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Special Issue

Artificial Intelligence in Engineering Education – Part I

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Special Issue on: Artificial Intelligence in Engineering Education – Part I

Andrés Díaz Lantada and José Luis Martín Núñez

AI-Powered Telepresence Laboratory: Generative AI Co-Pilot for Automated Experiment Guidance and Instruction

1412–1432

Phumrapee Meyer, Pravee Kruachottikul, Chakkrit Tantithamthavorn, Kittikul Kovitangoon, Ratchatin Chancharoen and Gridsada Phanomchoeng

This study presents an AI-powered telepresence laboratory designed to enhance engineering education by integrating a Generative AI co-pilot for automated experiment guidance and instruction. The system provides real-time procedural support, AI-assisted experiment monitoring, and interactive feedback, reducing instructor and lab technician workload while ensuring students achieve key laboratory objectives, such as following calibration procedures, interpreting sensor data, and understanding measurement uncertainty. The evaluation results confirm that the system improves student engagement, ensures procedural accuracy, and maintains learning outcomes comparable to traditional laboratory settings. Additionally, it redefines the roles of instructors and lab technicians, shifting their focus from direct supervision to curriculum development and AI system enhancement. By providing an accessible and interactive laboratory experience, this study demonstrates the effectiveness of scalable, AI-powered telepresence laboratories while acknowledging the continued need for expert oversight in complex experimental analysis.

Keywords: Generative AI; telepresence laboratory; engineering education; remote learning; collaborative; virtual laboratories; AI in education; large language models

Federated Learning for Accessible Engineering Education: A Survey on AI-Driven Personalization for Students with Disabilities

1433–1446

Belghachi Mohammed and Seddiki Noureddine

Federated learning (FL) offers a promising approach to improving accessibility in engineering education for students with disabilities by enabling personalized learning while preserving data privacy. This paper presents a comprehensive survey of current research on FL and AI-driven personalization in the context of inclusive education. It reviews applications such as adaptive assessments, accessible course materials, and assistive technologies, supported by real-world case studies that highlight feasibility and impact. Key challenges include computational overhead, data heterogeneity, algorithmic bias, and privacy risks. The review identifies gaps in existing work, including limited representation of certain disability types and methodological constraints. Future directions are proposed, focusing on explainable AI, edge computing, multimodal data integration, and interdisciplinary collaboration. The findings support the development of equitable, scalable, and privacy-respecting systems to foster inclusive engineering education.

Keywords: federated learning; accessible education; AI-driven personalization; students with disabilities; engineering education; privacy-preserving systems

Implementing Artificial Intelligence in Higher Education: A Pathway to Effective PBL

1447–1461

Silvia Lavado-Anguera, María-José Terrón-López and Paloma-J. Velasco-Quintana

This paper aims to investigate the integration of Artificial Intelligence (AI) into Project-Based Learning (PBL) methodologies within STEAM (Science, Technology, Engineering, Art, and Mathematics) education. It seeks to evaluate how AI can enhance the teaching-learning process, optimize project management, and foster digital competence among students and educators. An action research methodology is employed, consisting of iterative cycles of planning, acting, observing, and reflecting. The study focuses on developing, implementing, and assessing AI-supported PBL strategies. Data is collected through classroom observations, participant feedback, and performance evaluations to analyze the effectiveness and adaptability of AI-enhanced PBL approaches. The study provides empirical insights into the benefits and challenges of AI integration into PBL. Results suggest that AI can enhance project management, automate repetitive tasks, and support individualized learning. Challenges include technological limitations, user adaptability, and the need for adequate teacher training. The study is limited to the initial phase of implementation, with long-term outcomes yet to be measured. Findings are based on specific STEAM settings, which may limit generalizability. The paper highlights strategies for enhancing PBL through AI, including improving project planning, fostering digital literacy, and providing adaptive learning support. It addresses ethical considerations related to data privacy, informed consent, and algorithmic bias, emphasizing the need for responsible AI use in educational settings. This paper offers a systematic framework for integrating AI into STEAM-based PBL, contributing to the growing body of research on AI in education. It provides practical guidance for educators and policymakers, highlighting the transformative potential of AI in project-based learning.

Keywords: artificial intelligence; project-based-learning; higher education; implementation

Zachery Quince, Kathy Petkoff, Anna Lidfors Lindqvist, Emily Faulconer, Winn Chow and Sasha Nikolic

Generative artificial intelligence (GenAI) platforms are widely used to create images based on textual inputs. While these tools hold great potential to influence societal perceptions, they also risk perpetuating stereotypes and biases, particularly in fields like engineering, where stereotypical depictions are commonplace. Engineering images often reinforce traditional views of gender, race, and professional roles, raising concerns about whether GenAI tools can produce visuals that are truly inclusive and representative of diverse groups. This study aims to investigate the ability of two GenAI tools, Copilot and Canva, to generate diverse and inclusive representations of engineering teams. By analysing the quality and diversity of images generated using a systematic approach, the research provides insights into the biases embedded within these tools. The quality of the generated images had several flaws, including multiple missing or additional limbs, facial features, or fingers. This study revealed the flawed and generic images that GenAI tools can generate when asking to generate a simple engineering team. Racial, gender, and age-based stereotypes of engineers were a constant theme throughout the images. There was limited diversity and inclusion of Indigenous peoples, hair colour and length, and body shape and size. The findings are intended to set a baseline for future evaluations and improvements in GenAI platforms.

Keywords: GenAI; Ethics; Diversity; Equity; Gender; Image Generation; Stereotypes

AI-Driven Predictive Models and Chatbots for Early Intervention and Student Success in Higher Education: A Systematic Review

1473–1488

Felipe Emiliano Arévalo-Cordovilla and Marta Peña

Student attrition in higher education remains a persistent global issue, with dropout rates exceeding 40% in several countries. This necessitates the development of early evidence-based intervention strategies. Artificial Intelligence (AI) has emerged as a promising tool; however, its implementation is often approached in a fragmented manner. This systematic review analyzes the synergistic use of machine learning-based predictive models and conversational chatbots as an integrated system to support students' success. A total of 46 studies indexed in Scopus, Web of Science, and IEEE Xplore (2019–2024) were examined according to the PRISMA 2020 protocol. The results indicate that techniques such as neural networks and random forests achieve predictive accuracies above 90% for academic risk detection, with hybrid models reaching F1 scores of up to 0.99. Concurrently, chatbots are evolving into personalized virtual tutors with contextual response capabilities and 24/7 availability, achieving F1 = 99.75% and boosting academic performance by 25%. The integration of these technologies has a positive impact on student retention, motivation, and institutional efficiency. The future of support systems lies in integrated, ethical, pedagogically grounded, and student-centered AI ecosystems that can transform educational interventions into more inclusive and effective environments.

Keywords: conversational chatbots; dropout prediction; early intervention; educational artificial intelligence; higher education; machine learning; predictive models; student success

SHAP Analysis of Software Engineering Capstone Team Building Criteria

1489–1501

M. Khalid Shaikh and Mirka Saarela

To assist the students of software engineering in forming their cohesive capstone teams, a set of 127 criteria is available in seminal research in the literature. Those criteria were automated into a team recommendation system *Psychographd* which groups students based on their matching responses to a psychographic self-evaluation questionnaire. In the current research, these criteria are examined to explain which are most influential in fostering team cohesion. The data comprises the original student responses to the psychographic self-evaluation questionnaire collected before team assignments and their responses to the Group Environment Questionnaire used to assess the team cohesion after they began working in their recommended teams. SHAP analysis (SHapley Additive exPlanations), revealed how specific criteria promote or diminish cohesion, providing transparency into the recommendation process. The results demonstrate *Psychographd's* effectiveness and underscore the potential of explainable AI in optimizing educational team formation strategies.

Keywords: explainable AI; SHAP; capstone teams; software engineering; team building criteria

Integrating Generative AI into Engineering Education: A Case Study in Web Application Development

1502–1514

Roberto Barchino, Jose A. Medina, Rosa Estriegana and M. Lourdes Jiménez

The integration of Generative Artificial Intelligence (GAI) tools into higher engineering education holds transformative potential, especially in supporting programming and software development courses. This paper presents an exploratory study of GAI application in a fourth-year elective course in the Computer Engineering program at the University of Alcalá, focused on the design and development of web applications. In the course, students are required to design and implement a web application using the Model-View-Controller (MVC) design pattern with both client-side and server-side technologies. The study explores the impact of ChatGPT as a learning assistant, providing support in debugging, understanding, and implementing the MVC pattern. A conceptual model is proposed to evaluate the influence of ChatGPT across three dimensions: support in the learning process, support in academic performance improvement, and academic integrity. Additionally, the model examines how these three factors influence student satisfaction. To validate the model, a survey was designed and completed by all students enrolled in the course ($n = 72$). A mixed-method analysis was conducted, including descriptive statistics, relations analysis, and qualitative analysis based on an open-ended question. The main findings show that students perceive their learning and educational outcomes positively when using ChatGPT, although areas for improvement remain in satisfaction and academic integrity. Correlations indicate that increased learning is associated with higher satisfaction, while the perception of academic integrity appears to be independent. The qualitative analysis reveals that ChatGPT is regarded as a useful tool, though concerns arise around dependency and reduced cognitive effort. A regulated integration of ChatGPT is recommended to maximize benefits while minimizing potential negative impacts. This paper contributes to the growing body of evidence on the impact of GAI in education, offering a practical framework for integrating ChatGPT in project-oriented learning environments.

Keywords: ChatGPT; engineering education; web development; MVC pattern; GAI

Examining Engineering Students' Academic Performance Using Machine Learning Algorithms as a Data Analysis Tool

1515–1531

Carlos Felipe Rodriguez-Hernandez, Vinay Ram Gazula and Prateek Shekhar

As the demand for engineers continues to grow, understanding the factors that influence the academic performance of engineering students has become increasingly important. While much of the existing research has focused on predicting common indicators such as grade point average (GPA), the time it takes students to complete their academic programs (known as time-to-degree (TTD)) has received comparatively less attention. Furthermore, recent advancements in artificial intelligence and machine learning have provided new data analysis tools for performing predictive analysis on large educational datasets. This study leverages a range of machine learning algorithms, including multiple linear regression, binary logistic regression, decision trees, random forest, XGBoost, and LightGBM, to analyze GPA and TTD data from records of 7,871 undergraduate engineering students at a public research university in the United States. First, we evaluate the performance of these algorithms in two tasks: predicting GPA (regression task) and classifying TTD (classification task). Second, we examine how variables related to students' academic background (such as high school GPA, SAT scores, and major), demographic background (sex and underrepresented status), and socioeconomic background (eligibility for educational opportunity programs) contribute to predicting GPA and classifying TTD. The results indicate that multiple linear regression and binary logistic regression outperform single decision-tree methods. However, ensemble methods that combine multiple decision trees, such as random forest and LightGBM, provide better performance than regression-based models, particularly in predicting GPA. Moreover, the variable importance analysis using the SHapley Additive

exPlanations (SHAP) method reveals that students' background characteristics differentially predict GPA and TTD, with academic background variables holding the highest importance. The findings highlight the potential of machine learning techniques in examining educational datasets and offer insights for future research on leveraging machine learning as a data analysis tool in engineering education research.

Keywords: machine learning; engineering education; academic performance

Enhancing AI Algorithm in Digital Signal Processing Education, Through Extreme Programming: Constructive Approach in IoT Context 1532–1546

Mario Stojanović, Ana Matović, Marija Matović, Edis Mekić, Vanja Baždar and Zakaria Maamar

This research investigates the impact of integrating Extreme Programming (XP) into a Constructive Learning framework on Student Learning Outcomes (SLO) in Digital Signal Processing (DSP) and Artificial Intelligence (AI) applications, specifically focusing on application in Internet of Things (IoT) context. The study involved final-year undergraduate engineering students engaged in developing a virtual laboratory environment, leveraging XP practices such as iterative development, pair programming, continuous feedback, and test-driven development. Empirical findings, collected through surveys and structural equation modeling, demonstrated significant improvements across affective, cognitive, and behavioral dimensions. Students exhibited increased motivation, reduced anxiety toward complex DSP and AI tasks, deeper conceptual understanding, and enhanced practical skills essential for real-world IoT implementations. Overall, the results affirm that Agile methodologies like XP can effectively foster student engagement, practical competencies, and positive attitudes toward complex technical education, supporting broader integration in engineering curricula.

Keywords: Digital Signal Processing; Extreme Programming; Agile Methodologies; Internet of Things; Virtual Laboratory; Constructive Learning

AI-Based Performance and Grade Prediction for Undergraduate Industrial Engineering Students in Machine Component Design Course 1547–1555

Amjad Alsakrneh, Abedallah AlKader, Mo'en Alnasraween, Hamed Mubarak Al-Awidi and Alaa A. Towaiq

The availability of student data in educational institutions presents a valuable opportunity to apply machine learning (ML) techniques for predicting academic performance before the start of a new semester. Some variables can support early identification of students' potential performance and guide them in planning. In this article, we present predictive analysis models for the academic performance of engineering students at Yarmouk University during the years between 2019 and 2024. The machine learning models were applied using data collected from the university's registration office, with some demographic information. Various machine learning models were employed, including Support Vector Machine (SVM), K-Nearest Neighbors (KNN), Decision Trees, and Artificial Neural Networks (ANN) to identify the significant attributes affecting student performance in the machine component design course. The results present that factors such as CGPA and registered course load (in credit hours) significantly affect student performance. Among the models applied, ANN achieved the highest accuracy with an RMSE of 6.1, and the model SVR the lowest RMSE of 8.2. This research aims to assist students in identifying the potential outcomes early and provide advice to support students in registration planning.

Keywords: academic performance prediction; AI in education; engineering students, student data analytics

Section II

Contributions in: Attitude Scale, Digital Design, Teamwork, Capstone Projects, Creativity, Entrepreneurship, Identity, First-Year Engineering, Doctoral Education, Adaptive Learning, Faculty Development, Industry Academia Alignment

Development and Validation of an Attitude Scale toward Generative AI for University Students 1556–1568

Yao-Chung Cheng, Chien-Yu Lu, Kai-Jie Chen and Chuan-Tsai Lin

This study developed and validated the Generative AI Attitude Scale (GAIAS) to assess university students' attitudes toward generative AI. Using an online survey of 700 students from 85 Taiwanese universities (238 males, 462 females, mean age 24.23), exploratory factor analysis identified a 12-item, two-factor structure that captures positive and negative attitudes, explaining 61.71% of the variance. The scale demonstrated satisfactory internal consistency for the higher-order construct (Cronbach's $\alpha = 0.772$) and strong composite reliability for the two subscales (CR = 0.87 and 0.88). Convergent validity was acceptable for both dimensions (AVE = 0.528 and 0.552). Confirmatory factor analysis supported a higher-order model integrating the two attitudinal dimensions into a robust overarching construct. Concurrent validity was evidenced through favorable correlations with the Artificial Intelligence Anxiety Scale. Substantively, students in natural sciences and engineering reported more positive attitudes than peers in the humanities and social sciences, indicating discipline-specific orientations toward emerging technologies. GAIAS can help institutions gauge receptiveness to generative AI, tailor pedagogy to disciplinary needs, and monitor attitudinal change as AI tools diffuse across curricula. Future research should broaden sampling frames and employ mixed methods to deepen understanding of how attitudes and anxiety jointly shape technology adoption and educational outcomes.

Keywords: artificial intelligence; generative AI; attitude scale; Generative AI attitude scale

Integrating Industrial Tool-Based Formal Verification into ECE Design Verification Curriculum 1569–1584

Shruti Sharma, Mohamed Ghonim, Xiaoyu Song, Jin Zhang and Andrew Greenberg

Simulation, the traditional mainstay of digital design verification, faces increasing challenges as design complexity escalates. Formal verification, a widely adopted methodology for functional verification of Register-Transfer Level (RTL) designs in the industry, offers a compelling alternative. This paper addresses the critical need to integrate industry-grade formal verification techniques into academic curricula, a gap currently underserved. While some formal verification courses exist, they often rely on academic tools like SAT solvers and model checkers, limiting students' exposure to industry-standard practices. This paper details the development of a unique graduate-level course at Portland State University (PSU) that introduces industrial assertion-based formal verification, specifically utilizing tools like VC Formal. This practical, industry-focused approach distinguishes the course from traditional offerings. We outline the course development process, beginning with a capstone project that served as a pilot study to gather essential learnings and feedback. We then detail the curriculum design, including the course focus, grading structure, and the design of homework assignments and examinations. Student survey results demonstrate the course's significant positive impact on perceived industry relevance and job interview preparedness. Ultimately, this initiative aims to bridge the gap between academic theory and industrial practice in the rapidly evolving field of formal verification. This study explores the initial integration of industrial formal methods into a computer engineering curriculum.

Keywords: industrial formal verification; simulation; assertion based verification; engineering curriculum; digital design

Francisco Cima, Pilar Pazos and Ana María Canto-Esquivel

The dynamic context faced by engineers in the workplace requires the ability to work effectively in teams. Past research in engineering education has examined teamwork in project-based settings, but few capture the complexity of tasks in the engineering field. Additionally, there is a lack of theoretically sound and psychometrically valid measures to determine the true level of teamwork competencies. This work fills the gap of prior studies through two contributions. First, it examines teamwork skill development through participation in authentic engineering projects. Second, it employs a valid and reliable instrument grounded in team science to capture critical teamwork skills. This research evaluates the impact of a scaffolded approach to capstone projects on the development of teamwork skills when compared to a traditional approach. A quasi-experimental study was conducted to determine the effect of scaffolded collaboration on engineering students' teamwork skills. The sample included 122 students, of whom 66 were part of the comparison group, and 56 were in the treatment group. Teams of engineering students were assigned either a modified capstone with scaffolds or a traditional capstone. The scaffolds model best practices as part of project-based activities and tools built into the course. Results indicate that participants in the treatment group (capstone with scaffolded collaboration) demonstrated significantly higher skills in planning, execution, and interpersonal competencies than students in the comparison group (regular capstone). Our results suggest that using scaffolds to support project work can help strengthen engineering students' teamwork skills and prepare them to face collaborative work in their future careers. This study suggests a valid and reliable measure of teamwork skills that can be used by engineering programs to examine skill development and document ABET outcomes related to teamwork.

Keywords: teamwork skills; capstone projects; scaffolds; engineering teams

Unpacking the Creativity Paradox: A Systems Analysis of Misalignment, Barriers, and Opportunities in Graduate Engineering Education

1593–1604

Autumn R. Deitrick and Catherine G. P. Berdanier

While creativity has been studied within undergraduate engineering education, it has rarely been studied at the graduate level. Exploring students' perceptions of creativity in graduate engineering education can allow for the identification of broader systems-level barriers to creating a thriving creative climate. This exploratory study aims to unpack engineering graduate students' perceptions, both positive and negative, of creativity in graduate engineering education. By employing a systems theory framework, this research seeks to understand how structural and systems-level influences shape students' experiences and perceptions surrounding creativity. Data were collected through written survey responses from $n = 115$ engineering graduate students from R1 engineering programs across the United States. Using conventional qualitative content analysis, we identified emergent perceptions surrounding creativity in graduate engineering education. These perceptions were then analyzed through a systems analysis lens to uncover systems-level barriers and opportunities for fostering creativity. Our analysis revealed a significant misalignment between the recognized importance of creativity and its actual support in graduate engineering education. While students emphasized creativity's critical role in research, problem-solving, and career preparation, they also identified systemic barriers, including rigid degree structures, limited resources, inconsistent mentorship, and an institutional focus on measurable outputs (e.g., publications) over creative exploration. To address these challenges, advisors and administrators should integrate explicit discussions of creativity into academic programs, reframe degree requirements to value creative contributions, and promote structural changes that prioritize creative exploration.

Keywords: creativity; engineering; graduate students

Converting Students' Entrepreneurial Self-Efficacy into Tangible Entrepreneurial Actions

1605–1615

Lili Feng, Serrene Leong, Kenny S. L. Cheah and Jianbing Deng

This study explores the role of entrepreneurial self-efficacy (ESE) in bridging the gap between entrepreneurial intention and behavior (EIB) in the context of entrepreneurial education (EE). Despite the growing focus on EE, the conversion rate of intention to actual behavior remains suboptimal. Based on survey data from 256 vocational college engineering students in China and utilizing established scales for measurement, the study employs structural equation modeling (SEM) to test the proposed hypotheses. Results confirm ESE as a significant predictor of EIB ($\beta = 0.775$, $p < 0.001$), with strong explanatory power ($R^2 = 0.764$, $R^2 = 0.601$). The findings highlight the importance of ESE in transforming entrepreneurial aspirations into tangible actions and stress the need for experiential learning to enhance students' confidence and skills, fostering practical entrepreneurs who drive innovation and business success.

Keywords: entrepreneurial self-efficacy; entrepreneurial intention and behavior; vocational college students; entrepreneurship education; experiential learning

Engineering Identity Formation across the Undergraduate Years

1616–1630

M. Jean Mohammadi-Aragh, Rachel L. Kajfez, Abigail Clark and Soundouss Sassi

First-year engineering programs are one of the earliest opportunities for undergraduate engineering educators to support engineering identity formation and community building, both of which are important for retention. This research examines how engineering identity emerged across undergraduate engineering students' degree experiences starting in their initial year in university, and how engineering communities impacted engineering identity emergence. We conducted longitudinal interviews with students one, two, and three years after they began their engineering degrees. Through our analysis, we identified three themes from the participant interviews: (1) engineering identity must be claimed by the individual not gifted externally, (2) engineering identity was described by some participants in terms of an engineering mindset, a concept taught in those participants' first-year engineering course, and (3) first-year communities did not withstand time. More specifically, we found that for the participants in this study to reach the state where they claimed to be an engineer required experiences that served as recurrent positive feedback to push them to a *tipping point*, and that these engineering expertise confirming experiences were rarely directly attributed to engineering coursework or engineering student community membership. However, deliberate instruction about engineering mindsets may have indirectly supported engineering identity formation. Future quantitative investigations are warranted to (1) understand how educators can leverage engineering mindsets to support identity development and (2) understand the transferability of our finding that first-year communities do not withstand time and the mechanics of why this occurs.

Keywords: identity; community of practice; first-year engineering

Examining Qualifying Exams: A Qualitative Case Study of Graduate Students and Faculty Perspectives

1631–1642

Mayra S. Artiles and Kai Jun Chew

Qualifying exams are a major milestone graduate students need to pass on their doctoral journey, yet little research has examined them through an assessment lens. Using a case study approach, we investigated the perspectives of doctoral students and faculty in one chemical engineering doctoral program. Guided by Linda Suskie's five characteristics of good assessments – usefulness, cost-effectiveness, accuracy, value, and clarity of goals – we conducted and analyzed semi-structured interviews with eight graduate students and six faculty members. The study found that although both faculty and students view the qualifying exam as useful and efficient, the absence of clearly defined objectives limits its value and creates confusion for students. Faculty generally agree the exam assesses readiness for independent research, but their inability to articulate specific goals leads students to experience it as a high-stakes formality rather than a meaningful assessment, highlighting the need for greater clarity and intentionality. This study contributes a novel application of Suskie's assessment framework to graduate education and underscores the importance of aligning

assessment design with clear goals and inclusive practices to support doctoral student development. We present specific implications for practice to ensure equity and fairness as a product of this milestone regarding the clarity of its objectives and consider broader alternatives to this milestone.

Keywords: doctoral education; qualifier exams; assessment

A Depth of Study Analysis on First-Year Engineering Quantitative Literacy Tasks

1643–1652

Raenita A. Fenner, Peggy O'Neill, Elliot P. Douglas and Kerrie Douglas

This study investigates the nature and cognitive demand of quantitative literacy (QL) tasks in first-year engineering courses. Despite extensive research into QL in the general population, there is a limited understanding of its incorporation into engineering curricula, particularly the specific aspects expected of first-year engineering students. By employing a deductive Qualitative Content Analysis and an a priori coding scheme based on a systematic QL definition, this research categorizes QL instances within assignments. Concurrently, it uses an adapted version of the Task Analysis Guide for Science (TAGS) to evaluate the cognitive demand of these QL tasks. The findings highlight the primary requirements of QL tasks as cognitive interpretation and reasoning, mostly demonstrating a low-to-moderate cognitive demand. This suggests the tasks are significantly scaffolded, signaling an instructional focus on fundamental knowledge and engineering practices within the QL tasks.

Keywords: quantitative literacy; first-year engineering; qualitative content analysis; task analysis guide for science

Design and Implementation of an AI-Enhanced Teaching of Signals and Systems Course

1653–1664

Xin Xu, Dong Chen, Lei Yang, Biao Wang, Shuangbao Shu, Chengliang Pan, Jin Zhang and Haojie Xia

This paper presents a three-year pedagogical reform study investigating the impact of artificial intelligence (AI) and adaptive learning technologies on student outcomes in the Signals and Systems course at Hefei University of Technology (HFUT). Approximately 130 sophomore students majoring in Measurement and Control Technology and Instruments were divided into an experimental group receiving AI-enhanced instruction and a control group receiving traditional teaching. The study implemented and evaluated three key AI-driven interventions: (1) a machine learning-based cognitive blind-spot detection system using YOLO object detection models to automatically identify typical error patterns in circuit design and frequency spectrum analysis tasks, (2) adaptive virtual laboratory exercises with dynamically adjustable difficulty levels and incorporating real case studies based on individual student performance and feedback, and (3) a rigorous assessment framework employing NI Multisim practical exams evaluated with a detailed rubric. Results demonstrated that the AI-assisted cohorts demonstrated substantially improved performance. Notably, the AI-assisted group exhibited an approximately 32% lower error rate in the NI Multisim practical exam compared to the control group, a statistically significant improvement. Additionally, students in the AI-enhanced group showed higher engagement and confidence in tackling complex signal processing problems. The study concludes that integrating YOLO-based error detection and adaptive virtual labs significantly enhances learning outcomes. It contributes a validated pedagogical model for AI-driven personalized feedback in engineering education, supported by empirical evidence and an evaluation rubric, offering a framework for broader adoption in similar courses.

Keywords: engineering education; signals and systems; adaptive learning; object detection; YOLO

Model to Assist in the Optimization of Learning Environments for Engineering Teaching (OLEET)

1665–1674

Kristi J. Shryock, Lance L.A. White and Karan L. Watson

Engineering educators often juggle competing demands while striving to deliver meaningful classroom experiences, particularly in research-intensive institutions where teaching may be undervalued. This work introduces the Optimizing Learning Environments for Engineering Teaching (OLEET) model, a systems-level framework developed to support faculty iteratively aligning their instructional strategies with three interconnected domains: student composition, engineering topic, and instructor skills. Rather than prescribing rigid methods, OLEET empowers instructors to leverage their engineering identity and disciplinary expertise to craft pedagogical approaches responsive to student needs and content complexity. This model is grounded in an inductive qualitative study of 11 engineering faculty at a large R1 institution. Their reflections reveal conflicts between educator and researcher identities and highlight intuitive practices that OLEET formalizes. The main themes found in this study are the following: (1) Connecting Theory to Practice, (2) Active Learning and Engagement, (3) Motivational Strategies and Support, (4) Content Structuring and Scaffolding, and (5) Identity-Informed Teaching. The model's structure encourages adaptive and reflective teaching aligned with engineering design mindset, making it a practical and actionable tool for faculty development in engineering education. OLEET fills a crucial gap in faculty development literature by bridging established pedagogy with disciplinary identity to enhance instructional effectiveness in engineering classrooms.

Keywords: engineering educator identity; faculty development; responsive teaching; instructional design in engineering

Enhancing Learning and Deliverable Quality in Software Engineering through Oral Inquiry Audits

1675–1687

Pauline C. Wade, Hillary E. Merzdorf and Tracy Hammond

Industry-aligned quality assurance (QA) education remains underexplored in software engineering (SE) curricula, contributing to graduates' unpreparedness for QA roles due to misalignments between academic training and industry practices. This study examines the impact of Oral Inquiry Audits (OIAs) – a pedagogical tool derived from industry practices involving oral discussions on QA processes – on undergraduate SE students' group learning and project deliverable quality. Using a quasi-experimental design, SE students developing web applications for real clients within an ISO 25010:2023-aligned QA framework were divided into control (no OIAs) and treatment (OIAs) groups. Data collection included assessments of QA knowledge and customer feedback, with statistical analyses comparing results across groups. This study found that OIAs enhanced group learning and project deliverables in team-based settings, with the treatment group showing greater improvements than the control group, particularly in Integrity and Usability. OIAs can serve as a replicable academic tool to bridge academia-industry gaps by providing experiential, standards-aligned QA training, enhancing graduates' readiness for QA roles, and integrating ISO frameworks into SE education.

Keywords: industry-academia alignment; oral inquiry audits; pedagogy; quality assurance; software engineering; software quality; undergraduate education; zone of proximal development

Guide for Authors

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