandemic Analysis

782–789

Elizabeth C. Ore and Dante M. Garcia

This study examines the impact of environmental research fairs on the achievement of student outcomes in the Environmental Engineering Program at Universidad Continental (Peru) through a six-year longitudinal analysis (2018–2023). The dataset includes student-outcome direct measurements and judges' scores from 224 projects involving approximately 1,000 students. Fairs were conducted face-to-face in 2018, 2019, and 2023, and virtually in 2020–2022 due to COVID-19 restrictions. We compare pre-pandemic, pandemic, and post-pandemic periods to assess differences in performance associated with fair modality. Findings suggest that face-to-face fairs are associated with higher achievement in outcomes linked to experimentation, problem analysis, design, and communication, whereas virtual editions reduced opportunities for consistent external judging and hands-on demonstration. These results support the role of research and technology fairs as an active-learning strategy and inform improvements for both face-to-face and virtual implementations.

Keywords: outcomes; engineering education; research and technology fairs; active learning; COVID-19

Implementation and Assessment of a Cost-Effective Model for Differentiated Instructions in an Undergraduate Electrical and Electronic Technology Course

790–798

Xiaoliang Zhang, Tingting Chen, Weimei Shao and Songlin Zhou

Managing student heterogeneity in foundational engineering courses remains a persistent challenge, particularly for institutions operating under resource constraints. While intelligent tutoring systems offer promise, their implementation is often impeded by high costs and technical complexity. This study proposes a pragmatic intelligent approach, the “Goal-tiering, Data-sensing, and Dynamic-regulation” (GDD) model, which reconfigures standard Learning Management System (LMS) features to emulate adaptive instruction without requiring bespoke AI development. We detail the model's pedagogical architecture, which integrates multimodal data monitoring with automated, tiered interventions. To assess its efficacy, a quasi-experimental parallel-group study was conducted ($N = 133$), comparing the GDD-enhanced framework against traditional lecture-based instruction. Final exam scores in the experimental group exceeded the control group by 14.5 points, with the excellence rate rising from 19.7% to 72.6%. Crucially, qualitative feedback suggests that process-oriented assessment mitigates student anxiety and enhances perceived fairness. This research offers a validated, replicable framework for engineering educators seeking to operationalize data-driven instruction within existing infrastructural limits.

Keywords: emerging engineering education; differentiated intelligent instruction; local institutions; electrical and electronic technology course; human-computer collaboration

Revolution or Reliance? The Dual Impact of AI-Based Learning Tools on College Students' Academic Skills

799–817

Oenardi Lawanto, Cassandra McCall, Wade Goodridge, Zain Ul Abideen and Talha Naqash

This study investigates college students' perceptions of AI-based learning tools, particularly their use and acceptance of AI-based learning technologies, such as ChatGPT, to enhance their academic experience. The research aims to understand how motivational factors and learning strategies impact students' adoption or avoidance of these tools. Data were collected through a survey of 773 students from a range of academic disciplines at a public university in the western United States, offering insights into the diverse factors that influence their decision-making. This research sheds light on the potential of AI tools to support personalized learning, while also identifying the factors that shape students' engagement with these innovations. The findings reveal that Intrinsic Goal Orientation and Task Value were both significant predictors of opposition to AI, suggesting that students who are highly motivated by internal interests and value traditional academic engagement tend to view AI with skepticism. In contrast, these variables did not significantly predict support for AI, highlighting an asymmetry in how intrinsic motivation relates to AI acceptance. Critical Thinking, however, was positively associated with both opposing and supporting AI, indicating that students with stronger evaluative skills are more likely to take a definitive stance – either for or against – rather than remain neutral. Thematic analysis further showed that support for AI is primarily driven by its potential to enhance personalized learning, efficiency, conceptual understanding, and adaptability. Together, these results suggest that students' engagement with AI is complex and shaped by both cognitive dispositions and perceived educational values.

Keywords: AI-based learning tools; motivation; learning strategies

Teaching with Stories: Exploring the Effects of Narrative-Driven Engineering Curriculum for Middle School Students and Teachers

818–834

Jeremiah Pina, Sahara Pradhan, Rebecca Mazur, Glenn Ellis and Al Rudnitsky

This study explores the design, implementation, and evaluation of the Transforming Engineering Education in Middle Schools (TEEMS) curriculum, a narrative-driven, Next Generation Science Standards (NGSS)-aligned engineering program for sixth, seventh, and eighth-grade students. Grounded in Bruner's theory of narrative ways of knowing and Egan's Imaginative Education framework, TEEMS engages students through emotionally resonant stories that aim to foster both engineering knowledge and identity development. A mixed-methods evaluation that gathered data across three years of implementation in an urban U.S. school district examined learning outcomes and user experience among students and teachers. Quantitative results show statistically significant gains in both near transfer (efficiency) and far transfer (innovation) of engineering knowledge for students who received the TEEMS curriculum compared to those who received the standard curriculum. Disaggregated analysis highlights equity gaps across special needs, linguistic, and ethnic subgroups, pointing to areas for targeted instructional support. Qualitative findings reveal that stories enhanced emotional engagement, increased perceived relevance of engineering, and reduced anxiety among both

students and teachers. Teachers reported that TEEMS improved their confidence in teaching engineering and shifted their understanding of what engineering education could be. These findings suggest that narrative approaches may serve as powerful tools for both learning and equity in K-12 engineering education.

Keywords: narrative-based curriculum; engineering education; middle school STEM; knowledge transfer; imaginative education