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Special Issue
Guiding Engineering Educators: Keeping Pace with Scientific-Technological Change and Socio-Economic Development
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Nowadays, initial training courses for lecturers are widespread in universities. However, there are not enough research papers that analyze their impact and effectiveness. This paper focuses on the Universidad Politécnica de Madrid's case. In order to assess if the teaching training received takes effect in the lecturers' daily work, the study has collected data about 198 participants that have finished the Initial Training for University Teaching program. 115 of them answered a survey (adapted from Freixas et al.) analyzing the factors of their training transference. Participants acknowledged the learning value obtained during the program, indicating that they have implemented it in their own teaching practice. They perceive their students' interest, who encourage them to introduce the methodological innovations learnt during their training. On the other hand, they do not perceive support from their departments. They detect lack of support (within the degrees and departments) as well as the lack of provided resources as the main barriers. The weight of tradition on how lecturers face teaching is relevant, restricting the possibilities for changes. Results show very limited institutional recognition to the effort invested in their own training. Nevertheless, participants keep optimistic expectations about the positive assessment of the received training for their teaching career.

Keywords: engineer education; initial training; transfer of teacher training

For centuries, engineering has been taught based on diverse educational paradigms, with a remarkable predominance of traditional approaches. During the last decades, new educational paradigms and didactic strategies have arisen. Nevertheless, it was not always the case that engineering educators had a clear understanding of a paradigm or a strategy being used. Thus, after an exhaustive review of literature, this paper presents a guide for engineering educators that shows how the multiple didactic strategies are classified within the four educational paradigms found in engineering education (positivism, constructivism, socio-critical and communicative-critical).

Keywords: educational paradigms; didactic strategies; positivism; constructivism; socio-critical; communicative-critical

University teachers should devote time to three tasks: teaching, research and management. Some teachers do not know how to manage their time well so teaching tasks take too much time. In order to conduct research or fulfil their management responsibilities, they are obliged to work more hours than those stipulated in their contracts. Furthermore, they often have the feeling that, despite the long hours devoted to teaching, their students fail to obtain the results desired, and this feeling leads to frustration. Some ideas for helping teachers to optimize their teaching time are presented in this article, so that by improving their quality of teaching the number of hours can be reduced and, at the same time, better results can be achieved by their students.

Keywords: training and assessment of educators; time management; faculty training

The great technological development in which we are immersed has changed the scenarios, tools and forms of learning. In the light of those challenges, engineers must be able to develop new skills and abilities to face them, through planned technical pedagogical training that allows them to link technology with engineering education. As a result of previous research, the need for a link between technology and education in engineering was evident, as was the need for training in platforms for the creation of virtual learning spaces. To this end, the proposal was applied to a case study involving a group of engineering educators from the Escuela Politécnica Nacional de Quito. This research aims to present the results of the implementation of a training programme for engineering educators to improve their competence in new technologies and the teaching design methodologies applied to the design of online learning environments for engineering. To achieve this goal, the training included a framework based on pedagogical foundations, instructional and learning strategies, online learning technologies and good practices of engineering design activities, as well as a Learning Management System (LMS) platform adopted by the institution. The results of the implementation of this pedagogical technical training strategy show that 92% of engineering educators confirmed that the proposed framework helped them to develop online courses. In addition, 83% of engineering educators confirmed that the training course in the LMS tool was useful. Additionally, it was confirmed, with an acceptance of more than 90%, that the inclusion of the recommendations

for the design of the engineering activities was relevant. These results confirm the adaptability of engineering teachers to the application of new technologies and methodologies, and will enable the production of better qualified engineers to pursue this profession and face future challenges.

Keywords: training; teachers; engineering; virtual learning; e-learning; virtual education

In recent years the paradigm of teaching and learning has changed, with a plethora of research being conducted in this field, but all these changes and research have scarcely affected the lecturer training programmes. This paper presents a lecturer training programme implemented in a technical university and based on the competencies that lecturers should possess. To this end, we have conducted research to determine which competencies are essential and if our lecturers consider them important or are reluctant to acquire them. The programme is also designed to bring all the acquired techniques into the classroom and apply them to the student learning process. A further factor for the success of such training programmes is that lecturers should find them useful, not only for improved student performance, but also for their future professional careers, especially in an environment where promotion is dependent on papers published and grants obtained, and where education itself becomes a secondary objective. Our training programme started two years ago and since then has achieved all these goals, thereby creating a new network of lecturers committed to engineering education research and innovation.

Keywords: teacher training; professional competencies; teaching teachers; higher education teaching

Lecturers, especially those in technical or science degrees, require a basic and continuous training focusing on their skills as teachers in higher education. In order to facilitate the design of these training programs and to define objective criteria to guide the faculty's individual training, two taxonomies have been established. These are the result of 40 years of teaching training experience at the Institute for Educational Sciences of the Universidad Politécnica de Madrid. Two classifications have been agreed on, that depict the training activities and the lecturers' skills. They may be dynamically adjusted facilitating this way the monitoring and offer of the training activities. The skills classification enables the creation of scope and update coefficients which define a training reference profile at the university, allowing to calculate a fit index. The viability of this index has been confirmed, permitting the generation of individual training recommendations for lecturers.

Keywords: engineering faculty training, teaching competencies, training programs, training rate, automatic recommender

This article proposes an e-learning process for engineering educators involving a self-training approach. To develop the process, the researchers considered a set of entries to allow enrolled educators to engage in and successfully complete a training program without a lead instructor using an e-learning platform. In addition, the proposed process establishes a set of outputs that are the expected results and achievements that educators would be expected to obtain. In this study, educators play a double role: self-tutors and learners. As a case study, a Massive Open Online Course (MOOC) is used as a self-training program; the topic of the program is web accessibility. The use of this MOOC was proposed to a group of engineering educators. The case study shows how engineering educators can contribute to learning in society about web accessibility and its benefit to people, especially people with disabilities. Finally, the researchers present the advantages of using the proposed e-learning process, as well as its limitations.

Keywords: e-learning; self-training; engineering education; educators; higher education; web accessibility; MOOC

EDINSOST is a project aimed at tackling the challenges facing society. It is funded by the Spanish R&D+i Program. The objective of the project is to establish a framework to facilitate the training of graduates capable of leading the resolution of challenges in our society through the integration of sustainability training in the Spanish University System. For the training of graduates, it is essential to train teachers beforehand, since most of them do not possess competencies in sustainability. The EDINSOST project involves fifty-five researchers from ten Spanish Universities. It encompasses five engineering degrees and three degrees related to the three dimensions of sustainability, given their great impact on the short-term challenges confronting society. In view of its multiplier and long-term effect, the project also includes the Bachelor and Master's degrees of five Education degrees, because graduates from these courses will be the future teachers of new generations of citizens. To achieve its objectives, the project has defined a sustainability competency map for thirteen degrees in the fields of education and engineering. On the basis of this map, the most appropriate didactic strategies for sustainability training will be established, the state of the sustainability training requirements in teachers and students will be diagnosed, and finally, proposals will be made for training both groups. In this paper, the objectives of the EDINSOST project are presented, as well as some results of the first objective: the sustainability competency map for engineering degrees. The map is vital for defining the training needs of teachers and students and is easily adaptable to any engineering degree.

Keywords: training and assessment of educators; education for sustainable development; sustainability in higher education; sustainability competency map; faculty training, teachers training

The adoption of new technologies for education is changing, and it is reflected for instance, in the use of cloud-based applications for experimental practices in engineering courses and the inclusion of virtual courses in the educational process. Additionally, Educational Institutions are preparing Massive Open Online Courses (MOOCs) as a tool to offer education to students from all over the world. However, Accessibility in cloud-based applications, virtual platforms and MOOCs has not been widely taken into account in the design process that involves educators, especially in the tasks related to the production of educational resources.

The purpose of this study is twofold. On one hand, it aims to promote the inclusion of accessibility features in all phases involved in the online educational process. For this purpose, an open online course was prepared to train teachers on how to design accessible virtual courses. On the other hand, the goal is to identify the competences for educators involved in the creation of accessible digital educational contents in order to suggest a basic curriculum that can be used for Educational Institutions.

This work presents the accessibility experiences with engineering courses involving a strong component of scientific content and simulations. This work presents the proposed competences for engineering educators involved in the creation of accessible digital educational contents, with the purpose of implementing a basic curriculum that can be used for Educational Institutions to train their teachers on accessibility from the perspective of a student with disability. It is to be hoped that in some way in the future, the engineering educators will be able to transmit the accessibility awareness to their students, in order to have future engineers that will produce changes for the benefit of all.

Keywords: web content accessibility; usability; disability; WCAG 2.0; learning design; MOOC

Jacek Uziak, Ryan Barlow, Idalis Villanueva, Oenardi Lawanto and **Kurt Becker**

1549–1561   Development of a Graduate On-Line Certificate Program in Engineering Education

The paper describes the development of an online Engineering Education Graduate Certificate program. The program targets current and future engineering educators, both in academia (community colleges and universities) and industry. The goal is to improve the quality of engineering teaching and training by empowering students to become better and more knowledgeable engineering instructors through their understanding of educational theories and applications. The program intends to be fully online, with a combination of asynchronous and synchronous instruction.

Keywords: engineering education; graduate certificate; online education

Lucinda Berthoud and **Andrew Glester**

1562–1568   Developing a Community of Practice to Support the Space Engineering Higher Education Community

The UK-based Space Universities Network (SUN) was formed in 2016 with the aim of enhancing the quality of learning and teaching by providing support and resources to the space science and engineering higher education community. The goal of this research was to pilot the running of this education network as a Community of Practice and then to use the existing concept of value creation to evaluate it. A Community of Practice is a recognized way of encouraging interaction and shared best practice to learn together. This paper starts with a review of Communities of Practice in the literature, then describes the process that led to the foundation of the SUN network and its evolution. The methods and process used to establish the infrastructure and regulation of the community are discussed. Next, the UK context, the aims and objectives of SUN and the membership of the community are covered. Results include newsletters and email lists which have been used as methods of communication, training of staff has been achieved through workshops by recognized experts and a curated web-based repository of resources has been used to exchange ideas for classes, icebreakers, case studies, questions, shared facilities database and practical exercises. Evaluation of the community has been carried out via a survey of members. In conclusion, a community of practice has found to be a useful vehicle to enable the space higher education community to interact and learn from each other in order to raise the level of space education in the UK. Once firmly established, it is hoped to expand the network through partnerships with similar networks in other countries.

Keywords: Community of Practice; networks; Higher Education; evaluation; collaboration

Franziska Trede and **Reza Mahinroosta**

1569–1580   Strengthening Educational Partnerships: An Online Preparation Program for Engineering Partners

One of the key goals of professional engineering entry courses is to prepare graduates for the world of work, foster professionalism and strengthen employability. Universities can best accomplish this with effective, reciprocal educational partnerships with industry that include professional development support for host supervisors based on shared educational values and goals. To this end, a purposeful, self-paced, online preparation program for host supervisors was developed for an innovative, practice-based engineering degree situated in regional Australia. Survey methodology before and after the completion of the online preparation program was used to explore host supervisors' perceptions of its value and effectiveness as well as their views of what makes a good host supervisor. The results demonstrated that online preparation program was well received with supervision skills for cadet engineers the most informative of the five topics. Participant data provided evidence of host supervisors' insights into the complexity of their supervision role beyond training and recruiting technically competent future engineers. The paper discusses participants' keen interest in contributing to educating the next generation of engineers, their interests in purposeful, supervisor-centred professional development programs and concludes with implications for further research in this neglected yet so important aspect of engineering education.

Keywords: cadetship; host supervisor; professional identity; university-industry partnership; workplace learning; preparation program

Marija Božić, Jelena D. Ćertić, Milica Vukelić and **Svetlana Čizmić**

1581–1591   New Instructional Approach for Fostering Generic and Professional Competences: Case Study of the Project and Problem Based Learning Engineering Practice Course

In this paper, we present a novel instructional approach introduced to the final year engineering students with the aim of developing their generic and professional competences. The proposed approach, based on project and problem based learning and ill-structured problem solving, was analyzed in the context of competence development and implications for engineering educators. The results of our action research indicate that the generic competences that were found to be significantly fostered were: systems thinking, ambiguity tolerance, asking questions, solving ill-structured problems, ability to apply knowledge in practice, presentation and generating new ideas. Professional competences that were found to be significantly fostered all belong to higher order thinking skills, and include the ability to design and evaluate, analyze, interpret and create new engineering solutions. These findings provide empirical support for the use of applied student-centered strategies for developing competences relevant for future work, as well as reflections that can support engineering educators in designing similar teaching and learning environments.

Keywords: engineering students; generic and professional competence development; project-based learning; workplace simulation; implications for engineering educators

Noelia Olmedo-Torre and **María Martínez Martínez**

1592–1603   Detection of Training Deficiencies in the Autonomous Learning of Graphic Engineering Students: A University Teacher Training Experience Based on Competencies

The Universitat Politècnica de Catalunya·BarcelonaTech (UPC) offers a postgraduate teacher-training programme based on "Science, Technology, Engineering and Mathematics (STEM) postgraduate university teacher-training" competencies consisting of 15 ECTS, which officially began in September 2015. This Postgraduate course concludes with a final project carrying 6 ECTS in which students are required to design and plan an innovation in teaching to implement in the classroom and to analyse the results; this project is supervized by a senior female lecturer from the university with experience in teaching innovation. This article presents a final project that consists in planning different voluntary activities with the aim of increasing the level of acquisition of the autonomous learning generic competence of students engaged in Graphic Expression (GE). This is a core subject in the first year of all the engineering degree courses imparted at the UPC *Escola d'Enginyeria de Barcelona Est* (EEBE—Barcelona East School of Engineering). This set of activities will continuously generate a series of outcomes to provide students with formative feedback, thereby enabling them to detect deficiencies in the goals established for the subject and make improvements in good time. The results of these outcomes are then analysed and related to the compulsory assessments that are taken into account for the final evaluation of the said generic competence. Participation in these voluntary activities fosters the acquisition of the autonomous learning competence and contributes to a notable improvement in the teaching-learning process of spatial geometry. Furthermore, this postgraduate teaching innovation project has allowed the participating lecturer to apply the acquired competencies to the different subjects, which has resulted in improved student learning as well as enabling a senior female lecturer to advise another female faculty member of the same university by sharing her experience, which in turn has enriched the teaching experience.

Keywords: assessment tools; competencies; autonomous learning; engineering degree; graphic engineering

Juan D. Ortega-Alvarez, Camilo Vieira, Matilde Sanchez-Pena and **Ruth A. Streveler**   1604–1614   The Challenges of Assessing Transformative Learning: Lessons Learned from an Instructional Design Workshop for Colombian Engineering Faculty

The authors designed and delivered a workshop on Instructional Design for Colombian engineering faculty at three different universities. The workshop drew from the backwards design model and scholarly literature on engineering education. The participants were asked to assess the workshop using a pre-post survey with Likert-type items and open-ended questions. Results from the assessment of the first offering of the workshop suggested a change in participants' perspectives that the instrument could not fully capture. A revised instrument used during the second offering allowed deeper insights into this change. Based on these results, the authors argue that a professional development program can transform faculty's perspectives, particularly when it is aimed at helping faculty inform their teaching practice using evidence-based educational research. The assessment of such a program must, therefore, move from an incremental to a transformational notion of learning. The research question driving this work was: How can one assess the transformative learning of engineering faculty about instructional design? This experience with Colombian faculty suggests that a transformative learning framework can inform the assessment of participants' learning in professional development programs for engineering faculty. Preliminary results of the application of this framework suggest that most workshop participants transitioned from a teacher-centered to a learner-centered conception of teaching.

Keywords: engineering faculty development; professional development assessment; transformative learning; teaching conceptions

Anirudh Srinivasan and **Diana Bairaktarova**   1615–1625   Learning Thermodynamics with iPad: Adaptation and Learning Opportunities for both Instructor and Students

The use of technology in education is rising today. In such a scenario, it is important to discuss the results and the merits or demerits of using technology by both educators and learners. The aim of this paper is to present the adaptation and lessons learned from using iPads in an introductory thermodynamics course in a large engineering school in the USA. The discussion has been supported by results from a study conducted by the authors, accounting for students' learning. Findings are presented to provide evidence of students' conceptual understanding of thermodynamics concepts from two groups (a class using iPads and a traditional class with no use of iPads). For further understanding of the benefits of integrating technology in the engineering classroom, students' perspective is presented in this study as well. The paper concludes with suggested implications for renovating engineering education.

Keywords: iPad; technology; engineering education; thermodynamics

Luciano Andreatta Carvalho da Costa, Tânia Cristina Baptista Cabral and **Fabrícia Damando Santos**   1626–1633   Proposal for a Postgraduate Programme for STEM Education

In this article, we present fundamental principles and concepts for a postgraduate program focused on educating university lecturers in Science, Technology, Engineering and Mathematics (STEM). This program is being designed by the Science, Technology, Mathematics and Engineering (STEM) research group (GPEECE), which is linked to the State University of Rio Grande do Sul. Theoretical parameters are presented, as well as the actions needed to support a postgraduate program focused on students who have taken courses in the areas of Science, Technology, Engineering and Mathematics (i.e., future teachers of STEM). The results showed that the great differential of the course in relation to other similar courses is the specific focus in the classroom. This was one of the aspects that were most remembered by the students of the specialization course that represented the previous work for the proposed course.

Keywords: mathematics education; engineering education; education in the sciences; education for STEM

Section II
Contributions in: Learning Outcomes, Innovations, Faculty Development, Faculty Attitudes, Self Efficacy, Transfer Students, Virtual Teams, Team Based Learning, Project Based Learning, Biomedical Engineering

Damji Heo, Saira Anwar and **Muhsin Menekse**   1634–1643   The Relationship Between Engineering Students' Achievement Goals, Reflection Behaviors, and Learning Outcomes

Prior studies have shown that students' achievement goals play a key role in their learning strategies, decision-making processes, and learning outcomes. However, a majority of these studies were conducted with undergraduate psychology students. Thus, there is a need to explore the role of students' achievement goals on their reflection behaviors and learning outcomes in different fields, including engineering education. Based on our literature review in engineering education, there are a limited number of studies that investigated the relationship between achievement goals and students' learning outcomes. Therefore, we conducted this exploratory research study to investigate the relationship between achievement goals, reflection behaviors, and learning outcomes of engineering students. We used the Achievement Goal Questionnaire-Revised (AGQ-R) scale to measure 69 sophomore engineering students' achievement goals. Six response variables were included: average reflection quality, the total number of reflections submitted, two exam scores, the final exam score, and the total weighted learning outcomes. Based on our analyses, we found that the mastery approach was significantly related to the total number of reflections, the final exam score, and the total weighted learning outcome variables. The performance approach was also significantly related to the final exam and total weighted learning outcome. Mastery avoidance was significantly related to the total number of reflections, the second exam, and the total weighted learning outcome. Finally, performance avoidance was significantly related to the second exam, final exam, and the total weighted learning outcome. Overall, our findings are informative to researchers in the engineering education field for better understanding students' learning strategies, reflection behaviors, and learning outcomes relating to their goal orientation. Thus, this study provides benefits to researchers and other stakeholders such as faculty members or administrators in engineering education to develop more effective intervention programs that positively impact student motivation and their learning strategies as well as learning outcomes.

Keywords: achievement goals; reflection; engineering education; mobile learning

Matthew S. Barner, Shane A. Brown, Ben Lutz and **Devlin Montfort**   1644–1657   How Engineering Faculty Interpret Pull-Oriented Innovation Development and Why Context Matters

Faculty development programs often operate as platforms for disseminating pedagogical innovations amongst engineering faculty, but adoption of these innovations into engineering classrooms has been less than desirable. Such issues of low adoption are partially due to the limited opportunity faculty have to pull innovation development towards their unique instructional contexts. However, little research to date has focused on understanding how engineering faculty would interpret such an opportunity to pull innovation development with their own curriculum in mind. The purpose of this study is to investigate a faculty development

program wherein engineering faculty collaboratively developed curricular innovations for their mechanics of materials classroom with guidance from research on common student misconceptions. To explore the co-development of innovations, we conducted multiple interviews with the engineering faculty participants throughout the academic year. Participants interpreted this program and their co-developed curricular innovations as providing them with resources they needed to make curricular changes. Findings also demonstrated that faculty adoption of curricular innovations is highly influenced by context. By allowing faculty a greater role in the innovation development process, these contextual issues are more readily addressed. This study provides rich and detailed insight into how certain faculty approach adoption within their own contexts, which can improve faculty development and dissemination of pedagogical innovations in the future.

Keywords: faculty development; adoption of innovations; pedagogical innovations, mechanics of materials

Allyson J. Barlow, Ben Lutz, Natasha Perova-Mello, Kathleen Quardokus Fisher and Shane Brown   1658–1670   Factors of Sensemaking Affecting Engineering Faculty's Decision to Use the In-Class Cognitive Engagement Survey

While engineering education researchers have developed research-based instructional strategies (RBISs) to assist faculty in their teaching effectiveness and thereby student learning, uptake of these strategies remains challenging due to a wide range of faculty concerns. One established way to address such concerns is to involve them in the research and development process. In this study, we developed a tool to measure in-class cognitive engagement, an attribute most faculty recognize as crucial to student learning and used sensemaking as a framework to interpret faculty feedback on the survey's development. This tool, the In-Class Cognitive Engagement (ICCE) survey, was presented to faculty in an interview setting where they discussed and projected student interpretations and responses to survey items. We applied a sensemaking framework to the interview analysis to explore the ways participants might adjust or adapt to a new way of interacting with the world. In this case, the new interaction was the introduction of a cognitive assessment—the ICCE survey—into their classroom. We present findings that demonstrate the utility of sensemaking core properties to understand how faculty come to conclusions about the usefulness of the ICCE survey in their classroom. Implications of these findings include continued work directly with faculty to provide them with appropriate contextualization of RBIS-related instruments and broader use of technology (such as dashboard) to synthesize results to provide both timely and meaningful feedback to faculty.

Keywords: diffusion; adoption; faculty attitudes; engagement

Debapriyo Paul, Bimal Nepal, Michael D. Johnson and **Timothy J. Jacobs**   1671–1686   Examining Validity of General Self-Efficacy Scale for Assessing Engineering Students' Self-Efficacy

Self-efficacy has been found to be one of the key factors that are responsible for academic success of engineering students. However, there exist multiple instruments for determining the self-efficacy of engineering students and studies conducted in this area in the past have varied significantly in their use of a general or engineering domain-specific constructs. This work investigates whether an engineering-domain specific self-efficacy measurement instrument is required for determining the self-efficacy beliefs of engineering students or whether a general instrument will suffice. Furthermore, this study also aims to investigate the effect of gender, class level, and transfer status of students on their engineering self-efficacy beliefs. Over two hundred engineering students from Texas A&M University and Houston Community College are surveyed on 39 questions divided across 6 distinct self-efficacy instruments. The survey data was then analyzed to determine whether there exists a significant difference in the scores obtained across the generic and the domain-specific instruments. Factor analysis is also performed to explore the interrelationships among the questions belonging to different self-efficacy instruments. The results reveal that there exists a significant difference in the scores across the two types of instruments.

Keywords: self-efficacy; community college; transfer students; tinkering

Brett R. Stone, Matthew O. Wald, Steven E. Gorrell and **Michael C. Richey**   1687–1700   Collaboration Task-Technology Fit for Student Distributed Engineering Design Teams

Engineers in industry are increasingly called on to work with teammates located in multiple geographic locations (virtual teams). Engineering education has an interest in helping students learn how to best collaborate in these types of situations. Four years of multi-university, multi-disciplinary engineering capstone projects are investigated and related literature is thoroughly examined to demonstrate which collaboration tools, at different stages of the product development process, meet the needs of virtual team members for communication tasks. Student engineering design teams with team members located at various locations should, during the early, middle, and late stages of the product development process, emphasize the use of collaboration tools that will best meet the needs of each stage. In the early stages, teams should emphasize rich communication mediums, such as in-person kick-off meetings. In the middle stages, tools which allow team members to perform their individual work while staying in-sync with their remotely located teammates, such as web conferencing and shared data editing tools, become important. In the late stages, as the team shifts from digital work to physical work, tools such as texting and in-person meetings become more necessary.

Keywords: virtual teams; collaborative learning; computer-mediated-communication; systems engineering

Melina Vidoni, Jorge Marcelo Montagna and Aldo Vecchietti   1701–1708   Project and Team-Based Strategies for Teaching Software Architecture

Software Architecture remains a difficult topic to teach. This is because of the problem's complexity, and the integration of interpersonal and technical skills with knowledge from different areas. This paper presents the introduction of Project-Based Learning (PBL) and Team-Based Learning (TBL) in a Software Architecture undergraduate course. The goal for students is to apply in practice the concepts learned using ATAM (Architecture Tradeoff Analysis Method) to evaluate case studies of real-world architecture. PBL is known for allowing students to experiment with realistic problems and improve their negotiation and communication skills. TBL offers a different approach to group-based activities, by using them to determine the structure of the course. This approach is applied in an optional course in a Systems Engineering degree; its results are positive, having increased students' attendance and active participation levels. A student survey also shows acceptance of the new methodology.

Keywords: project-based learning; team-based learning; software engineering; software architecture

Arti Ahluwalia, Carmelo De Maria, Andrés Díaz Lantada, June Madete, Philippa Ngaju Makobore, Alice Ravizza, Licia Di Pietro, Mannan Mridha, Juan Manuel Munoz-Guijosa, Enrique Chacón Tanarro and **Janno Torop**   1709–1722   Biomedical Engineering Project Based Learning: Euro-African Design School Focused on Medical Devices

Biomedical engineering (BME) has the potential of transforming medical care towards universal healthcare by means of the democratization of medical technology. To this end, innovative holistic approaches and multidisciplinary teams, built upon the gathering of international talent, should be encouraged within the medical industry. However, these transformations can only be accomplished if BME education also continuously evolves and focuses on the internationalization of students, the promotion of collaborative design strategies and the orientation towards context relevant medical needs. In this study we describe an international teaching-learning experience, the "UBORA (Swahili for 'excellence') Design School". During an intensive week of training and collaboration 39 engineering students lived through the complete development process for creating innovative open-source medical devices following the CDIO ("conceive-design-implement-operate") approach and using the UBORA e-

infrastructure as a co-design platform. Our post-school survey and analyses showed that this integral teaching-learning experience helped to promote professional skills and could nurture the future generation of biomedical engineers, who could transform healthcare technology through collaborative design oriented to open source medical devices.