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Ahmad Ibrahim

Evaluation of an Immersive VR-based Chemical Production Safety Learning Using a Transferable Psychosomatic Approach 777–797
Hongfei Xu, Yuanyu Zheng and Jeremy S. Liang

Considering effective transfer of knowledge and skills in chemical production safety, virtual reality (VR) technology is adopted to build training platform of safety operation. This study focuses on shortening the breach between the highly demanded human-machine interactions and the learning approaches utilized in process engineering by experimentally evaluating the effectiveness of different learning approaches in an image-based unusual state. The trainees' performance are assessed through quantifiable measures, learning efficacy and performance, used for the specific objectives. The result reveals that testable training in VR for complicated safety-specific activities is not statistically different from the conventional lecture mode. But VR learning shows an appreciable positive enhancements in participants' perceptions of entire learning and their existence on task during the training. Also, it reveals that the knowledge retention rate of video-based lecturing can be over-validated if left unchecked. The positive results of this method lie in improving the dependability, reducing damage costs and enhancing safety performance in chemical operation process.

Keywords: process engineering; immersive environment; simulation of operation learning; methodologies of learning and evaluation; chemical safety education

Investigating an Asynchronous Model for Incorporating Social Aspects of Engineering Work into Engineering Design Courses 798–810
Erika A. Mosykowski, Shanna R. Daly and Steven J. Skerlos

This paper describes an implementation study of the Social Engagement Toolkit (SET), a library of trainings on various topics related to socially engaged design and engineering. The customizable SET trainings include asynchronous hybrid learning blocks intended to facilitate instruction on socially engaged engineering topics by non-expert instructors in a range of engineering courses, as well as live expert instruction and entirely virtual instruction, developed for online courses in the 2020–2021 academic year. The SET seeks to foster much-needed socially engaged engineering skills among undergraduate engineering students, while addressing potential barriers to curricular change, such as instructor motivation and prior training. We examined the incorporation of the SET into multiple sections of a senior-level capstone course and a project-based introduction to engineering course to understand the experiences of early adopter faculty and their students. This paper describes faculty's motivations for and their experiences with implementing the SET in their classes, strengths and challenges of the toolkit, and the perceived influence on and relevance to students' course work and future academic and professional plans.

Keywords: instructional change; engineering design; socio-technical thinking

Development of Survey Instruments to Measure Undergraduate Engineering Students' Entrepreneurial Mindset: Connections and Creating Value 811–822
Meagan E. Ita, Meg E. West and Rachel L. Kajfez

The inclusion of entrepreneurial concepts into undergraduate engineering curriculum has proliferated over recent years. Entrepreneurially Minded Learning (EML) is a common approach for teaching the Entrepreneurial Mindset (EM) and is grounded in opportunity and impact recognition as well as attributes including Curiosity, Connections, and Creating Value (3C's). Faculty across many institutions have made efforts to include EML into curriculum and developed instruments to assess the efficacy of these efforts on student outcomes. However, existing assessment instruments fail to adequately characterize individual attributes that make up an EM. In this study, we describe the development of two indirect surveys to assess the EM attributes of Connections and Creating Value. The two Likert-type scale surveys were constructed using the Kern Entrepreneurial Engineering Network (KEEN) EML framework and institutionally developed EM Learning Objectives and were implemented into a First-Year Engineering Program at the beginning and end of the 2021–2022 academic year. An Exploratory Factor Analysis (EFA) on the Autumn 2021 data (n = 215 student responses) suggests four factors that describe the variance in Connections survey data; these factors contain content we describe as (1) Integrate Outside Information, (2) Consider Social, Economic, and Environmental Factors, (3) Define Connections, and (4) Make Connections within Engineering Design. An EFA on Creating Value survey data (n = 206 student responses) suggests three underlying factors: (1) Create Value within Engineering Design, (2) Attitude and Approach Toward Value Creation, and (3) Create Value for Others. A paired analysis of 101 student responses between the beginning and end of the academic year was conducted for survey validation. This analysis reveals that students' views on their believed ability to "Integrate Outside Information" and "Make Connections within Engineering Design" increased significantly over the academic year. Student views on their abilities to Create Value across all factors also increased significantly. Collectively, these findings suggest where students experience growth in these attributes of EM over their first year in engineering and provide evidence that EFA solutions can reasonably detect such growth over time. Future work includes more rigorous validation efforts and expansion to broader populations. This study presents a first step toward establishing validated instruments for the characterization of Connections and Creating Value EM constructs across institutions.

Keywords: entrepreneurial mindset; exploratory factor analysis; assessment; first-year engineering

Sheng-Jen (“Tony”) Hsieh

A low-cost portable programmable logic controller (PLC) kit consisting of a controller module and three swappable special function modules – Basic I/O, Sensor, and Automated System – was designed, built, and evaluated. The special function modules can be quickly connected to or disconnected from the controller module to teach different aspects of automation and control, including PLC programming fundamentals, sensor applications in automation, I/O interfacing, and system integration concepts. The kits were used within an upper-level undergraduate manufacturing automation and robotics course to provide students the opportunity to practice programming fundamentals while still in the classroom and for a system integration project in which students built small-scale working models of automated systems. Kits with Basic I/O and Sensor modules were evaluated by 80 students and kits with the Automated System modules were evaluated by 12 students. Evaluation results suggest that the Portable PLC kit is both usable and useful for helping students to practice PLC programming concepts. Students appreciated the opportunity to immediately practice concepts taught during lecture and to visualize results. In addition, students who used Portable PLC to build an automated system found the experience to be helpful for understanding how to interface devices and for integrating the concepts learned in class.

Keywords: programmable logic controller; automated systems; industrial automation education

Predicting Academic Performance of Students in a Computer Programming Course using Data Mining

836–844

Ivan Peračić and Ani Grubišić

The purpose of this work is to analyze data from the learning platform Moodle to predict the academic performance of the student in Programming class course. We used six machine learning classification techniques to extract a pattern from student Moodle using two datasets. In the first dataset, grade is in binary categorization (pass/fail), and in the second dataset grade is in a three-level categorization (fail, good and excellent). The research applies all possible combinations of eleven features for the selection of best predicting features, so we examined a total of 24432 prediction models on both datasets. The results show that Logistic Regression obtained the best results on binary dataset and Random Forests obtained the best results on three-level grade categorization, in terms of accuracy, precision and recall. We showed how the same classifiers on different features can give very similar results. In other words, there is no single best prediction model that significantly outperforms the others, but there are several very similar models that differ in the number of features selected and the selected classifier.

Keywords: data mining; predicting student performance; data mining classification; feature selection

Design, Fabrication, Testing, and Implementation of a Low-Cost Venturi Meter for Hands-on Active Learning

845–859

Aminul Islam Khan, Olivia M. Reynolds, David B. Thiessen, Olusola Adesope, Bernard J. Van Wie and Prashanta Dutta

In engineering education, conceptual understanding of the subject matter is as important as the attainment of practical skills. Therefore, teaching methodology should be designed in such a way that it enhances student conceptual understanding. To enhance conceptual understanding of fluid flow measurement, in this study, we report on the development of a low-cost, small-sized, reproducible, highly visual venturi meter module for active learning. With this module, students can conduct fluid flow experiments in their classroom or lab setting to learn the fundamental principles behind the venturi meter. Quantitative measurements of flow rates and associated parameters with the module reveal its usefulness for demonstrating fluid flow physics, while worksheet-guided studies promote student engagement and conceptual understanding. Results of pretest, posttest, and motivational survey assessments show that the module and associated activities improve conceptual understanding, result in a surge in confidence, and reinforce the desire to participate. Therefore, based on the findings, the modules developed can be used to enhance student understanding in fluid mechanics courses.

Keywords: venturi meter; hands-on experiments; fluid mechanics; flow measurement; active learning

A Validated Assessment Tool: Students’ Perceived Value of Engineering Laboratories in a Virtual Environment

860–876

Kimberly Cook-Chennault and Ahmad Farooq

Experimental laboratories are required for all engineering disciplines to fulfill undergraduate degree requirements. These capstone laboratories are designed to reinforce fundamental science, technology, engineering, and mathematical content associated with core aspects of the discipline. These laboratories are usually physical experiments; however, the emergence of online degrees, the COVID pandemic, and the development of virtual lab technologies have expanded how students experience capstone labs. An instrument is needed to measure the relationship between students’ engineering role identity, technology acceptance, and prior learning experiences. This study reports the development and validation of a Student Perceived Value of an Engineering Laboratory (SPVEL) assessment instrument for capstone mechanical and aerospace engineering laboratories. The items for the SPVEL assessment instrument were constructed according to three theoretical models: The Technology Acceptance Model (TAM), Inputs-Environment-Outcome (IEO) Conceptual Model, and Engineering Role Identity (ERI). An exploratory load factor analysis was conducted on responses to thirty-five questionnaire items to discover the underlying factor structure of the dataset. Squared multiple correlations were used as prior communality estimates, and the principal axis factoring method was employed to extract the factors. The study was conducted in a capstone senior Mechanical and Aerospace engineering laboratory course at a university in the northeastern United States with 227 undergraduate participants. Six factors were extracted, and Cronbach’s alpha for data reliability was found to be 0.86 for the set of thirty-five questions and within the range of 0.67 to 0.94 for all six factors. Thus, this SPVEL assessment tool had high internal consistency of reliability coefficients. The SPVEL Assessment tool provides a mechanism for observing how students interact with and experience engineering laboratories. The relationships between students’ ability to leverage prior experiences and learn from the laboratory experience, prepare for their roles as engineering professionals, and accept innovative technologies used for teaching engineering education are also forms of information gleaned from this tool. Using the SPVEL assessment instrument could enhance the literature on evaluating the effectiveness of undergraduate engineering laboratories and facilitate the improvement of laboratory design in undergraduate mechanical and aerospace engineering laboratory environments.

Keywords: assessment tool; instrument validation; engineering laboratory; technology acceptance model; engineering role identity; I-E-O conceptual model

Application of Problem-Based Learning to Promote Critical Thinking Disposition Among Engineering Undergraduates

877–885

She-Ping Tian, Li-Juan Wang, Feng Zhang and Tao Han

Previous studies have shown that the problem-based learning (PBL) is an effective approach for engineering education. This research explores the impact of the PBL approach on engineering students’ critical thinking (CT) disposition. A quasi-experimental design with quantitative and qualitative data analysis was used. An experimental class with 61 students was taught with the PBL approach, whereas a control class of 63 students adopted the traditional lecture-based learning. A Chinese version of the California Critical Thinking Dispositions Inventory was used to evaluate the participants’ CT disposition. Evidence collected from quantitative surveys and qualitative data indicates that: after a semester of teaching circuit theory with PBL, the CT disposition survey scores of students from the experimental class had significantly increased, while there were no significant differences between pre-tests and post-tests for the control class.

Keywords: circuit theory; critical thinking disposition; problem-based learning; engineering education

Staša Zeković, Stanislav Grgić, Igor Maraš, Jelena Atanacković Jeličić and Milena Krklješ

Augmented Reality (AR) has found many purposes over the years, and it is constantly being explored and improved. With its effective and attractive combination of virtual objects superimposed in a real surrounding, many have considered or already implemented AR technology as a part of developing education and learning process. With architecture being a visual and engineering discipline, this paper questions how beneficial would presenting and learning through AR be for architecture students. Two AR files have been created and tested by students, and then a survey has been carried out. The first file includes an exhibition space that questions the potential of a presentational tool in education, while the second file includes a green roof cross section questioning its usefulness as an education manual developing students' engineering and visual comprehension. The aim of this paper is to present the results in order to enhance the current architectural education system through AR, having in mind the benefits of a more pragmatic, interactive tool, as well as the disadvantages and limitations that come with it. It is concluded that the students praised the green roof file more, finding that they lack better understanding of engineering concepts, rather than needing AR as potential presentation tool. Possible outcomes could be an app-textbook or an online textbook containing different educational AR files helping students master subjects and prepare them for the exams.

Keywords: augmented reality; architectural education; presentation; learning process; iOS device

Technology in Online Education: The Factors that Influence Student Acceptance and Satisfaction

897–905

Cristóbal Fernández-Robin, Noah Silva and Diego Yáñez

The objective of this study is to identify the factors that have the highest influence on technology acceptance and satisfaction with online education through variables and scales previously used in the literature, including the perception of service quality for online education, online learning acceptance and satisfaction, perceived usefulness, and perceived ease of use, as well as control variables. The hypotheses proposed were validated through a confirmatory factor model, using the responses of an online survey for undergraduate students, totaling 410 responses. The findings are consistent with previous articles, and it was also found that students perceive and evidence that their expectations of usefulness and ease of use come to increase their acceptance and satisfaction with online education. The results also indicate that some variables assessed, such as teachers, support systems, delivery platforms or channels, and internet speed, are factors that affect acceptance regardless of the usefulness or ease of use perceived by students.

Keywords: online education; technology; acceptance; service quality; support; teachers

Outreach Program for Middle and High School Students to Promote Transportation Engineering

906–920

Olivia Willis, Cheryl Reed, Yan Zhang and Xianming Shi

Introducing children to transportation engineering through outreach is essential to meeting the future need for transportation engineers. An online activity was designed in Qualtrics, consisting of survey questions, a pre-activity test pertaining to transportation engineering, links to educational videos, a transportation game, a post-activity test to gauge learning, and a short essay. Participants were recruited through local middle and high schools and through TRIO Upward Bound Math-Science programs nationwide. The students would perform better on the post-test survey than the pre-test survey, indicating the occurrence of learning and the one-direction t-test revealed that the improvement was statistically significant. The relationships between gender, grade, and the improvement on the content questions were analyzed using box plots. The male-identifying students had higher scores overall, but similar levels of improvement occurred for both male and female students. The 8–10th grade students improved the most among the various grade levels. The students reported enjoying the activity and having an increased interest in transportation engineering. Overall, the online survey with videos, games, and engagement questions proved to be an effective outreach method. These results shed light on the design of future outreach projects as the effects of the pandemic may last.

Keywords: outreach; recruitment; engineering curriculum; transportation

Architectural Engineering Students' Experiences in a Hybrid Design Studio

921–936

Jelena Milošević, Ivana Rakonjac and Andrej Josifovski

In response to the COVID-19 global pandemic's effects on the educational landscape, information and communication technologies have been used to implement diverse curriculum contents and provide a transition of traditional learning activities into remote or hybrid learning. This paper describes how a digital learning framework was implemented to transform a classroom-based architectural design studio into a setup that complements face-to-face and online activities, allowing for optimal operation under restricted conditions. The learning experience in this hybrid design studio was investigated using qualitative content analysis, while data from pre- and post-course surveys, and data from the learning platform's analytics, provide insight into the participants' perceptions of the course. Findings show that students' assessments of hybrid learning are generally positive; however, further development of this pedagogy could provide even better responses to accessibility, acquisition, and operation challenges. The study offers a perspective on how to adapt learning in order to provide continuity of educational process beyond changing circumstances and could inform further reviewing and discussion on directions of long-term redefining of a studio design in post-pandemic times when teaching modes are likely to have a more significant online component.

Keywords: architectural education; design studio learning; hybrid learning; emergency learning; remote education; online education; learning design experience; COVID-19

Perspective of Malaysian Undergraduate Engineering Students on Academic Plagiarism

937–948

Wan Hanna Melini Wan Mohtar, Wan Ikhlas Wan Mohtar, Siti Nur Eliane Suriane Shokri and Huda Abdullah

A fundamental step in formulating an appropriate guideline for plagiarism for undergraduate engineering students in Malaysia is understanding their perspectives on plagiarism in academic exercises. Five key exploratory elements are discussed, i.e., awareness, types, reasons, solutions and impacts of plagiarism in unsupervised academic exercises. The perspectives of 270 students from the four core disciplines, and including the architecture department, which involves first, second, third, and final year students, were obtained using an open-ended survey. Data suggests that engineering undergraduates are fully aware of what plagiarism is and understood that plagiarism is an academic offence. A high percentage 79.7% of the respondents – admit to routinely and consciously committing plagiarism due to the habitual characteristics of a student. The absence of a clear guideline by the university regarding the consequences of committing plagiarism further abetted the students to commit the offense. Seventy-four percent of the respondents preferred that plagiarism cases to be handled internally and settled at the discretion of the module convener. Although the students are highly aware (79.7%) notion of plagiarism, this does not correspond to the same level of awareness in the implications of the consequences of being caught. This suggests that students are not deterred by the moral ramification of plagiarism, whilst justifying their actions based on the overwhelming pressure to get good grades.

Keywords: exploratory elements of plagiarism; Malaysian university; engineering undergraduate students; plagiarism actions

Automated Intelligent Feedback Based Learning in a Software Development Project Management Course

949–960

Juan J. López-Jiménez, José A. García-Berná, Ambrosio Toval, José L. Fernández-Alemán and Ali Idrí

This paper presents an empirical study of a formative assessment approach based on intelligent diagnostic feedback. A public audience response system called SIDRA was integrated with clustering-based data analysis to generate diagnostic feedback for guided learning. A total of 138 computer science students enrolled in a Software Development Project Management course during

the 2021/2022 academic year were taught using two different strategies. Eighty students in the experimental group used intelligent SIDRA (i-SIDRA), while 58 students in the control group received the same training but without using i-SIDRA. A statistically significant difference in final exam grades was found between students using i-SIDRA versus a traditional teaching methodology ($U = 3306, p < 0.001$). No statistically significant differences were obtained in the final grades between the elaborated feedback group and the reduced feedback group in the two experiments ($T(5,190) = -1.928, p = 0.110$ and $U = 443, p = 0.474$) conducted to evaluate the effectiveness of the two types of feedback at the end of the semester. No statistically significant differences were reached in the increase of correct questions from the first to the last attempt during the feedback-guided learning process, between the elaborated feedback group and the reduced feedback group in the two experiments carried out ($T(19) = 0.217, p = 0.831$ and $U = 699, p = 0.542$). In a questionnaire rated on a five-point Likert-type scale, students stated that i-SIDRA feedback promotes clarification and understanding of concepts ($MD = 4$).

Keywords: e-learning; feedback; intelligent systems; project management

Immersion Experiences for Biomedical Engineering Undergraduates: Comparing Strategies and Local Partnerships at Two Institutions 961–975

Justin Huber, Steven Higbee, Christina Espinosa, Babak Bazrgari and Sharon Miller

Immersion experiences for undergraduate students in biomedical engineering are key contributors to their ability to identify medical needs. Despite this, as few as 25% of surveyed programs report providing such opportunities. Since 2010 when the National Institute of Health began its R25 grant mechanism to support curricular development toward team-based design, several institutions have established programs for immersion experiences, which provide precedent for their implementation. Published results from such immersion experiences highlight successes in structure and changes in student perspectives after these experiences. As more institutions expand their biomedical engineering curriculum with new immersion-focused programs, it is important to learn from these precedents while also considering opportunities to improve. For newly funded groups that are developing and implementing programs, they may find improved success by strategic use of unique partnerships. However, these partnerships may not be immediately evident to program organizers. Our objective is to discuss two institutions that recently established programs for immersion experience. In the comparison of our two immersion programs, we found five overlapping core features that include: immersion partner collaboration, team-based immersion experiences, needs-finding emphasis, team-based engineering design experiences, and immersion assessment and evaluation. Both programs developed collaborative partnerships with nearby medical schools. Additionally, one program partnered with a community resource (i.e., Human Development Institute). Despite nuanced program differences, we found that students at both programs self-reported increased knowledge or confidence in aspects of the design process (e.g., identifying and refining user needs, concept generation). Our results also highlight student gains unique to their programs – UK students self-reported gains on disability topics and IUPUI students self-reported gains on socioeconomic awareness. In summary, immersion partner collaboration, or partnership, surfaced as a core feature for both programs, and students in both immersion programs endorsed enhanced knowledge or confidence in engineering design.

Keywords: experiential learning; evidence-based practice; clinical immersion; user needs; engineering design

Exploring the Research Enterprise in a Hispanic-Serving Institution: A Systems Thinking-Informed Case Study of Graduate Advising in an Engineering College 976–985

Mayra S. Artilles, Natali Huggins, Holly M. Matusovich and Aidsa I. Santiago

Hispanic-Serving Institution (HSIs) hold much promise for increasing access to graduate education, yet little is known about their research enterprise and the experiences of their graduate students. This case study interviewed seven stakeholders in one HSI's engineering college and employs a systems-thinking approach to uncover how this institution balances the needs of its graduate students with its institution's research support. Our findings reveal a complex relationship between this institution's research enterprise and its graduate advising activities, as maintaining the HSI's teaching mission while accommodating research activities creates limitations and mixed messaging. However, we also found that building research collaborations with other high research status institutions can provide more resources and opportunities beyond what the HSI institution can provide. Overall, our study highlights the importance of understanding the dynamics between research and teaching missions in HSIs in any effort to increase research and promote graduate education in such contexts.

Keywords: graduate advising; research enterprise; Hispanic serving institution

Improving and Assessing Self-Awareness of Undergraduate Mechanical Engineering Students: A Case Study from Chile 986–1001

Rodrigo Pascual, Andrés Pucheu, Nicolás Bravo, Catalina Quiñones and Juan Ross

The Covid-19 pandemic, the rise of artificial intelligence and major societal changes have meant disruptive changes in how to achieve education everywhere and at all educational levels. Increasing uncertainty and complexity motivate a reevaluation of the role of engineers in the future society and what skills will matter more in the work market and society. Such a context has inspired and/or forced a series of changes in active learning strategies. This paper describes a course-level learning hybrid methodology that has been implemented in a mechanical-engineering curriculum. The methodology combines concepts from three bodies of knowledge: *cultural materialism*, *social cognitive learning*, and *transactional distance theory*. A blend of activities is proposed to enhance the active learning of students. Through in-class collaborative problem solving, the provision of spaces for reflection and exploration of self-awareness, and a project work that culminates with an open seminar, the aim is to develop technical and the so-called XXI century skills, in particular, self-awareness skills. Such an approach would better prepare students for the ongoing uncertainties and future professional and interpersonal situations. The case study shows promising results that have been documented through self-perception and self-efficacy surveys from students and alumni. The proposed method helped students to achieve the learning outcomes of the course, increased their engagement, and allowed them to exercise their self-awareness as a complement to their development of technical skills.

Keywords: transactional distance; social cognitive theory; active learning; 21st century skills; self-awareness

Improving Oral Presentation Skills of Graduate Engineering Students with Web-based Collaborative Problem-Posing and Self/Peer Assessment 1002–1011

Ai-Jou Pan, Chin-Feng Lai and Pao-Nan Chou

The increasing focus on developing students' oral presentation skills has stimulated research on the integration of innovative learning strategies for oral presentation activities. Nevertheless, research focusing on applying innovative learning strategies to oral presentation activities in engineering courses is limited. To enhance oral presentation activities in engineering, the current study systematically integrated collaborative problem-posing strategies with self- and peer assessment into engineering statistics courses with 37 engineering graduate student participants in Taiwan. A one-group pretest-posttest quasi-experimental design was applied to investigate the effectiveness of web-based collaborative problem-posing with self- and peer assessment on engineering graduate students in engineering statistics courses. The correlations between students' self- and peer assessment and instructors' assessment were also examined to evaluate validity. The results indicated that the students' oral presentation performance significantly improved after the experimental teaching of web-based collaborative problem-posing with self- and peer assessment. Nonetheless, no statistically significant improvement was identified in students' motivation. Additionally, teacher assessments of oral presentation performance were highly correlated with peer assessments and moderately correlated with students' self-assessments. Limitations of the present research and recommendations for future research are provided.

Keywords: oral presentation; engineering courses; collaborative problem-posing; self-assessment; peer assessment

Borja Bordel, Ramón Alcarria and Tomás Robles

In the last fifteen years communication paradigms have radically changed. From relations mostly based on synchronous and face-to-face conversations, to formal emails and phone calls and, today, videoconferences and different asynchronous chat mobile applications. This change has also affected higher education, where many innovative strategies and instructional tools enabling communication among students and with professors, have been implemented. The final objective of all these mechanisms is to increase the impact of the tutorial action, thanks to a fast and continuous interaction with professors and the collaborative learning among students. However, informal observations seem to show that some tools and/or strategies are more successful than others, depending on the teaching and learning methodology. Therefore, this paper aims to study the impact of different communication tools and strategies in the higher education students' learning, including academic results, motivation competence acquisition level. We are focusing on blended and online methodologies, as they are implemented in most current engineering degrees. The study considers five subjects analyzed during three different courses. Four different communication instructional tools were also studied, including forums, emails, Telegram and Discord. Besides, four different communication strategies were also considered. Results were evaluated using statistical methods. Results show the improvement in the students' learning is especially relevant when chat applications and immediate responses are provided in the context of online teaching methodologies. In blended methodologies, on the other hand, chat applications are clearly preferred too, although improvement may be achieved with almost any tool.

Keywords: communication tools; communication strategies; engineering education; blended methodologies; online methodologies