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Special Issue

Section I

**Reconsidering Engineering Education: Embracing the Continuum from
Emergency Remote Teaching to Future Learning Paradigms**

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Mobile Applications and Classroom Response Systems to Enhance Learning Performance: An Experience from Digital Competences 266–279

Maylin Suleny Bojórquez-Roque, Luis Magdiel Oliva-Córdova, Antonio Garcia-Cabot and Eva Garcia-Lopez

In the post-pandemic context, higher education has seen a significant transformation, highlighting the importance of digital competences for academic success. This study investigated how students' digital competences influence their satisfaction with mobile applications and classroom response systems (CRS) and how these variables impact academic performance. It used a quantitative design and developed a questionnaire based on the Common European Framework for Digital Competences (DigComp), assessing five dimensions: (1) information and media literacy, (2) communication and collaboration, (3) digital content creation, (4) responsible use, and (5) digital problem-solving.

The sample consisted of 374 undergraduate STEM majors selected by stratified random sampling. Data collection was conducted online via Google Forms. The questionnaire also measured satisfaction with using mobile apps (Padlet, Trello, Canva) and CRS (Quizizz, Mentimeter, Nearpod), along with academic performance. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in RStudio.

The results of this study underscore the need for action in educational practice. They reveal significant relationships between digital competences and satisfaction with educational technologies, which in turn positively influence learning performance. These findings emphasize the importance of integrating digital competences into the curriculum to enhance educational outcomes. Implications for educational practice include the development of strategies and policies that effectively integrate digital competences, thereby improving students, experience and academic success.

Keywords: digital competences; mobile applications; classroom response systems; academic performance; post-pandemic education; PLS-SEM

What has Persisted and What has Not: A Longitudinal Study of Changes in Teachers' Experiences of Project-Based Teaching and Learning Through the COVID-19 Pandemic 280–290

Avneet Hira, Emma Anderson and Peter J. Woods

In this qualitative longitudinal study, we follow and share experiences of teachers from four different high schools in the United States that represent different institutional contexts (Urban, Suburban, Rural, Public and Charter) around how the COVID-19 pandemic impacted their teaching of hands-on Project-Based Learning (PBL) courses. The data is part of a larger study that is aimed at supporting schools transition from traditional to PBL teaching that allowed us to have multiple touch points for this longitudinal study in May 2020, May–June 2021, and December 2021–January 2022. Following a qualitative inductive and then deductive analysis approach, we ask three research questions: RQ1: What changes to teaching made in response to the pandemic in PBL high schools have persisted? RQ2: What aspects of teaching from before the pandemic have returned in PBL high schools? RQ3: What role has technology played in changes to teaching and learning over the course of the pandemic in PBL high schools? We learn how teachers' responses to the pandemic afforded them an ability to use technologies as tools in support of teaching and learning, and finding ways to prioritize what is truly meaningful for their students. We also learned that teachers and students missed in person connection with each other and with the communities their projects were situated in, and also realized the limitations of working on screens. We also share our findings around how learning management and specific task-oriented technologies have persisted in use beyond the pandemic. We conclude the paper with a discussion on the dichotomy of the promise of PBL for pandemic-time and post-pandemic education, and how teachers, the hidden work they do every day, and the ethic of care they bring to their practices is by no means replicable by technology.

Keywords: project-based learning; educational technologies; hands-on learning; teachers

Should Distance Learning be More Widely Implemented in Formal Education of IT Engineers? 291–307

Lidija Ivanovic, Boza Miljkovic and Dragan Ivanovic

This study examines the pros and cons of shifting to a distance learning model within the information technology (IT) education across different education levels. The study is based on a survey and addresses two research questions: Does the transition from in-person to distance learning have a negative impact on the performance of IT students? How does the experience of IT students with distance learning compare to the opinions of non-IT students in other studies? Participants of the survey were students from two IT high schools and three universities. The survey responses were analysed and synthesised using the method of average and

quartile values for numerical data. Moreover, Pearson correlation coefficient was used to investigate correlation between different indicators. A content analysis was used to examine open-ended questions regarding the benefits and drawbacks of distance learning. Results show that technical challenges aren't prominent in IT education; both students and educators are equipped for online learning. However, common issues related to distance learning, such as lack of student motivation and self-discipline, and disengagement from the learning process, persist regardless of the education field. The impact of negative aspects of distance learning on students' performance varies depending on the student's personality and cultural background. However, research has also demonstrated that age and maturity play a significant role. There is a correlation between age and changes in student performance when switching from an in-person to a distance educational model. The Pearson correlation coefficient is 0.73.

Keywords: information technologies; digital learning resources; digital learning tools; knowledge transfer; social interaction

Teaching and Time Efficiency of Using eLearning for Arduino Microcontroller Course: A Case Study

308–324

Š Koprda, M. Magdin, D. Tuček, M. Munk and T. Příbaň

The field of automation and robotics is not only the domain of industry but is increasingly part of our everyday life. We are in contact with so-called Smart devices practically all the time – robotic vacuum cleaners, lawn mowers, smart watches, but also any other accessories in our household, which together create a smart house. Whatever device it is, it must always contain a certain specific control unit. Since smart devices together with control units are becoming a permanent part of our lives, their implementation also requires the attention of teachers at secondary and higher schools for the training of qualified workers who would be able to build or service such devices. The labor market is in a constant deficit of highly qualified experts for the maintenance of current technology and the creation of new generations of automation, IoT devices, and telecommunications. The purpose of this contribution is to analyze the current teaching possibilities in the field of microcontroller programming at secondary vocational schools in Slovakia and abroad. Based on this knowledge, we wanted to design a logically organized and unified e-learning course to increase educational support (increase didactic efficiency) and evaluate the effectiveness of the curriculum we created, the way the tested students work, and compare their knowledge progress. The results of the experimental study carried out by us show that currently the e-learning course no longer increases the didactic effectiveness from the point of view of obtaining a better evaluation, but it significantly contributes to the activity of the students, the way of working with the study material, as well as the time spent in the course.

Keywords: microcontrollers; online education; classic form; time efficiency

Impact of Didactic Strategies and Teaching Practices on Faculty Generations in Education

325–338

Claudia Elsa Rodríguez Medellín, Margarita Del Rosario Yau Flores, Martha Patricia Guzmán Brito, Asad Abbas and Nada Eltaiba

This research explores the influence of educators' generational differences on the educational process, a topic that has garnered considerable attention in recent decades. The study posed the research question, "What is the impact on the educational process of students from the different faculty generations' didactic strategies, pedagogy, technological consideration, teaching practices, and training?" These differences encompass a range of variables, including the professors' personality traits, technology utilization, values, work-related attitudes, leadership styles, teamwork dynamics, work-life balance, and career patterns. These characteristics have manifested differently in their interactions with students in classrooms. In July 2023, 154 teachers from Tecnológico de Monterrey actively participated in this research, coordinated by the Faculty Development and Educational Innovation Center (CEDDIE). Data collection occurred through an online quantitative questionnaire. After sending the survey link, we obtained complete responses from all participants. A thorough analysis of the research findings showed that faculty generation significantly associated with didactic strategies, teaching training and practices, where faculty generation has insignificant association with pedagogical aspect, and technological consideration. This research also shed light on how teachers can improve mutual understanding, respect differences, and cultivate greater motivation when interacting with their students. Furthermore, this study discerned disparities in the teaching-learning practices of different teacher generations. Recognizing the unique generational characteristics of educators is crucial for developing tailored training programs for the specific requirements of each age-range cohort of teachers.

Keywords: educational innovation; faculty generations; higher education; teaching practices; faculty development; skills; Tec21

Impact of Collaborative Learning, Interactivity, Social Presence, and Engagement on the Development of Social Intelligence Competency in Higher Education Students

339–351

Samantha Carissa Sierra, Martha Elena Núñez, Asad Abbas, Mohammad Khubeb Siddiqui and Suliman Aladhadh

Higher education institutions are vital in shaping responsible citizens with the skills to address global challenges. This research paper explores the development of social intelligence competency among higher education students attending Tecnológico de Monterrey (TEC), Mexico. TEC, a leading institution focusing on 21st-century skills, integrates transversal competencies, including social intelligence, into its educational model. Our study investigated factors influencing the acquisition of soft skills, the role of academic institutions in promoting social intelligence, and the benefits for students. We proposed a set of hypotheses postulating collaborative learning, interactivity, social presence, engagement, and development of social intelligence competency as interrelated constructs. To investigate these relationships, we conducted a survey and designed specific course activities to gauge the effectiveness of social intelligence interventions. We administered the Google Forms survey to 62 students enrolled in an industrial design program course. The outcomes were scanned and examined using IBM SPSS version 26 software. Our hypotheses posited significant associations between independent variables (collaborative learning, interactivity, social presence, engagement) and the dependent variable (students' social intelligence development). This study contributes to understanding the importance of social intelligence in higher education and offers insights for educators and institutions on how to prioritize its development.

Keywords: higher education; educational innovation; social intelligence; collaborative learning; competency development; TEC21, soft skills

Evaluating the Usage of ChatGPT for Educational Purposes Through the Extended Technological Acceptance Model

352–364

Jelica Stanojević, Miroslav Minović, Ivana Kovačević and Milica Maričić

The emergence of ChatGPT has affected the educational sector profoundly. This study aims to contribute to the exploration of factors influencing the adoption of ChatGPT for educational purposes using an extended Technology Acceptance Model (TAM) with self-efficacy and Perceived Satisfaction (PS) constructs. A total of 200 IT engineering students at the University of Belgrade, Faculty of Organizational Sciences, completed the devised survey. Structural Equation Modeling (SEM) was employed to investigate paths between proposed model constructs. Based on the results of the study, all original TAM hypotheses were confirmed. Perceived Ease of Use (PEOU) positively influences Perceived Usefulness (PU) and Behavioral Intention (BI). At the same time, PU positively affects BI which positively affects the Actual Usage (AU) of ChatGPT for achieving educational goals. Also, it was shown that self-efficacy does positively affect PEOU and PU. PS affects BI and is influenced by PU and PEOU factors. The study additionally demonstrated that there is no significant disparity in the factors influencing adoption and perceived satisfaction based on gender or type of education (formal or non-formal). Conversely, the duration of usage notably impacts ChatGPT's utility for educational purposes, with prolonged usage correlating with higher levels of positive perception towards ChatGPT.

Keywords: ChatGPT; Technology Acceptance Model; E-learning

Wen-Chih Chang

Artificial intelligence (AI) and data visualization are increasingly used in learning and education. In this study, we used Microsoft Teams for online lessons, incorporating problem-solving learning in a university course on data visualization that included tools like Microsoft Power BI Desktop, Tableau Public, and NodeXL. We designed several problem-based learning topics to demonstrate that integrating problem-based learning into teaching is beneficial and provides quality education. We used a quasi-experimental design, arranging experimental and control groups. The research results were verified through a t-test, showing a significant difference between the experimental and control groups' post-test scores.

Keywords: problem-based learning; university course; data visualization; Power BI Desktop application

Innovating Digital Signal Processing Course Design Post-Pandemic: Blended Teaching and Engineering Education Accreditation

371–384

Yuan Ning

In response to the challenges posed by the post-pandemic era, this study reexamines the Digital Signal Processing (DSP) course design, integrating innovative blended teaching methods aligned with engineering education accreditation standards. We developed a multidimensional teaching model that synergizes online and offline methods with practical, project-based, and case-based approaches, tailored to current industry demands. This model incorporates virtual simulations and real-life scenarios, enhancing the learning experience and preparing students for modern engineering challenges. Our reform's key aspects include a tiered experimental teaching system, improved digital and interactive tools, and practical projects to solidify DSP concepts. These adaptations have notably enhanced student performance in technical skills, teamwork, communication, and innovative thinking, marking a significant step forward in engineering education.

Keywords: blended teaching; DSP Course; engineering education; post-pandemic education; educational innovation

Section II

Contributions in: Divergent Thinking, Engineering Practice, Innovative Media, Students' Satisfaction, Teaching Approaches, E-Learning, Smart Manufacturing, Internship, Mastery Learning, New Engineering Education, Peer Groups, Social Skills, Virtual Reality, Generative AI

Upsetting the Convergence Norm: Investigating Practitioner Engagement in Divergent Thinking

385–397

Laura R. Murphy, Shanna R. Daly and Colleen M. Seifert

Both divergent and convergent thinking processes are core to engineering practice. Engineers can divergently explore many potential approaches, perspectives, and solutions and then ultimately converge on one to pursue. Because convergent processes dominate engineering education and practice, engineers often struggle to diverge while solving engineering problems. Divergent thinking can support complex problem solving, innovative solutions, and engagement with diverse perspectives, but research on its use in engineering is limited to design concept generation. We interviewed 20 engineering practitioners to explore how they engaged in divergent thinking during problem-solving. We identified 17 dimensions described by practitioners as impacting their divergent thinking practices during engineering projects. Practitioners described shaping their divergent thinking engagement through personal knowledge, perspectives, and actions, and pointed to influences from organizational structures, culture, and processes. This evidence suggests an engineering culture where 'convergence is king' fails to meet the needs of engineering practice and education.

Keywords: divergent thinking; engineering practice; engineering culture; professional practitioners

Innovative Media for Teaching and Learning Engineering Drawing: Opportunities for Future Learning and Research

398–408

Andri Setiyawan, Zsolt Lavicza, Adi N. Cahyono and Guillermo Bautista, Jr.

Literature reviews related to learning media are important in determining the reference of innovation and sustainable research. This study describes the types of learning media innovations that already exist, the problems faced, and the development model applied in developing engineering drawing learning media innovations in Vocational High Schools (VHS) as engineering education at the high school level. A systematic literature review of scientific articles published between 2020 and 2024. The results of this study reveal that most learning media innovations focus on developing learning materials and techniques, while fewer innovations develop the learning environment. The problems behind the existing innovations are mainly caused by difficulty in understanding engineering drawing materials, especially orthographic projections, less innovative teachers, and learning resources that are still conventional and non-standard. Research and development of engineering drawings is generally carried out using the 4D, ADDIE, Borg & Gall models. Evidence from these studies suggests that future engineering drawing teaching and learning should be conducted with a real-world approach by presenting the shape of the components or mechanical parts. One of the most plausible research agendas is to develop learning media using 3D print technology for component modeling or tangible forms to support the learning process. It goes beyond vocational education. However, it can also apply to engineering education for pre-service teachers, technical training, and university engineering education. Engineering drawing is a mandatory subject, a fundamental knowledge and skill that students must learn.

Keywords: innovative media; engineering drawing; vocational high schools; engineering education; orthographic projection

The Relationship Between Teaching Approaches and Engineering Students' Life Satisfaction

409–421

Dragan Lj. Bjelica, Marko Mhić, Dejan Petrović, Ivana Peruničić Mladenović, Dejana Pavlović, Duško Bodroža, Mihajlo Djukić, Valerija Dabetić, Anđelija Djordjević Tomić

Through an analysis of formal and informal education and its relationship to life satisfaction among engineering students, our study examines how academic activities offered by educational institutions affect students' life satisfaction and whether there is a relationship between these activities, life satisfaction, and academic performance. A 63-item MANSA questionnaire was developed to measure six characteristics of academic activities to assess life satisfaction: Approach to teaching and learning, support for improving understanding, academic creativity, positive evaluation of teaching staff, positive evaluation of educational institution, and positive evaluation of personal academic performance. Using a sample of 1,638 students from diverse academic backgrounds, six regression analyses were conducted to determine which academic activities contribute to higher student life satisfaction. The results suggest that academic growth in higher education can be enhanced through positive engagement and faculty-student interaction. However, life satisfaction did not have a significant effect on GPA in secondary or higher education. The study identified specific academic activities that contribute to improving students' quality of life, including recognizing critical knowledge, creative thinking, general academic activities, and parental support. Positive evaluations of faculty, educational institutions and personal academic performance, such as teamwork and clear verbal skills, also significantly predicted better quality of life. The

study shows that positive academic practices, such as effective approaches to learning, support for understanding, engaging academic activities, and positive evaluations of faculty and institutions, significantly improve students' life satisfaction (LS) and subjective quality of life (SQL).

Keywords: life; satisfaction; students; education; GPA; MANSA

Enhancing Programming Proficiency: The Role of Interactive E-Learning Tools in Student Success

422–431

Mohammed Yahya Alghamdi

This study investigates the impact of combining e-learning platforms W3Schools and Rafid Learning Management System (RLMS) on programming education at Al-Baha University, focusing on student motivation, perceptions, and academic performance. Rafid Learning Management System (RLMS) refers to an e-learning platform that has been designed uniquely for Al-Baha University courses access and communication between the instructor and the learner. A total of 100 diploma-level IT students participated, divided into two groups: An Experimental Group that used W3Schools for tutorial and RLMS for course content delivery and a Control Group taught through conventional lectures. The results of students' self-perception about the programming and their programming experience were measured through pre and post-experiment questionnaires. It was found that the Experimental Group fared better than the Control Group to an average of 20 percent, and coded 8 percent more than the Control Group ($p < 0.05$). Since correlation analysis focused on e-learning engagement and academic performance, its significance was found highly positive, equal to 0.5460, $p = 0.0000000013$. These findings favor Self-Determination Theory and Expectancy-Value Theory and suggest that higher levels of autonomy, interaction, and improvement of the perceived value of learning are positively related to motivation and academic achievement. The significance of this study lies in its contribution to the growing body of research on e-learning in programming education, especially in the Middle Eastern context. It demonstrates how combining interactive, self-paced, and collaborative e-learning tools can enhance programming skills, boost student engagement, and improve academic performance. The study highlights the importance of integrating such platforms into programming curricula, offering practical insights for educators aiming to optimize digital learning experiences. Further research is recommended to explore the long-term effects of e-learning in programming education.

Keywords: e-learning platforms; programming proficiency; Rafid Learning Management System (RLMS); W3Schools

Integrating Digital Twins into Small to Medium Sized Manufacturers: A Roadmap for Engineering Internships

432–452

Terrance L. Speicher, Joanna F. DeFranco, Charles D. Stricker, Jr. and Soundar Kumara

Industry 4.0 includes implementations of digital twins (DT) that facilitates smart manufacturing enhancements. Unfortunately, integrating DT into small and medium-sized manufacturers (SMM) continues to be a challenge. To address this problem, the landscape of DT literature was analyzed, and the results were used to create a phased DT integration plan for SMM involving engineering student interns. This paper presents the results of a systematic literature review (SLR) and a roadmap for DT adoption in SMM. Data was extracted from the included literature and qualitatively analyzed to determine themes related to the benefits, challenges, use cases, and best practices of DT. The benefits of implementing DT were efficiency/optimization, quality/customization, maintenance management, safety monitoring, and operator training. The challenges extracted to overcome in implementing DT were connectivity, data analytics, automation, and instrumentation. Relevant DT use cases among the literature were at the levels of machine, work cell, production line, and manufacturing factory. The best practices for DT applications were related to information exchange, digital representation, and reference architecture. Ultimately the literature analysis provided the background to create an integration framework for DT in SMM who struggle to take advantage of Industry 4.0 technology. Engineering educators can implement the provided roadmap to satisfy ABET student outcomes while promoting DT adoption in SMM by involving engineering student interns.

Keywords: digital twin; cyber physical system; smart manufacturing; intelligent manufacturing; engineering internships; engineering education

Navigating Mistakes: How Undergraduate Engineering Students Learned to Achieve in a Mastery Learning Course at a Hispanic-Serving Institution

453–475

Carlos L. Perez and Dina Verdin

Mastery learning can help the development of engineering students at Hispanic-Serving Institutions (HSI) by offering multiple opportunities to succeed and allowing for individualized instruction. This educational strategy has been shown to positively affect student performance and learning. Making and correcting mistakes is a key feature of mastery learning courses, yet, there is a lack of understanding of how students react to mistakes and the factors that help students learn from mistakes. We conducted a longitudinal qualitative study with seven engineering students from a Hispanic-Serving Institution who experienced a mastery learning engineering course. The data sources examined were longitudinal interviews, course syllabi, and course grades. We utilized reflexive thematic analysis and longitudinal analysis to explore how individual students described changes in their reactions to mistakes, identify cross-participant patterns in their reactions to mistakes, and examine the factors that facilitated students' learning from mistakes. We found that students experienced an increase in their abilities to learn from mistakes due to some of mastery learning's architectural features. Even after making several mistakes on exams, students experienced an increase in positive emotional reactions and a reduction in negative emotional reactions. Towards the final weeks of the course, some students started to feel negative emotional reactions to mistakes due to the lack of opportunities to achieve the learning objectives. Mastery learning's focus on academic growth fostered a stronger sense of belonging among the women in the study. This investigation provides evidence of ways HSI students may benefit from mastery learning courses, its effects on HSI students' academic development and wellbeing, and women's sense of belonging. HSI servingness can be enhanced by providing equitable opportunities for all students to succeed and fostering a supportive learning environment via mastery learning.

Keywords: mastery learning; mastery-based grading; Hispanic-Serving Institution; longitudinal; qualitative

Strategic Initiatives for New Engineering Education in China

476–491

Lina Wei and Wei Zhang

The New Engineering Education represents a reformative direction in engineering education, and it is grounded in the evolving needs of China's strategic development and international competition. This study conducted comprehensive interviews at 15 representative universities in the field of New Engineering Education, aiming to clarify the strategies for New Engineering Education in China and offer valuable insights for its future development. Specifically, this study aims to address the following research questions: (1) What are the core implementation strategies for New Engineering Education in China? (2) How to determine suitable New Engineering Education strategies for different types of universities? (3) Which transformation strategies are most suitable for traditional and emerging engineering fields? Initially, a theoretical model for New Engineering Education was formulated based on the literature. Subsequently, through semi-structured interviews, first-hand data on New Engineering Education strategies in 15 universities were collected. Methods of content analysis were then adopted to process the data to further verify the conceptual model. The findings reveal that discipline integration, discipline derivation, industry-led and discipline-driven approaches are primary pathways for New Engineering Education. In addition, the New Engineering Education pathway has been widely recognized by several universities. The discipline type and institution characteristics significantly determines the chosen strategies (path). Local universities tend to face more limited options in terms of New Engineering Education strategies.

Keywords: New Engineering Education; strategic initiatives; implementation path

Emmanuel C. Ukekwe, Adaora A. Obayi, Folake O. Adegoke and Godfrey U. Ogbonna

Grass root programming is an essential skill that should be encouraged in Computer and Engineering as it is the driving force of computing. Effective teaching and understanding of computer programming requires practical sessions which can be enhanced through peer and collaborative learning. It is difficult to identify and construct peer coding groups that will re-teach and improve weaker students during practical programming classes especially when the class size is large. In this work, a conceptual model for identifying and constructing peer coding groups for practical programming classes is proposed. The model employs K-Means and Semi-Latin Square properties to cluster weak and strong-performing students based on their previous performance scores and construct formal and equitable peer coding groups for improved learning. The model was tested using the performance scores of students in a Southeast federal university in Nigeria on Computer programming application courses for 2021/2022 and 2022/2023 sessions. A sample of 228 and 194 students were selected for the two sessions respectively. Results recorded a significant difference in the mean score of students who used the model over the ones who did not use the model at ($t_{413,513} = 3.34, p < 0.001$). The average project score for students that used the model was 2.47 per cent more than those that did not use the model. An implementation guideline for the model was also presented.

Keywords: peer coding; Semi-Latin Square; weak-performing students; strong-performing students; K-means; clustering; equitable peer groups

Analyzing Engineering Course Emphases: A Closer Look at Social and Contextual Practices Observed in Required Mechanical Engineering Courses

507–526

Jingfeng Wu, Erika A. Mosykowski, Shanna R. Daly, Joi-Lynn Mondisa and Lisa, R. Lattuca

Engineers must solve complex problems that require comprehensive engineering skills including technical skills as well as assessing social and community impact, applying engineering ethics, and engaging stakeholders. Thus, researchers stress expanding skill development beyond technical expertise to social and contextual skills, which have been underemphasized in engineering programs. In our study, we observed course content discussed by instructors during lectures in required mechanical engineering courses across an undergraduate program at a large, research-intensive university in North America to examine emphasized practices and whether social and contextual practices were included. Our findings revealed that the most commonly emphasized engineering practice was overwhelmingly learning foundational technical knowledge. In addition, we found that social and contextual engineering practices were rarely emphasized in the required ME courses across five ME subfields. As social and contextual skills can impact comprehensive problem solving approaches and who pursues engineering work, we suggest approaches for better integration of more comprehensive approaches as well as clear messaging about what aspects of engineering are emphasized in engineering programs.

Keywords: engineering practice; social and contextual skills; mechanical engineering undergraduate courses; classroom observations

Application of Virtual Reality for Sustainability Education

527–547

Seneshaw Tsegaye, Cijy Elizabeth Sunny, Senthil B. Girimurugan and Jordan Kooyman

Virtual reality (VR) stands as a cutting-edge educational platform facilitating the visualization of intricate engineering and sustainability concepts, yet there exists a notable research gap regarding its potential to enhance sustainability education. This study compared traditional lectures, VR animations on flat screens, and head-mounted VR on student knowledge retention and engagement in sustainability education. A quasi-experimental design was employed with Pre (N = 55), Post-1 (N = 55), and Post-2 (N = 51) assessments to measure content knowledge and perceptions, using both quantitative and qualitative data. Mann-Whitney tests showed significant differences between Pre and both Post-1 ($p = 0.0028$) and Post-2 ($p = 0.0044$), but not between Post-1 and Post-2 ($p = 0.5014$). Content knowledge improved with both VR head-mounted displays and flat screen methods compared to traditional lectures. However, VR with head-mounted displays performed better than flat screen methods. The perception survey analysis used a two-sample test for proportions to compare the delivery modes. Post survey scores indicated that head-mounted VR had higher mean and median values compared to traditional and flat screen methods, suggesting it was perceived as more valuable, engaging, and effective in learning. Sentiment analysis of open-ended responses showed that students rated the flat screen delivery mode more positively in Post-2. Although head-mounted VR showed a similar trend, it didn't achieve the same level of positivity. Enhancing the user interface and visual quality could improve its positive sentiment. The results highlight VR's effectiveness as an educational tool, providing immersive, customizable learning environments and risk-free simulations that could transform sustainability education and equip future leaders for global challenges.

Keywords: virtual reality; VR; sustainability; engineering education; knowledge retention; perception

AI-Assisted Personalized Learning System for Teaching Chassis Principles

548–560

Chin-Wen Liao, En-Shiuh Lin, Bo-Siang Chen, Cheng-Chia Wang, I-Chi Wang, Wei-Sho Ho, Yu-Yuan Ko, Tzu-Hsin Chu, Kuang-Min Chang and Wen-Jun Luo

This study develops a generative AI-assisted personalized learning system for the Principles of Chassis course in Taiwan's Vocational High Schools' Dept. of Auto Mechanics. Using large language models, it provides adaptive content on transmission, suspension, steering, wheel, and braking systems. The research documents the design process, focusing on knowledge transformation, personalized content generation, and abstract concept instruction. The system underwent rigorous validation by eight subject matter experts, comprising three automotive engineering professors, two vocational education specialists, two AI/educational technology experts, and one industry expert with extensive practical experience. Implementation testing involved 35 students and two experienced teachers, with expert evaluations showing the system's effectiveness in personalized learning, especially for complex chassis concepts, receiving positive feedback from users. The study contributes to teaching innovation in automotive education and offers insights for similar systems in other courses. Future research will explore broader applications in Taiwan's vocational education.

Keywords: generative AI; personalized learning system; principles of chassis; vocational high schools

Guide for Authors

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