Contents

Section I
Special Issue
Selected papers from the 2019 International STEM in Education Symposium : Innovative Vision for STEM Education and Teaching

Guest Editor
Feng-Kuang Chiang – Shanghai Normal University, Shanghai, China

Section II
Contributions in: Active Learning, Problem Solving, Identity, Hidden Curriculum, Employability, Metacognition, Motivation, PBL, Flipped Classroom, First Year, Expert vs. Novice, Simulations, Instructional Change, Capstone Design, Team Performance, Remote Laboratories, Computer Engineering, Civil Engineering, Graphics Engineering, Mechanical Engineering, Industrial Engineering, Robotics, Engineering Education Studies

The 2019 International STEM in Education Symposium was successfully held at Southwest University in China from 20 to 22 November 2019, with a primary theme of Innovative Vision of STEM Education and Teaching. Scholars from all over the world conducted eight themed reports concerning the relevant theories, cases and practices of STEM education to jointly explore the innovative teaching ideas in STEM education. This editorial discusses the plan and structure of the symposium, shared excellent STEM practice cases at the symposium, and introduces the progress and research characteristics of Chinese STEM education at the symposium.

Keywords: STEM education; instructional innovations; interdisciplinary research

This study built a behavioral learning engagement model for learners in online courses in colleges and universities, and conducted an empirical study based on this model with the aim of exploring learners' learning behavior in online courses and its influence on academic performance. The study sample comprised of 301 learners who participated in an engineering online optional course offered by a comprehensive university in western China. Clustering analysis and multiple linear regression indicated following results: (1) during studying the online courses, learners' overall behavioral learning engagement is low; (2) there are differences in behavioral learning engagement and academic performance among learners of different genders and subject backgrounds; (3) according to the online behavioral learning engagement and academic performance, learners can be divided into "Active learning", "Passive learning" and "Achievement-driven"; (4) there are significant differences in the influence of behavioral learning engagement of different types of learners on academic performance.

Keywords: online courses; behavioral learning engagement; academic performance; colleges and universities; participation; concentration; interaction; performance effort; regularity

STEAM education is based on solving real problems and projects, carrying out interdisciplinary integration and skills training; Design thinking emphasizes the double spiral relationship between design and thinking, which has the dual attributes of generative and creative; Deeper learning as an efficient learning method, faced with the complex problems of high-quality talent training. The research with 522 Chinese high school students as experimental objects which analyzed the reliability, validity and regression of research data by using the scales of STEAM, design thinking, and deeper learning, explored the relationship between STEAM instruction, design thinking and deeper learning. The experimental results show that: gender and grade have little effect between the three; design thinking is the main object of STEAM instruction; design thinking is subordinate to deeper learning; STEAM instruction is a learning pattern to deeper learning.

Keywords: STEAM instruction; design thinking; deeper learning; relationship representation; empirical research

Liqiao Nong, Lanlan Zhang and Geping Liu   1461–1471   English as Second Language Curriculum from the Perspective of STEM in Chinese Engineering Undergraduates

This study investigated language leaning beliefs in Chinese engineering undergraduates and find out the relationship between language learning beliefs and current teaching materials and curriculum, aiming to enhance engineering undergraduates' learning effectiveness and teachers' teaching strategies. In addition, suggestions and recommendations from the perspective of STEM for English as second language curriculum and teaching strategies are provided. A total number of 560 engineering undergraduates' language learning beliefs are investigated with Horwitz' Beliefs about Language Learning Inventory (BALLI) from 8 universities in China. A mixed-method methodology was developed, one that uses both quantitative and qualitative tools. More specifically, multivariate regression analysis was applied to analysis database. The findings in our survey revealed that, firstly, the overall situation of Chinese engineering undergraduates is not so satisfactory. And the prior knowledge of them is in the medium level. Furthermore, factors that affect students' learning beliefs were apparent, such as foreign language aptitude, difficulty of language learning, nature of language learning, learning and communication strategies, motivation and expectations. We concluded by exploring the language learning beliefs in Chinese engineering undergraduates and the appropriate way in curriculum design from the perspective of STEM education, interdisciplinary curriculum design were encouraged applied in English as second language in engineering education.

Keywords: engineering undergraduates; English learning beliefs; learning Strategies; English curriculum; STEM education

Hong-Liang Ma, Xiao-Hong Wang, Ming Zhao, Lin Wang, Mei-Ru Wang and Xu-Jia Li   1472–1479   Impact of Robotic Instruction with a Novel Inquiry Framework on Primary Schools Students

Blended learning has been widely used in K-12 schools, including robotic instruction. This study considers a novel inquiry learning framework in robotic classes, integrated LEGO 4Cs process with engineering CDIO approach together, which emphasizes project-based and authentic learning. To examine the effect of the new learning framework, a quasi-experimental method is conducted in two elective mixed-age classes (with 3rd and 5th grade students), and quality of student engagement and artifacts are evaluated, accompanied with semi-structured interviews. Results show that this framework: (1) significantly improves students' learning engagement towards STEM, and (2) positively improves students' engineering thinking skills. The findings can help inform instructional strategies to encourage more K-12 students to engage in STEM field.

Keywords: robotic instruction; STEM pedagogy; engagement; engineering thinking

Li Li, Chun-Hao Chang and Feng-Kuang Chiang   1480–1491   Investigating How Children Learn and Perceive Engineering Design Knowledge Through Automotive Design Practices

This study investigated the effect of automotive design practices on elementary school children's engineering design knowledge as well as perceptions. We designed an automotive engineering design course with knowledge from each of the four STEM subject to engage fifty-six 6th graders in a four-week long design intervention. To ensure the effectiveness of the course, the design-based approach was adopted, producing two iterations of intervention to align pedagogy with observed learning outcome. Three measures were implemented to investigate changes in one's engineering design knowledge and perception before and after the intervention, including (1) the Knowledge Measure, (2) the Self-efficacy Measure and (3) the Design Process Measure. It was found automotive design experiences improved participants' overall understanding of STEM knowledge while changes in mathematics were most apparent. Significant differences in participants' self-efficacy were found in the second iteration, such as goals orientation, sketching and prototyping. Lastly, through graphical analysis, we found participants' engineering design process was improved after the automotive design intervention.

Keywords: engineering education; automotive design; elementary school; interdisciplinary STEM knowledge; self-efficacy

Victor Flores   1492–1504   Improving Students' Learning Skills for Developing a Software Project using Active Learning Techniques: Service-learning and Agile Software Development

Agile software development methodologies are currently used to improve the performance of software application development with the active participation of the client. Service-learning is an active methodology that has been applied in several teaching areas and multiple areas of knowledge at college level. Several papers propose software project development based on agile methods in learning contexts, but papers focusing on efforts to combine Service-learning with agile software development methods to improve students' software development project skills are not so common. This paper reports the experience of combining Service-learning with the stages of a software development methodology inspired by Agile Manifesto. It describes a teaching innovation, which consists in providing students with an active and motivating teaching-learning environment in a computing subject to attain three objectives: (1) improving students' skills for developing high-quality software applications in a working context similar to professional software development practice; (2) decreasing the subject drop-out rate; and (3) familiarizing students with solidarity and community work. This pilot experience at a university in northern Chile involves the active participation of a community partner (Help Desk for People with Disabilities at Antofagasta Municipality). This paper describes the methodology used in the creation of a software product (prototype version) in the context of solidarity work for regional Paralympic games. The innovation was developed within the framework of a subject in the Major in Computer and Information Technology Engineering. Twelve students participated in this teaching innovation, obtaining encouraging results concerning the attainment of objectives. There was an active participation with 90% passing students; drop-outs decreased to 0%; and students worked very closely and professionally with the community partner.

Keywords: active learning methodologies; software architecture; meaningful learning; service-learning

Gianpiero Cabodi, Paolo Camurati, Paolo Pasini, Denis Patti and Danilo Vendraminetto   1505–1528   Schema-Based Instruction with Enumerative Combinatorics and Recursion to Develop Computer Engineering Students' Problem-Solving Skills

Learning and teaching problem solving is a hard task, no matter the domain. Computer Science is no exception. Recursion is a paradigm often used for problem solving, but it is non-intuitive and it is unnatural. Most second programming courses (*CS2-level*) for Computer Engineering students apply recursion to mathematical problems or basic recursive data structures with a limited focus on problem solving. Third programming courses (*CS3-level*) deal with search and optimization problems and they use recursion because of its ability, due to its backtracking mechanism, to explore the whole solution space. However, most of them do not rely on a systematic and well-formed approach to teaching this approach to problem solving. Our main contribution is to adopt schema-based instruction for recursion-based problem solving, where schemas come from Enumerative Combinatorics. This is the core of our attempt at developing second-year computer Engineering students' problem-solving skills. We provide the students with these schemas as templates in the C language to guide them step-by-step in solving search and optimization problems with uninformed and complete algorithms. To extend the applicability of this approach to other than small-size problems, we show students how they can introduce pruning to limit search while keeping it complete. We present experimental evidence we gathered for our second-year *CS2+CS3* programming course for Computer Engineering students at Politecnico di Torino, a major technical university in Italy. We evaluate students' perception of the approach in terms of understanding and of ability to apply it. We compare students' perception to faculty expectations and we evaluate students' performance in terms of improvement in the success rate at exams. Data prove that the approach we adopt is beneficial both in terms of quantitative results (success rate at exams) and qualitative results (knowledge and skills acquired by students).

Keywords: applied computing; education; schema-based instruction; theory of computation; algorithm design techniques; recursion; problem solving

Angela Minichiello and **Emily Hanks**   1529–1548   Becoming Engineers in the Middle Years: Narrative Writing as Identity Work in an Undergraduate Engineering Science Course

In this qualitative research study, we engaged engineering undergraduates enrolled in a 2nd year engineering science course in a narrative reflective writing exercise in order to explore processes of identity recognition and re/construction within the early, technical engineering curriculum. During the final week of the course, ten participants (two female, eight male) generated qualitative data including reflective narrative accounts of their experiences during the semester-long course. After the conclusion of the course, a team of two researchers jointly interpreted the experiential stories in light of participants' course performance records, including homework scores, exam scores, and final grades. The researchers, who were also engineering instructors, collaboratively engaged with their experiences teaching and providing support to students in the course, and with personal reflections on their own undergraduate engineering education, to jointly interpret the data. Student-authored narratives were analyzed in context to identify instances of identity recognition and performance, narrative tensions existing between concurrent roles, and identity re/construction through sense-making. Multiple identity theory and growing bodies of research that link professional role transitions and narrative writing to professional identity development processes were used to scaffold the findings. In this study, we identify and describe multiple instances of personal and professional identity recognition, role-based tensions, and identity re/construction and sense-making within participant narratives. Findings suggest that further exploration of narrative-based reflective writing as a pedagogical tool to support early undergraduate identity development in technical engineering courses is warranted. Findings have implications for the design and instruction of technical courses within engineering, as well as courses within other practitioner-based fields wherein identity development plays a key part in role transition and professional formation.

Keywords: engineering education; identity; middle years; narrative pedagogy; reflection; sense-making

Idalis Villanueva, Marialuisa Di Stefano, Laura Gelles, Kate Youmans and **Anne Hunt**   1549–1569   Development and Assessment of a Vignette Survey Instrument to Identify Responses due to Hidden Curriculum among Engineering Students and Faculty

One of the pivotal goals in engineering education is to broaden participation of different minorities. An overlooked barrier yet to be explored is how hidden curriculum and its connected constructs may impede this goal. Hidden curriculum (HC) refers to the unwritten, unofficial, and often unintended assumptions, lessons, values, beliefs, attitudes, and perspectives in engineering. This paper will present the development and assessment of a mixed-method vignette survey instrument to evaluate the responses of current engineering students and faculty when exposed to several examples of hidden curriculum. Results from 153 engineering students and faculty across the United States and Puerto Rico were used to assess the survey sub-subscales (HC awareness, emotions, self-efficacy, and self-advocacy). Findings revealed Cronbach alpha coefficients of 0.70 (HC awareness), 0.73 (emotions), 0.91 (self-efficacy), and 0.91 (self-advocacy). The overall instrument had a reliability of 0.74. Alongside HC awareness, we found that among different axes of inequity, gender, role, and institution type are important elements that shaped the responses of these engineering populations.

Keywords: hidden curriculum; engineering; mixed-methods; vignette; survey; faculty; students

Qixia Hu, Lingxia Gao, Lei Jiang, Zhen Wang and **Yunli Gao**   1570–1584   Factors Influencing Employability of Civil Engineering Graduates in China

The employability of graduates is a metric to assess the teaching achievements of higher education. Employability is complex, multi-dimensional, and is closely associated with specific industry characteristics. Thus, employability must be studied for a specific major in order to provide any practical guiding significance. The aim of this study was to determine the major factors contributing to the employability of graduates in civil engineering and provide the basis for setting appropriate goals to effectively cultivate civil engineering professionals by improving teaching strategies. Recent graduates of civil engineering programs who graduated between two and five years ago were selected as the subjects, and questionnaires were completed by 279 graduates. The results showed that 88% of civil engineering graduates are working in a position related to their specialty. Graduates were more satisfied with their current positions and work environments than they were with their salaries and future career development prospect. We analyzed the factors contributing to the employability of graduates, and defined three major factors of occupational quality, development potential, and professional capacity. These data suggest guidelines for the rational setting of goals to effectively cultivate civil engineering professionals, design an improved practical curriculum, adjust teaching methods, and modify course assessment indicators.

Keywords: civil engineering; graduates; employability; influencing factors

Elif Ozturk, Bugrahan Yalvac, Michael D. Johnson and **Xiaobo Peng**   1585–1594   Investigating the Relationships Among Engineering Practitioners and Undergraduate Students' Adaptive Expertise Characteristics and Experiences

In this study, we explored the prospective and practicing engineers' adaptive expertise characteristics and documented the relations among their demographic information including gender, age, work experience, first-generation college student status, major, and education level. An Adaptive Expertise Survey (AES) and demographic questionnaires – designed by the researchers – were administered to collect data. A total of 606 participants, 23 of whom were practicing engineers, completed the Survey and demographic questionnaires. We conducted F-tests (ANOVA) to explore and document the relations among the participants' adaptive expertise characteristics and their demographics. The relations among the overall and sub-dimension scores of the AES and the participants' demographics were statistically significantly related. The more engineering experience the participants had, the more adaptive expertise characteristics they reported. Engineering undergraduates, who had technical employment and research experience related to engineering, had higher metacognitive self-assessment and overall dimension scores than the students who did not have any technical employment and research experience.

Keywords: adaptive expertise; engineering education; metacognition; epistemology

Juan Alejandro Melian-Melian and **Jorge Martin-Gutierrez**   1595–1604   Influence of Motivation on Learning Approaches of Students Using Learning Objects in Graphics Engineering

This paper provides details of a study in which multimedia Learning Objects (LOs) have been designed and built for the field of Graphic Expression and then have been used by 54 students into the subject Graphic Expression Applied to Building Design of Building Engineering Program as a teaching aid for the purpose of analysing the affect of motivation on students' approaches to learning following LO use. They were used the instrument "*Motivated Strategies for Learning Questionnaire (MSLQ)*" for measuring motivation and the "*Revised Two-Factor Study Process Questionnaire (R-SPQ-2F)*" was used to measure the approaches to learning, Findings show that following the use of LOs in Graphic expression motivation is linked to approaches to learning, independently of their intensity, producing a significant difference between the variables for Approaches to Learning and the variables for Motivation that correspond to Intrinsic Goal Orientation, Task Value, and Control of Learning Beliefs.

Keywords: learning objects; motivation; approaches to learning; graphic expression; MSLQ; R-SPQ-2F

Michael Woodrow, Andrew L Gillen, Roxanne Woodrow and **José Torero**   1605–1614   Investigating Varied Pedagogical Approaches for Problem-Based Learning in a Fire Safety Engineering Course

Fire safety engineering is a critical component of a well-rounded engineering undergraduate curriculum but is understudied in the context of engineering education literature. Guided by previous work in problem-based learning, we conducted a multiple case study structured around three sections of a fire safety engineering course for students across engineering programmes. Our goal was to develop a better understanding of the impact of different pedagogical approaches on students. These approaches were chosen for study because they align with predominating approaches to industry practice in fire safety engineering. Classroom observations and student coursework from each of the three sections were used to evaluate the different approaches: (A) controlling (the specialist approach), (B) student autonomy (the generalist approach), and (C) combination strategy (autonomous/generalist and controlling/specialist). Findings confirm more autonomous/generalist approaches foster positive student experiences and outcomes, but a balance of instructional techniques is still needed. It is clear that more work needs to be done to explore engineering education in the context of fire safety engineering, and this study provides preliminary results that suggest areas for future scholarship.

Keywords: problem-based learning; motivation; interdisciplinary

Kaela M. Martin and Jonathan M. Gallimore   1615–1624   Comparing Student Performance in Flipped and Non-Flipped Space Mechanics Classrooms

Recent advances in active learning have shown that flipped learning is an effective pedagogical approach, but few studies have examined the differences between a flipped and non-flipped course across numerous semesters with the same instructor teaching both formats. This study examines the performance of students in an upper-level space mechanics course in flipped and non-flipped settings over seven semesters. Students in the flipped course performed better on peer evaluation, homework, and exams leading up to the final exam. The course is required for all aerospace engineering students who can decide to pursue the aeronautics (aircraft) track or the astronautics (spacecraft) track. After flipping the course, students in the astronautics track had larger gains in performance compared to in the aeronautic track implying that the flipped course helped students that could readily perceive how they would use the course concepts in the future (astronautics). When examining the viewing habits of students in the flipped courses, watching more videos was associated with higher grades on course elements. Students who watched videos for a longer time and viewed more unique videos received higher scores on graded course elements. This study implies that flipped learning is a successful pedagogy that improves student learning in an upper-level engineering course.

Keywords: flipped classroom; active learning; aerospace engineering

Abigail Clark, Renee Desing, Cassondra Wallwey, Rachel Louis Kajfez, Jean Mohammadi-Aragh and **Soundouss Sassi**   1625–1639   Tracking First-Year Engineering Students' Identity Metrics

The first year of any engineering curriculum is critical. It has the potential to provide a strong foundation in the engineering discipline and positively impact a student's engineering identity. Specifically, increases in engineering identity have been shown to increase student persistence within the engineering field, along with other benefits. However, despite the importance of engineering identity, little is known about how First-Year Engineering (FYE) programs impact identity development. In order to provide insight on identity development, we examined the changes in a set of identity-related constructs (major choice, career choice, engineering identity, belonging in engineering, and engineering expectancy/ability) of FYE students at two different institutions with differing FYE structures. We gathered and analyzed results from three surveys administered across the first year of engineering. Three hundred students completed the initial survey, ninety of those three hundred completed the second survey, and fifty-one of the ninety completed the third and final survey. Our results indicate an increase in all the constructs from the beginning to the end of the year for students at both institutions. However, we observed a decrease in most constructs from the second to the third surveys. We also observed differences in career choice and engineering expectancy/ability across the two institutions. Additional research is needed to better understand the reason behind these changes; however, we believe this work has laid the foundation for better understanding changes in identity-related constructs for students in FYE.

Keywords: student development; survey; first-year; identity

Jeremi London, Christina Lam, Jessica Borders, Logan Perry, Steven Ayer and **Wei Wu**   1640–1651   Experts' and Novices' Perspectives on the Priority of Affective Dimensions in Civil Engineering: A Mixed Methods Study

Although some have called for engineering curricula that fully integrates learning in the head (cognitive), hand (skill), and heart (affective) domains, others acknowledge the difficulty of overhauling existing curriculum to adequately prioritize the "heart". The opinions of experts are often consulted to inform curricular changes, but this is rarely compared to the opinions of novices. There is a need for a better understanding of both experts' and novices' perspectives on the role of the "heart" in engineering education and in engineering work. With an emphasis on civil engineering, this study uses a convergent parallel mixed methods research design and Shulman's Three Apprenticeships framework to investigate expert and novice perspectives on the priority of affective constructs in undergraduate education and their approach to designing facilities for users with needs different from their own. Data was collected from civil engineering experts and novices at an annual regional civil engineering-focused conference. Results suggest experts and novices may have different perspectives on which values should be emphasized earlier versus later in civil engineering education. Implications of the results from this study suggest that while many values should be emphasized in engineering education, it might be important for educators to emphasize certain values (e.g., compassion) earlier rather than later to assist in the development of a well-rounded engineer.

Keywords: expert vs. novice; affective dimensions; civil engineering design

Martin Jaeger and Desmond Adair   1652–1666   Impact of Computer-Based Feedback Style on Learning Effectiveness in Simulation-Supported Courses

With increasing computer power and the simplification of creating computer-based simulations, the opportunities to include simulation and serious games in engineering education have been enhanced over the last years. However, the impact of different system-feedback approaches on students' learning has been studied much less. The purpose of this study is to compare the impact of "reflective feedback" with the impact of "corrective feedback" on learning effectiveness when engineering students apply a simulator to support their learning of engineering processes. Based on the simulation of a continual improvement process, a semi-quasi experiment design, with pre-tests and post-tests carried out by a total of 175 students of an experimental group and a control group, is applied. The experiment is replicated in order to identify the impact of a larger time span between the lecture introducing the topic and the simulator application. Findings show that both feedback approaches lead equally to higher learning effectiveness with regard to eight out of ten learning concepts when the simulator is applied one week after the lecture. Corrective feedback is found to encourage students to memorize correct answers, whereas reflective feedback is found to contribute to deeper understanding of underlying concepts. However, if the simulator is applied four weeks after the lecture, a tendency of reduced learning effectiveness is identified. Engineering educators and educational institutions are encouraged to incorporate simulations to support students' learning, but they need to be aware that a larger time span between lecture and simulator application could reduce the learning effectiveness.

Keywords: simulation game; educational simulation; learning effectiveness; computer-based feedback; feedback style; civil engineering; mechanical engineering

This research describes a pilot program for propagating active learning within engineering education starting with a group of nine interested instructors from two departments. The first and second authors served as the discipline-based coaches for these instructors, and the propagation program involved community discussions, one-on-one coaching, classroom observation, assessment of student perspectives, and feedback to and follow-up with the instructors. This approach aligned with the professional development and coaching literature as well as emergent change strategies identified by Henderson and colleagues. This work is important because STEM education has not generally taken a research-based approach to dissemination of pedagogical innovations, and research on sustained change is only in its early stages. Using a case study approach involving instructor interviews, documentary data (i.e., discussion notes), and classroom observation, the program was assessed based upon instructor participation and accomplishments (including scholarship of teaching and learning activities), plans for continued active-learning use, and valuation. Of the nine initial instructors, seven participated in the one-year program until the end, including three who also engaged in scholarship of teaching and learning. All seven used active learning, as confirmed by observation or interview. Based on their interviews, instructors identified the program's "people" focus, in particular one-on-one coaching and community discussions, as strengths of the program, as supported by the coaching literature. A finding of this research is that benefits were achieved despite non-ideal levels of instructor participation in all program aspects. The goal is to share an implementation and assessment approach with other educators considering relationship-driven, emergent strategies for adoption or expansion of active learning.

Keywords: instructional change; active learning; educational scholarship; engineering education; propagation; coach

Team-based design courses are offered in the majority of engineering programs. While teams are critically important for successfully completing design projects, the relationship between team characteristics and team performance are not fully understood. This paper presents an approach for identifying the characteristics of student design teams in the middle of a design course that significantly and positively correlate with the teams' performance at the end of the course. In this paper, we illustrate the approach in a two-semester capstone design course in which some team characteristics that significantly correlated with team performance were different in the middle and at the end of the course. For example, team characteristics that significantly correlated with team performance were *team composition* in both semesters, *supportiveness of organization context* and *team psychological safety* only in the first semester, and *clear direction* only in the second semester. By knowing such team characteristics, course instructors may be able to survey teams in the middle of a design course to find teams that have higher risks of performing poorly at the end of the course, take an early action to help those teams, and possibly improve their performance.

Keywords: design teams; team characteristics, team performance

In this paper, we report on our experience to develop a way for exposing industrial engineering (IE) students, already in their first year of studies, to the challenges of industrial robot operation. We implemented a workshop in which students performed spatial manipulation tasks, using a conventional robot Scorbot-ER5 and a modern Baxter. The goal of our study was to examine how the students learn through exploration of robot affordances and how the learning impacts their appreciation of the role of robotics in IE, interest in industrial robotics, and spatial awareness. We conducted two case studies: in the first, students operated Scorbot-ER5 in virtual and physical modes, and in the second, students operated both Scorbot-ER5 and Baxter, in the virtual mode. The study focused on students' performances, their difficulties, and responses about of the workshop contribution. Students' success in learning robot affordances was indicated by the improvement in task performance. The spatial difficulties that students faced in exploring affordances of the robots, and the ways by which they coped with the difficulties were identified and categorized. Most of the students self-evaluated that the workshop highly contributed to their spatial awareness and interest in industrial robotics and exposed them to the role of robotics in industrial engineering. These evaluations were significantly higher in the second study, in which students also operated the modern robot Baxter.

Keywords: industrial engineering; first-year students; robotic manipulation; robot affordances

This study is concerned with improving the effectiveness and quality of technical education through the use of virtual reality technology. To do so, we have examined the effects of an application of a Virtual Reality-Supported Remote Access Laboratory (VRRALAB) system we developed using remote access and virtual reality technologies on students' learning experience. The advantage of such a remote access laboratory is that use of equipment that requires experience, such as working under high voltage, can be hazardous to novice users, whereas interactively using a real device from a virtual reality-supported remote access laboratory environment comes with no such risk. We have used an experimental design with 74 associate degree mechatronics program second class students who were divided into the control and experiment groups. They were enrolled on the same Programmable Logic Controller (PLC) course using the applications prepared for VRRALAB design. The experimental group was given a 4-hour training session using the basic subjects of a PLC lesson with the VRRALAB application with a traditional method, whilst the control group was taught only in conventional fashion. Both the control and experiment groups were assessed using the same exam questions. It was found that students who studied with VRRALAB were more successful than those who did not. Satisfaction levels among students using VRRALAB were also found to be high when measured by a questionnaire survey. The results indicate that remote access laboratories using virtual reality are likely to increase the quality of learning and satisfaction levels.

Keywords: virtual reality; augmented reality; remote lab; PLC training; education

This study explores the thematic structure of a large body of scholarly proceedings in Engineering Education. To this end, we first provide a mixed method that combines topic modeling, a machine learning methodology designed to extract the thematic structure of large data, with qualitative analysis of its results. Second, we identify the major topics among the engineering education studies, their trends over time, and the semantic similarities between topics that have similar trending patterns. Our dataset includes over 14,000 conference proceedings published between 2007 and 2016. Our analysis identified 26 topics that have been the focus of engineering education scholarly work, as approximated by the conference proceedings published in the American Society of Engineering Education. We report our results by providing insights on trending topics and their relationships.

Keywords: engineering education; systematic review; text mining; machine learning; topic modeling