

The International Journal of Engineering Education

Contents

Section I

Special Issue

Emerging Technologies to Enhance Engineering Education

Guest Editor

Patricia Ordóñez de Pablos—The University of Oviedo, Spain

Ahmad Ibrahim	521	Editorial
Patricia Ordóñez de Pablos	522	Guest Editorial
Hoda Baytiyeh	523–532	Internet Contribution to the Engineering Students' Learning

Nowadays, the internet represents an essential tool that enables students to not only communicate but also access vast amount of information on a broad range of topics. This study investigates the impact of internet use on engineering students and how it has contributed to their academic advancement. The study offers an analysis of the responses of engineering students ($n = 1376$) enrolled in three major universities in Lebanon. Participants completed a survey that collected various data related to demographics, how long they have been using the internet, how many hours/week they spend on the internet, and the purpose of these activities. Participants were also asked to rate, using a 4-point Likert-type scale (1 = very little, 4 = very much), 22 items that reflected the degree to which their internet use affected their skills. An exploratory factor analysis was applied to the 22 items that generated four knowledge factors involved in internet use: non-formal, informal, professional, and social. Informal was shown to be the most important knowledge factor for participants, followed by non-formal, social, and professional. This study contributes in general to the literature of engineering education and in particular to the contribution of technology use in learning.

Keywords: internet use; informal learning; engineering education; Lebanon

Cornelio Yáñez-Márquez, Mario Aldape-Pérez, Itzamá López-Yáñez and Oscar Camacho-Nieto	533–542	Emerging Computational Tools: Impact on Engineering Education and Computer Science Learning
---	---------	---

Computational tools have become an almost permanent element and one that must be present in novel schemes of interactive learning, practically for every educational topic in engineering education. A pretty natural environment for the application of such emerging technologies is that of scholar courses immersed in computer sciences learning, either in technical, superior or postgraduate teaching. Of particular interest are the teaching—learning processes of such topics as artificial intelligence, pattern recognition, neural networks, and associative memories. This interest arises from the magnitude of enrichment gleaned when the kind of emerging computational tools mentioned above are applied to these processes. The current paper focuses on describing and analyzing the positive impacts achieved in the teacher—student interactions through the application and everyday usage of a set of emerging computational tools that the authors have previously and currently employed in postgraduate computer sciences courses. Notice, however, that the results presented here are applicable—in a straightforward manner—to engineering education in general.

Keywords: emerging technologies; engineering education; computational tools; computer science learning

Gianluca Elia, Giustina Secundo, Wael Fateh Assaf and Ayham Fayyumi	543–559	Web 2.0 Blended Learning to Introduce e-Business Contents in Engineering Education: a Pilot Case Study in Jordan
--	---------	--

Blended Learning (BL) is considered a promising pedagogical approach. Some researches demonstrated that students' satisfaction is higher for BL courses compared to completely online or face-to-face (F2F) courses. Moreover, the explosion of web 2.0 tools and the success of the “read-write Web” are reconfiguring the individual and collaborative blended learning processes. Based on this assumption, this paper investigates the effectiveness of web 2.0 BL for the design and delivery of a pilot course on e-business topics. Two experimentations have been organized involving undergraduates engineering students of the University of Jordan. According to the obtained results assessing students' reaction, learning and behaviour, the BL model proposed in the article revealed more effective than traditional F2F learning. A survey conducted at the end of the course also showed that students were satisfied with the pedagogical approach, and their academic achievements were also significantly improved. Findings demonstrate that successful BL programs require innovative curriculum design strategy based on new principles such as: a) the involvement of heterogeneous stakeholders in the course's design phase; b) the focus on competence development rather than on knowledge transfer; c) the choice of team work as an additional component to evaluate individual students' performances; d) presence of remote and F2F interactions among peers and between teachers and students; e) the usage of web 2.0 tools as enablers of collaborative learning processes and social networking; f) continuous tutoring both for content and technological issues. These findings can help engineering colleges and universities to design and offer more effective learning courses.

Keywords: blended learning; web 2.0; engineering education; curriculum design; learning assessment, e-business

Jacky Xi Zhang, Li Liu, Patricia Ordóñez de Pablos and Jinghuai She	560–565	The Auxiliary Role of Information Technology in Teaching: Enhancing Programming Course Using Alice
--	---------	--

Teaching and learning programming are the fun and also pain part for instructors and students in academic institutions, from the famous “Hello World” simple codes to advanced feature application software, there is a long and tough way to go for most of the students. Within limited teaching hours, instructor's presentation and explanation of the computer language are not attractive enough to raise and improve students' interest for learning proactively as students have different learning styles [1]. From the observation and the query, most students are more comfortable with learning by visual presentation—diagrams, video, animation, verbal explanation and trying things from their own interesting story. This paper describes a teaching approach for Java programming by using Alice—an innovative 3D programming environment that make it easy to help students learn fundamental programming concept in the context of creating animated movies and simple video games [2]. Evidence of students performance in

learning Object-Oriented programming as a result of this approach are shown in this paper by statistical data that gathered, summarized and observed from fall semester of 2012.

Keywords: programming course; Alice; 3D programming environment

Elizabeth C. Bristow, Jakob C. Bruhl 566–575 Effect of Supplemental Instructional Videos on Student Performance in Engineering Mechanics Class
and **J. Ledlie Klosky**

Short, instructor-created videos were introduced to a junior-level engineering mechanics class for use as a supplementary resource. The videos focus on a single course concept and demonstrate appropriate problem-solving technique. This technique was found to appeal to students across a variety of majors and learning style preferences and was shown to be effective regardless of a student's past academic history. Many students realized modest to moderate improvement in performance on homework assignments and exams by using the videos as a review. Based on student feedback and access patterns, the videos are shown to serve as a valuable supplement (but not a replacement) for traditional in-classroom instruction. The future of digital content libraries and virtual environments for learning is also discussed.

Keywords: video learning; asynchronous learning; online learning

Ana-B. González-Rogado, M^a-José Rodríguez-Conde, Susana Olmos, 576–584 Key Factors for Determining Student Satisfaction in Engineering: A Regression Study
Miriam Borham and F. J. García-Peñalvo

The aim of this study is to present empirical evidence of the influence of the use of active didactic methodology on satisfaction with regard to teaching received by engineering students in Spain. Student satisfaction is one of the result indicators established, based on student opinion, to measure the quality of the Spanish university system. It is an important index and is directly related to facilitating the learning process, because a satisfied student is likely to be more receptive in the teaching/learning process and therefore, less likely to abandon university studies. This problem is particularly relevant in certain areas of knowledge, like, for example, Engineering and Architecture. We present here the results obtained in an experimental type study carried out in the Escuela Politécnica Superior de Zamora, University of Salamanca, Spain. Our aim is to discover the influence of satisfaction level in relation to the application of active methodologies. In order to do so, we carried out a comparative study and repeated experiment (with student samples from two academic years) of the results of satisfaction levels obtained for students following a course based on traditional methodology consisting of lectures and evaluation by means of a final examination (control group), and for students who followed a course based on a student-focussed teaching/learning methodology consisting of constructive learning, collaborative work, bLearning resources and learning process integrated evaluation (experimental group). 218 students from four engineering degree courses took part in the experiment. Based on the variables selected, a satisfaction survey was designed and carried out and, using a multiple regression multivariate statistical technique, the joint relationship of a series of predictor variables was analysed in relation to the criterion or dependent variable. The results obtained reveal the existence of different relationships between predictor variables and criterion, depending on the didactic methodology used. This paper focuses mainly on the stages of the statistical process used to obtain results.

Keywords: student satisfaction; active learning methodology; formative processes in engineering; blended-learning; experimental design in education

Plácido Rogério Pinheiro, Isabelle Tamanini 585–595 Verbal Decision Analysis Applied on the Choice of Educational Tools
and **Thais Cristina Sampaio Machado** Prototypes: A Study Case Aiming at Making Computer Engineering Education Broadly Accessible

Nowadays there is a growing demand for professionals with knowledge on software processes. With the aim of introducing these techniques to a considerable number of people, in an easy and accessible way, this paper presents ideas for educational tools that support its teaching. Currently, the only way people can have a good knowledge on the area is attending to formal courses, and our aim is to divulge the area via Computer Engineering Education techniques, such as educational tools or games that arouse people's interest for learning. This way, six prototypes are defined and Verbal Decision Analysis methods will be used to help selecting the prototype that fits the necessity of the users. The ORCLASS method will be applied using the ORCLASSWEB tool, with the aim of classifying the prototypes in two groups, acceptable and unacceptable designs. Then, the prototypes of the first group will be ordered using a tool based on the ZAPROS III-i method so that the most preferable interface will be selected. The research results show that the use of qualitative methods of decision support can benefit significantly on selecting the preferable interface for future development of real educational tools applications.

Keywords: verbal decision analysis; ORCLASS; ZAPROS III-i; educational tools prototypes

Xi Zhang, Hui Ma, Yina Wu, Patricia Ordóñez de Pablos and Weiguang Wang 596–602 Applying Cloud Computing Technologies to Upgrade the Resource Configuration of Laboratory Course: The Case of Quality Engineering Education Platform

The cloud computing (CC) is an important emerging information technology for the information resource optimizing. In this case study, we applied CC technology in the quality engineering education platform design process, and investigated the effects of CC on saving resources, optimizing process, and education innovations. First, we described the designing and applying process of CC education platform. Then, we designed a measuring software aided method on evaluating quality of CC application. Finally, a standard was applied to evaluate university laboratory's management ability on CC platform. By applying cloud computing technology in quality engineering courses, and providing evaluating method, this research has both teaching and research implications for engineering education, like teaching students how to management cloud computing platform with "learn by doing" model.

Keywords: cloud computing technology; laboratory; resource configuration; management evaluation

Abdulhameed Alelaiwi and M. Shamim Hossain 603–609 Evaluating and Testing User Interfaces for Engineering Education Tools: Usability Testing

Evaluation of users interfaces for engineering education tools such as E-learning is important to have enhanced real learning experiences in this domain. To this end, in order to have this experience, we conducted usability studies to see its impact. E-learning usability studies require the involvement of real end users. Different users with varying backgrounds and levels of human-computer interaction (HCI) knowledge behave differently when using e-learning tools. To study user behavior in the e-learning context, an empirical usability study on a specific e-learning tool was conducted. The study uses usability evaluation questionnaires collected from two different groups of Software Engineering Students: one group with HCI knowledge and the other without. The objective is to collect the technology enhanced learning experience from the real users to see the impact of engineering education. It is found that end users without HCI knowledge are more satisfied than those with HCI knowledge, as the latter have higher expectations concerning the tool.

Keywords: usability studies; enhanced learning technology; learning experience with software engineering students; technology impact on students

Andrés Faiña, Jesús López-Rodríguez and Laura Varela-Candamio 610–617 Using Game Theory in Computer Engineering Education through Case Study Methodology: Kodak vs. Polaroid in the Market for Instant Cameras

Our teaching proposal lies in explaining some of the core concepts of non-cooperative game theory by means of real cases of strategic decision within the computer engineering education. The innovative features of our methodology are based on the use of PC simulations to analyze the strategic decisions faced by Kodak and Polaroid under several circumstances. The discussion of the Kodak vs. Polaroid case fits very well to introduce the students the economic perspectives within the more technical discipline of engineering. With this new e-learning method, on the one hand, the students of computer engineering get a more realistic and complete vision in their learning and on the other reduce the degree of abstraction of the theory itself and thereby a greater motivation and interest in social sciences are achieved.

Keywords: game theory; non-cooperative games; Nash equilibrium; case study; engineering education

M. Shamin Hossain, Abdullah Alghamdi, Abdulhameed Alelaiwi, Ahmed M. Ghoneim and Md. Abdur Rahman 618–624 Web Service based Collaborative E-learning Environment for Engineering Education

With the increasing growth of communication technologies and pervasive devices, a number of collaborative services are being built for ubiquitous learning access to e-learning environment. However, there exist so many devices with similar functionality but with heterogeneous QoS capability. In order to have suitable services according to desired QoS, services need to be selected. This article presents the corresponding solutions to service selection for collaborative e-learning environment. The experimental results not only showed our solution is more efficient than the similar system but also proved that our solution can work well for web services-based collaborative e-learning environment, especially for enhanced engineering education.

Keywords: web service; e-learning; collaborative service; QoS

Jorge Martín Gutiérrez and María Dolores Meneses Fernández 625–635 Applying Augmented Reality in Engineering Education to Improve Academic Performance & Student Motivation

Students starting at university are accustomed to using the latest generation of devices and technology for communication, leisure and work. All technological progress allows for the use of innovative learning tools in education, causing significant changes in teaching methods and the students' learning processes. Augmented Reality (AR) in education is an emerging area, so this paper analyses how this technology influences academic performance and encourages student motivation. We are starting from the hypothesis that the use of didactic material based on AR technology will improve motivation and the academic performance of students, so new didactic material has been developed using AR to explain the contents of standard mechanical elements. This research yields results that indicate how engineering students obtain better academic results and are more motivated, when the new generation of technological tools is incorporated into the learning process. Twenty five first year students studying for a Mechanical Engineering degree used AR technology to assist them in the subject of graphic engineering. During the study, a control group of twenty two fellow students used traditional class notes. All these students took an exam and two surveys to give feedback on the teaching material: one for finding out the effectiveness and efficiency of the material itself, together with the level of student satisfaction; another for assessing the level of student motivation when using the technology available during the study. The results showed a significant statistical difference between their academic performances, proving to be higher in the experimental group; this group also showed a higher level of motivation than the control group.

Keywords: augmented reality; engineering education; standard mechanical elements; motivation; academic performance

María Teresa García-Álvarez, Eva Suarez Alvarez and Raquel Quiroga Garcia 636–643 ICTs and Learning: A Challenge in the Engineering Education

The present educational context of higher education in the European Union shows the importance of developing a teaching based on learning. Information and Communication Technologies (ICTs) favor the development of a more active role of students by means of the creation of a flexible and an interactive learning where student is the centre. These technologies have been incorporated in engineering degrees too where learning based on experimentation and exploration acquires a great relevance.

The objective of this paper is to study the role of ICTs in the learning process of engineering students in a subject of Economy. In this context, we analyze the learning results obtained by students of computer engineering before and after the use of a learning virtual platform. At the same time, the main advantages of such tools are discussed. Results indicate that these students obtain a better learning by means of the use of ICTs.

Keywords: information and communication technologies; learning; knowledge; engineering; economy; virtual learning

Valentina Dagiene, Bronius Skupas and Eugenijus Kurilovas 644–653 Programming Assignments in Virtual Learning Environments: Developments and Opportunities for Engineering Education

The aim of the paper is to present observations on automatic and semi-automatic assessment for programming assignments used in different e-learning contexts. Teaching of programming is an important part of different Informatics Engineering, Computer Science or Informatics, Computing, Information Technology and Communication courses in Universities and high schools. Students taking these courses have to demonstrate competences in problem solving and programming by creating working programs. Checking program validity is usually based on testing a program on diverse test cases. Testing for batch-type problems involves creating a set of input data cases, running a program submitted by a contestant with those input cases, analysing obtained outputs, etc. Assessment of programming assignments is as complex as testing of software systems. A lot of automatic assessment systems for programming assignments have been created to support teachers in submission assessment. However the problem of balance between the quality and the speed of assessment for programming assignments is important. Authors conducted the research on the possibilities of advanced semi-automatic approach in assessment, which can be used as compromise between manual and automatic assessment. A semi-automatic testing environment for evaluating programming assignments is developed, and the practical use of this system in Lithuania's optional programming maturity examination is presented. Presented research is useful for evaluating results of engineering education in general, and informatics/computer engineering education particularly.

Keywords: engineering education; programming assignments; computer program assessment; automatic and semi-automatic assessment; personalised feedback; virtual learning environment

Miguel Torres, Rolando Quintero, Marco Moreno, Giovanni Guzmán and Félix Mata 654–662 The Role of Engineering Education for Semantic Retrieval of Geographic Objects based on Ontological Descriptions and Conceptual Schemas

Geospatial information retrieval is not a trivial task. An integrated view must be able to describe various heterogeneous data sources and its interrelation to obtain shared conceptualizations. Ontology engineering is rapidly becoming a mature discipline, which has produced several tools and methodologies for building and managing ontologies for different purposes. In this paper, a methodology to semantically retrieve geospatial information based on ontological descriptions and conceptual schemas is proposed. It consists of providing semantic representations, which explicitly describe the properties and relationships of geographic objects represented by concepts, while the behavior describes the objects semantics. The work presents a methodology to integrate and share geospatial information. The approach is driven by application ontology, which has been designed using the GEONTO-MET methodology. The work is intended to establish the basis for the semantic processing oriented towards semantic information integration and retrieval. The semantic retrieval is an approach very useful in applications focused on semantic web and e-learning in order to process and infer knowledge with a wide range tools in Engineering Education.

Keywords: semantic information integration; application ontology; ontological description; conceptual schema

In previous research we proposed a new type of learning object named Collaborative Complex Learning Object (CC-LO) in support for teaching and learning engineering education by the virtualization of live collaborative sessions, with the aim to leverage the knowledge elicited during the collaboration and produce interactive and attractive resources to be played by learners. We claim this type of pedagogically and technologically augmented learning resources is able to overcome endemic problems found in collaborative learning of on-line engineering courses, such as lack of authentic interactivity, user empowerment, social identity and challenge, thus having a positive effect in learner engagement. In this paper we report on the experiences gained in the production, deployment, experimentation and validation of the CC-LO approach from the live collaborative sessions occurring in real on-line engineering courses of the Open University of Catalonia (UOC). The ultimate goal is to evaluate and validate how our approach can support engineering education at the UOC, and in particular observe the impact on the collaborative learning performance during the on-line discussions. The novelty of this paper is the integration of our approach into the actual phpBB-based Web forums that support specific engineering courses at the UOC and in particular their in-class discussion processes and collaborative activities.

Keywords: engineering education; live collaborative learning; discussion forum; collaborative complex learning object; virtualized collaborative sessions; learning engagement; Open University of Catalonia

This article describes an experience of the use of Personal Learning Environment (PLE)-Portfolio to compile various digital artifacts in virtual spaces, which represent a theoretical content learning process associated with knowledge, in a competency-based context, using a variety of Web 2.0 tools. Based on the Learning Spiral as a framework for curriculum design in connectivism and in the co-association, it created lessons, activities, and projects in order to create dynamic learning situations that contribute to the development of thinking skills and mental habits of first-year college students of technical engineering education at the Higher Technical Network Administration and Computational Support of the Lota Arauco Technical Training Center at the University of Concepción. To analyze the experience, it proposed an evaluation model that was built using ICT, evaluative principles, a defined competencies standard, evidence and types of ICT assessment. As data instrument collection, rubrics were used that allowed to determine what students did with and without ICT. Main results of this experience are the generation of a methodological and evaluative model that facilitates theoretical learning, from the paradigm of learning using ICT, for example to promote higher competencies development in students, incorporating ICT seamlessly into a learning activity, increasing motivation and collaborative work in the physical and virtual classrooms.

Keywords: Web 2.0; ple-portfolio; e-learning evaluation; competencies; evaluation models with ICT

Virtual environments are head-referenced computer displays that give users the illusion of displacement to another location. They have potential uses in applications ranging from education and training to design and prototyping. In this paper a virtual visit at Palacio de Bellas Artes in Mexico is described. The Palacio de Bellas Artes is the biggest and the most important cultural center in Mexico City which has halls for exposing pictorial and sculptural works and it shelters the National Theater and the National Museum of Architecture. The interior of the building is decorated with murals painted by the most prominent Mexican artists. The whole place is a place of culture. The application is educational software developed by computer engineers that allows users to visit this cultural place from any part of the world. The modeling of the building is accomplished by the use of three-dimensional techniques and online services. The virtual visit is not panoramic and the user can get around the scenarios that have a texture that allows the virtual world to be more real, therefore, the view is more attractive to the visitors. The software is an important contribution for education because it allows the knowledge of one of the most important cultural contents in the world via Internet.

Keywords: Virtual environments; Education; Three-dimensional techniques; Blender; Fine Arts Palace; 3D

This research is focused on developing an approach for learning activities in a virtual learning environment employing Web 2.0. These activities are incorporated into the design of a course intended to contribute to the development of generic and specific competencies. Input from subject experts was utilized in developing the approach.

A pilot project was implemented and assessed in a Civil Engineering and Informatics course at the Universidad Católica de la Santísima Concepción. The approach was assessed through a developed guide to the most effective course design based on learning theories relating instructional design to learning outcomes.

Keywords: competencies; Web 2.0; engineering education, virtual learning environment

Section II

Contributions in: Content Analysis of Engineering Education Journals, Assessment Methods, Curriculum Design, Laboratory Work, Psychological Factors and Academic Performance, Nanotechnology, Electrical Engineering

This study aims to employ a Google database to explore worldwide engineering education journals. Research questions focus on four areas: (1) journal indexing, (2) journal characteristics, (3) frequently cited articles, and (4) H-index profiles. A three-stage content analysis, which included journal sampling, journal examination, and journal identification, was used to obtain related data. A total of twenty engineering education journals were identified and examined through a quantitative investigation. The findings yielded in the study may allow engineering educators and researchers to gain in-depth information about journals in the engineering education area, to understand various ranking methods, and to select a suitable journal when submitting a manuscript for publication.

Keywords: content analysis; engineering education journal; Google database; H-index

When used appropriately, self- and peer-assessment are very effective learning tools. In the present work, instructor formative assessment and feedback, self-assessment (SA), and peer-assessment (PA) have been compared. During the first part of a semester, the students followed a continuous formative assessment. Subsequently, they were divided into two subgroups based on similar performances. One subgroup performed SAs, and the other followed PA during the last part of the course. The performances of the two groups in solving problems were compared. Results suggest that PA is a more effective learning tool than SA, and both are more effective than instructor formative assessment. However, a survey that was conducted at the end of the experiment showed higher student confidence in instructor assessment than in PA. The students recognized the usefulness of acting as peer assessors, but believed that SA helped them more than PA.

Keywords: peer assessment; self-assessment, formative evaluation; evaluation methods

The present study aimed to introduce a new approach to curriculum planning for a university nanotechnology curriculum based primarily on outcome-based education according to a competence-based perspective. To achieve this study purpose, curriculum mapping was used to explore nanotechnology curricula in higher education in Taiwan. Considering, as the initial point, the competencies of varied nanotechnology that professionals are expected to develop in higher education, the main competencies were identified through the content analysis of 600 course syllabi collected from thirteen nanotechnology-related undergraduate and graduate programs in nine leading universities in Taiwan. Next, courses were further analyzed and linked to the identified nanotechnology professional competencies, taking advantage of curriculum mapping, and consequently re-organized into a comprehensive curriculum map. Implications of design features in particular and important applications of the developed curriculum map are discussed.

Keywords: curriculum mapping; nanotechnology education; outcome-based education

The control lab module presented in this paper culminates with a hands-on experience of the basic theory given in an introductory control systems course. This module, which is placed during the last two sessions of an undergraduate control laboratory course, focuses on the modelling of two DC motors with different characteristics, parameter identification, and the impact of different model-order reduction techniques on control design. This module integrates theoretical, numerical and experimental analysis of practical relevance, and redirects students to focus more on performance measures and analysis. This paper details the objectives, equipment needed, laboratory lectures, experimental procedures, and observation and analysis desired for this module. It also includes assessment results pertaining to student learning. In addition, this paper provides a novel condition for neglecting the armature inductance. This condition, which is elaborated theoretically and verified experimentally in this paper, is shown to be more reliable than the two conditions presented in the literature.

Keywords: engineering education; laboratory experiment; experiential learning; DC motor control; modelling; parameter identification

A course entitled 'Introductory Project in Electrical Engineering' was developed and implemented at the Department of Electrical Engineering of the Technion—Israel Institute of Technology. The course was designed to expose students in the third semester of their studies to the discipline of electrical engineering and enhance their systems thinking skills. The major component of the course was a team-based design project of a window cleaning robot. The present study, which used quantitative instruments alongside qualitative ones, reveals significant improvement of systems thinking skills among the students who took the course.

Keywords: introductory engineering course; project-based learning; systems thinking

The current study examined the effects that psychological factors have on academic performance through imagination. The study also compared the different ways these factors affect science and engineering majors. A survey was administered at six universities across different regions of Taiwan. The participants in this study were divided into two groups. The first group consisted of 387 science majors, whereas the second group consisted of 386 engineering majors. A structural equation modeling was used to test all the hypotheses proposed. The results showed that the structural models of both majors were similar to each other, but the effects of each variable in the structures were different. Through the mediator effect of imagination, *self-efficacy* had the greatest influence on the academic performance of both groups. *Generative cognition* was identified as the second major predictors of student performance, but its effects on academic performance were slightly negative. The effects of both *intrinsic motion* and *negative emotion* on the science group were smaller than on the engineering group. The influence of *inspiration through action* on the science group was greater than on the engineering group. Finally, practical applications of the current study were suggested. Both limitations and future research were discussed.

Keywords: academic performance; engineering education; imagination; psychological factors; science education