

# The International Journal of Engineering Education

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#### Special Issue

#### Current Trends of E-Learning in Engineering Education

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Yu-Hung Chiang and Hei Chia Wang	454–460	Effects of the In-flipped Classroom on the Learning Environment of Database Engineering

The growth of information technology has led to the introduction of blended learning classrooms. A “flipped” classroom is a specific type of blended learning environment that allows students to learn outside the classroom through e-learning and then interact with the teacher inside the classroom. Although flipped classrooms have many advantages, some issues, such as low motivation prior to lectures, remain and should be improved. This paper proposes an in-flipped classroom to overcome the problems found in existing flipped classrooms and evaluates this type of classroom using a Database Engineering course in a master’s program. This study uses the College and University Classroom Environment Inventory (CUCEI) to investigate the learning performance of the newly proposed in-flipped teaching environment. The results show that students in an in-flipped classroom exhibit better individualization than those in a traditional classroom and have increased interest in cooperative learning. The study also finds that students are more easily engaged in lectures and develop self-directed, self-regulating, and self-determined skills through the proposed method.

**Keywords:** in-flipped learning; collaborative learning; blended learning; problem-based learning; college and university classroom environment inventory

Gillian M. Nicholls and Sherri L. Restauri	461–475	Instituting and Assessing the Effectiveness of Focused e-learning Modules in Engineering Education
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This study examines the development, utilization, and assessment of e-learning modules designed to assist students in mastering core concepts in a hybrid undergraduate engineering economic analysis class. The online learning aids focused upon key conceptual material that students had historically experienced difficulty learning within this course. The modules consisted of a short audio/video “micro-lecture” (ML) recording about a particular topic accompanied by downloadable reference documents containing the associated ML PowerPoint® slides and example problems. Automated assessment exercises were created for students to practice their grasp of the concepts. The online assessments and reference materials were hosted within the course learning management system, while the ML videos were accessed through a separate distance learning platform. Detailed records of students’ use of the MLs, online assessment scores, exam performance, prior academic performance, and demographic variables were gathered. This data was compared to results for students in two previously taught sections who served as controls for the study. Although preliminary data indicates that the focused modules have been helpful to some students, data results overall were inconclusive in demonstrating improved learning outcomes across the board for students in the targeted course. Recommendations for improvements to data collection across multiple selections, methodology design, and e-learning tool implementation are provided for future studies.

**Keywords:** e-learning; micro-learning; hybrid; micro-lecture; learning management system; student persistence; online learning resources; lecture capture; Mediasite; Panopto; generative learning; active learning; learning assessment; m-learning; analytics; dashboard

Kyungsun Park	476–485	Instructional Design Models for Blended Learning in Engineering Education
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The purpose of this study is to develop instructional methods and processes for designing authentic contexts of blended learning in engineering education. Design strategies for the reproduction of professionals’ authentic contexts are suggested with guidelines for the actual development of a blended learning course. According to the development research methodology, along with a prototype e-learning course, six design strategies were developed as follows: (1) select and identify authentic tasks that practitioners or experts can solve; (2) analyze the context of solving the authentic task; (3) model experts’ cognitive and behavioral processes of solving the authentic task; (4) develop assessment tools for the authentic task; (5) apply instructional strategies to provide authentic contexts by using technologies; and (6) develop instructional resources and environments. Two task analysis methods, activity theory and PARI (Precursor–Action–Results–Interpretation), were employed to identify authentic troubleshooting problems of energy auditing. Constructivist learning models and strategies were implemented; they had been adopted from situated learning, anchored instruction, cognitive apprenticeship, and goal-based scenarios. The research implications and limitations are discussed for generalization in future studies.

**Keywords:** blended learning; activity theory; PARI; troubleshooting problems; constructivist learning models

Dorina Gnaur and Johan Clausen	486–494	Teaching Smart with Podcasts
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The purpose of this paper is to explore the potential of digital technology, such as podcasts, to stimulate the learning environment in engineering education by advancing student learning from a focus on fixed disciplinary content and habitual examples towards higher procedural and conceptual knowledge forms. The paper examines how a pedagogically aligned use of podcasts can support deeper and more integrative learning in an engineering course. The findings reveal the importance of planned pedagogic alignment between content knowledge and the use of technology, and expose the role of a qualitatively enhanced student–teacher interaction in re-centering teaching on active learning and on problem-oriented, functional knowledge. It shows how minor alterations in

teaching design caused by the integration of digital tools, in this case the use of podcasts, can enhance student learning. However, in order to extend beyond reproductive learning, podcasts have to be part of an engaging pedagogic design involving active learning and provide a privileged space to stimulate inquiry and encourage multiple perspectives. Informal access to teacher/expert facilitation in small study groups can provide a less intimidating support to help navigate the troublesome realms of disciplinary advancement and prepare for future challenges.

**Keywords:** podcasts; pedagogic design; thresholds concepts; problem based learning

**Po-Hsin Huang, Ming-Chuan Chiu, Sheue-Ling Hwang and Jan-Li Wang** 495–504 Investigating E-Learning Accessibility for Visually-Impaired Students: An Experimental Study

STEM education has long been recognized as the foundation for national competitiveness and future prosperity. In STEM, mathematics serves as the key to other areas (science, technology and engineering). Existing evidence shows that an integrated curriculum in mathematics enhanced the majority of students' performances on standardized tests. However, many visually-impaired students seem to fail to reach proficiency in mathematics. In this paper, we present a new approach to promote vision-impaired students' overall math performance and enrich their learning experiences. We first investigated student learning difficulties and then developed a new mathematics curriculum with the integration of the Digital Accessible Information System (DAISY). This curriculum mainly addresses DAISY-compliant electronic textbooks that can be displayed on a Non-Visual Desktop Access (NVDA) screen reader. Finally, we conducted an experiment in order to evaluate the effects of the new teaching approach. The experiment included a four-day pedagogical program and an assessment session. Specifically, the test focused on students' mathematics scores and their NASA-TLX subjective mental workload. The findings showed that the value of the NASA-TLX subjective scales ( $t = 4.271$ ,  $p < 0.05$ ) was significant and the student accuracy rate increased. Thus, we conclude that this new method effectively improved vision-impaired students' proficiency in mathematics.

**Keywords:** visually impaired students; curriculum development; e-learning; usability testing; DAISY

**Reidar Kvadsheim, Hårek Haugerud, Hugo L. Hammer, Alfred Bratterud and Laurence Habib** 505–520 Does Clicker Use Improve Exam Scores? A Controlled Randomized Experiment in a Bachelor-Level Course in Software Engineering

This paper reports a study of clicker use within an undergraduate course in Operating Systems. It is based on a controlled, randomized experiment with a crossover design that measures learning outcomes by means of test questions at different levels of cognitive difficulty. The study aims to investigate whether clicker use primarily promotes superficial learning, whereby students reapply uncritically a previously seen solution in a new situation, or a more genuine learning whereby they analyze new situations and solve new problems. The results suggest that students attending clicker-based lectures obtain better exam scores than students attending corresponding traditional lectures in the same course. Moreover, the superior scores achieved by the students attending the clicker-based lectures were most pronounced for exam questions that required knowledge of the subject matter. The article concludes that clicker-supported lectures may be tried out helpfully in engineering education to promote learning. Advice is given as to how one may proceed.

**Keywords:** clickers; student response systems; web application; controlled, randomized experiment; crossover design; learning; knowledge of subject matter; bachelor course; software engineering; engineering education

**Yücel Ugurlu** 521–528 User Attention Analysis for E-learning Systems—Towards Intelligent Tutoring

We propose a new approach for e-learning systems that incorporate user voice activity information to build collaborative and intelligent learning environments. The proposed algorithm is based on the pitch frequency, power amplitude, and duration of a voice activity signal. Voice activity detection was integrated with the e-learning system for teaching LabVIEW-based graphical programming and it was tested on a group of students. The experimental results showed that the proposed approach is practical and highly suitable for real-time applications. Finally, student survey results are introduced to measure the e-learning satisfaction and user attention analysis approach.

**Keywords:** human–computer interaction; e-learning; LabVIEW; voice activity detection; intelligent tutoring

**Enosha Hettiarachchi, M. Antonia Huertas and Enric Mor** 529–540 E-Assessment System for Skill and Knowledge Assessment in Computer Engineering Education

E-assessment has become increasingly interesting in higher education. However, it is not an easy matter. It does not work to transfer, directly, face-to-face assessment models to online education. Indeed, the nature of such assessments has often been limited to automatically corrected quizzes, compounds of simple type of questions such as 'multiple choice questions'. This kind of e-assessment can be considered knowledge-based but not skill-based because cognitive skills and practical abilities cannot be assessed via such a kind of simple type of question. On the other hand, formative e-assessment, which assists the learning process by being part of it, and not just occurring at the end of it, like the traditional face-to-face examination, seems to be the best kind for assessing skills acquisition. Thus, when it comes to an e-assessment in computer engineering education, where skill-based assessment is needed, there is no general system that can be used for both skill and knowledge formative e-assessment. Considering this, the paper proposes an e-assessment system that supports a formative assessment model that goes beyond simple types of questions and introduces an interactive dynamic environment for both skill and knowledge assessment in an online education. Furthermore, the impact of introducing formative e-assessments in computer engineering education to support and improve the students' learning processes was evaluated in a real scenario, a Logic course at a fully online university. Based on data analysis, it was observed that the use of the system and the model had a positive impact on student learning and performance. Students learned through more engagement with the system and, as a result, their performance in the final examination had improved. The system also provided added benefits to teachers through automated marking and tracking of students' progress throughout the whole course.

**Keywords:** e-assessment; higher order skills acquisition; knowledge acquisition; interactivity; online higher education; computer engineering subjects

**Sonia Pamplona, Nelson Medinilla and Pamela Flores** 541–552 Assessment for Learning: A Case Study of an Online Course in Operating Systems

This study explores the effects of a formative assessment on operating systems, a subject that is part of the computer engineering degree at an online university. The formative assessment that we designed was based on the following goals: (a) to promote meaningful learning and (b) to make students aware of their learning processes. The research methodology used was the qualitative case study. The sample was composed of 9 students out of 13 who were enrolled in the class. The qualitative data analyzed were obtained from formative assessment tests taken by the students during the course. The empirical evidence shows that the assessment produced deep reflection on both the subject's main concepts and the student's learning style, which corroborates the results of other research in this area. This case study can help engineering teachers to create formative assessments for online courses.

**Keywords:** e-learning; online learning; formative assessment; assessment for learning; operating systems

This paper introduces our best practices of integrating a variety of e-learning 2.0 tools and services to support the learner–learner virtual interactions in a global engineering class, which is jointly offered by five world leading engineering schools with a total of 108 course participants. A qualitative data analysis was conducted to analyze the text chat history collected from this global engineering class. The effectiveness of four specific e-learning tools/services are evaluated and compared. These include: discussion board on learning management system, web conferencing service, mobile messaging service, and social networking service. According to the analysis results, different tools/services play complementary roles in supporting diverse kinds of learner–learner virtual interactions, and some overlapping roles in between certain tools/services may inspire development of future e-learning tools/services.

**Keywords:** e-learning 2.0; learner–learner interactions; global class

**Wen-Hsiung Wu, Wen-Cheng Yan,  
Wei-Yang Wang, Sung-Lin Li and  
Hao-Yun Kao**

567–573 Comparison of Varied Social Media in Assisting Student Learning

In recent years, a trend has emerged of integrating aspects of social media to promote learning outcomes in the field of engineering education. However, most previous studies of this phenomenon only investigated the application of a single type of social media and few studies conducted a comparison analysis of the impact of different social media on student learning. Hence this study investigates the impact of two different social media, Facebook and wikis, on the learning process through questionnaires and follow-up interviews. Significant findings included indications that the different social media showed distinct and specific pedagogical features, and that effective use of social media in learning contexts requires the involvement of a teaching assistant (TA) as facilitator.

**Keywords:** social media; Facebook; wiki; learning process

**Noemí Merayo, Patricia Prieto,  
Ramón J. Durán, Juan C. Aguado,  
Patricia Fernández, Ignacio de Miguel,  
Rubén M. Lorenzo and Evaristo J. Abril**

574–588 M-learning and E-learning Interactive Applications to Enhance the Teaching–Learning Process in Optical Communications Courses

In this paper, we propose to enhance and speed-up the teaching–learning process in optical communication subjects by designing and implementing new e-learning and m-learning strategies and applications. The new educational scenario demands a methodological renewal focused on the learning process and the acquisition of skills. In this way, telematic and interactive tools can promote this change due to their flexibility and great development. As a consequence, students can be provided with a set of powerful software tools that help them to increase their autonomy and their capacity to acquire skills. The range of tools that is nowadays available is enormous, but we have chosen strategies based on e-learning and m-learning applications in order to take advantage of the different strengths of the two approaches. First of all, we propose to provide subjects with high flexibility by designing voice-guided tutorial videos of complex concepts and software simulators used in lectures and laboratories. In particular, in this paper we focus on subjects from the optical communications area, since this area is highly complex and it is a good scenario for the practical use of our proposal. The main objective is to promote a virtual access to optical communication experiments and simulations related to laboratory subjects. However, these video-tutorials also look to be a powerful tool in lectures to explain fundamental principles and physical phenomena better. On the other hand, we have designed a set of Android applications, since mobile learning is an effective technique to transform and strengthen the traditional training and learning strategies. The involvement of mobile devices in the learning process aims to improve the interaction of teachers with students and to be used as a complementary support to increase their capacity for work and their motivation out of class. In summary, the development and integration of these software techniques exhibit great advantages since they may speed-up some learning tasks and they can be used to enhance the quality of the teaching methodologies.

**Keywords:** Bologna; e-learning; video-tutorials; m-learning; Android

**Mengping Tsuei and Ri-Teng Lai**

589–596 Development of an Online Engineering Drawing System to Enhance Junior High School Students' Learning in an Engineering Graphics Course

The purposes of this study were to develop the HappyCAD online engineering drawing system and to examine its effects on students' learning. The HappyCAD system includes instructional management and engineering drawing modules. The engineering drawing module provides three-dimensional (3D) models and interactive 3D solids. Learners can interact with the system and use various tools for drawing. Students can also receive feedback from teachers and redesign their engineering drawings. The HappyCAD system was implemented as an e-learning tool in an engineering graphics course for junior high school students. Students' perceptions of online learning with HappyCAD in engineering drawing were reported along with learning outcomes that resulted from their use of the e-learning tool. This study demonstrated the positive effects of an online engineering drawing system on students' engineering drawing literacy. The finding suggests that students generated positive attitudes towards learning engineering graphics in an online environment. Students' error patterns in drawings were also analyzed in this study.

**Keywords:** online engineering drawing system; junior high students; engineering graphics; e-learning

## Section II

### Contributions in: Active Learning, Technology Assessment, Wiki System, Team Work, Motivation, Creativity, Entrepreneurship, Engineering Education Research

**Prateek Shekhar, Matt Demonbrun,  
Maura Borrego, Cynthia Finelli,  
Michael Prince, Charles Henderson  
and Cynthia Waters**

597–609 Development of an Observation Protocol to Study Undergraduate Engineering Student Resistance to Active Learning

Student resistance is often cited as a major barrier to instructors' use of active learning, but there are few research-based strategies for reducing this barrier. In this paper, we describe the first phase of our research—the development and validation of a classroom observation protocol to assess student responses to instructors' use of active learning. This protocol, which draws upon other published observation protocols, allows researchers to capture data about instructors' use of and students' responses to active learning. We also present findings from four first and second year engineering courses at two institutions that demonstrate the variety of ways engineering students resist active learning and strategies that engineering instructors have employed to reduce student resistance.

**Keywords:** active learning; instructional strategies; observation; student resistance

Research carried out in recent years suggests that students in Higher Education are not always motivated and lack the learning skills and work habits to overcome first-year difficulties at the university. As a consequence, the approach to teaching the subject was to blame for allowing a significant number of dropouts and underachievement. Starting from several educational experiences carried out since 2005, this paper presents an overall model with the emphasis on student-centered learning and formative feedback. The teaching approach is based on good practices that are supported by commonly available technology resources so as to maintain a manageable faculty workload. Technical resources are a very helpful resource to face large groups of students without losing learning feedback quality, but it is not a solution per se. Thus, on-line activities have been designed to support individual formative feedback with asynchronous teacher interaction, while face-to-face learning is still very important and oriented to promote peer interaction and collaboration. The presented model has produced successful results during several consecutive academic years with samples of more than 500 students per year and the participation of 11 lecturers. This work analyses quantitative indicators to demonstrate that teachers are able to carry out a reliable representation of their student progress, despite the use of different student-centered activities. Generally speaking, student active participation has grown significantly, achieving 65% success. The model and its starting conclusions can be extrapolated to many high education courses.

**Keywords:** higher education and computer engineering; educational technology; first-year (freshmen) engineering success; student engagement; tactile displays; technology assessment

The purpose of the study was to explore the effect of group composition by using wikis in classrooms. A wiki system was created for students to learn a chemical engineering theme. A quasi-experiment with pre-test and post-test design was adopted to fulfill the research question. The research participants were 116 eighth graders from three classes at a public junior high school in Taiwan. Students from three classes were divided into three types of group compositions: homogeneous, heterogeneous and natural selection groups. A criterion test defined as a learning achievement was developed to measure the students' understanding of chemical engineering knowledge. The educational experiment lasted for six weeks. 'Added contents directly related to the course' and 'modified contents from other groups' were two online behaviors defined as wiki performances. The results showed that the effect of group composition did not influence the students' learning achievements and wiki performances. Even though students, when engaging in wiki environments, in all homogeneous, heterogeneous, and natural selection groups achieved similar learning achievements of engineering knowledge, there were significant differences between their pre-tests and post-tests in all three groups. In particular, students in the heterogeneous group exhibited a better learning improvement than in the other two groups.

**Keywords:** group composition; wiki system; K-12 engineering education; chemical engineering

Team work is considered a valuable teaching technique in higher education. However, the assessment of an individual's work in teams has proved to be a challenging task. Consequently, self- and peer-evaluations are becoming increasingly popular for the assessment of individuals in a team work, though it is essential to determine whether students can judge their own as well as their peer's performance effectively. Self- and peer-evaluations have been applied in different disciplines and their authenticity with regard to teacher's assessment has been evaluated in the literature but this issue has not been investigated in the field of engineering education so far. In this study, a peer- and self-assessment procedure is applied to the evaluation of a project work conducted in teams of 3 or 4 students. The participants were engineering students taking two similar courses related with database design and development. It is found that a majority of the students were unable to assess themselves as objectively as their instructor. Further, it is observed that successful students tend to under-estimate, whereas unsuccessful students tend to over-estimate, their own performance. The paper also establishes that the results of self-assessments are independent from the gender factor.

**Keywords:** engineering education; self-assessment; team work; performance; Z-test

In the United States and around the world, engineering programs face issues of demotivation and attrition. Many small studies have examined a few motivational characteristics in engineering education, generally treating variables as discrete and using simple correlational analyses. Given the complex, interactive nature of motivation for learning and development, the field of engineering education needs studies that model interactions among multiple variables informed by a multi-theory approach to motivation. Once demonstrated, these relationships and model can be tested for similarities or differences in more diverse groups. To address this gap, we present a systematic approach to model and validate interactions of multiple motivational characteristics. This study assessed the motivational profiles of 80 junior and senior students in mechanical engineering design, and tested the data for correlations to verify the strength of their overall relationships. Then, the researchers created an interactive, directional model informed by theory and precedent in the literature, and further tested the relative influence of the interrelated factors, to identify those most influential on key outcomes, using multiple regression. Correlations indicated 28 possible paths, which were built into the hypothetical model, and the multiple regressions eliminated 15 of those pathways, leaving the 9 most influential factors and 13 most significant predictive pathways modeling the course engagement and the career efficacy and success expectations of these advanced engineering students. This approach of modeling the influences among different constructs helps to reduce the noise and confusion from multiple, sometimes conflicting findings, and refine understanding of students' motivation that can contribute to more effective engineering education.

**Keywords:** motivation; retention; mechanical engineering

This study aims to probe into the effect of the BOPPPS (Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment, Summary) application on university students' creativity learning effectiveness. This study applied BOPPPS instructional strategy to creativity project making and combines creativity and creativity instruction design items as the criteria to design creativity project making and develop the "Creativity BOPPPS<sup>2</sup> Modle". The "Creativity BOPPPS<sup>2</sup> Modle" includes the following: (1) teachers' creativity instruction; (2) students' creativity learning; and (3) multiple evaluations of creativity. By case experimental instruction, and according to the statistical analysis of the student questionnaire survey and text analysis of students' creativity project making, this study found that university students' creativity learning effectiveness of BOPPPS is significant and positive. Finally, this study generalized the key points of instruction of different stages of "Creativity BOPPPS<sup>2</sup> Modle", and proposed the suggestions for instruction and future research, in order to enhance university students' creativity learning effectiveness and the significance of project-making courses.

**Keywords:** BOPPPS; creativity; project making; university students

Using Lego, we proposed a six sigma game to enhance entrepreneurship for engineering students. The game considers not only the importance of quality in the product design and development phase but also aspects such as project management, IP awareness, ethics, and green technology for technology-based entrepreneurship. In particular, we let the participants choose one from a number of available Lego sets of two generations, in which a tradeoff relationship exists between technology and cost. The effects of the proposed game varied over different education levels.

**Keywords:** Lego; technology management; quality; entrepreneurship; six sigma game

**Natascha van Hattum-Janssen,  
Bill Williams and José Manuel  
Nunes de Oliveira**

674–684 Engineering Education Research in Portugal, an Emerging Field

Engineering Education Research (EER) has been increasingly recognised as an autonomous field of research with an important global role to play in preparing engineers to meet the technological and social challenges of tomorrow. In this article, the authors use Fensham's criteria for defining an emerging field of inquiry to characterize the evolution of EER in Portugal. They find that although there is as yet relatively little structural support for EER, data on research output suggests that the national and international contribution of Portuguese scholars to the field is on the increase in quantitative and qualitative terms. The authors identify challenges such as a perceived lack of legitimacy of the field and limited funding opportunities as factors limiting the development of this research field and hindering the diffusion and implementation of proven good practice at national level. They suggest that management support and availability of resources are key factors in meeting these challenges. They identify two important strategic goals for Portuguese EER scholars: research partnerships with international engineering education researchers and closer collaboration with researchers in learning science.

**Keywords:** Engineering education research; evolution of a field of inquiry; Fensham's framework