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Special Issue
Engineering Education Everywhere: Good Practices
for Emergency Situations and Remote Regions – Part 3

Guest Editors
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This paper presents a framework that operationalizes education in emergencies for multiple types of practitioners. We use *localized* introductory university-level engineering courses implemented in two refugee camps – one in Jordan and one in Kenya – as case studies to outline our challenges and opportunities in teaching engineering in displacement. Our framework for engineering education for tertiary learners in emergencies builds on an extensive critical analysis of the Global Framework for Refugee Education, principles and actions put forth in the Global Compact on Refugees, and research conducted in on-site engineering education programs in two refugee camps using a *localized* approach. Also, this paper develops tailored recommendations for engineering education from across the broad, core definitions and calls for action made in numerous humanitarian reports and international policy documents. This framework is relevant at the global and local levels to plan and deliver engineering education programs for tertiary learners in displacement, humanitarian, and development settings; learners develop engineering competencies to support planning and emergency preparedness. Our framework is transferable across formal and informal learning settings and can be a valuable tool for engineering educators to support the course development or assessment of existing engineering education programs.

Keywords: refugee camps; localized engineering; self-reliance; engineering education; displacement

COVID-19 has generated the largest disruption of the present century, forcing mankind to evaluate many paradigms. Educators have faced the challenge to develop teaching strategies suitable for distance learning, which is particularly complex for those engineering concepts where service learning is an effective approach. This paper presents a remote service based learning strategy, used to teach seismic vulnerability assessment to fourth-year Civil Engineering students at Universidad de La Sabana in Colombia. This strategy involved five stages and was adapted to be carried out remotely by students in their homes using a combination of several tools such as remote maps. The main activities were the seismic vulnerability assessment of the students' houses and the remote assessment of the building stock of Cajicá, a municipality close to the University campus. The learning outcomes were assessed using evaluation rubrics. The results show that the proposed strategy is effective, as 100% of students scored at the top level of the rubric at the fifth stage. In addition, they indicate that service learning in a close context like the family generates motivation and commitment in students to their learning process. Overall, this experience demonstrated that service learning is an effective strategy for teaching engineering concepts in a remote environment. It also showed that although COVID-19 required the development of new teaching strategies, this did not become a limitation to fulfill the learning outcomes.

Keywords: service learning; seismic vulnerability; COVID-19; teaching strategy; learning experience; STEM education

In 2020, the novel coronavirus 2019 (COVID-19) became a catalyst for the development of online teaching. However, online teaching has faced the problems of insufficient teaching flexibility and weakened teacher management, which has greatly affected teaching effectiveness in science and engineering. A task-based method has universality and applicability in teaching activities. This method, combined with the diversified auxiliary tools in online teaching of the task-based method, in undergraduate geophysical courses was adopted. Following online teaching in spring 2020, students have made great progress in terms of geophysics competition. In addition, the statistical results of the questionnaire showed that more than half of undergraduates endorsed task-based teaching. This study indicates that online task-based teaching in geophysical courses has already made initial progress in increasing the flexibility of teaching, improving students' self-learning awareness, and developing their exploration and design skills. Task-based online teaching can be widely promoted for earth science and other science and engineering majors.

Keywords: task-based method; online teaching; geophysics; undergraduate courses

The coronavirus disease 2019 (COVID-19) has changed education, which stimulated the adoption of online teaching and learning. Therefore, the research on the impact of COVID-19 on online laboratories, which can be used for online teaching and learning assessment, is crucial to enlighten the effects of COVID-19 on engineering education. Using the online laboratory Networked Control System Laboratory (NCSLab) as a case study, the research in this paper is aimed to fill the gap of COVID-19 on education by exploring the visitors and users of this online laboratory. To illustrate the impact of the COVID-19 pandemic, a special 100-day time slot in 2020 within the COVID-19 pandemic is selected, and data are collected from a web analytics tool and

records in the NCSLab database. For comparison, corresponding data in 2018 and 2019 are also collected within a specific 100-day time slot. The results show that there is an increase in both the numbers of visitors and users to NCSLab, and an increase in experiment configurations during the COVID-19 pandemic compared with the previous two years in 2018 and 2019, which indicates that more learners are seeking alternatives for remote learning. The evaluation results show that the online laboratory is helpful to the comprehension of course content and achieves intended outcomes, while the use of online laboratories as a replacement for traditional laboratories is controversial. As the effects of the COVID-19 pandemic may continue for years globally, the research in this paper could provide insights for future research and development of online laboratories and also for other online education platforms.

Keywords: engineering education; online laboratories; COVID-19; web analytics; education platform

Remote Laboratories for Automated System Education: Design, Evaluation, and Outreach   1513–1522

Sheng-Jen Hsieh

Studies have shown that authentic learning experiences enhance student interest in a subject and facilitate learning transfer to real-life situations. Because industrial-scale automated systems are expensive, their availability at educational institutions is often very limited. Remote labs can potentially provide more opportunities for hands-on, authentic, and self-paced learning experiences and are especially valuable during a pandemic. This paper describes four remotely accessible automated systems. Instructors from two-year and four-year institutions were invited to participate in a one-day workshop. The workshop included demos of the remote systems and presentations about how these systems were built and being used in the classroom. Eight workshops were held and were attended by a total of 58 instructors. Evaluation results suggest that the workshops were helpful and relevant. Future directions include establishing a network of remotely accessible resources, including lesson plans and links to automated systems.

Keywords: remote laboratories; automated systems; faculty professional development; industrial automation education

The Telepresence Laboratory for a New Campus Life Since the Covid-19 Crisis   1523–1535

Ratchatin Chancharoen and Gridsada Phanomchoeng

The Covid-19 crisis transformed students' campus lives into a new normal. With telemeeting applications, the regular face-to-face lectures are being converted into online lectures. However, the conventional online/offline simulation and remote laboratory cannot provide a real experience of laboratory apparatus and investigations, including cooperative learning. Therefore, the telepresence laboratory is established and utilized for the 2103–360 Mechanical Engineering evaluation and Laboratory II class, which was fabricated for third-year undergraduate mechanical engineering students. To satisfy seven outcomes, students must examine the accuracy, repeatability, and resolution of an IGUS Drylin linear motion system in this lab. The lab, with a telepresence laboratory, is conducted 10 times in a semester where there are two groups of 4–5 students participating in Lab A at a time. Based on the students' findings of the analysis, it can be concluded that the telepresence laboratory can provide all learning outcomes to students. Also, regarding the investigation, more than 86% of students agreed that the lab assisted them in defining issues, designing experiments, conducting experiments, analyzing, concluding, and reporting skills. More than 77% of students agreed that they learned about the equipment from the lab. Also, 89% of students are satisfied with the lab, and 91% of students would recommend other students to take the telepresence laboratory. In conclusion, the telepresence laboratory can be employed in place of the regular face-to-face lab. It succeeds in promoting collaborative learning, where students discuss and work together to complete a task. The investigations are designed with a real-time web interface. Students can utilize their mobile devices to access and control the equipment. This practice complies with the new normal.

Keywords: telepresence; remote laboratory; online experiment and laboratory; online learning; simulation-based learning; Covid-19

Teaching Fluid Mechanics and Heat Transfer in Hands-on and Virtual Settings with Low Cost Desktop Learning Modules   1536–1549

Olivia M. Reynolds, Bernard J. Van Wie, Heidi Curtis, Jacqueline Gartner, Katelyn Dahlke, Olusola O. Adesope and Prashanta Dutta

Although there is extensive literature documenting hands-on learning experiences in engineering classrooms, there is a lack of consensus regarding how student learning during these activities compares to learning during online video demonstrations. Further, little work has been done to directly compare student learning for similarly-designed hands-on learning experiences focused on different engineering subjects. As the use of hands-on activities in engineering continues to grow, understanding how to optimize student learning during these activities is critical. To address this, we collected conceptual assessment data from 763 students at 15 four-year institutions. Students completed activities with one of two highly visual low-cost desktop learning modules (LCDLMs), one focused on fluid mechanics and the other on heat transfer principles, using two different implementation formats: either hands-on or video demonstration. Conceptual assessment results showed that assessment scores significantly increased after all LCDLM activities and that gains were statistically similar for hands-on and video demonstrations, suggesting both implementation formats support an impactful student learning experience. However, a significant difference was observed in effectiveness based on the type of LCDLM used. Score increases of 31.2% and 24% were recorded on our post-activity assessment for hands-on and virtual implementations of the fluid mechanics LCDLM compared to pre-activity assessment scores, respectively, while significantly smaller 8.2% and 9.2% increases were observed for hands-on and virtual implementations of the heat transfer LCDLM. In this paper, we consider existing literature to ascertain the reasons for similar effectiveness of hands-on and video demonstrations and for the differing effectiveness of the fluid mechanics and heat transfer LCDLMs. We discuss the practical implications of our findings with respect to designing hands-on or video demonstration activities.

Keywords: hands-on learning; virtual demonstration; COVID-19

Tracking Students' Visual Attention During E-Learning in the Time of COVID-19   1550–1561

Željko Gavrić, Miroslav Minović and Vanja Mišković

The COVID-19 virus pandemic has forced many educational institutions to use various platforms to conduct online classes. Online learning can hardly replace the classic form of teaching, and the involvement of students is often not at a satisfactory level. This paper researches the method of detecting students' attention during online learning based on monitoring eyes and face tracking. The analysis of the face, eye, and the probability of opening the right and left eye, enable the detection of the level of students' visual attention. The paper proposes a system that detects the visual attention of students by using a smartphones' camera and presents the experimental results obtained by using this system during the Covid-19 pandemic.

Keywords: COVID-19; online learning; visual attention tracking; eye-tracking; eye detection

Assessing the Effectiveness of Virtual Workshops with Active Learning Approaches in Construction Education   1562–1576

Yewande S. Abraham, Bilge Gokhan Celik, Max Spaan and Natalie Mansson

Research suggests that online learning should be more engaging and collaborative to provide a compatible alternative to in-person learning. Many educators have implemented active learning in their in-person classrooms, while only a few assess how effective similar techniques are in virtual environments. The authors hypothesize that virtual learning, including active learning components, can improve student learning in virtual environments. Furthermore, the authors hypothesize that learning in virtual settings would be affected by students' gender, ability, and familiarity with the topic. The authors conducted a quasi-experimental study involving eighty-seven students from two institutions who participated in an online workshop covering fundamental concepts in construction

scheduling. They were split into two groups: one group had no prominent active learning component, while the other was exposed to an active learning component. All participants completed pre and post-workshop surveys to assess their learning of the workshop outcomes and explore the effectiveness of virtual workshops and active learning components in online course delivery. The results of this study suggest that virtual workshops are effective in teaching construction scheduling, while active learning in the form of virtual pair-work does not have a significant positive impact on student learning. Furthermore, student performance in virtual workshops significantly differs based on gender, ability, and familiarity with the topic. Therefore, instructors need to be aware of significant student performance challenges, particularly for males and those with some familiarity with the topics covered in virtual workshops. Since this study was conducted during the COVID-19 pandemic, the authors present further challenges and recommendations for educators and institutions under similar emergency circumstances.

Keywords: active learning; virtual education; COVID-19 pandemic; construction scheduling; construction management

Is Team-Based Online Learning Activities Enhances Critical Thinking Skills of Engineering Students or Not? An Exploratory Study During the COVID-19 Pandemic

1577–1583

Asad Abbas, José Luis Martín-Núñez and Kamran Iqbal

This study was conducted during the COVID-19 pandemic to explore whether team-based, online learning activities play a role in enhancing undergraduate engineering students' critical thinking skills. To conduct the study, we distributed a Google Form–based online survey among undergraduate engineering students through Tecnológico de Monterrey learning management system platform during the fall semester of 2020. In total, we received 50 complete responses through a convenient sampling approach. To analyze the quantitative data, we applied a hierarchical regression technique using the IBM SPSS 26.0 statistical software program. The findings of this study affirm that participation in team-based online learning activities meant to improve (1) the quality of learning and (2) reasoning ability have a significant positive correlation with critical thinking skills of undergraduate students in engineering programs. We also conclude that quality of learning has higher significant association with critical thinking skills as compared to reasoning ability

Keywords: COVID-19; critical thinking; educational innovation; engineering education; e-learning; team-based learning

The Impact of the COVID-19 Pandemic on the Development of Engineering Students' Professional Skills

1584–1594

Douglas W. Stamps

A survey instrument was administered to civil, computer, electrical, and mechanical engineering students to determine the impact that their design courses had on the development of their professional skills, which included engineering design, and attitudes about their program of study. The results of this survey were compared to results from the same survey administered to prior engineering students from the previous eight years to determine the impact of the COVID-19 pandemic. As part of the survey, students identified challenges to academic learning, although the challenges generally did not adversely impact their attitudes about their program of study. Over three quarters of the students perceived that the pandemic had a negative impact on learning engineering design. Yet they rated their understanding of the design process similarly to the pre-pandemic groups, suggesting that they were able to overcome challenges presented to them during the pandemic. Nearly three quarters of the students perceived that the pandemic had a negative impact on the development of their professional skills. However, despite these challenges, the only professional skills students rated lower than the pre-pandemic period was oral communications and time management. The students rated their ability to manage a project, communicate in written form, and develop their leadership skills similarly to the pre-pandemic period. Finally, students rated an increase in their ability to work on a team and develop mentoring skills compared to the pre-pandemic period.

Keywords: professional skills; soft skills; COVID-19; pandemic impact; engineering design

Scaffolding of Practical Learning in Bioprocess Engineering and its Contribution to Soft and Specific Skills

1595–1605

M. L. Castelló, A. Heredia**, J. Calvo-Lerma, A. Asensio-Grau and P. J. Fito

The COVID-19 pandemic has brought many changes in learning methodologies at all educational levels, including higher education. Under these circumstances, one of the most difficult challenges to face is to approach practical and laboratory learning at university when students' attendance to the physical laboratory space is restricted. The future graduates of Bachelor's Degree in Biotechnology are appealed to master many instrumental techniques related to this field. The article describes the scaffolding actions carried out to successfully adapt onsite laboratory sessions to virtual ones and evaluate the students' perception about the contribution of the online methodologies to the practical skills of bioprocess engineering. Two voluntary groups of students were formed, one to attend the practical lessons on site and the other online. The suggested scaffolding was structured in four different types of materials and resources: screencasts, pedagogical articles, calculation sheet templates and online assessment tests. Students' perception was collected by means of an e-questionnaire. About 70% of students thought the online platform allowed them to follow the practical tasks in a way equivalent to face-to-face teaching and 62.1% found that online model presents more advantages than disadvantages than the onsite model. 85.7% of students considered that practical tasks highly contributed to their capacity of solving complex problems and master mathematical tools, while 65.7% of them associated the practical task with their availability to understand the principles of bioengineering. However, 40% of them thought that the online model satisfactorily contributes to the acquisition of these specific skills.

Keywords: learning objects; scaffolding; virtual lab sessions; practical skills; bioprocess engineering

Evaluating the Influence and Modification for Environment and Sustainability Learning Outcome in Environmental Engineering Course During COVID-19 Pandemic

1606–1614

Nurmin Bolong and Ismail Saad

The pandemic has influenced most of us either directly or indirectly. In ensuring the education is always in line with the National Education Philosophy in developing holistic, entrepreneurial, and balanced graduates, the Civil Engineering Program of Universiti Malaysia Sabah utilizes the UMS-OBE system, particularly in course outcome (CO) input to the program outcomes (PO) in the assessment and reporting of student's performance. As the main stakeholders, learners and lecturers must be actively engaged in the rationale and motivation of implementing the OBE mechanisms. Hence this paper evaluated the course learning outcome and measured their perceptions by categorizing the ranked perception feedback on project-based learning (PBL). This paper highlights the modification in implementing PBL that previously involved physical work on-site. Due to the movement control order (MCO) enforced due to the covid-19 pandemic, the course assessment targeted to instill the program outcome (PO) of Environment and Sustainability attribute was strategized into 3 phases. The analysis found that the course outcome has been successfully achieved, even though a slight decrease was observed from the previous regular face-to-face mode. A slight decrease was observed in the overall grade achievement and course outcome analysis. The instructional modification and intervention in Project-Based-learning to improve online learning strategies, despite the requirement for engineering community fieldwork through the learner's feedback responses during the three phases in model strategies for course outcome pedagogy, have shown optimistic input by learners and has continuously engaged them through the Project-based-Learning completion.

Keywords: outcome-based assessment (OBE); engineering education; COVID-19 pandemic; Movement control order (MCO); field-work learning requirement; project-based learning (PBL)

Architectural Engineering Students' Perception of Knowledge Acquisition in a Senior Project Course Delivered Synchronously Online Due to COVID-19

Shaher Rababeh, Seyedali Abolmaali, Nadine Al-Bqour, Michael Zaretsky Juan A Balderrama, Mohammad S Rababeh, Toleen Alzubi and Palisha Shthapit

The COVID-19 pandemic, which began in spring 2020, led to the sudden termination of conventional learning systems. Since then, Synchronous Online Distance Learning (SODL) has been employed as an alternative teaching modality in engineering education. During this shift, educators were required to maintain successful Student Learning Outcomes (SLOs). Therefore, a substantial question was raised about how we could ensure that the knowledge presented through SODL approaches is of sufficient quality? This study aims to develop a tool to evaluate the students' knowledge acquisition while utilizing SODL approaches in engineering education in order to define the ability of this approach to maintain educational continuity, when forced to transition to SODL. A Design-Based Research (DBR) methodology was adopted to link the qualitative research variables in this study; the variable of dimensional analysis is one substantial approach to identifying the aspects of SLOs in a SODL Architectural Engineering (AE) senior project while the collaborative component of this study has been integrated as in-depth structured interviews. Following our analysis, findings indicate that SODL does not necessarily compromise students' skills in acquiring knowledge; furthermore, it advances the AE senior projects curricular paradigm positively.

Keywords: architectural engineering; student experience; synchronous; senior project; knowledge acquisition; online distance learning (ODL); student learning outcomes (SLOs); Design-Based Research (DBR)

Emergency Remote Learning: Developing an Understanding about Online Learning Features and Students' Feelings

Oenardi Lawanto, Assad Iqbal, Wade Goodridge, Angie Minichiello and Muhammad Asghar

In mid spring 2020, an unprecedented Covid-19 induced switch of learning mode, from face-to-face instruction to online learning, disrupted not only teachers, but also students, both cognitively and emotionally. This study seeks to understand how students felt about their capabilities to succeed in the online learning environment (OLE) and which online learning features (OLF), offered to them by their instructors, positively, negatively, or neutrally impacted their learning. Three research questions guided this study: (1) What online learning features did students perceive as contributing positively, negatively, or neutrally to their learning and how were these perceived contributions related to students' demographics?; (2) How did students feel about their capabilities to succeed in the OLE?; and (3) How did students' feelings change during their online learning experiences and how did these changes relate to students' gender, academic performance, and prior online experience? An online survey was designed and face-validated to solicit information about students' perceptions about online learning features and feelings about their capabilities to succeed in the OLE. The 13-item survey consisted of 10 multiple-choice/multiple-answer and 3 open-ended questions. One thousand two hundred and thirty-seven ($N = 1237$) students taking 27 different courses, from 6 different institutions participated in the study. Presentation of the qualitative analyses of open-ended survey responses is outside the scope of this paper. Findings suggest that the three most frequent OLFs provided to students were electronic homework submission, recorded video lectures, and electronic exams. While video lectures, homework electronics submission, and downloadable documents or files were reported to be the top three OLFs that contributed positively to students' learning, poor internet performance, online exams, and projects were the top three OLFs that were reported to have contributed negatively to student learning. Changes in students' feelings during the online learning experience were also reported.

Keywords: online learning; online learning features; online learning environment; student feelings; emergency remote learning

Engineering Students' Social Networks and Alters During the COVID-19 Pandemic

Julie P. Martin, Amanda C. Emberley, Kerrie Douglas and Rene Soto-Perez

Social capital is essential to students' success and persistence in academic goals. However, during the period of emergency remote teaching brought on by the COVID-19 pandemic, students were isolated from their social networks. The purpose of this study was to examine how engineering students' social capital changed during the period of emergency remote teaching, looking closely at both the instrumental and expressive social capital from the people (alters) in students' social networks. We used an explanatory sequential mixed method approach that included collecting data from first-year students and capstone design students using the Undergraduate Support Survey and student interviews. We found differences between the types of alters that the two groups of students identified as influential to their success and persistence, including the groups of alters they identified (e.g., professors vs peers) and the length of relationship with their alters. We also present results from the interviews, highlighting examples of expressive and instrumental supports in both group before and during the pandemic. Overall, we found that the advanced students had more well-developed social networks than the first-year students to rely on during the transition. The first-year students, however, relied mostly on lifelong relationships. They did not have, and did not continue to develop, university-based social networks. We include examples of innovative ways that students maintained and strengthened their social networks and point to future implications of this work.

Keywords: social capital; emergency remote teaching; team-based learning; ALTERS, COVID-19

COVID-19 in Spain: Transition from Face-to-Face to Emergency Remote Teaching for an Industrial Electronics and Automation Engineering Degree

Pilar I. Vidal-Carreras and Lourdes Canós-Darós

This paper analyzes the changes for a degree in Industrial Electronics and Automation Engineering at a Spanish university in the confinements caused by the outbreak of the Covid-19 pandemic. The purpose was to find out the practices that the faculty university intuitively choose for use in teaching and evaluation, and to check if they were adequate in the emergency situation. The challenges faced by university faculty worldwide following the confinements caused by the outbreak of the Covid-19 pandemic were enormous and have no precedence in the digital knowledge era. The study of the teaching transitions realized allow the university and all agents involved to better reinforce the strong points and to focus improvements on the weak points with the goal of better preparedness for future crises. Three aspects of the transition to online teaching are considered: the changes in the evaluation systems, the preferred modes (synchronous, asynchronous, or bichronous) and the tools most used. According to the results, the evaluation systems enjoyed a level of stability that indicated institutional tools already existed providing online support for successful execution. The interaction between teacher and student dominated the basic training and compulsory course subjects, while asynchronous teaching was more apt for the elective subjects. Text-type teaching resources were chiefly used. While it was true more multimedia types could have been used, the suddenness of the changes as well as the uncertainty around their durations may have contributed to their incomplete development.

Keywords: COVID-19; electronics engineering education; engineering students; emergency remote teaching; online teaching, skills

The Unequal COVID-19 Epidemic Effect: Minorities Gap in Engineering Education in Israel

Avshalom Danoch and Neta Kela Madar

The COVID-19 global pandemic imposed a pause on life and higher education due to lockdowns and quarantines. Many students faced extreme financial hardship, making it difficult to continue their academic pursuits. The current study compares the pandemic's impact on Sami Shamoon College of Engineering (SCE) students' performance, dropout rate, and satisfaction with teachers before and during the pandemic. Like universities worldwide, SCE faculty scrambled to transition to online learning quickly. Our findings suggest that students were initially frustrated, but they were more understanding by the second semester of

the pandemic. However, Arab students were forced to drop out at a disproportionate rate compared to Jewish students. More Arab students dropped out during the pandemic than in previous years, suggesting the pandemic affected them more substantially. Despite all the hardship, student performance did not suffer.

Keywords: COVID-19; pandemic; higher education; Israel; Arab

Susann Beier, William Armour, Xinxing Chen and Irene Renaud-Assemat

The COVID-19 pandemic exacerbated the teaching challenges of engaging students, building a learning community, and creating enriching learning experiences. Here, we present an authentic, asynchronous assessment method applied as a peer-assessed virtual conference task. The peer assessment and facilitation effectively generated a strong sense of community and teamwork (95% agreement) and enabled the students to generate a deeper understanding of the course content (73% agreement) by fostering critical self-reflection (87% agreement). Student engagement excelled whereby many choose to engage in additional presentations outside of their allocated peer markings. Consistently positive feedback highlighted the task's utility as an online learning tool and its efficacy in shaping a collaborative class community besides remote teaching condition. Additionally, the multi-faceted nature of the assessment promoted a broad range of effective teaching qualities, including collaboration, communication, and application of theory in innovative contexts which lends itself to higher education. Overall, the virtual conference tool and its peer-based facilitation can be considered for effective engineering education practice, which may also apply to other scientific disciplines to improve student learning and experiences.

Keywords: virtual assessment; community building; virtual conference; peer assessment; peer marking; authentic assessment; engineering education practice; advances in engineering education; remote learning; team building; higher education; self-reflection