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Contributions in: Concept Mapping, Teaching Concepts, Non-Cognitive Factors, Creativity, Students' Satisfaction, Identity, Retention, Curriculum Development, M-Learning, Technology Integration, Engineering Careers, Capstone Projects, Design Education, Software Design, Game Design, Big Data Processing, Virtual Laboratories, Simulations, Heat Transfer, Communication Networks, Construction Engineering

Ahmad Ibrahim	293	Editorial
Ning Fang	294–303	An Analysis of Student Experiences with Concept Mapping in a Foundational Undergraduate Engineering Course

Concept mapping is a powerful graphical technique for helping learners organize knowledge and visualize connections and relationships between relevant concepts. The present study is an investigation of student experiences with concept mapping in a foundational undergraduate engineering course titled Engineering Dynamics. A total of 165 undergraduate engineering students from two recent semesters participated in the present study. This paper provides representative examples of student-generated concept maps. Student comments collected at the end of each semester were analyzed using content analysis. Students provided positive feedback, for example, concept mapping helped students make connections between concepts; reviewed what students had learned; visualized, understood and organized concepts; saw the bigger picture of dynamics; and thought more clearly about concepts. Students also provided negative feedback, for example, concept mapping was busy work, did not help in understanding concepts, was a small percentage of credit of the final course grade, and students had other ways to learn concepts. The results reported in this paper are useful for engineering educators and researchers to develop a better understanding of the strengths and limitations of concept mapping in teaching and learning engineering courses.

Keywords: concept mapping; student experiences; engineering dynamics

Michael Prince, Margot Vigeant, Katharyn Nottis and Gary Nottis	304–315	Teaching Concepts Using Inquiry-Based Instruction: How Well Does Learning Stick?
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This work examines the impact of inquiry-based learning activities (IBLAs) on students' conceptual understanding of four critical heat transfer concepts. Previous research has shown that IBLAs create significant learning gains compared to traditional instruction as assessed by the Heat and Energy Concept Inventory (HECI). A typical end point for assessing student learning is at the end of the activity, where students demonstrate significantly improved understanding relative to before the activity. This paper investigates how durable that understanding is, and how well this understanding transfers to solving new problems in the same conceptual area. The results show that retention of conceptual learning is generally good, with little drop off in most measures of students' conceptual understanding after several weeks. However, the durability of the learning is affected by several factors, including the concept area itself, the difficulty of the concept, and the degree of transfer required. In cases where the learning does not "stick", it is found that students' initial preconceptions continue to hold some sway on their thinking.

Keywords: inquiry-based activities; conceptual learning; transfer

Ryan R. Senkpeil and Edward Berger	316–328	Impact of Non-Cognitive Factors on the Performance of First-Year Engineering Undergraduates
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This study of 575 undergraduate engineering students was designed to determine the impact of students' non-cognitive factors on their first year performance in college, beyond what their academic credentials can account for. In engineering—where most students are applying with exceptional academic credentials—these "cognitive" factors become poor predictors of student performance. Therefore, a non-cognitive survey was administered to undergraduate engineering students. A factor analysis was used to group the 36 non-cognitive survey items into four distinct factors: self-discipline, anxiety, plasticity, and follow through. These four non-cognitive factors predicted an additional 9 percent of the variance in first year GPA beyond what high school GPA and standardized test scores predicted. It was also discovered that gender moderates the impact between certain non-cognitive factors and first year GPA. These results varied based on classroom setting.

Keywords: non-cognitive factors; interventions; student performance

Hongbing Chen, Tianqi Tao and Chunfang Zhou	329–339	Fostering Creative Young Engineers in Chinese Universities
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Recently, China has called for an economic shift from the concept of "Made in China" to "Created in China", which has driven growing attention on how to foster creative engineers in China. This paper will provide a literature review and analysis aiming to answer two research questions: (1) how can we combine the concepts of creativity, engineering work, engineering education, and their interactions into one theoretical framework? And (2) according to the proposed framework, what are the potential strategies we can suggest to foster creative engineers in Chinese universities? Accordingly, this paper firstly discusses a three-dimensional framework based on an analysis from a literature review involving knowledge, behavior, and culture. Secondly, we suggest a series of potential pedagogical strategies aiming to foster creative Chinese engineers by: (1) taking a social constructivist approach to creative learning; (2) developing the laboratory a place of creative work; and (3) making the university campus a creative culture. Therefore, this paper contributes to bridging creativity, engineering education, and Chinese learning culture from a systematic perspective, which also has implications for other contexts around the world, both theoretically and practically.

Keywords: creativity; engineering practice; engineering education; Chinese culture; pedagogy innovation

Magaly Dantas De Melo, Jamerson Viegas Queiroz, Fernanda Cristina Queiroz, Jesus Leodaly Salazar Aramayo and Clayton Levy Lima De Melo 340–350 Determination of the Factors Contributing to Graduate Students' Satisfaction: A Case Study from Brazil

Considerable academic research has attempted to identify the determinants, dimensions and attributes of university students' satisfaction. Using structural equation modeling, the present study aimed to determine whether the European Customer Satisfaction Index (ECSI) can measure the satisfaction of graduate production engineering students in Brazil. To that end, a survey was conducted of 483 students enrolled in the 30 master's and doctoral courses registered with the Coordination for the Improvement of Higher Education Personnel (CAPES) in Brazil. The data collection instrument used was a structured questionnaire consisting of 34 questions, based on the ECSI. The study met all the statistical criteria established for its validation, in addition to exhibiting moderate goodness of fit, explaining 76.40% of student satisfaction. Finally, after a number of adaptations, the ECSI model was suitable for measuring graduate student satisfaction, maintaining all the constructs observed in the original model.

Keywords: graduate studies; satisfaction; ECSI model; production engineering

Anita D. Patrick, Maura Borrego and Alexis N. Prybutok 351–363 Predicting Persistence in Engineering through an Engineering Identity Scale

Identity is emerging as an underlying explanation for persistence in engineering, but few prior studies have directly measured the engineering identity of engineering students, nor compared it with observed persistence. Of these studies, there are connections between (a) students' math, physics, and science reported interest, performance, competence, and recognition and (b) their identification and persistence in these domains and engineering. This study expands on that research by adapting previously validated scales of math and science identity to predict engineering identity and persistence. Data used in this study were drawn from a cross-sectional sample of undergraduate engineering students in mechanical and civil engineering ($n = 474$). We used exploratory factor analysis to analyze engineering identity items adapted from prior survey studies. We used logistic regression to predict engineering identity and one-year persistence after controlling for gender, major, students classification, and mother's education. The engineering identity factors align well with previously validated math and physics identity factors as evidenced by the factor loadings and Cronbach's alpha. Results from logistic regression models indicate that engineering interest, recognition, and performance/competence significantly predict engineering identity after controlling for student classification, major, and mother's education. Moreover, males and females report approximately the same attitudes on these predictors. Major, classification, and engineering interest were significant predictors of persistence in engineering. Gender was neither a significant predictor of engineering identity nor persistence in engineering. This study is the first step in using an engineering identity scale to directly measure engineering identity in undergraduate students beyond the first-year.

Keywords: identity; persistence; retention; survey; undergraduate

Murat Karakaya, Meltem Eryilmaz and Ulas Ceyhan 364–370 Analyzing Students' Academic Success in Pre-requisite Course Chains: A Case Study in Turkey

There are several principles which have been accepted as approaches to successful curriculum development. In spite of the differences in the proposed sequencing of topics, all approaches basically depend on the pre-requisite chains to implement their educational approach in the curriculum development for specifying the order of the subjects. In this research, two pre-requisite chains representing two different curriculum development approaches are taken into consideration in a case study. The first research question considered is whether academic success in a follow-up course is positively related to success attained in the pre-requisite course. The second one is whether or not the selected curriculum development approach for deciding the chains has a significant impact on the academic success relationships between a pre-requisite and its follow-up course. To answer these questions, course data of 441 undergraduate students who graduated from the Atılım University between Fall 2001 and Spring 2015 semesters were collected and analyzed. The results indicate that the success levels gained in a pre-requisite and its follow-up course are correlated. Moreover, different curriculum development methods can affect this correlation. Thus, curriculum developers should consider appropriate approaches to improve student success for deciding chaining courses and their contents.

Keywords: curriculum development; pre-requisite chain; academic success

Mostafa Al-Emran, Vitaliy Mezhyuev and Adzhar Kamaludin 371–380 Students' Perceptions Towards the Integration of Knowledge Management Processes in M-learning Systems: A Preliminary Study

It is highly important for the higher educational institutions to understand the factors that affect the students' acceptance of Mobile Learning (M-learning) systems as a prior step to the implementation of such systems. From the M-learning perspective, the literature ignores some factors that could contribute to improve the knowledge acquisition, sharing, application, and protection, and how such factors could affect the M-learning acceptance. From the Knowledge Management (KM) perspective, research shows that KM processes have a positive impact on the acceptance and implementation of many Information Systems (IS). We observed that the existing literature overlooks the impact of KM processes on M-learning acceptance. Accordingly, the main objective of this study is to analyse the students' perceptions towards the integration of KM processes in M-learning systems. A mixed method (questionnaire and interviews) was used for data collection. An online survey has been sent to IT undergraduate students in two different universities in two different regions namely, Universiti Malaysia Pahang (UMP) in Malaysia and Al Buraimi University College (BUC) in Oman. 305 students responded to the survey. Results indicated that around 74% of students reported that it is interesting to incorporate KM processes in M-learning systems. Additionally, results pointed out that 93% of the students indicated that they would use the M-learning system in their studies if all KM processes will be taken into consideration. It is imperative that these results will assist the M-learning systems developers to take these factors into their consideration while designing and developing such systems. Furthermore, educators may need to elaborate their teaching strategies in a way that suits the use of these systems and meets the students' needs.

Keywords: M-learning; knowledge management processes; acceptance; perceptions

Wei-Fan Chen, Pao-Nan Chou, Yen-Ning Su and Heng-Yan Chen 381–387 Electrical Engineering Faculty's Perspectives Towards Integrating Technologies into Teaching and Learning

This study investigated electrical engineering faculty's perspectives towards technology integration in classrooms. A survey research method obtained professors' perceptions of technology integration. A questionnaire developed in the study consisted of four psychological constructs: development of digital learning material, digital learning technology use, school administrative support, and individual instructional perception (defined as personal barriers to technology adoption). One hundred twenty-eight electrical engineering faculty members in Taiwan participated in the study. The findings show that the overall electrical engineering professors' attitude towards technology integration in classrooms is positive. Faculty members perceive individual instructional perception, such as time investment and teaching burden, to be a major concern for integrating technologies into teaching and learning. Age and academic rank do not strongly influence their attitudes towards technology integration.

Keywords: technology integration, learning with technology, technology in engineering education

Worldwide studies show that science and technology careers are not very attractive to younger students. The declining student interest in engineering careers is problematic due to the existing shortage of engineering professionals and this situation needs to be quickly improved. Initiatives setup to tackle this situation have been too focused on formal education and results were not impressive. New tools and strategies are required to address this issue in such a way that matches the interests of the youngsters. ECity is a European initiative that motivates students to follow an engineering career by giving them a basic understanding of engineering problems and tasks through a city-simulator video-game. Implementation results show that there is a correlation between the enjoyment of the game and the understanding and willingness to follow the engineering path. Results also show that the game had a higher impact in younger, basic-education students than in older, secondary education students. Therefore, this kind of initiatives should take place at an early age-level.

Keywords: engineering; engineering careers; serious games; simulation; STEM; video games

In this paper we discuss the result of piloting a methodology for Engineering Final Year Projects (FYP) assessment that takes into consideration professional skills acquisition. The FYP is structured around three milestones; skills are assigned to each milestone according to the tasks required in each phase, and a list of indicators have been designed for every phase. The criteria are specified in a rubric and are made available to students. The FYP implementation includes evaluation methods and a homogeneous assessment throughout the project development in order to provide students with valuable project implementation support, to facilitate the project organization, to improve the quality of projects and thereby to reduce the academic drop-out rate. The proposed methodology has been implemented and piloted at the Barcelona School of Informatics, and the conclusions can easily be generalized to any other Engineering degree. This paper presents the results of the FYP for 1,569 students. The average percentage of students finishing FYP in previous degrees was 65% on average, whereas in the case of the Bachelor Degree in Informatics the percentage rose to 90% with the methodology proposed in this paper. In addition, 95% of these students finished their FYP in less than one year, compared to only 65% who finished it in less than one year in previous Degrees.

Keywords: final year project; assessment of final year project; assessment of professional skills

Engineers are increasingly required to work in teams that span time zones and cultures. Engineering education has begun to attempt to prepare students for this environment. An important topic is how to best form teams of students for distributed design projects. The goals of this research were to validate a method for organizing teams to maximize team performance and identify and validate metrics for individuals that would help in the organization of distributed teams of student engineers. A review of previous, related research is provided. A description of the proposed method of team organization is given, along with methods of data collection and a comparison of the proposed method to common methods. How students were divided into teams and each team's method of organizing sub-teams are described. Use of online surveys, tests, statistical methods, and other data gathering and analysis methods are explained. Statistical analysis of survey results and qualitative results of interviews and observations suggest that a profile-based method for organizing teams results in significantly higher team satisfaction. Some methods for measuring and/or predicting individual attributes related to teamwork, such as the significance of participation in team sports, were validated. No correlation was found between which university a student attended and a student's level of satisfaction with his or her team. Team success in distributed, multi-disciplinary student design teams can be improved by gathering information about team members and using a profile-based method to organize team members into sub-teams and leadership positions.

Keywords: virtual teams; multi-university capstone; distance learning; team performance

This paper describes a paradigm of engineering education to implement design activities throughout the engineering curriculum. Traditionally, engineering design is taught through a capstone experience where students implement the concepts learned in technical courses. There is growing interest in changing this paradigm to teach the technical concepts through the hands-on activity of design. However, there are significant challenges to implementing this paradigm. These include time, coordination, and expertise limitations. This paper describes a paradigm where design is centralized to a specific course activity while the design artifacts are learning aids that support the other technical courses and correct misconceptions of concepts presented in those courses. We conducted a preliminary study in a 16-week design course for 89 junior and senior undergraduates in mechanical engineering. Results indicate the approach both improves the design decision-making skills of students and provides a workable framework to implement design throughout an engineering curriculum.

Keywords: design education; situated cognition; cognitive apprenticeships

Embodied Conversational Agents (ECAs) are interactive characters that exhibit human-like qualities, such as facial expressions, lip-synch, or emotional voice, and are able to communicate with humans, or with other ECAs by using natural human capabilities (speech, gestures, etc.). However, to make current ECAs' dialogue management strategies more appealing and real to the user, they should be aware of general knowledge about the external world. This factual knowledge, which is independent of personal experience, should be stored in their semantic memory. This paper presents a knowledge-based solution to improve learning through ECAs with factual knowledge based on semantics. In particular, we build this semantic memory by means of a novel proposal known as Daira. Moreover, we integrated Daira with Maxine, a powerful animation engine for developing applications with embodied animated agents. To illustrate the potential of our approach, we designed a proof of concept in which our system is able to provide data from the online Great Aragonese Encyclopedia (GEA), written in Spanish, to engage students. The experiments performed show the feasibility and efficiency of our proposal. In particular, we demonstrated that using enriched ECAs when searching information can enhance learning motivation and learning performance, making the interaction process much more accurate, simpler, and near to the students.

Keywords: embodied conversational agent; maxine; factual knowledge; learning; semantic memory

This paper describes the change in software design strategies used by novice programmers over the course of one semester by using verbal protocol analysis. Our participants were nine first-year undergraduate students (novices), and two experts. Overall, we observed that two types of strategy were used by the novice programmers. The most common strategy observed in our participants, at the beginning of the semester, was a UI-based strategy that focused on system components from the user's perspective. This strategy is often overly simplified with little operational and technical details. Another type of strategy used by novices later in the study was a functional-centered strategy in which novices incorporated programming concepts into their design. Novices who used the latter strategy were able to provide more operational detail than when the UI-based strategy was used. We also found that, due to lack of experience, the designs were still very preliminary. In addition, the novices also exhibited opportunistic design behavior more often than systematic behavior (i.e., a top-down or bottom-up strategy) during the semester. We argue that teaching programming knowledge and skills alone will not develop students' software design knowledge effectively.

Keywords: psychology of programming; verbal protocol analysis; software design; human factors

Simon McCallum, Deepti Mishra and Mariusz Nowostawski 471-481 Enhancing Software Engineering Education with Game Design and Development

The benefits of integrating game development in software engineering education are multifold. It keeps the students interested, engaged and motivated during the courses and can potentially open a range of employment opportunities for students who would like to pursue a career in the game industry. The present study reports the design and delivery of four game related courses in Bachelor in Programming. A "red thread" of game courses are used to motivate the software engineering material, while a software engineering approach was used for regular addition of new courses and updating existing courses. As the authors were involved in teaching across all levels, they were able to retain an overview of the curriculum as a whole while implementing these improvements. Integration of new courses and new content requires testing and constant evaluation. The motivation for the assignments and the assessment of the courses are discussed in relation to development and Self-Determination Theory. The courses are reviewed for their contribution against both the SWEBOK knowledge areas and the IGDA curriculum framework. Further, lessons learnt about using games to teach software engineering to improve education are included.

Keywords: game programming; software engineering; undergraduate curriculum; training

Alenka Kavčič, Matevž Pesek, Ciril Bohak and Matija Marolt 482-496 Introducing On-site Customers in Agile Software Development Projects: An Alternative Approach to Project Work in Engineering Education

In the paper, we propose a way to enhance collaboration between schoolteachers in need of good educational content, contributing their ideas from practice, and computer science students, who participate as software developers in the engineering education projects. The paper addresses the problems we have encountered during the development of educational games. Several groups of computer science students who were developing educational gaming applications as part of their projects were lacking basic didactic skills for developing a final product, which would be valuable for use in class. Some problems arose from the fact that the teams used ad-hoc methodologies for developing their applications. To address the problem, we propose an amended agile development methodology for the presented scenario, with strong emphasis on inclusion and collaboration of schoolteachers as on-site customers. A collaboration environment was prepared for the agile teams, encouraging students and schoolteachers to work together, share ideas, and provide relevant feedback. Altogether, 48 students and 8 schoolteachers participated in the study. The interactions of schoolteachers and agile teams were assessed in different ways: through observations during workshops, by analysing activities in the collaboration environment and by monitoring the system log files. The presented collaborative environment proved a useful tool for supporting communication and cooperation between members of the agile teams, but only in the teams where the schoolteachers accepted such a way of remote communication. Just the availability of the tool was not enough to improve the collaboration; the motivation for remote communication has to come from the team members.

Keywords: e-learning; educational games; user-developer collaboration; knowledge exchange; agile software development

Jianliang Gao, Jinfang Sheng and Zuping Zhang 497-504 Big Data Processing: A Graduate Course for Engineering Students

In the era of big data, professional graduates mastering big data technology are in urgent demand for both academia and industry. Nowadays, it is timely to set up a new course about big data processing for engineering students. In this paper, we design the course of big data processing for the graduate students with engineering backgrounds. This course provides a general overview of the frontier field of big data processing. The main advantages of this new course include: (1) it is a new big data processing course and introduces the newest technology such as Hadoop and Spark, which is great helpful to engineering students; (2) the course includes theoretical knowledge, as well as practical aspects of big data processing, which makes this course more suitable for engineering graduates than the related big data training courses. The survey results of recent four years illustrate that this course is successful as an emerging course for engineering education.

Keywords: big data; emerging course; engineering education

Ani Ural 505-513 A Virtual Biomechanics Laboratory Incorporating Advanced Image Processing and Finite Element Modeling

Biomechanics is an emerging field within mechanical engineering. The number of students who are interested in biomechanics has been increasing in recent years. Therefore, integration of biomechanics concepts into mechanical engineering curriculum is currently of high interest both for students and faculty. This paper outlines a virtual bone testing laboratory that was developed and implemented in a biomechanics course as a part of the graduate mechanical engineering curriculum. Five virtual experiments were designed utilizing advanced image processing and finite element modeling. These experiments incorporated interactive visualization, manipulation, and virtual testing of actual bone images to evaluate the mechanical response of bone. The virtual laboratory created a hands-on learning environment while bridging the gap between theory and real life behavior and helped develop a deep understanding of the underlying fundamental principles of complex mechanics concepts. The assessment of the effectiveness of the virtual experiments through surveys demonstrated an improvement in students' overall understanding of the course material. In summary, the virtual laboratory complemented the theoretical components of the course and created a richer learning environment for the students.

Keywords: virtual laboratory; finite element modeling; biomechanics

The thermal boundary layer concept is an abstract topic due to the difficulty of direct observation. Three different approaches are used to allow students to visualize the thermal boundary layer for a geometry that is relevant to heat exchanger design. We focus on the case of a heated cylinder in cool water for both natural and forced convection. High-magnification videos of the boundary layer were made using a telecentric imaging system. Numerical simulations of the experimental system agree with observations. A set of ultra-low-cost desktop learning modules based on shadowgraphy were constructed to allow students to directly see aspects of natural and forced convection from a cylinder. Numerical simulations and telecentric imaging clearly show the initial diffusive growth of the boundary layer and subsequent onset of buoyant convection. When flow is initiated, both show a thinning of the boundary layer on the upstream side of the cylinder. The boundary layer itself may be impossible to see by eye for the low-cost experiment, however, the plume and disruption of the boundary layer by laminar cross flow can be seen. We implemented the thermal boundary layer visualization activities in a fluid mechanics and heat transfer course with 48 students. Numerical simulations and videos were shown after which the thermal boundary layer modules along with the worksheets were given to students. Statistical analysis of pre- and posttest results shows significant improvements for three out of five questions with moderate to very large effect sizes. Feedback is positive, with students finding the exercises interesting, helpful, informative, and well-explained. We believe that these visual representations aid learning and can actively engage students in the learning process.

Keywords: low-cost desktop learning module; thermal boundary layer visualization; shadowgraph; heat transfer simulations; hands-on learning

Traditional lectures are not effective for teaching practical subjects. Therefore, it is important to develop a sufficient methodology to provide the conceptual and practical aspects of a course to the students. In this paper, we describe the challenges faced in the implementation of active learning methods in the subject of Data Communication & Computer Network in vocational education at the Federal Institute of Brasília. The experiences resulted in a blended methodology, which combines collaborative and problem-based learning with a learning management system. The flipped classroom was also applied in order to enhance the quality of the references used by the students in the solutions. In addition, traditional apps and social networks were used to improve the communication between students and teachers. The practical activities were applied in a small computer network laboratory, but in the first semester of 2016 it was improved, and a new high performance Datacentre was built. Thus, interdisciplinary aspects and research were explored including the relationship between vocational and graduate courses. Moreover, transversal skills, such as teamwork, leadership, self-confidence and autonomy in decision-making were developed. The research was conducted from 2011 to 2016, and 147 students were enrolled with an average of 14 students per class. Such features demonstrate that the learning methodology must be fit for the course and the educational level in order to become effective.

Keywords: problem based learning; flipped classroom; learning management systems; blended learning

This paper investigates the use of a case study to improve students' learning outcomes in construction engineering. The improvements were measured using the Laboratory for Innovative Technology and Engineering (LITEE) survey instrument. Five constructs were used to assess students' learning outcomes: higher-order cognitive domain of learning, self-efficacy, ease of learning, teamworking, and communication skills. Using a sample of 15 students, we collected both quantitative data (survey questions) and qualitative data (open-ended questions) on learning outcomes and students' perceptions of the effectiveness of using a case study. The results showed that working with a real case study significantly improved students' higher-order cognitive domain of learning. Our findings suggest that case studies can be used as an effective tool to improve students' learning in the classroom.

Keywords: case study; cognitive skills; teamwork; construction engineering