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Contributions in: Life Long Learning, Constructive Approach, STEM, Invention, Creativity, e-Learning, Innovation, Curriculum Design, Academic Performance, Flipped Classroom, PBL, Design Teams, Additive Manufacturing, Cooperative Learning, Blended Learning, Teaching Workshop, Lean Construction, Medical Devices, Robotics, Engagement, Aptitude Test, Motivation, Communication Skills

- Ahmad Ibrahim** 1567 Editorial
- Francisco Falcone, Ana Vazquez Alejos, Javier García Cenoz and Antonio Lopez-Martin** 1568–1583 Implementation of Higher Education and Life Long Learning Curricula based on University-Industry Synergic Approach

In this paper, the experience in collaboration and feedback between different agents from University, Private Companies and Public Companies is presented. Several learning scenarios, from undergraduate studies, postgraduate studies, in-house training and external training, have been implemented and all of them have a common preparation basis. Due to the fact that it has been possible to interact and to allow interaction between all of the different agents, a very fluid and consistent feedback has been present in the process. This interaction has led to the identification of key elements in the learning process, of generic as well as specific competences directly demanded by industry, as well as topics of improvement in the methodology followed in Lifelong Learning programs within Industry. Such information is the basis of actions, some of them implemented and others in implementation phase within different specific courses in Engineering curricula.

Keywords: accreditation; engineering education; European Higher Education Area (EHEA); learning skills; quality assurance; EUR-ACE

- Rejhan Nišić, Edis Mekić and Emir Pećanin** 1584–1593 Constructive Development of Physical Laboratory Exercises Without Manual as an Attitude Changing Approach

This research analyses the implementation of Constructive Approach in development of a modern and efficient laboratory environment. In this context, Constructive Approach means students develop virtual or simulated environments based on their theoretical knowledge, and without already prepared solutions. A new generation of students developed a negative opinion towards laboratories and consider simulated environments as modern and challenging. The objective of this work is to achieve that laboratory for digital communication based on Constructive Approach is implemented. The opinions of 25 students were tracked during the implementing semester by constructive qualitative analysis on tri-component attitude model. The students had an experience in the implementation of different methods in laboratory during their previous semesters. The results showed that opinions towards laboratory was changed to a positive spectrum on three distinctive levels cognitive, behavioral and affective one, compared with the previous opinions towards simulated laboratory environments.

Keywords: constructive approach; cognitive level; behavioral level; affective level

- Feng-Kuang Chiang, Liyan Wang, Jingjing Zhang, Xiaomei Yan, Yehong Yang and Li Chen** 1594–1604 Mapping STEM Education from 25 Years of NSF-Funded Projects

In the last two decades, the focus on science, technology, engineering, and mathematics (STEM) education led by the US has attracted growing attention from governments and research councils worldwide. This study investigates the implementation of STEM in the US by analysing the National Science Foundation (NSF) funding strategies for STEM. The NSF is a major source of federal support for education and educational research in the US. The data show that the NSF funded STEM education projects from 1993, which was an immediate response to the AAAS (American Association for the Advancement of Science) advocacy for science literacy. This study examined the STEM education projects funded by the NSF from 1993 to 2018. The results suggested that both the number of funded STEM education projects and the amount of total funds increased continuously. This funding involved most of the NSF divisions, among which the Directorate of Education and Human Resources shouldered the responsibility for most of the funding, followed by the Directorate of Engineering, which is aligned with its mission to promote the development of the future workforce in engineering. The funded projects laid the foundations for STEM education by funding a wide range of research projects, including research on the basic theories of STEM education, effective classroom practices, and developments in different areas. Recently, the NSF increased the funding for small-scale projects in response to policies that require the implementation of STEM educational practices at every educational level throughout the nation. In addition, the NSF has also been focused on ensuring inclusiveness for disadvantaged groups and promoting informal learning in STEM education.

Keywords: STEM education; National Science Foundation; funded projects

- Valeriy Likholetov and Sergei Aliukov** 1605–1617 Problems in Engineering Education, Engineering and Invention

Problems are the main link in the evolution of the system of engineering education, engineering and invention. In this paper the system of relations of engineering education, engineering and inventive activity is discussed. An analysis of the relationship of the level of knowledge necessary for solving educational and real-life tasks and skills leading to the creation of inventions is given. The goal of the paper is to bridge the existing gap between technologies (methods) of solving real engineering problems and educational tasks in the field of education (didactics). The objectives of our study are the following: (1) to substantiate and propose a more correct (than the existing definitions) definition of the task (as a task system); (2) to build on the basis of a systematic approach a generalized (“minimized”) typology of task systems; (3) to substantiate and build a model, as well as to hold (from the position of verification) a reflection of the relationship of real engineering problems and training tasks as minimized models of cognitive

actions. By analogy with the typology of inventions (products and processes), problems are considered “in statics” and “in dynamics”. The problem of goal setting is discussed. Based on the analysis of taxonomy of problems, a model of their generalized typology is proposed. The authors’ definition of a problem is given on the basis of its functional nature. A model of the relationship of educational and real production problems is proposed. This model can be used as a task constructor of various degrees of difficulty in learning process.

Keywords: problem; education; engineering; invention; theory of solving inventive problems; modeling; taxonomy; chronotope

Yasemin Tekmen-Araci and Blair Kuys 1618–1629 The Impact of Excessive Focus on Performance During Engineering Design Process on Creativity

Creativity is considered to be a central requirement for engineering practice. Many studies have previously pointed different creativity blockers and the challenges of enhancing creativity in engineering education. However, there has been limited study on the relation of product performance (functionality) and product creativity in an engineering design education context. The purpose of this research is to ask how focus on product performance affect product creativity during the engineering design process. We seek to better understand the different levels of emphasis on performance and creativity during the engineering design process and their mutual relationship. To address this, a qualitative investigation was adopted in two engineering disciplines—one traditional in mechanical engineering and one relatively new in product design engineering. The main data collection methods were classroom observations and interviews with the students and instructors. 8 instructors and 8 students were interviewed. Learning materials of each studied unit such as unit outlines, project briefs and assessment rubrics were also analysed allowing for triangulation to be achieved. The findings show that the excessive focus on product performance during the engineering design process trivialises and diminishes the role of creativity. To enhance creativity in engineering education this study advocates challenging students with open-ended design problems, valuing the design process in addition to the design product, and allowing assessment for creativity; not purely performance. Our findings indicate that in addition to product performance, engineering instructors should emphasise product creativity in engineering design problem solving process. Future work is needed to understand the applicability of our results.

Keywords: engineering design education; design process; problem solving; creativity

Maria Assumpció Rafart, Andrea Bikfalvi, Josep Soler and Jordi Poch 1630–1641 Impact of Using Automatic E-Learning Correctors on Teaching Business Subjects to Engineers

An innovative higher education is the visible outcome of the combination of the proliferation of Information and Communication Technologies (ICT) and novel approaches in education. We position our paper in this context, describing the experience of using an automatic e-learning corrector and its impact on both *academic results* and aspects of *student perception*. A total of 333 students doing technical degrees took a basic business administration course and the field work was conducted within this framework. An e-learning platform called *ACME_Business*, which automatically corrected and assessed all the exercises proposed, was designed, developed and implemented as the novel element of the course. The validity of the proposal was tested at the Polytechnic School of the University of Girona in Catalonia (Spain). The results show that implementing the solution is helpful in the learning process and in monitoring courses and that its use improves academic results. The perception assessment showed that the students had a very good opinion of the learning experience using the proposed ICT tool. Beyond these highlighted benefits for students, teachers save time and effort, and their workload is reduced. The novelty of the solution lies in the enormous potential for personalisation, the full automatization of exercise *generation, correction, feedback and grading*, and the dual educational approach wherein students gain knowledge in business administration and mastery in spreadsheet use.

Keywords: e-learning; business; engineering; Higher education; ACME

Catherine T. Amelink, Kirsten A. Davis and Bevlee Watford 1642–1655 Learning Experiences that Facilitate Innovation and Workforce Preparation: Exploring the Impact of In-Class and Extracurricular Activities

The ability to think innovatively is necessary for important workforce outcomes and is linked to the production of successful entrepreneurial endeavors. Gaining a better understanding of in class activities and extracurricular experiences that facilitate development of innovative thinking plays a critical role in developing engineering graduates who can contribute innovative ideas and solutions in the workforce. A mixed-method study (N = 595 survey, N = 52 focus group) was undertaken to understand what classes, groups, activities, or other resources influenced students’ innovative thinking. Our findings indicate that as engineering students progress through their undergraduate career they feel more prepared to contribute innovative solutions in future workplace settings. However, our study indicates that students do not engage in activities that facilitate development of innovative thinking skills until their fourth year of study. Educators would benefit from weaving opportunities throughout students’ undergraduate experience including those that incorporate increased opportunities for students to share ideas, gain different perspectives, and solve problems in environments inside and outside of an engineering classroom.

Keywords: innovation; extracurricular activities; work force preparation; innovative thinking skills

Teresa Redomero, Valeria Caggiano, Jose-Luis Poza-Lujan and Vincenzo Antonio Piccione 1656–1666 Fostering and Assessing Soft Skills of Engineering Students

This paper presents and discusses the results of a research project aiming at assessing the achievement of soft skills. To measure and assess their level, a standard questionnaire was used. The test was carried out with two different groups of students, or recently graduated, in the field of engineering as well as in the field of education. The total number of participants has been 489. This allowed us to make a comparative analysis in order to detect specific engineering soft skills. The research project was fostered by the idea that present changes ask the higher education systems to re-think and re-design the pedagogical approaches to both didactics and to the objectives of didactics at all levels, university curricula included. In this paper the analysis of data collected within academic settings is reported, with the aim of demonstrating that attention must be concentrated within all educational, training, scholastic levels.

Keywords: curriculum design; engineering education curriculum; engineering skills; labour market; soft skills

Paul Bazelais, David John Lemay and Tenzin Doleck 1667–1672 The Effects of Testing on Academic Outcomes of College Students in an Electricity and Magnetism Course

Testing can influence student learning outcomes by influencing their approach to study and to learning. It is important to understand the influence of testing on students’ learning outcomes to optimize instruction. We examine the role that testing played in a science course, to examine the effect of testing on retention and performance on a standardized final exam. This study compared two sections—experimental condition with testing (N = 35) and comparison condition with homework (N = 39)—of an Electricity and Magnetism course in a pre-university program to explore the role of the testing effect, that is, whether taking a test aids subsequent learning and retention. Results indicated that the students in the experimental group had a higher final exam average and greatest achievement gains. Our findings corroborate previous research and suggest that the traditional homework-based instructional strategy is a less effective approach for science learning or later retention compared to an instructional approach incorporating regular testing. Implications of these findings and the importance of testing in science instruction are also discussed.

Keywords: testing effect; academic performance; learning outcomes; STEM education; pre-university students; electricity and magnetism course

L. Moreno-Ruiz, D. Castellanos-Nieves, 1673–1683 Combining Flipped Classroom, Project-Based Learning, and Formative Assessment Strategies in Engineering Studies
B. Popescu Braileanu, E. J. González-González, José Luis Sánchez-De La Rosa,
C. L. O. Groenwald and C. S. González-González

This paper presents a methodology that encourages and fosters proactive student participation in individual and collaborative learning. The methodology combines Flipped Classroom, Formative Assessment and Continuous Assessment, Project-Based Learning, and Problem Solving using Simulators strategies, with an integrated teaching and learning system (ITLS), called SIENA. The tool serves to automate some of the processes inherent in the methodology and serves as a bridge across all of the educational process involved. The methodology has been tested in both undergraduate and postgraduate degrees in Computer Engineering studies, the former in a blended learning subject and the last in an on-line subject findings to date have proven positive. In addition, we have applied a unified theory of acceptance and use of technology model to ITLS and it has proven to be a useful tool in the learning process.

Keywords: flipped classroom; project-based learning; continuous assessment; collaborative learning; active participation; motivation; learning performance

Shun Takai and Marcos Esterman 1684–1697 A Review of Team Effectiveness Models and Possible Instruments for Measuring Design-Team Inputs, Processes, and Outputs

Good teamwork is essential to successfully complete team-based design projects. As such, engineering students are expected to learn how to work collaboratively. While team-project-based design courses have been implemented in almost all engineering and engineering technology disciplines, achieving full contribution by all team members has been a persistent challenge. In this paper, we review instruments for measuring design-team factors (i.e., inputs, processes, and outputs) that may be used for collecting data for forming effective and collaborative design teams. To guide the literature review, we first review existing team-effectiveness models. Next, we propose a new model for student design teams and illustrate possible associations between design-team factors. We then review instruments for measuring these factors using the new model as a literature-review framework.

Keywords: design teams; team formation; team effectiveness

Gustavo Capilla-González, Héctor Plascencia-Mora, Israel Martínez-Ramírez, Valentina Arévalo-Arredondo and Josué U. Villalpando-Hernández 1698–1702 A Comparative Study of the Impact of Using Additive Manufacturing as a Learning Tool on the Multi-View Drawing of Geometrical Components

This paper presents a comparative analysis of the multi-view drawing of a simple geometric component by using a traditional isometric-view drawing and a three-dimensional model generated by additive manufacturing. The study was performed during a one-year period encompassing two engineering drawing course groups of 30 students each, with no gender distinction. The experimental work analyzes fundamental aspects of engineering drawing such as the correct selection of frontal auxiliary's views, hidden lines, dimensioning under ISO standard by employing and evaluation rubric with four weighting levels. From the results, it can be observed that the use of physical three-dimensional models allows students not only to have a better comprehension of the geometric projections of objects but also to strengthen the hands-on skills required in the engineering educational programs.

Keywords: multi-view drawing; educational impact; geometric component

Josh Tenenberg 1703–1724 Factors Affecting Free Riding on Teams: Implications for Engineering Education

Teamwork is increasingly promoted as a teaching-learning modality in engineering education at the tertiary level, due to its often being required in formal accreditation, ubiquity in professional engineering practice, and leveraging of successful cooperative learning methods from primary and secondary education. Despite its promise, it frequently suffers from the problem of free riding, where group members do not carry out a fair share of work. Although virtually unreferenced in the engineering education literature, a large research base exists in the social and behavioral sciences for understanding the causes of free riding in collective action settings. The purpose of this paper is to summarize some of the key results from this research, to provide an index into it for readers who may wish to delve deeper into this literature, and to discuss concrete implications for structuring engineering education research and practice related to teamwork. The summarized results include the importance of social norms, particularly of fairness and reciprocity, norm enforcement and internalization, making explicit commitments, the repeated interactions required to develop trust, and the role that reputation plays for individuals within information-sharing networks.

Keywords: cooperative learning; teamwork; team-based learning; self-managing work teams; social dilemma; free riding; cooperation

Larisa Olesova and Dazhi Yang 1725–1737 Engineering Students' Cognitive Learning and Perceptions in a Blended Learning Course

This study examined how cognitive learning was expressed by graduate engineering students ($n = 20$) in a blended course consisting of a face-to-face ($n = 12$) and online synchronous sections ($n = 8$), and students' perceptions ($n = 41$) toward the blended course. Specifically, this study examined (1) how cognitive learning was expressed by students when they worked in face-to-face groups, mixed groups (combination of online and face-to-face students), and individually in a blended engineering course, and (2) potential differences between face-to-face and online students' perceptions of the blended learning course. The participants were graduate students at a large public university in the Mid-Atlantic region of the USA who enrolled in a sixteen-week blended System Engineering Design course. There were three face-to-face groups with two students per group ($n = 6$) and four mixed groups with three students per group ($n = 12$). Two students worked individually. The findings revealed that when students worked in groups, the level of their cognitive learning was higher than working individually. In addition, when students worked in mixed groups in combination with face-to-face and online students, the levels of their cognitive learning was higher compared with those of the face-to-face groups. To answer the second research question, data were collected over four semesters of the same course with the same instructor. There was no significant difference between the online and face-to-face students' perceptions regarding the overall course instruction and course effectiveness. However, the online students responded more positively about their course instructor's encouraging them to be actively involved in the course content through assignments and other activities.

Keywords: blended learning; cognitive learning; group work

Nick A. Stites, Edward Berger, Jennifer DeBoer and Jeffrey F. Rhoads 1738–1757 A Cluster-Based Approach to Understanding Students' Resource-Usage Patterns in an Active, Blended, and Collaborative Learning Environment

Data on how pedagogical innovations in engineering education impact the students' experiences and achievement are often lacking. The goal of this study was to identify and understand how and why students engaged with the resources available in an active, blended, and collaborative learning environment. We collected survey data from 581 engineering students on how frequently they used nine different resources of an undergraduate dynamics course. A cluster analysis identified nine, qualitatively-unique resource-usage patterns. We then analyzed 44 student interviews and found that students often exhibited their resource-usage patterns because of their perceived expectations and values for a given resource. The findings of this study provide instructors with data-driven information on the archetypical resource-usage and help-seeking behaviors of their students. Instructors can use this information to better coach their students and to design curricula and resources that support many different subgroups of students, not just the stereotypical or average student.

Keywords: cluster analysis; help seeking behavior; resource usage; engineering education

Allen C. Estes, Stephen J. Ressler, 1758–1786 The ASCE ExCEED Teaching Workshop: Assessing 20 Years of
Camilla M. Saviz, Brock E. Barry, Carol Instructional Development
L. Considine, Norman D. Dennis, Jr.,
Scott R. Hamilton, David S. Hurwitz,
Tanya Kunberger, Thomas A. Lenox, Tonya
Nilsson, James J. O'Brien, Jr., Robert J.
O'Neill, David A. Saftner, Kelly Salyards,
Ronald W. Welch, Dion K. Coward and
Leslie E. Nolen

The Excellence in Civil Engineering Education (ExCEED) Teaching Workshop (ETW), a week-long teacher-training program sponsored by the American Society of Civil Engineers, has been improving the quality of university teaching for twenty years. The 41 workshops conducted over this period have produced 963 graduates from 253 universities around the world. This article celebrates the history of this landmark faculty development initiative. It assesses the extent to which the ETW provides a unique contribution and has influenced teaching practices in U.S. civil engineering programs. This assessment includes participant satisfaction, the long-term influence on participants, the influence on those participants who became ETW faculty leaders, the satisfaction of the deans and department heads who sponsored the participants, the scholarship that has resulted from the ETW, and the implied influence on the engineering students who ultimately benefit from this workshop. Finally, the future direction of the ETW is addressed. Although the workshop is intended primarily for civil engineering programs in the U.S., the results of this study are also highly relevant to other engineering disciplines and to engineering programs outside the U.S.

Keywords: faculty development; teaching effectiveness; instructional development; workshop assessment; ExCEED; teacher training; civil engineering education

Dilsen Kuzucuoglu, Bilal Umut Ayhan 1787–1802 Integrating Lean Construction into the Civil Engineering Curriculum
and **Onur Behzat Tokdemir**

Lean production concentrates on creating more value for customers by eliminating waste thoroughly with a holistic approach that affects all processes. The construction industry is now trying to apply the principles of lean production. However, the integration process is advancing still gradually. Many challenges and constraints affect the adaptation of lean construction. Training and education are becoming a critical success factor in overcoming the barriers to applying lean principles. The objective of the study is to introduce a collective preparation process of lean construction course, which relied on a piece of factual knowledge about lean principles. The study intends to intensify the adaptation progress and extend lean education at universities, especially for the ones located in developing countries. The process began with defining the existing production problems of the construction industry by conducting semi-structured interviews with lean construction practitioners. Then, the current state of lean construction education was examined to structure the significant elements of the course. The current state of Turkey and the U.S. were investigated in terms of lean construction to determine the teaching methods, student constraints, and resources. The information collected via research and interviews formed the frame of the planned lecture. Next, the evaluation process was introduced for enhancement and strengthening the lean construction course. Three-step evaluation tasks were presented to determine whether the given course was sufficient for meeting the industry's needs or not. Ultimately, the proposed research aims to develop a unique process to offer Lean Construction courses through universities by generalizing the content of lean construction education.

Keywords: lean construction; Delphi method; engineering education

Licia Di Pietro, Ermes Botte, Riccardo 1803–1815 Teaching Design Standards and Regulations on Medical Devices Through
Granati, Stefano Moroni, Matilde Tomasi, a Collaborative Project-Based Learning Approach
Giovanni Vozzi and Carmelo De Maria

The final goal of a course of Medical Device Design is to convey the importance of multidisciplinary approach in Biomedical Engineering (BME), where scientific and technical knowledge has to address the clinical needs of patients and healthcare providers, and has to promote problem-solving abilities and teamwork. In such context, project/problem-based teaching-learning methods have been suggested among the more effective strategies for bridging technical competences with the development of transversal skills and consequently in the professional formation of engineering students. In the BME field, standards and regulations on medical technologies have a paramount role, as they ensure safety and efficacy of the devices but, despite their importance, it is difficult to engage students' attention when teaching norms and legislations. This paper describes the teaching/learning experience in a new course on Laboratory of Biomedical Technologies at the first year of the Master's Degree programme in BME at University of Pisa (Italy), where standards and regulations were introduced as design constraints for the project-based final examination. The collaborative design and prototyping of a walking frame are discussed in detail, to demonstrate the feasibility and the challenges of the proposed approach.

Keywords: medical devices; standards; regulation; project-based learning

Sheng-Jen ("Tony") Hsieh 1816–1826 Development and Evaluation of Remote Virtual Teach Pendant for
Industrial Robotics Education

In industrial robotics education, students often do not have sufficient opportunities to practice skills such as robot programming due to large class sizes, limited lab time, and the cost of robots. There is an urgent need for engineers with industrial robot knowledge and programming as part of their skill set. A teach pendant is a commonly used and inexpensive method of programming industrial robots. This paper describes the development and evaluation of a virtual teach pendant and web server that enables students to do lab exercises remotely. It has been used to help students become familiar with robot anatomy, practice robot motion planning, and program a robot remotely to complete a simple pick-and-place assembly task. The system has been evaluated by 19 two-year college students, 159 four-year college students, and 150 high school students. Pre and post-testing and survey results suggest that the system is useful for learning robot anatomy, motion planning, and robot programming; students would like to have more tools like this to help them learn; and the interface is user-friendly and easy to manipulate. Future directions may include adding advanced programming functions (such as conditional and loop structures) and providing haptic feedback.

Keywords: robotics; robot programming; teach pendant; remote operation

Denise R. Simmons, Nathaniel J. Hunsu 1827–1838 Enabling Multi-Dimensional Measurement of Student Engagement in
and **Olusola O. Adesope** Engineering Learning Environments

Engineering student engagement is linked to belonging and persistence, which have been shown to influence graduation rates. Little is known about the ways in which engineering engagement is influenced by peers and faculty, motivation, satisfaction, and belonging in a learning setting. This research describes the approach used to develop the items to measure post-secondary students' engineering engagement in their learning environment. Having an instrument that assesses engineering student engagement relative to their disposition toward their academic discipline, themselves, other students, and faculty will extend the research base on engineering student learning and retention and answer specific calls to examine these factors. We used several statistical techniques including exploratory and confirmatory factor analyses ($n = 976$) to explore the reliability and validity of the engagement subscales. Exploratory and confirmatory factor analyses of the data indicated that the instrument best fits a six-factor model. The factors are: Major Satisfaction, Academic Discipline Belonging, Major Valuing, Achievement Striving, Peer Interaction, and Positive Faculty Relationship. The consistency of the observed inter-factor correlations strengthens the validity of the PosSE Survey as an instrument that measures different facets of affective engagement.

Keywords: engagement; persistence; survey development; confirmatory factor analysis

Mechanical aptitude refers to individual differences in understanding and learning how simple machines work. Tests of mechanical aptitude are predictive of performance in engineering jobs and capability to learn about mechanical processes. The advancement of technology has led to existing mechanical aptitude tests becoming dated. Commonly used tests are known to be gender-biased, limited in use (diagnostics tests), and are not freely available for use in educational settings. This work presents the development of a Mechanical Aptitude Test (MAT). The mechanical aptitude items were designed and tested across four phases in large samples of engineering and non-STEM students across four U.S. universities ($n = 1,718$). An item analysis of the last phase ($n = 599$) was conducted to screen questions not meeting established criteria for item difficulty and item discrimination. After, a one-factor confirmatory factor analysis was run with diagonalized weighted least squares. The one-factor confirmatory factor analysis fit well with exceptional fit indices (CFI = 0.994, TLI = 0.993, RMSEA = 0.02 90%CI[0.004,0.3], SRMR = 0.059), albeit a rejected model chi-square, $\chi^2(34) = 146.939$, $p = 0.042$. The current MAT scale consists of 17 multiple choice items, narrowed down from a larger bank of 68 items, covering topics related to mechanical insight, mechanical knowledge, shop geometry and measurement, and tool knowledge.

Keywords: mechanical aptitude; instrument development; item analysis

Antoni Perez-Poch, Fermín Sánchez-Carracedo, Núria Salán and David López 1851–1858 Cooperative Learning and Embedded Active Learning Methodologies[®] for Improving Students' Motivation and Academic Results

In recent years, a number of teaching strategies have been applied in higher education to improve students' academic results and motivation, with a focus on active methodologies. Embedded Methodologies[®], defined as a mixture of learning strategies which are combined in a single educational environment, have a potential for boosting this impact. Embedded Methodologies[®] with Cooperative Learning, Just-In-Time Teaching and active informal methodologies are proposed herein. Both methodologies are an integral part of the course design, and students are exposed to a variety of on-line and face-to-face activities, which enhance their educational experience. The authors present a ten-year longitudinal study in which academic results and student satisfaction were reported by a standardized survey among 294 students attending a subject on "Telecommunications and Internet" at EEBE Engineering School from UPC-BarcelonaTech (Spain). The results show that these Embedded Methodologies[®] significantly improved students' motivation and their final marks; in particular, for those students at risk of failing the subject, but not with the lowest grades. This approach was found to be the best predictor of their grades in the subject, among other factors such as their performance in the University Entrance exam. Students' perception of the quality of teaching and their academic results were significantly enhanced when compared with those students that were exposed to only one active methodology or none at all, thus suggesting that a mixture of motivational learning techniques boost their impact on the students' learning process and on their motivation.

Keywords: embedded methodologies; cooperative learning; active methodologies; just-in-time teaching; teaching quality; engineering education

John R. Haughey, D. Raj Raman, Joanne K. Olson and Steven A. Freeman 1859–1871 Robots, Motivation, and Academic Success

Educational literature has long supported strong correlations between student motivation and academic success. STEM literature has more recently shown mechatronic experiences to have positive impacts on these constructs, albeit limited empirical grounding. Therefore, the purpose of this study was to conduct a pilot experiment to empirically quantify differences in undergraduate student motivation and academic success in a mechatronic vs. a non-mechatronic experience, as well as examine the correlation between student motivation and academic success in both groups. We used a quasi-experimental, non-equivalent control vs. treatment design to collect $n = 84$ responses from multiple sections of a single undergraduate course. The multivariate dependent variable of student motivation was measured using the *Motivated Strategies for Learning Questionnaire's* motivational orientation items. Our multivariate dependent variable of academic success was based on final course grades, final project scores, and quiz scores. Using ANCOVA and differences of proportions, we found no statistical difference in motivational orientation—specifically *value choices* and *expectancy beliefs*—in the mechatronic vs. non-mechatronic experience. In contrast, statistically significant differences in project scores and final course grades were observed in the mechatronic experience group. Additionally, we found no significant correlation between student motivation and academic success. These results indicated that students in the mechatronic experience, while earning significantly higher grades, did not exhibit different levels of motivation, leading to no association between student motivation and academic success. Even so, future research is needed to further understand the nuanced dynamics of motivational orientation within a mechatronic experience.

Keywords: mechatronics; robotics; motivation; engagement; academic success; student learning

Javier Senent-Aparicio, Patricia Jimeno-Sáez, Mauricio Arias, Leonard O'Driscoll, Julio Pérez-Sánchez, Loreto León, Francisco J. Alcalá and David Pulido-Velázquez 1872–1880 Preparation of Technical Posters as a Tool to Improve Transversal Competences of Civil Engineering Studies

Adaptation to the European Higher Education Area implies a change of educational paradigm. In addition to the incorporation of academically directed activities and new tools for transmitting information, the change of approach also means new training explicitly oriented to develop the new professional competences. This paper presents the results from a funded teaching project aimed at exploring the use of the scientific poster as a tool to improve transversal competences in Civil Engineering students. To cope with this objective, a total of 68 civil engineering students from two different universities in Spain and Ireland were chosen. The poster design allows students to do in-depth research on a specific topic and to engage its research inquiry. The student's perception of this project was evaluated by means of two questionnaires surveyed prior and after the poster presentation. The research findings suggest that the scientific posters elaboration enables the development of different transversal competences of the students such as comprehension and integration, teamwork and leadership reinforcement, and effective communication. About 94% of respondents felt that this activity was valuable in improving their communication skills.

Keywords: civil engineering students; transversal competences; scientific poster; communication skills; research initiation