SHAPING ENGINEERING EDUCATION FOR THE 21ST CENTURY

Book of Abstracts of the 4th International Conference of the Portuguese Society for Engineering Education

Lisbon, June 21-23, 2021

TÉCNICO LISBOA

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PREFACE

Dear All,

Welcome to the 4th International Conference of the Portuguese Society for Engineering Education - CISPEE 2021.

Recent technological developments and rapid social changes have brought new challenges to engineering education in the 21st century. Thus, it is important to share and disseminate new inclusive pedagogical practices, innovative teaching and methodologies, that encourage other teachers to try new ideas, and can contribute to better prepare young female and male engineers to be able to anticipate, take part and respond to the future challenges of our society.

We have prepared a very exciting scientific program with a range of interesting sessions and hot topics involving the ultimate research on **Shaping Engineering Education for the 21st Century**, motivating sharing of good practices and debate of ideas.

This conference is a join organization between Instituto Superior Técnico and the Portuguese Society for Engineering Education-SPEE, aiming to debate the role of Higher Education Teaching (and Teachers) in today's and future Societies, and bringing to the discussion hot topics such as: Digitalization in Education; Gender Balance and Diversity in Engineering; Learning Strategies, Leadership and Engineering Skills in the VUCA World; The Ethical Challenge of Engineering in the XXI Century, Redefining Spaces in the University of the Future, beside others.

We invite all to participate actively in CISPEE2021, promoting sharing of good practices and experiences, contributing to rethink teaching and pedagogical models towards new Engineering Education Era.

The Organizing Committee of CISPEE2021,

Raquel Aires Barros
Alexandra Moutinho
Ana Moura Santos
António Rodrigues
Beatriz Silva
Isabel Gonçalves
Leonor Moura
Pedro Brogueira

CONFERENCE PROGRAM

DAY 1

Monday, June 21, 2021

09:00	**Opening Session (Raquel Aires Barros, Filomena Soares, Rogério Colaço, Bárbara Gabriel)**		
09:15	**Zita Martins (IST, Ulisboa): Gender Balance and Diversity in Engineering (Chairs: Filomena Soares and Pedro Brogueira)**		
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	Scientific Session 4 Topic: Learning Strategies, Leadership and Engineering Skills in the VUCA (Chairs: Ricardo Simões and Pedro Brogueira)	Scientific Session 5 Topic: Learning Strategies, Leadership and Engineering Skills in the VUCA (Chairs: José Figueiredo and Isabel Gonçalves)	Scientific Session 6 Topic: Redefining Spaces in the University of the Future (Chairs: Paulo André e Alexandra Moutinho)
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DAY 2

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	Scientific Session 10 Topic: Learning Strategies, Leadership and Engineering Skills in the VUCA (Chairs: Cristina Caridade and Isabel Gonçalves)	Scientific Session 11 Topic: Gender Balance and Diversity in Engineering (Chairs: Maria João Meireles and Ana Moura Santos)
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11:00	52 - Design do Produto: Uma experiência interdisciplinar no ensino superior, **Daniel Gaspar** (Polytechnic Institute of Viseu), Diana Reguenga and Rui Carreto	20 - Fostering Women to STEM MOOCs (the FOSTWOM project), Carlos Turró, **Ana Moura Santos** (IST, ULisboa), Paola Corti and Valeria Baudo
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	Scientific Session 13 Topic: Learning Strategies, Leadership and Engineering Skills in the VUCA (Chairs: Júlia Justino and Alexandra Moutinho)	Scientific Session 14 Topic: How I Turned Digital in One Week Due to Pandemic (Chairs: Maria João Meireles and Isabel Gonçalves)	Scientific Session 15 Topic: Teachers Learn and Improve. They are not born experts (Chairs: Cristina Borges and Beatriz Silva)
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15:30	**Workshop 5** - Iterative methodologies in complex problems:3D Mapping (José Gonçalves Pinto) **Workshop 6** - Interactive Lectures with Active Learning (Sofia Sá) **Workshop 7** - Design thinking for Pedagogical Innovation (Joana Mendonça and Guilherme Victorino) **Workshop 8** - Learning from modern board games to make engaging lecture (Micael Sousa) **Workshop 9** - Continuing pedagogical development for Faculty: challenges and opportunities (Ana Salgado, Ana Freitas and Nuno Oliveira)		
17:00	End of Day 2		

DAY 3

Day 3 - Wednesday, June 23, 2021

09:15	**Arlindo Oliveira (IST, Ulisboa): The Ethical Challenge of Engineering in the 21st Century (Chairs: Paulo Oliveira and Ana Moura Santos)**		
10:00	Break		
10:15	Scientific Session 19 Topic: Learning Strategies, Leadership and Engineering Skills in the VUCA (Chairs: Paulo Afonso and Alexandra Moutinho)	Scientific Session 20 Topic: Teachers Learn and Improve. They are not born experts (Chairs: Andrew Valentine and António Rodrigues)	Scientific Session 21 Topic: Gender Balance and Diversity in Engineering (Chairs: Carla Boura and Pedro Brogueira)
10:15	57- An experience of using Kahoot! while going online, **Sofia Cruz** (FEUP), António Coelho, Diana Urbano and João Pedro Pêgo	96 - Evolution of Engineering Education Research in Portugal and Spain: a scientometric study, **Andrew Valentine** (University of Queensland) and Bill Williams	79 - A Survey about Gender Diversity in a More Gender-Balanced IT Firm, **André Santos** (ISCTE), Joana Alexandre and Fabiane Meireles
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11:00	73- Designing Maths Interactive Lessons, **Ana Moura Santos** (IST, ULisboa) and Domenico Brunetto		64 - The students' integration in pandemic times: MIEIC.OnBoard 2020/2021, **Bruno Lima** (INESC TEC and Faculty of Engineering, University of Porto) and António J. Araújo
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12:30	Lunch Break	
13:30	Scientific Session 25 Topic: Teachers Learn and Improve. They are not born experts (Chairs: Gonçalo Cruz and Isabel Gonçalves)	
13:30	50 - Programming learning in higher education: a Systematic Liretacture Review, **Ceres Germanna Braga Morais** (University of Rio Grande do Norte State) and Antônio José Meneses Osório	
13:45	111- Observing Classes at Técnico (2010-2019): Do observations impact on the quality of teaching?, Filipa David, Leonor Moura, Patrícia Simões, Gonçalo Moura, Marta Graça and **Isabel Gonçalves** (IST, ULisboa)	
14:00	31 - Learning engineering contents from different courses through a hands-on activity teamwork, **Anabela Alves** (University of Minho) and Filomena Soares	

14:15	Break
14:30	**Round Table** - The Impact of ICT on Engineering Education: past, present and future
15:30	**Awards (António Rodrigues, Teresa Peña, Vanderli de Oliveira) and Closing Session (Raquel Aires Barros, Filomena Soares, Rosa Vasconcelos, Luís Oliveira e Silva)**
16:00	**End of Day 3**

PART I – ABSTRACTS

A Comprehensive Plan for Increasing Participation of Underrepresented Students in Engineering Fields

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***Abstract* - This paper describes an extensive approach for improving the academic performance of engineering students from underrepresented groups. The overall goal of the project is to increase the retention and preparation of engineering students by increasing the number and thus the throughput of students through effective recruitment and retention strategies. To achieve this goal, our objectives are to 1) improve passing rates; 2) enhance student motivation to learn; 3) improve graduation rate; and 4) engage students in developing effective lifelong learning skills. Novel pedagogical techniques such as the Key and Gatekeeper course are utilized. Preliminary findings suggest that this approach, which builds on a successful pilot program funded by Texas Higher Education Coordinating Board and National Science Foundation, can dramatically increase student retention and GPAs, particularly in underrepresented populations such as majority of students at the University of Texas at San Antonio (UTSA), who are mainly Hispanics. Freshman engineering intervention through Just in Time Math (JITM) project curriculum and delivery is also utilized as a Key course. Taught by engineering faculty, the JITM course includes lecture, laboratory and recitation components. Using an application-oriented, hands-on approach, the JITM addresses only the salient math topics actually used in the core entry-level engineering courses. These include the traditional physics, engineering mechanics, electric circuits and computer programming sequences. This project also emphasizes the need to look at the concept of engineering education program tracking and assessment from a proactive rather than reactive view so that our proposed methodology for increasing retention and preparation among underrepresented groups can be quantitatively measured and replicated. Thus, a tracking, monitoring and prediction tool called the Continuous Engineering Education Monitoring and Prediction Methodology (CEETPM) has been developed as part of this project in order to close the continuous quality improvement loop by quantifying baselines and improvements, and feeding data back into the system in order to plan more effectively and efficiently. In essence, the proposed CEETPM is a novel statistical framework for assessing and quantifying the inherent uncertainty and variability associated with student outcomes data to systematically monitor, track, control and predict outcome levels that directly affect retention and quality. We believe that this tool will constitute an important deliverable in its own right, thereby maximizing the benefit that can arise from this proposed project through the transfer of this technology. The pedagogical and programmatic techniques proposed herein are designed to affect long-range improvement in engineering education at a predominantly Hispanic Serving Institution and to increase the throughput of underrepresented ethnic minorities, particularly minority women, into the Engineering disciplines. The structure of this project is such that we attain sustainability by the third year so that long-range improvement is affected.**

Keywords—Engineering Education; Just in Time Math; Continuous Engineering Education Monitoring and Prediction Methodology

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Learning from experience

The teacher´s perspective

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Abstract— **This communication assesses the issue "Teachers learn and improve, they're not born experts". I present a personal reflection, based on a bibliographic review, on the one hand, and on my thirty years of experience of teaching in a higher education institution, the Faculty of Engineering of Porto University (Portugal), on the other.**

Along this way, I can reaffirm the importance of learning from experience, through which teachers come to learn with different interlocutors, with different technologies, and with different teaching/learning methodologies.

Teachers´ learning processes (like students´ ones) are diversified and based on written, oral, hearing, sensory, and even on a kinaesthetic apprehension (that combines several feelings and senses). So teachers learn not only through cognitive stimulation. They also learn with their students (either in the scope of the classroom or in extra-class talks), with their colleagues (informally and/or in the scope of conferences and meetings to discuss pedagogic themes and practices), and with new technologies and teaching methodologies (in training initiatives or in conferences/debates).

Teachers´ learning processes (like students´ learning processes) are mainly based on cognitive learning. They enable the insertion of different contents into the cognitive structure, in an organised way, thus engendering an arranged information complex ([1];[2];[3]). Teachers´ "learning from experience" is based on this cognitive ability to learn with experiences, attempts, achievements, and mistakes. This cognitive stimulation may be triggered resorting, in classes, to the application of videogames typical techniques in real world situations applied to teaching, aimed at developing practical problems, raising awareness and/or motivating students for specific teaching sessions.

The experience gained by teachers along their careers is relevant in what concerns their knowledge of students´ features, behaviours and attitudes (according to their age group), and the awareness of the evolution of their motivations, beliefs, tastes, and preferences. The learning processes are reciprocal between teachers and students: students learn from teachers, but the opposite is noticeable as well. Some good examples are the challenges often posed in classes by most proactive, critical, and inquisitive students, or even students´ mastery of computational techniques and softwares.

Learning and teaching have increasingly resorted to new methodologies. Such is the case of "active learning processes", "problem-based learning", "flipped learning", "distance learning" (electronic-learning and blended-learning, the former consisting in virtual classes and the latter in its conjunction with face to face classes), functional education, and the use of new platforms as google or moodle, or even apps (for instance, applications to support foreign language learning) ([4];[5];[6];[7];[8];[9]).

These new methodologies represent a challenge for teachers, as they force them to rethink the contents of the curricular units, and, especially, the ways how they should convey knowledge in order to increase its impact and the strength of their message.

In brief, each learning moment represents a new challenge and a new step forward in order to permanently improve teachers´ knowledge, competences and skills.

Keywords— class interactivity; cognitive learning; new technologies; teaching and learning methodologies

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Innovative STEAM MOOCs from Técnico Lisboa

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***Abstract*— Since October 2016, Técnico Lisboa from the University of Lisbon (tecnico.ulisboa.pt), has been aiming to position itself in the latest developments of Massive Open Online Courses (MOOC) with a pedagogic strategy that takes into account both Portuguese and International Higher Education context [1] in the areas known as Science, Technology, Engineering, Architecture and Mathematics (STEAM). The twelve online courses produced so far, are developed through a multidisciplinary collaboration between our teaching staff community and the MOOC development team. Tutors, instructional designers, and graphic designers begin to ideate and design the STEAM contents according to the pedagogical model of the project. This includes online courses available at different levels of education: Bridging courses on basic sciences and technology, Graduate courses on topics from 1st and 2nd cycles of higher education and Extracurricular courses on transversal topics from STEAM areas (courses.mooc.tecnico.ulisboa.pt). All online courses are in Portuguese and/or English and can include transcripts and texts from other languages. Each MOOC Técnico course has a planned duration of 4 to 5 weeks corresponding to a workload of 6 to 8 hours per week (circa 1.5 ECTS per MOOC) [4]. The multimedia solutions for contents, mainly short and medium-length educational videos [4], are worked out by the team in order to make it clear, visually stimulating, and fit to the digital media, where it will be made available. The MOOC Técnico courses allow different forms of assessment: Quizzes, Peer review and Formative assessment [3], that enable an enrolled participant to earn a free certificate upon successfully achieving at least 60% of the planed graded course activities.**

The process of designing a MOOC Técnico course begins with a teaching staff or startup team proposition on producing online courses with the before mentioned pedagogic characteristics. During the pre-production, teachers and tutors work together with the team in order to produce attractive storyboards that are carefully revised and validated [5]. After the scientific validation from the tutors, the audio-video attractive material is recorded in the Técnico Lisboa studio. Parallel to this collaborative work, the teaching staff structures the course contents in the MOOC Técnico platform (mooc.tecnico.ulisboa.pt), a customized Open edX platform. More than 20,000 participants are presently enrolled in our online courses. In our presentation, we'll give examples of producing and designing innovative MOOCs, one per each type of MOOC: a bridging course on Markov matrices (mmX) directed at Maths Highschool students, a graduate online course on Epigenetics and Human Health (epigeneticX) aimed at students from the Computer Science and Bio Engineering areas, and a transversal MOOC on Machine Learning (in production). We hope by sharing our knowledge experience, that teaching staff, startup teams, and instructional designers, who develop and research course material for their Higher Education learning programs can identify value in our processes and creative techniques and support them in their future course development targeted at a broader audience.

Keywords—MOOC design and production, STEAM online courses, video storyboards, attractive educational videos.

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Fostering Women to STEM MOOCs

The FOSTWOM project

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***Abstract*— The *Fostering Women to STEM MOOCs* (FOSTWOM) project is a three-year initiative approved for funding under the European Commission's Erasmus+ Projects. The project is coordinated by Universitat Politècnica de València (UPV), and the other partners are Instituto Superior Técnico. (IST), Politecnico di Milano (Polimi), Royal Institute of Technology (KTH), Conservatoire National des Arts et Métiers (CNAM) and two high schools, one from Portugal, another from Italy. The FOSTWOM project intends to use the inclusive potential of Massive Open Online Courses (MOOCs) [1] to propose STEM subjects free of stereotyping assumptions on gender abilities. Moreover, the consortium is interested in attracting girls and young women to science and technology careers, through accessible online content, which can include role models' interviews, relevant real-world situations and strong conceptual frameworks [2].**

The FOSTWOM's main goals are: To mitigate the effects of stereotyping about gender-based STEM ability; Raise the number of female students and learners attending courses in the areas of STEM, both, as enrolled students in higher education institutions, and as STEM MOOCs' participants. In order to achieve the main goals, the priority actions in which further concrete measures are been taken care of are the following:

- Develop a Toolkit to design, produce and validate STEM MOOCs under a gender balance perspective, considering the results of a needs diagnosis on STEM barriers [2]; This Toolkit is presently open and accepting comments in the FOSTWOM website;

- Create one transversal, one bridging and one graduate STEM MOOC; The transversal course designed with MOOC's content, instructional and visual experts in mind, aims to analyze existing STEM MOOCs through a gender balance perspective and gives guidelines for using the Toolkit; The bridging MOOC, namely designed for secondary and undergraduate students, will be an introductory course on Machine Learning, Math and Ethics and is also currently under production; The graduate MOOC aims to STEM students and will be about relevant and cross disciplinary applications of Human-computer Interactions;

- Promote intensive training sessions to secondary and tertiary education teachers and technical staffs regarding the design and production of gender inclusive STEM MOOCs and their implementation in face-to-face classes (e.g. flipped-classroom strategies).

In this work we aim to present the first FOSTWOM's results: The Toolkit, and the storyboards of the transversal and bridging courses that are being designed and produced within the project. We will discuss how the Toolkit will support the MOOC producers' community, and also the general public, to realize whenever a given STEM content is delivered in a gender balance way or not. We believe that even a highly technology-centered delivery format as a MOOC can serve to pay attention to different learning styles of female students that are being recognized [2] and can affect positively the overall percentage of women in STEM.

Keywords—women careers in STEM; gender balanced MOOCs; gender-balance toolkit

ACKNOWLEDGMENT

This work is supported by European Commission's Erasmus+ – KA2 Cooperation for Innovation and the Exchange of Good Practices – Strategic Partnerships for Higher Education.

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Problem-based/Mobile Learning for Courses in Electrical Machines, Drives, and Electric Vehicles

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***Abstract*—We focused on new learning approaches to teaching the already designated old-fashioned (but still the core of today's technology) electrical machines and their applications.**

Pedagogical practices were developed using a problem-based learning approach (Fig. 1) and also active learning processes as, for example, mobile learning supported by QR codes for laboratory classes (Fig. 2). All tools were applied to the courses of Electrical Machines and Drives and Electric Vehicles of the Electrical and Computer Engineering Integrated Master at Instituto Superior Técnico (IST).

The project is supported by an online learning platform, as shown in Fig. 2. The option is justified by sharing content among students in the platform and having tools for calculating and analyzing metrics regarding students' performance.

Our approach was divided into two modules: Module 1 - ELECTRICAL MACHINERY FOUNDATIONS; and Module 2- ELECTRIC DRIVES. For this framework, the following materials were developed:

1. **Short descriptive videos (*mobile learning*, <4 min.) with brief explanations of the laboratory work in the courses of *Electrical Machines* and *Drives and Electric Vehicles*.**

This feature allowed students to visualize the work to be done during the laboratories, avoiding simple questions related to the assembly and gaining more time for the actual discussion of the laboratory results (about 1004 views in all videos until today).

2. **Design a set of tests/exercises online with an automatic response, encouraging students to test their knowledge proactively. Responses are stored anonymously in the database for consultation by course professors.**

After implementing this feature, 644 responses to the online tests were recorded. Besides providing feedback to students about their knowledge, it allowed professors to understand which topics were less understood by the students.

3. **Simulation models developed for the FIAT electric vehicle and motor speed control dynamics, both models made available in the FIAT-Competition Project (Fig. 1).**

These models were developed by students in groups of four, from the dynamic vehicle model to the dynamic electromechanical model of the electric motor and its drive. These allowed creating a simulation tool to fit the controlling parameters and have a competition between students. These models were based on the FIAT electric vehicle available at the Electrical Machines Laboratory.

4. **During the "Drives and Electric Vehicles" course, the first activity associated with the practical component as problem-based learning was developed with a project of real application of electric machines in traction systems: the FIAT-Competition Project. Each group competed with its methodology for controlling the motor speed of the FIAT vehicle that consumes the least amount of electrical energy.**

The impact of this project on improving the quality of education is evident in Fig. 3. It shows how students' grades improved in 2018/2019 compared with previous years. The number of reproved students (RE) dropped from about 27% on average between 2015-2017 to 3% in 2018/19.

Fig. 1 – Problem-based learning for the *FIAT-Competition Project*.

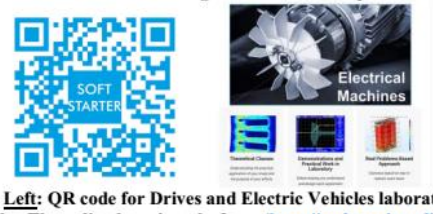

Fig. 2 – Left: QR code for Drives and Electric Vehicles laboratory (*try it*!!). Right: The online learning platform (http://mel.tecnico.ulisboa.pt/)

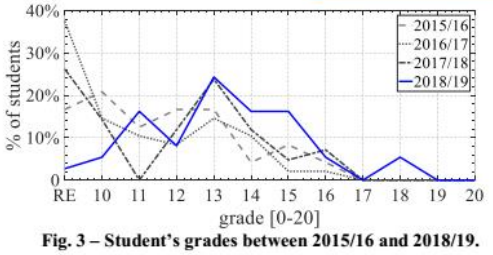

Fig. 3 – Student's grades between 2015/16 and 2018/19.

Keywords— problem-based learning, mobile learning; electrical machines; electric vehicles.

ACKNOWLEDGMENT

This work was supported by Instituto Superior Técnico (IST), under the Pedagogical Innovation Projects program.

Electrical Systems of Solar Photovoltaic Technology, Applications and Learning Methodologies

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***Abstract*—The main objective was to introduce new digital communication and information technologies as pedagogical instruments for teaching activities on the course of Integrated Electrical Systems of Solar Photovoltaic Technology (SEITSF), of Electrical and Computer Engineering Integrated Master at Instituto Superior Técnico (IST). In this context, a framework was proposed based on developing pedagogical activities supported by problem-based learning models and active learning processes.**

The project was divided into modules according to the program objectives: 1) Semiconductor Materials and Photoelectric Effect; 2) Photovoltaic panels: technical and economical options taking into account the effects of shading, temperature, and aging; 3) Off-grid/on-grid Hybrid Photovoltaic/Thermal Collectors; and 4) Sizing and optimization of electric photovoltaic systems.

These modules were addressed through two teaching components: a) an online e-learning platform and b) a practical component based on problem-based learning. In summary, the following materials were developed:

1. Development of an online platform with the following elements: a) Short videos with brief explanations of the laboratory works; b) Development of simulation models to demonstrate several PV working conditions; c) Laboratory guides adapted to the new content; d) Online tests/exercises with automatic feedback to encourage students to test their knowledge proactively. (Student's answers are stored anonymously in a database); e) Create a database with the best works done by students in the Problem-Based Learning component.

2. Development of a problem-based learning component based on the design of a photovoltaic system for an application of student choice. The project ended with a 15min presentation of the work to all SEITSF course faculty and students. Upon completion of the semester, the best works were selected and displayed on the online platform.

The project was successfully applied, showing good results in applying PBL models and active learning processes. One example was the impact of the developed videos for the laboratory works, Fig. 1. These videos were given to students the week before the laboratory to visualize the main methodologies and the main work objectives. With these videos, students were able to quickly assemble the experiments. They were more focused on analyzing the results, allowing more attention to the results and actively searching for answers. In the last two years, the number of students enrolled in the course was 130, and the number of video visualizations was 670.

Another example was the impact of elaborated tests/exercises, with 197 answers registered in the database. With these, it was possible to identify the topics where students had more difficulties, Fig. 2. From the PBL project, students were able to design PV systems for real cases, as their homes, and understanding the required capital investment and expected revenue under real conditions.

All these components promoted an active learning process and enabled active communication between faculty members and students. All project components are continually being improved based on the results and students' feedback—more information about this project in http://seitsf.tecnico.ulisboa.pt/.

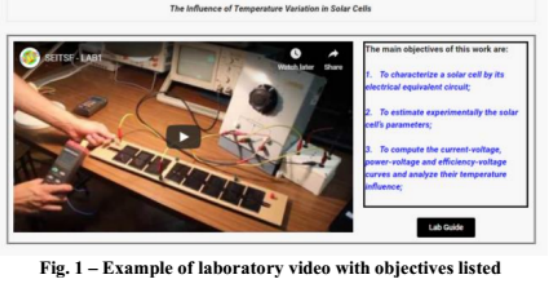

Fig. 1 – Example of laboratory video with objectives listed

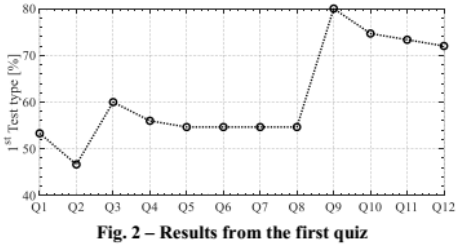

Fig. 2 – Results from the first quiz

Keywords— photovoltaic systems; active learning; problem-based learning.

ACKNOWLEDGMENT

This work was supported by Instituto Superior Técnico (IST) under the Pedagogical Innovation Projects program.

Portuguese engineering education in the context of the 2018 MIT Report on the global state of the art

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***Abstract*— In 2018 MIT published a report commissioned from UK expert Ruth Graham [1] that aimed to set out the state of the art in engineering education and exemplify it by providing information on institutions around the globe recognised as being innovative in the field. The report included case studies on 4 institutions: University College London (UCL) in the UK, TU Delft in Holland, Singapore University of Technology and Design (SUTD) in Singapore and Charles Sturt University (CSU) in Australia. Mindful of the fact that no Portuguese institution had been mentioned in the report, the Board of the Portuguese Society for Engineering Education (SPEE) decided it would be valuable to bring together decision-makers from national engineering schools to discuss the MIT report and use it as a basis for thinking about the future of engineering education in Portugal. Adopting a structure previously used in the field to analyze such a meeting of experts [2] this Abstract describes the organization of the event, the discussions that took place and considers possible outcomes.**

Keywords—MIT report; state of the art; Portuguese engineering education.

I. PARTICIPANTS

The encounter was a half-day event that took place on a weekend in a hotel located on the coast in the centre of the country. Participants included deans and senior staff from the engineering faculties of the universities of Aveiro, Beira Interior, Coimbra, ISCTE Lisbon, IST Lisbon, Minho, Porto and Tras-os-Montes and Alto Douro while the polytechnic sector was represented by ISEL Lisbon, ISEP Porto, ESTBarreiro Setúbal and EST Setúbal. The Portuguese Ordem dos Engenheiros was also represented along with the Board of SPEE who acted as facilitators for the activities. Of the total of 16 participants in the event, 6 were female.

II. STRUCTURE OF THE EVENT

The aim of the session was to first receive input from one of the engineering schools identified in the MIT Report. This would be followed by small group sessions to analyze other case studies in the report followed by a plenary session of feedback from the groups that would include pointers for future developments of engineering education (EE) in the national context. The initial plenary session was in the form of a roundtable led by Professor John Mitchell, Vice Dean Education, University College London Engineering and Co-Director of their Centre for EE. John Mitchell described how UCL created an Integrated Engineering Programme [3] that provides a framework incorporating a set of core curriculum elements that are taught alongside discipline-specific components throughout the entire undergraduate degree programme. He explained that the integrated program had begun in the Civil Engineering Department and was then extended across eight engineering departments and eight different programmes, each programme having a three-year Bachelors (BEng/BSc) and a four-year Integrated Masters (MEng/MSci variant) engineering programs. The integrated program has a strong focus on real world problem solving in partnership with industry partners. At regular intervals throughout the degree, students from across the faculty come together to engage in interdisciplinary research and design projects. It essentially introduced and delivered a complete revision of EE across the majority of the Faculty. After John Mitchell's presentation, participants worked in small groups to analyze the initiatives at TUDelft, CSU and SUTD and they then presented their findings. The following section is based on the authors' analysis of notes taken during these small group presentations and of the posters used to accompany each one.

III. DISCUSSION

After the input on international examples there was then a debate on the value and feasibility of such initiatives within the Portuguese context. A widely shared observation was that getting authorization/accreditation from the national accreditation agency A3ES for radically changed engineering programs could be challenging. Participants also observed that it would be important to have empirical evidence to show the outcomes and impact of initiatives to rethink EE programs, such as those that are being currently prepared by a number of national universities that are due to lose their integrated master's programs, and to evaluate the effect on the careers of their graduates. With regard to empirical data, it was noted that the majority of the internationally recognized innovative engineering schools have introduced research centers focusing on EE and in most cases, these include PhD programs in the area. The SPEE representatives stated that whereas no such approach has been undertaken yet in Portugal, it is one of the society's aims to help bring this about.

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Optimization of the teaching and learning process with classroom response systems - clickers

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***Abstract*— In a new teaching paradigm, the key role of the teacher should be to challenge students to place questions and guide them in finding the answers to those questions. This requirement should be complemented with new teaching methodology and assessment methods, aiming to develop the student's creativity and critical capacity. Moreover, the students are expected to attain an integrated view for the studied technologies, as well as the ability to apply this know how in other multidisciplinary contexts.**

The introduction of these new pedagogical strategies requires real-time assessment tools, allowing the immediate correction of the aspects related to the contents taught. One mechanism for implementing this learning process strategy, in real time, is through the use of classroom response systems (clickers), which can also be used for grading and attendance recording [1].

In this work we report the results obtained with clickers in two courses (Optoelectronics - 33 students and Telecommunications Fundamentals - 230 students). Both courses were from the integrated master's in electrical and Computer Engineering, taught in the 1st. semester of 2018/2019.

The clickers were used to pose 4 to 6 conceptual questions and to peer discuss the results. The students had 30 to 90 seconds to answer, through the terminal, after that, the answers were analyzed and the correct interpretation of the proposed problem was discussed.

It was demonstrated that the use of clickers is an appropriate tool for the implementation of several teaching / assessment methodologies. However, the implementation in lectures with many students should be avoid, it is suggested to used them in lectures with less than 40 students. The clickers were also tested in exams grading.

Keywords—classroom response systems; conceptual questions; exams grading.

ACKNOWLEDGMENT

This work was developed within the scope of the PIP projects financed by the IST pedagogical council, 2018 edition, and co-financed by the department of electrical and computer engineering.

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Social Innovation Lab

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Abstract*— Engineering Schools have been enabling students to develop the skills needed to identify technology-based business opportunities and implement them within new and established organizations. Many of these technologies bring new ideas that meet social needs, create social relationships and form new collaborations – social innovations. However, these specific social challenges are still not being explicitly included at the core of many engineering courses curricula and, in general, on educational strategies at engineering schools globally. In this sense, the Social Innovation Lab (SILAB) at Instituto Superior Técnico (IST) was created to address the current gap in the educational system by focusing mainly on frugal innovation – "do more with less" – aimed at solving social problems experienced by several local communities in the world. Its mission is to: (i) leverage the students' creativity, integration with external communities, research skills and capabilities to develop socio-technical innovation and entrepreneurship; (ii) stimulate the creation of goods and services which fulfill the needs of local communities and communities in emerging markets and (iii) actively promote the cooperation between stakeholders, a social responsible mind-set, the empowerment of local communities and business models that truly target world changes. Accordingly, the SILAB involves makers, researchers and students from different backgrounds who develop their projects under supervision of professors and specialists and it encompasses: (i) a new educational model integrating an economic and human dimension of technology; (ii) a mobility program where students develop in-site solutions that potentiate the well-being of vulnerable communities; (iii) an international network of partners and (iv) a physical laboratory where different stakeholders can interact and generate products that meet the needs of base-of-the-pyramid communities. The main activities that have been carried out so far involve the physical laboratory at IST and the development of socially innovative projects. For instance, DETU, a platform developed in the Industrial Engineering and Environment course which helps senior mobility, and E-MITRA, an app for illiterate farmers that facilitates the participation in public supporting schemes, developed in the Technology Based Entrepreneurship (TBE) course. TBE students had the chance to develop projects tackling challenges from remote communities and travel to India in order to validate their concepts. SILAB created a scientific committee with IST professors who are involved in projects connected to their area of expertise. This contributes to the achievement of better outcomes and to broaden SILAB's national and international partnerships. The present article not only describes what the key activities and best practices at SILAB are, but it aims particularly at discussing why Higher Education Institutions (HEI) (particularly engineering schools) should connect engineering with social impact; and it uses SILAB as an innovative case-study to show how it can be done. The SILAB is, therefore, a pilot for a new educational model that can be successfully implemented by other HEI. The creation of more Labs like SILAB@IST can function as a decentralized network and become a world-wide grid of students, researchers, professors, universities, companies, and social enterprises promoting solutions towards the well-being of the population in the world.

Keywords—component; formatting; style; styling; insert (key words)

ACKNOWLEDGMENT

Financial support was obtain through the participation in the Pedagogical Innovation Project (PIP) of the Pedagogical Council at Instituto Superior Técnico (IST), and through the prize award on the participation of the 1st Edition of Banco Português de Investimento (BPI) TechInnov Social Innovation challenge. We thank the Department of Engineering and Management at IST for their ongoing support and collaboration with the Social Innovation Lab.

Exploring the Delphi method for educational purposes

The ENERPHI and ANIPHI technological web-platforms

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***Abstract*— The teaching of participatory processes is highly relevant for future professionals who are going to be involved in, or aid, decision-making processes under complex and uncertain environments. The teaching of such methods has been based on a traditional face to face education. However, given advances in technologies, there is an opportunity to enable students to explore and learn about participatory processes by using new technological platforms. The objective of this work was to design and implement an innovative pedagogical approach, based on the Delphi method [1], to teach participatory methods on a web basis. Namely, it was our aim that this approach: would teach students on a learn by doing format about how to involve a (potentially) high number of participants in an interactive way; and would enable students to discuss controversial issues while participating in new interactive formats (web-based) to complement face to face teaching. To meet these aims, the developed pedagogical approach was based on the use of new technological web-platforms (WELPHI, available at www.welphi.com). The Delphi was selected for being a "method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem" [1, p.3]. Delphi is recognized as a valuable "knowledge acquisition technique" for developing different models of knowledge [2, 3]. Despite this, its use for educational purposes has been scant, with only one reference being found in the literature [4]. Within our innovative pedagogical approach, we developed two platforms adapted to two different educational contexts. The first context takes place under an educational project promoted by the KIC InnoEnergy initiative and aligned with the teaching of participatory processes within the 'Decision Support Models' (with application to Energy) course held at Instituto Superior Técnico (University of Lisbon, Portugal). For this context, we developed the ENERPHI platform (http://enerphi.tecnico.ulisboa.pt/), a platform to help students studying and implementing web-Delphi processes in Energy decision-making contexts. The platform complements face to face education and encompasses a set of intuitive audio-visual pedagogical tutorials to enable students using the Welphi platform through a hands-on-approach. The second context takes place within the Erasmus+ Anicare project (2017-2020), a European project aiming to support animal welfare (a controverted topic, with multiple and sometimes extreme ethical and scientific perspectives) teaching. Within the ANICARE project, we developed the ANIPHI platform (https://erasmus-anicare.eu) that makes use of the iterative nature of the Delphi method as a learning process to generate both reflection and (non-face-to-face) debate among learners, to complement face to face educational processes. A set of problem-situations and videos prompts individual reflection from learners. At the same time, the debate takes place in follow-up Delphi rounds where learners are faced with the perspectives, practices, experiences and values other than their own (i.e. from other learners). The educators assume the role of process facilitators in this proposed approach. Several educators have tested both the ENERPHI and the ANIPHI platforms, showing the benefits of using the Delphi method as a 'learning instrument' [4]. ENERPHI has shown to be a practical pedagogical approach to teach participatory methods as it has allowed students to collect first-hand experience on the challenges of developing participatory evaluation models, namely when conflicts of stakeholders' views are present. Students have shown to become autonomous to implement Delphi processes within their research. The ENERPHI platform collected great interest among students and has been used in multiple master theses in real-life corporate contexts [5]. ANIPHI has shown to allow students/learners to develop critical, ethical and creative thinking in a non-face to face format, by creating a dialogue between values, experiential knowledge and scientific knowledge. The platform is being used by different universities across Europe to educate about animal welfare, and its use is being explored to other educational areas.**

Keywords*— *decision-making; Delphi method; higher education; innovative pedagogy; WELPHI

ACKNOWLEDGMENT

The authors would like to acknowledge the support provided by InnoEnergy Teacher Benefit Projects ENERPHI (2016) and ENERPHI 2 (2017) and 3 (2019); and the Erasmus+ programme of the European Union ANICARE.

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MOOC Técnico Analytics

Improving students online learning

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***Abstract* — We focus on the benefits of having an analytics tool in MOOC Técnico platform (mooc.tecnico.ulisboa.pt) the customized Open edX platform of Instituto Superior Técnico. MOOC Técnico Analytics is a service that provides statistics on video visualizations integrated into the online courses running in the platform (courses.mooc.tecnico.ulisboa.pt). It is mainly composed of two parts: the integration with the Open edX platform [1] to capture data about course usage, and a Web application that provides statistics based on the data collected. This system enables tutors to easily visualize course statistics in real-time, and also allows consulting course statistics for future analysis. The dashboard provided by the Web application allows tutors to access real-time statistics from video visualization with different precision levels, such as the course level and individual video, along with customizable time intervals. At the course level, it is possible to determine the MOOC daily video watch time, obtain a sorted list of the course videos organized by trends, based on the number of watched hours, and a distribution of time spent watching videos for each unit in the course. At the individual video level, it is possible to identify the playback events distribution, such as the number of "play" and "pause" events, recognize the most-watched segments of a video, and also visualize "seek forward" and "seek backward" events (see Fig. 1). By analyzing all this information, it is possible to gain knowledge of the general students' profile and student common behaviour while navigating through a course. The identification and analysis of such patterns can provide important information, both to MOOC instructional designers and to course tutors, about the relevance of a given video in the course. These patterns can help pinpoint which sections in a video might need to be rearranged: sections with many "pause" or "seek backward" events may suggest that the contents are not conveyed clearly to students, or that on-screen graphical aids about the subject might be necessary. For instance, before the analytics system was implemented in MOOC Técnico platform it was considered good practice in designing the course to have one introductory video for each topic within a MOOC, where the instructor explained in general terms what was going to follow in that topic. After this tool was running, based on the statistics provided, the team was able to conclude that those videos were not relevant for the majority of the participants (very few viewers, many "forward seek events"). The introductory videos are now replaced with brief introductory texts, and the production of those videos is avoided. We expect to have further examples in the near future, which will allow the MOOC Técnico team to reduce course production costs and start concentrating on video content quality. By validating and improving the course videos it will be possible to meet students' needs and foster MOOC participants' higher engagement in course content, and therefore contribute to better success rates [2].**

Fig 1.: Playback events distribution, heatmap of segment views and video seeking in one of the videos of Matrizes de Markov course.

Keywords—Learning Analytics; MOOC videos, Open edX platform

ACKNOWLEDGMENT

This work is supported by the Instituto Superior Técnico, University of Lisbon, and in particular was supported by the Pedagogical Council of Instituto Superior Técnico, through Pedagogical Innovation Projects, PIP 2018.

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Gender-related differences in Civil Protection Engineering students

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***Abstract*—** It is being recognized that civil protection is yet traditionally considered mostly a male sector, but women have been taking safe steps in the affirmation of an action, where their skills and domains are unquestionably asserted in added value in an effective and efficient modern civil protection.

The integration of women in civil protection, despite its reduced representativeness, is already an assumption by part of society. To gain a better insight, we analyze the social construction processes behind this representativeness, which are based on gender standards in civil protection engineering. The purpose of this work is, thus, to analyze students' gender patterns in the civil protection engineering bachelor's degree. The data presented are derived from the Higher Institute of Education and Sciences' (ISEC Lisboa) civil protection engineering bachelor's degree and 295 students were considered. This degree has existed at ISEC Lisboa since 2007, and has already formed 114 engineers, 44,4% of them matriculated in the last decade. Almost all students (82.2% of women and 91.6% of men) are Portuguese and about 50% of them (48.9% of women and 47.6% of men) are from the district of Lisbon.

Statistical data analysis, from 2007 to 2019, show that the number of females undertaking this course (15.2%) is expressively lower than the number of males (84.8%). Considering the gender age, 55.6% of females are between 18 and 35 years while 73.5% of males have more than 35 years (p-value = 0; Chi-square test). This age difference may explain the course's access regime, since most men enter through the "Over 23 regime" (58.8%) while women enter through "Other regime" (62.2%) (p-value = 0.009; Chi-square test). When applying for the bachelor's degree, the number of female students with qualifications higher than the 12th grade is higher than the male number (28.1% against 17.5%), while with a qualification lower than 12th grade the ratio is opposite (men - 26.3%, women - 9.4%). However, according to the result of the chi-square test, this difference is not statistically significant to conclude that the two variables are dependent. Student success has no gender relation since, statistically, women neither rank higher nor are the ones who graduate the most (p-value = 0.702; Chi-square test). The drivers and reasons behind these gender trends are poorly understood. Probably are an evidence of biological gender differences in abilities and interests or a cultural issue or it may reflect the family conservatism still rooted in our culture.

Nevertheless, despite the gender imbalance, the number of women in civil protection at the level of management and command functions has been increasing in Portugal for the last decade, some of them trained in civil protection engineering. This is a process that already presents a set of evidence regarding the pertinence of the inclusion of female professionals in the civil protection ranks. It is, of course, still and also a cultural issue, where it appears that the barriers and frontiers to this rise begin to be diluted and broken down, due to the skills and competences demonstrated by these female professionals in the exercise of the profession, until then markedly a male domain.

***Keywords*—** *Civil Protection; Engineering; Gender; Education; ISEC Lisboa.*

Using active methodologies for teaching basic concepts in engineering:

The influence of the experimental approach to deal with the alternative concepts of heat and temperature

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Abstract— **This research aims to contribute to improving the quality of engineering education, by focusing on the introduction to the fundamental thermodynamics' concepts. Thermodynamics is one of the foundations of many engineering problems, the need to discuss the best methodologies for approaching the fundamental concepts of heat and temperature in the first years is justified [1]. The research intends to evaluate the impact of valuing the alternative conceptions of these concepts in the classroom. The knowledge of students' alternative conceptions is of great importance in the teaching-learning process of natural and exact sciences. These conceptions assume a central role, because all the work developed in the classroom must be done in such a way that students are encouraged to present, question and test their previous ideas [2]. While teaching of Natural and Exact Sciences, the students' difficulty in relating the theory developed in the classroom with the reality around them is a significant barrier, as the theory is made up of concepts that are abstractions of the students' reality [3]. Therefore, to achieve a significant learning according to Ausubel definition [4], it is necessary to follow an active teaching approach, i.e. it is necessary to evaluate the students' initial knowledge, identify alternative conceptions, develop a dialogical and reconstructive questioning process, promote communication and value the epistemic function of the processes involved [5]. In this way a new active approach to teach the fundamental concepts of heat and temperature concepts was developed and tested in two classes of the 9th grade of the Secondary School "25 de Junho" in Vila Municipal de Massinga, in Mozambique. In one class the methodology was tested and in the other class was used as control. A pre-test was implemented to identify and characterize the alternative conceptions and the level of both classes was equivalent. Then, in the experimental class, three lectures were taught on heat, temperature and direction of spontaneous heat transfer using an approach in which the focus was on valuing the students' alternative conceptions. In the control class, the same classes took place using the traditional expositive method, without taking into account the alternative concepts. After applying a Post-test, the results showed that in the experimental class the level of correct answers rose from 42.6% in the pre-test to 91.4% in the post-test, while in the control class the rise was 46, 7% in the pre-test to 57.7%. The research shows that by valuing the students' alternative conceptions, there was significant learning in the formulation of the concepts of heat and temperature.**

Keywords— alternative concepts; active learning; thermodynamics teaching

ACKNOWLEDGMENT

The authors would like to acknowledge Fundação Calouste Gulbenkian for the support of the partnership between Universidade Eduardo Mondlane and Instituto Superior Técnico in the development of the Doctoral Program in Science and Technology in Energy, Universidade Eduardo Mondlane, Mozambique.

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Programming learning in higher education: a Systematic Liretacture Review

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Abstract*— This paper presents a Systematic Literature Review (SLR) to analyze articles that address methodologies, strategies and tools for learning programming at the higher education level. The choice of this research method was due the SLR represents a type of study whose methodology is well defined, so that it can evaluate the research in a careful, reliable and objective way [1]. For this study, the review was carried out in four databases: RCAAP, Web of Science, Scopus and IEEE Xplore. For this, was defined a research question: "How is the process or programming learning in higher education", the keywords, the necessary equation for the study, the inclusion and exclusion criteria, as well as the review protocol. Initially, 346 articles were found, of which 218 were pre-selected. After applicate the inclusion and exclusion criteria, eight articles remained, which allowed us to frame the subject treated in the topics of interest for our content analysis. Thus, three central themes, related to each other, were defined in order to verify: (1) the factors that can influence a student to learn programming (2) the competencies / knowledge / skills that are necessary for learning programming and (3) the main difficulties faced by students during programming learning. Based on data analysis, we were able to verify among the factors that can influence students to learn how to program the methodology adopted by the teacher [2, 3] , the understanding of basic concepts [2, 3,4 4], motivation [2, 3, 5, 6], vocation [2], self-confidence [6] and the method of study of the student [2]. About the skills that the programming student must have to learn how to program we have: problem solving skills [2, 3, 6, 7, 8], logical thinking [3], reading ability and interpretation of the code [2, 3, 6]. Finally, about the main difficulties faced by students to learn how to program, we can mention not understanding the basic concepts [7, 9], the numerous and heterogeneous classes [2, 6], the lack of knowledge in mathematics [2, 9], lack of time to study [7]. Also based on the research conducted, it was found that difficulties in programming learning can lead students to drop out of the course [2, 3, 6, 7], fail in the discipline [3, 6], frustration [3, 6] and demotivation [2, 6]. However, the analyzed studies point out methodologies and tools that can assist students in programming learning. Through the results presented, this article contributed with an overview able to guide other researches, encouraging how to apply these approaches in a real classroom environment. (Abstract)

Keywords—programming learning; competences; learning dificulties; methodologies; tools (key words)

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Promoting Faculty pedagogical development: the strategy for a public engineering Higher Education institution

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Abstract **—** The challenges in higher education have been reconfiguring a new educational paradigm around the Bologna Process. In this scope, the need to promote strategies that support faculty in educational change and renewal processes became evident to make them more capable and competent in assuming their new and expanded roles.

The literature highlights the incipient existence of explicit and regulated policies for developing the academic staff's career. The existing initiatives are disparate at the institutional level, centered on the institutional Development Plans and mainly promoting the digital/technological competencies and not so much the pedagogical competencies.

Aware of such challenges, this public Higher Education engineering institution considered as an investment to prioritize the professional development of its academic staff and faculty members in the pedagogical area through the following objectives:

i) Assess the pedagogical component of the academic career in the annual faculty evaluation;

ii) Enhance the pedagogical component of the academic career with the yearly attribution of Pedagogical Excellence Awards and with videos about 'Excellent Professors;

iii) Promote the 'De Par em Par' program (based on peer collaboration and in the opportunities for diagnosing pedagogical performance discussion with peers);

iv) Promote individual pedagogical assistance to academic staff who intend to apply for funding of pedagogical projects;

v) Promote a course for initial training in Higher Education pedagogy, targeted to doctoral students and researchers that support teaching activities or wish to pursue an academic career (voluntarily, taking place every six months);

vi) Promote formal training opportunities in the pedagogical area (lifelong learning, voluntary and free training for participants, taking place every month).

However, the literature encompasses plenty of evidence that for young faculty, as relevant as the set of instruments available for their pedagogical development, is the possibility of being coached by more experienced academic staff along the first years of their career. As a proof-of-concept, the Department of Industrial Engineering and Management runs a pilot mentoring program for junior faculty. The program runs for five years (until tenure) and involves the assignment of a mentor and a financial envelope to support the young professors' academic activity.

Altogether, these initiatives have been this HEIs strategy to position itself on the national scene as a reference institution in the area of pedagogical quality, with excellent professors.

This communication aims to present this public Higher Education engineering institution strategic program for its academic staff's pedagogical development, the results obtained and the associated challenges and constraints.

Keywords — Higher Education; Faculty; Continuous professional development; pedagogical training

Product Design

An interdisciplinary experience in higher education

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***Abstract*— In the last two decades, higher education has undergone successive reforms in the area of teacher integration and the use of innovative approaches in the learning of Engineering and Design[1]. The present article describes an experience of education by interdisciplinary project, based on the project methodology of design. This is a methodology widespread in design theory textbooks, based on universal methodologies by the authors Bruno Munari and Gui Bonsiepe[2]. In an attempt to apply this methodology in the teaching of Engineering and Science, one lecture from the course of the Industrial Management - Product Design - was associated with a similar lecture taught in the Marketing graduation course, involving about fifty students. Eight teams were selected at the beginning of the semester, composed of students from both degrees - Industrial Management and Marketing - who worked together from the creativity phase to the physical production phase of the prototype, tests and trials. Two of the aims of this interdisciplinary project were to increase the motivation of the students by making each class responsible for their specific areas of knowledge and to stimulate the development of technical design skills and transversal skills. Such objectives, besides having been achieved, were also the factors that led to the success of this methodology. It was concluded that the experience was enriching for students, teachers and the academic community. The involvement of the students was evident throughout the semester, and an increased effort was observed in obtaining the final product and associated contents in the programmed period. The exchange of knowledge between the students of both degrees promoted the recognition of the added value of this interdisciplinary learning.**

Keywords*— *Design, Teaching, Interdisciplinarity, Methodology

ACKNOWLEDGMENT

This work is funded by National Funds through the FCT - Foundation for Science and Technology, I.P., within the scope of the project Refª UIDB/05583/2020. Furthermore, we would like to thank the Research Centre in Digital Services (CISeD) and the Polytechnic of Viseu for their support.

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Teachers' perceptions about active learning:

results from a four-year training program

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***Abstract*— All over the world engineering teachers have been changing their practices by implementing active learning strategies. Some studies highlight the importance of these strategies for the effectiveness of students learning [1-3] and others point out the difficulties for teachers' practice [4]. Considering these potential difficulties, the Federal University of Itajubá (UNIFEI), Brazil, decided to implement a four-year program (2016-2019) for teachers' professional development in the Campus of Engineering at Itabira. This program aims at supporting engineering teachers in developing pedagogical competences to enable changing teaching and learning processes. The program, called pipBIRA (Pedagogical Innovation Program at Itabira), has three phases: diagnosis (identifying teachers' experiences and expectations); development (implementing a total of six twenty-hours workshops about active learning in engineering education); dissemination (presenting the results). The objective of this work is to study the teachers' perceptions about active learning in two perspectives: What teachers think about active learning? What was the added value of the workshops for teachers' practice?**

For the first question, the data was collected through questionnaires, aimed at the identification of teachers' experiences and expectations about active learning. A total of 28 teachers answered the questionnaire. The main findings of the diagnosis phase point out that teachers understanding about Active Learning is not consensual. Most of the teachers (60.7%) already had the opportunity to implement active learning strategies but they also recognized that the expositive method is predominant. Some difficulties regarding the implementation of active learning strategies were identified by the participants, namely related to the active role students must have in the classroom and teachers' hesitation concerning to the amount of content they need to cover in the course. The participants also highlighted the need to provide feedback to students, cooperate with other teachers and be able to organize the teaching and learning process in a different way.

For the second question, at the end of each workshop (development phase) the participants were invited to fill a questionnaire in order to identify the relevance of the topics and the activities for innovating their teaching practice. Furthermore, it was also expected to highlight the positive aspects of the workshop and to include suggestions for the next one. In average it was possible to collect approximately 22 answers per workshop.

The overall perspective of the teachers about the workshops were extremely positive, particularly in terms of the relevance of the topics for Active Learning in Engineering Education, mainly the activities carried out in teams, the moments of feedback, sharing experiences and reflecting about their teaching practice. The most challenging aspect referred was the difficulty to maintain the engagement during the workshop, because they need to manage other activities they had during the week (e.g. teaching, meetings, etc.).

The findings suggest the importance of training in Active Learning, for engineering teachers being able to create learning environments where students are more engaged and motivated. As future work, a long-term study of the impact of the program will be developed, in order to understand its contribution for effective changes in engineering education.

Keywords—Engineering Education; Active Learning; Teacher Professional Development; Training Program

Acknowledgments

The authors would like to thank to UNIFEI for the support it gave and to all staff that collaborated with the program pipBIRA.

This work has been partially supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

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Face-to-Face and On-line Physics Teaching on Engineering Courses

Strategy Effectiveness Measurements

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***Abstract*— Due to the recent global events, in this case, the Covid-19 pandemic, a new challenge arises at all levels. Higher education was one of the most affected areas. This communication presents the use of interactive simulation software in on-line Physics education. This resource is directed towards Engineering courses which are offered in an institution of higher education in Mozambique. In the field of Physics, it was necessary to move from face-to- face teaching to on-line teaching. This discipline is divided into two semesters as Physics I and Physics II, with their components, in theory, problems and laboratory. To implement the laboratory classes, a search on the web was done and a virtual lab model was selected, which made use of interactive simulation experiments. In the first semester, the laboratory experiments were selected based on the criteria that they exist in laboratory work in a face-to-face system. In the second semester it was possible to develop totally new laboratory experiments. The conventional LabFis was reinvented as a virtual LabFis. Using a platform of open access, the lab guides were prepared for the different experiments. The student is guided to use the simulations to get an effective learning. To measure the effectiveness of this strategy on the on-line system, an analysis was done of the assessment results of three groups of fifty students of different Engineering courses. A comparison was established for results in Physics I and Physics II. The assessment results compared are of the year 2019, and the year 2020. The average of students' assessments is used as an indicator of effectiveness of the adopted strategy. In general, it was observed an improvement on this indicator. After an uncertain start, the students were motivated and welcomed these changes. They adapted satisfactorily to the new paradigm.**

Keywords—Physics education; online teaching; virtual laboratory; strategy effectiveness

ACKNOWLEDGMENT

This work was possible through the support from my institution. My deepest gratitude goes to those Physics teachers who supplied invaluable advice, manuscript suggestions, and classroom work which made possible this article.

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ATHENA: Reshaping European Higher Education through a New Competency Cluster Ontology

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***Abstract*— ATHENA is a European University, including the Polytechnic Institute of Porto, the Hellenic Mediterranean University, the University of Siegen, the University of Maribor, the Niccolò Cusano University, the University of Orléans and the Vilnius Gediminas Technical University, which aims at delivering highly qualified professionals for the labour market assuring a swift and effective transition from Education to labour and advancing the transfer of knowledge and research results to the society. Its mission is to deliver inclusive, innovative, high-quality international education permanently aligned with global market needs, addressing societal and environmental challenges as well as European research priorities, thus granting the highest employability standards, effective career transitions to our students and added value to our ecosystem.**

Within the scope of its mission, ATHENA seeks to reshape higher education by creating a competency cluster ontology which may serve the purpose of linking up the work developed within HEI with that developed at enterprises. A competency model seeks to describe performance excellence, and it usually includes a number of competencies which are applied to multiple occupations roles within a specific organisation. In this way, a competency model is a means by which HEI communicate which behaviours have been acquired by students, which are being required, valued, recognized and rewarded with respect to specific occupational roles by enterprises [1]. As Bates [2] refers, a "competence is the ability to do something successfully or efficiently", whereas "a *competency* is seen as a pathway that leads to that end state of competence." In fact, learning based on competencies assumes that "knowledge can be codified, repeated and tested" [2]. Therefore, it undertakes a more objective, behaviourist and social-constructive approach towards learning, by focusing on the fostering of skills [4].

Bearing all this in mind, the ATHENA consortium aims at building a competency cluster model made of skills and competences units (SCU), i.e., any structured academic activity that promotes learners' skills and competences and that is represented in the SCU space, a multidimensional coordinate system. This is a system which maps the set of properties that are deemed relevant in order to describe an academic activity from the points of view of its outcomes, processes, tools and pedagogies.

Following an ethnographic approach, combining both qualitative and quantitative methods, this study focuses on the work undertaken by the ATHENA Board of Education, which includes members from each member university, who have collaboratively contributed towards the creation of the competency cluster model. Therefore, we resorted to the following collection tools: dialogical negotiation of knowledge on the topic, through both chats and forums; questionnaires on the development of the model by local teams; application of the model onto the fields of Electrical and Electronics Engineering and Informatics [3].

Results portray that collaborative work foster the development of a kaleidoscopic overview on the creation of a competency cluster-based framework which may act as a trigger into a revolutionary change in European Higher Education teaching and learning [4].

Keywords—competency cluster, skills and competences unit, higher education, European universities

ACKNOWLEDGMENT

This work is co-funded by the Erasmus+ programme of the European Union through the Education, Audiovisual and Culture Executive Agency, under the scope of the project 101004096—ATHENA—EAC-A02-2019. The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

This work is funded by National Funds through the FCT - Fundação para a Ciência e a Tecnologia, I.P., under the scope of the project UIDB/05198/2020 (Centre for Research and Innovation in Education, inED).

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Virtual Laboratories in Polytechnique of Viseu- VLAB

Sciencies & Enginneering Teaching Innovation

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Abstract— ***Studies carried out to evaluate the effectiveness of the use of traditional and non-traditional (virtual) laboratories suggest that the student's performance and learning results are equal or superior in the latter in all learning areas [1]. Virtual labs allow students to understand the basic principles and theory behind laboratory experiments, and to put them in practice, at least virtually. A simulation is an effective tool in training students in the use of both classic and sophisticated equipment and complex instruments used in biological and chemical laboratories. Virtual laboratories circumvent the use of expensive and dangerous biological and chemical agents, eventually toxic to users and to the environment. Above all, the technology of the virtual laboratory may be economically viable. From the experience as teachers, it is known that students really like to have "hands-on". But this alternative can allow for complimentary, individualized, repeated experimentation without fear of failure. Students will be able to train safety practices and create work habits, having more time to "be" in the laboratory and train activities. There is also the advantage of "visualizing" theoretical concepts in a more creative way, building molecules, interacting with reactions, changing variables and making mistakes - learning from their actions. Thus, it is possible to enhance the development of students knowledge and skills, in a game-based learning method, accessible at any time and place. When using virtual laboratories, activities can be developed at home, in a period of confinement, but also in the classroom, in autonomous work or as an introduction to a new technique. Above all, virtual labs will make a difference when it is impossible to use physical means to promote the necessary learning to acquire laboratory skills. It is possible to carry out experiments at any time, on any equipment and anywhere. In a fun way from a gaming perspective, increasing its effectiveness [2]. Another potential could also be achieved: to go further in relation to the material resources existing in the IPV laboratories, to evolve in knowledge and to promote new experiences. It allows preparing students for the future even though it is not possible to move between laboratories and institutions, ensuring this experience remotely. The entire Polytechnic of Viseu community is involved, both through teachers and students from the various organic units and various courses in chemical and biological sciences, as well as through communication activities, with teachers and students from the Advertising and Public Relations course The global involvement of the institution will allow expanding the field of action, to assess the effectiveness of the applied methodologies and to replicate the knowledge acquired in this area to other areas. Included in the VLAB project, are the collection of testimonials and workshops, international conference and communication activities - press conferences and website, in order to divulge what we consider a best practice in (Engineering) Education.***
It is expected at the end of this one year project to do an evaluation of the effectiveness of the learning outcomes and the proposal for the institution to implement Virtual labs globally.

Keywords—Science; virtual learning; chemistry laboratories; biochemistry laboratories; innovation

ACKNOWLEDGMENT

This work was financially supported by the Polytechnic Institute of Viseu and the Portuguese Foundation for Science and Technology (FCT) through Polytechnic Institute of Viseu within the scope of the project Refª UIDB/05583/2020. Furthermore, we would like to thank the Research Centre in Digital Services (CISeD) and the Polytechnic of Viseu for their support. The authors acknowledge the participation of all the teachers and students evolved in this project and that are very important for the its success.

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Metrology and Engineering: What´s the Binomial?

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***Abstract*— It is widely accepted that engineering is a branch of science and technology making practical application of knowledge where measuring instruments and measurements provide a fundamental tool. Furthermore, the growing concerns with quality assurance in industrial processes and facilities based on traceable measurement results are known within the subject of metrology. The benefits of having recent graduates with competencies in metrology are also very important in engineering applications. Considering the relevance of the science of measurements in engineering, the paper presents an approach for further developments in engineering education, where new lines are pointed out. The discussion is structured around the study plan and its scientific syllabuses of the master's degrees offered in Portuguese universities. The commonality of subjects that emerged from metrology and engineering practices tied to employability skills required from graduates and postgraduates of engineering degrees is presented. It is also explained that to introduce the subject of metrology into undergraduate engineering degrees, the support given by the literature and by the professional experience from professors and metrologists are fundamental elements that may be considered.**

Keywords*— *Education, engineering, metrology, university

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Student representation promoting transversal competencies and a dynamic academia

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***Abstract*— The technological and socioeconomic revolution of the last decades has initiated the debate on engineering education, with a rising emphasis on the emerging challenges of our modern and globalized society. In this regard, transversal competencies have seen their relevance reinforced, constituting a major asset to the education of successful engineers. Alongside this, the interaction between students and academia is another crucial and increasingly valued aspect, both considering career planning, and their vital contribution to a dynamic and innovative environment of a school in constant mutation. It is, therefore, essential to establish solid representative bodies, engaging students in discussion and ensuring an effective student voice before Governing Bodies.**

At Instituto Superior Técnico (IST), the Student Representative Body comprises one student per degree per year. Each Student Representative is responsible for identifying and reporting any relevant issues among colleagues and conveying students' concerns, ideas and feedback to faculty and school administration.

Student Representatives are critical for the IST communication chain, which requires a qualified group of students provided with all the necessary tools and knowledge. After pinpointing a gap regarding Student Representatives training, the Pedagogical Council implemented the Student Representative Training Programme (SRTP). It consists of a series of training sessions covering a wide range of topics that aim to improve both technical and soft skills, throughout each academic year. Particularly, technical seminars are intended to provide Delegates with practical knowledge on their functions, along with main academic procedures, Técnico's organigram, scheduling of examination periods and academic regulations and calendars. Additionally, these students are coached in transversal competencies, namely feedback, ethics, conflict management or leadership matters. More than 100 Delegates have completed the SRTP in the first two years, a number which should be significantly exceeded in the current edition.

Student Representatives duties are inherently associated with the development of certain competencies on coping with a Volatile, Uncertain, Complex and Ambiguous (VUCA) World. Their continuous engagement, promoted by the SRTP, reinforces those competencies, namely communication skills, problem-solving, management of unpredictable situations, decision making and decisiveness, fair attitude and empathy. According to a 2018 study by McKinsey Global Institute, the demand for entrepreneurship and initiative taking capacity will rise 32% by 2030, followed by leadership, managing others and advanced communication skills, proving the relevance of this sort of training [1]. Moreover, SRTP has enabled widespread access to a range of tools and skills that allow personal development and the establishment of a more consistent, effective and solid Student Representative Body. SRTP has been observed as a valuable network generator, improving dialogue between students with diverse experiences and backgrounds, while optimizing communication protocols between students and Governing Bodies. This network proved its impact during the COVID-19 pandemic, when decision-making occurred in real-time, ensuring successful implementation of pedagogic and assessment guidelines.

Student Representatives play a crucial role in enabling and assisting the School's continuous improvement process, enhancing teaching and learning practices. Furthermore, the extent of competencies acquired may be the key to differentiate future engineers, more prepared to embrace new challenges of an ever-changing world.

Keywords*— *Transversal competencies; Student representatives; Engineering skills.

Acknowledgment

The authors would like to thank the support of the Pedagogical Council of Instituto Superior Técnico, the encouragement of Professor Raquel Aires Barros and Professor António Rodrigues, and the contributions of present and former responsible colleagues for the Student Representative Training Programme: Pedro Garvão Pereira, Gonçalo Matos, Ricardo Lameirinhas and Beatriz Isidro.

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Gender Parity in Engineering Education

The Brazilian Case

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***Abstract*— In 2020, it was estimated in a report of the World Economic Forum (WEF) [1] that gender parity would be reached in 99.5 years from then. In 2021, due to the COVID-19 pandemic, a new report from the WEF states that the gender parity was set back by a generation with the number of years until parity reaching 135.6 [2]. In Engineering Education, achieving gender parity is a challenge recognized by the Research Agenda for Engineering Education [3], which calls for research that seeks to measure the impact that diversity and inclusiveness can bring to engineering processes and products.**

In our research project, called STEM Equality (*Igualdade STEM*, in Portuguese) [4], we use the STEM and Gender Advancement (SAGA) framework created by Unesco in 2017 [5] to assess the gender parity in Brazilian higher education; something that was not done previously. The data related to higher education in Brazil used in our research comes from the Higher Education Census, a database maintained by *Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira* (INEP) of the Ministry of Education. This Census is the most complete research instrument about Brazilian higher education institutions, students, and professors [6].

In a previous paper published on our first findings [7], we showed that, in 2018, only 30% of the enrolled students in STEM degrees in Brazil are female, a number that rises to 63% in non-STEM degrees.

Being the acceptable range of gender parity defined by the SAGA project between 45% and 55% [5], one finds in Engineering degrees that only 7 of the 46 Brazilian higher education degrees have gender parity. In the remaining 39 degrees, 4 of them have a predominance of female students and the other 35 degrees have a predominance of male students with 18 of them having 75% or more of male students enrolled. The situation is even direr in Mechanical Engineering (90% male students), Computer Engineering (89% male students), Software Engineering (88% male students), and Electronic Engineering (88% male students).

In this work, we intend to present a follow-up to these results by analyzing the most current data available from the 2019 Higher Education Census. We will also compare this data with the previous year and give a special focus to the Engineering degrees while also analyzing the other STEM courses as defined by the SAGA framework. It will be very interesting to compare these figures with the Portuguese numbers of enrollees in STEM degrees in the last couple of years.

Keywords*— *gender parity; STEM; higher education; SAGA Unesco; data analysis

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The Heroine's Learning Journey applied to a MOOC: Machine Learning, Maths & Ethics

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***Abstract*— The *Heroine's Learning Journey* is a motivational approach, using an appropriate discourse, for decreasing the underrepresentation of women and girls in STEM courses. The ultimate goal is to apply the Journey as an educational plugin to STEM Massive Open Online Courses (MOOCs). On the other hand, the MOOC of *Machine Learning, Maths & Ethics* aims to be designed and produced as the first of a series of online courses that can give young women a flavor of careers in computer science together with relevant content from different topics of machine learning. We envisage to use specific guidelines [1] for designing gender balance content, which includes texts, images and interviews, focused on practical and hands-on projects. Then, during the running of each MOOC, various resources will be available through an educational plugin, the online version of the *Heroine's Learning Journey*, as motivational videos, narratives and gamification, which will support the learning journey of girls enrolled in the MOOC. The project is therefore connected to the *Fostering Women to STEM MOOCs* (FOSTWOM), and it is also part of the "Igualdade em STEM" (STEM Equality), a partnership between the Federal University of Rio de Janeiro and the Instituto Superior Técnico. Recent indicators that show how many women careers in STEM are compromised can be found in studies from organizations like UNESCO [2] and the European Commission [3]. Some factors that can contribute to the resolution this problem (and are related to our proposal [1]) are the following: a lack of visibility for projects developed by female STEM students; insufficient inclusive language; lack of specific groups/rooms where they are welcomed; general prejudice in technology groups and finally, very few internship opportunities granted. Our proposal for the *Heroine's Learning Journey*, in narrative form for the educational area with focus on female learners in STEM courses, is a narrative freely adapted from the Hero's Journey developed by Joseph Campbell [4], and the Heroine's Journey proposed by Maureen Murdock [5]. In the present talk we aim to present the general outline of the narrative of the *Heroine's Learning Journey* and of the *Machine Learning, Maths & Ethics* MOOC. Both of them designed as means to attract girls and young women to science and technology careers in general, and for supporting female students throughout the online programming activities, in particular.**

Keywords—STEM education; Machine Learning; gender balance narratives; MOOCs

ACKNOWLEDGMENT

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

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Combined analytical and computer simulation problem solving in engineering education

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***Abstract* —** Very often students struggle with bridging knowledge and competences between different courses within a given degree. This leads to a perception by the students that courses are self-contained, and they might only appreciate how to integrate the competences from different courses in their professional life after finishing their studies. To mitigate this difficulty, students can be given the opportunity to solve a problem from multiple perspectives, supported by the respective techniques, through joint projects that bridge courses. This paper reports such as approach, applied to teaching product designers basic engineering skills of strength of materials, namely the mechanical performance of parts under load.

Learning styles vary among students and have continuously been receiving more attention by researchers and faculty. The better we understand the characteristics of a student group, the easier to maintain good social relationships and a climate that fosters development of the necessary skillset. Students are also evermore exposed to information quickly and readily accessible, and learning has to be aligned with the current information age. As such, teachers must take into account the different learning styles of students and find opportunities to enable them [1-2]. A common feature among all learning styles is student engagement and promoting use-case / case-studies to give students perspective on the application of knowledge [3]. Considerable attention has been given to peer interaction between students, mainly in distance learning [4-5], and between students and faculty [6], but much less to interactions between different courses.

In the present work, we have tried to meet these challenges in the context of teaching strength of materials (a topic that interests both designers and engineers) at the undergraduate level to a class of second-year industrial designers (which often have to deal with both aesthetic requirements and structural mechanics). Traditionally, the students group takes a course on strength of materials that gives them the analytical tools to calculate stress and strain on a given geometry under load (without computational tools), and a separate course on advanced product modelling that gives them computational tools to model any geometry in 3D. However, students often exhibited limited understanding on the practical uses of the analytical methods and at the same time struggling to understand the relationship between numerical results and physical effects on the materials when presented with prediction features of the computational tools. In great part this is because when solving strength of materials calculations by hand, without a visual support representing the physical part deforming and eventually breaking, it is indeed difficult to have a feel for what the numbers imply. And, concomitantly, when visualizing predictions from computational software without understanding the physics behind the calculations, students are unable to appreciate what the software is doing in the background or think critically about the results (often resulting in a black-box use of the software).

By introducing a common project among these 2 courses and forcing students to combine analytical and computer simulation tools to solve a given realistic case-study challenge, we simultaneously boost problem solving abilities and we lead students to build a more robust skillset from each of the 2 courses. The project is set so that students have to calculate two aspects: whether a given geometry will yield under a given load case and, if it does not, how much the structure deforms. In each case, they have to calculate the result both by analytical calculation by hand, and then by simulating with 3D modelling computer software. Students are expected to compare the results from both approaches, and to discuss them critically. Subsequently, the faculty of each course analyze the given scenarios and explain to students what they were expected to identify and observe. Different load cases (and geometric variations) are provided so students will encounter scenarios where parts will fail, where deformation is so small that it does register visually at a meaningful scale, and where deformation is noticeable to the naked eye.

Through this experiment integrating 2 different courses we have found that students, on the one hand, gain a deeper appreciation of the tools, and on the other hand, understand better the practical application of the analytical equations to real world problems. This will simultaneously improve their ability to critically assess simulation results, as they know which equations are being used, and thus, their scope and their limits. The same principle can be employed in a plethora of scenarios between different courses in higher education degrees, and we are certain this kind of interaction between courses is a key drive in boosting educational performance.

Keywords — computer simulation; product design; mechanical performance; strength of materials; education innovation.

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Adding a dimension to pedagogy through 3D printing

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***Abstract*— In this article, it is intended to describe the process of design and materialization of three-dimensional models using Computer Aided Design (CAD) and 3D printing to support the teaching of "Resistance of Materials" of the Integrated Master in Civil Engineering (MIEC) of the Faculty of Engineering of the University of Porto (FEUP).**

Learning is always easier with the right tools and 3D printing adds a new dimension to the pedagogical experience, allowing problems to "jump" from the blackboard to the student's hand, materializing elements or experiences that are difficult to visualize on paper or too complex/expensive to perform at full scale. The use of visible and palpable models allows teachers and students to contextualize concepts through the immediate application of skills and learning using simulations and demonstrations, relating theory with real situations of their day-to-day making experience as the basis of learning.

After mastering the process of designing and printing the models by the teacher, he intends to extend the use of the means acquired to students, so that this revolutionary technology can motivate and promote innovation, giving them tools to develop concepts and products based on their ideas. Certain of the success of this project, the results obtained with the use of this "tool" in the academy will be disseminated, motivating students and teachers from other curricular units to use it as a pedagogical strategy.

The project "Adding a dimension to pedagogy through 3D printing" was one of the winners in the annual competition (2020/2021) of "Pedagogical Innovation Projects" at the University of Porto, through the Pedagogical Innovation and Educational Technologies Unit of the Rectory.

Keywords — pedagogy; 3D printing; Computer Aided Design (CAD); Resistance of Materials, Civil Engineering.

ACKNOWLEDGMENT

The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g." Avoid the stilted expression "one of us (R. B. G.) thanks ...". Instead, try "R. B. G. thanks...". Put sponsor acknowledgments in the unnumbered footnote on the first page.

The author wishes to thank the Pedagogical Innovation and Educational Technologies Unit of the Rectory of University of Porto for the support and recognition given to this project.

This work was financially supported by: UID/ECI/04708/2019- CONSTRUCT - Instituto de I&D em Estruturas e Construções funded by national funds through the FCT/MCTES (PIDDAC).

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GENEE, Group for Students with Special Needs, working for inclusiveness in Técnico Lisboa

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***Abstract* — The University of Lisbon currently has 372 Students with Special Educational Needs (SSEN), in a universe of 50000 enrolled students. Of these 372, about 100 students are enrolled in STEM degrees. Among the most prevalent conditions, one can find specific learning difficulties, mental health and autism spectrum conditions. The goals of the Group of Students with Special Needs at Técnico Lisboa (GENEE) founded an year ago are: to raise awareness of the entire academic community to the emerging reality of SSEN; to foster practical measures to their inclusion not only during their academic life; and to ensure smoother transitions to their future engineering careers. GENEE's goals are inspired by the United Nations Sustainable Developments Goals [1], in particular by the 4th objective - Quality Education, and the Salamanca Declaration Principles, Policy and Practices in the area of special educational needs [2], namely the idea of an inclusive community capable of contributing to the development of socially responsible academic campuses [3]. While it can be read in the first document that we must "guarantee access to inclusive, quality, equitable education and promote opportunities for lifelong learning for all"; in the second we find the definition of the objective of creating "schools for all - institutions that include all people, accept differences, support learning and respond to individual needs".**

The first idea of creating GENEE emerged in 2017/18, and the interdisciplinary group became official in March 2020. To support its main goals GENEE is presently developing several actions that should contribute to an inclusive Técnico Lisboa, from everyone to everyone, taking into account all the involved stakeholders: SSEN, all enrolled students, academic staff, employees of several academic services. The actions to be promoted through projects aim at developing effective support for actual and future SSEN, together with the promotion of a larger number of academic research and studies on inclusiveness and diversity. More specifically, GENEE's actions are organized around several areas of expertise in order to serve its main objectives: 1) Legislation and SEN Regulation, highlighting the IST Regulation for SSEN [4] and the development of Support Manuals for Students and Teachers. 2) Physical and Digital Accessibility to support the IST community, which highlights the construction of GENEE's website to aggregate useful information about resources and services available to support SSEN. Among these services there is the Project IST Inclusive Library, which aims at surveying and implementing the accessibility needs of SSEN users and promoting the training of library staff. 3) Pedagogical Practices and Training, implemented through the *Ensinar a Ensinar* project, carried out in collaboration with the SSEN Network of the University of Lisbon, and which aims to produce several informative, didactic and training videos. These videos will allow to disseminate the good practices to be followed by all stakeholders regarding SEN. 4) Employability – the area with the responsibility of thinking about solutions to smooth the transition to the job market, empowering SSEN and professionals, and bridging services with a key-role at this stage, namely Student Support Services (Campus Alameda and Campus Taguspark), Academic Unit and Technology Transfer Office (with Career Development programmes and corporate partnerships). Evaluation of students' experience and needs, as well as inputs from team members, guides the work into specialized responses, such as promoting access to inclusive job opportunities and to personalized orientation for finalist SSEN. Finally, 5) Events – area in charge of organizing activities for bringing awareness, debating questions, investigating solutions and creating new ideas within the special educational needs' context.

In order to be able to evaluate the effective achievements and results from GENEE's actions so far, until the end of 2021, there will be applied a questionnaire to several stakeholders: SSEN, all enrolled students, academic staff, employees of several academic services, and it will be created a focus group. It will follow a publication of the findings based on the answers to the questionnaires and the feedbacks during the talks of the focus group.

Keywords — Students with Special Needs; inclusive higher education; physical and digital accessibility; didactic videos; special needs employability

ACKNOWLEDGMENT

WE ARE GRATEFUL FOR THE SUPPORT OF THE TÉCNICO LISBOA MANAGEMENT BOARD, IN PARTICULAR THE MANAGEMENT COMMITTEE OF TAGUSPARK CAMPUS FOR THE FORMALIZATION OF GENEE, AND TO DR ANA FONSECA FOR THE CONSTANT SUPPORT OF THE NEE NETWORK OF THE UNIVERSITY OF LISBON TO THE GENEE REFERENCES INITIATIVES.

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ScientISST Notebooks: Design Considerations and Lessons Learned

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Abstract

In this work we explore the potential of using open access software tools towards a more interactive learning process [1, 2]. ScientISST Notebooks are designed to enrich the learning experience of students, namely in practical and laboratory activities in biomedical engineering. These materials are built in the Jupyter Notebooks format, a free cloud-based environment that enables the creation of documents incorporating live code, equations, graphics and narrative text. It enables students to work in-person or virtually, and has proved to be an effective option during the COVID-19 outbreak.

The project is hosted on GitHub, as it is currently the platform most widely used by the community at large to share software. ScientISST Notebooks can be accessed locally, or directly used online. In particular, the Binder cloud service [3] integrates directly with GitHub, enabling the creation of an online Jupyter environment based on Docker containers, without needing to install any local software. Other options include Google Colaboratory [4] and Azure Notebooks [5].

The repository structure includes six main categories (each corresponding to one folder): A. Signal Acquisition; B. Graphical User Interface; C. Signal Processing; D. Feature Extraction; E. Classification; F. Applications. These were chosen to cover the most common topics in engineering courses. Each new content is included in the appropriate folder and assigned a unique identifier code. Currently the repository has 50 ScientISST Notebooks, automatically summarized in a Master Table.

Moreover, the repository contains complementary folders with example files, resources, templates and utilities. In fact, a set of tools has been built around the project needs, aiming at making the Notebooks creation easier, standardized, and scalable. The template is as a key tool that we made available to support the creation of new contents by suggesting structure, common exemples, and styling guidelines (Figure 1).

Further utility tools support stakeholders in the creation of new pedagogical contents. These are coded in Python scripts and can be used to easily interact and update the JSON objects that constitute a Jupiter Notebook, or to make automatic editing to individual notebooks or the whole repository (e.g. in styling, paths, etc). For instance, these have been used to update the whole repository every time the template suffers an adjustment. Moreover, the utility tools include mechanisms that help speed up the creation of contents, e.g. by processing raw scripts and providing formatted ScientISST Notebook proposals.

Preliminary user experience results underline positive aspects in the "ease of use", possibility to experiment "everywhere" and "interactivity" of the notebooks to run and experiment Python code. The usability reported by the students through the System Usability Scale (SUS) questionnaire had an overall score of 78.68%.

Keywords— m-Learning; Internet of Things; digital notebooks; project-based learning; biomedical engineering.

ACKNOWLEDGMENT

The authors would like to express their appreciation to the students, for their feedback and constructive suggestions. This work has been partially funded by Instituto Superior Técnico (IST) under projects "ScientIST" and "ScientIST-NOTES", and by FCT/MCTES through national funds and when applicable co-funded EU funds under the project UIDB/50008/2020.

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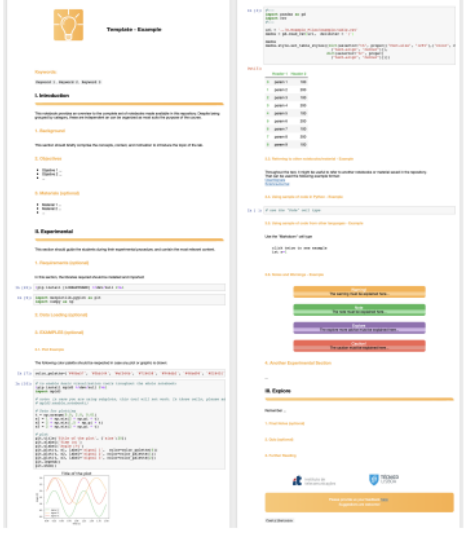

Figure 1 - Template designed for ScientISST Notebooks.

Introduction to Mechanical Engineering

Promoting interdisciplinary context, methodologies and experiences for first year engineering students in hybrid learning and teaching

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***Abstract* — This contribution aims to describe the subject "Introduction to Mechanical Engineering", a curricular unit of the first year of the Integrated Master Program on Mechanical Engineering of the University of Aveiro (UA). Due to the matricial system of UA, the first semester for mechanical engineering freshmen is composed of different curricular units on a number of scientific areas rather than mechanical engineering, carried out by professors also apart from the Department of Mechanical Engineering (DME), namely: mathematics, physics, chemistry, and informatics. Therefore, students coming to UA for a Mechanical Engineering degree only have their first contact with their Department, professors and researchers in their second semester, by means of two specific subjects: "Technical Drawing", and "Introduction to Mechanical Engineering". Related to the latter, and starting on February 2020, modifications were implemented in order to provide students with an inclusive, comprehensive and coherent interaction with a number of different contents and areas within the mechanical engineering world, such as: solid mechanics, structural mechanics, material sciences, fluid mechanics, automation, robotics, nanotechnology, sustainability and circular economy, and introduction to mechanical design. This strategy aims to provide an integrative approach to both classical and unconventional areas of intervention within the current reality of mechanical engineers, while providing students with a wide vision of what can be their academic and professional paths in the near and long term future.**

As of March 2020, and with the onset of Covid-19 pandemics, the predefined teaching and learning strategies needed to be completely changed, with extra layers of complexity on the communication, team work, and collaborative aspects within the curricular unit. This work provides a report on the experiences, challenges and opportunities to both students and professors during the curricular years of 2020 and 2021, where hybrid (presencial and online) teaching and learning methodologies coexisted, as well as perspectives for the future of such an ambitious operational and pedagogical model that, although relatively common in anglo-saxon countries [1,2], is still not explored in portuguese Higher Education Institutions.

Keywords* — *engineering education; hybrid teaching and learning; first year students; integrative and inclusive teaching/learning

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Digital resources in remote learning: The students perspective

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***Abstract*— The COVID-19 pandemic is having a major impact in higher education worldwide. One effect is the need to adapt teaching methodologies to the new reality of remote and digital learning. It is well known that education is constantly undergoing changes, due to the development of society and globalization [1]. Since the late 20th century, due to the internet growth, an increasing number of universities have begun to offer remote learning, which allows the students to manage their own time, and schedule, so they can study during their free time [2-6]. This is a major benefit for working-students. Even though several universities in Portugal have invested in express learning courses to help their teachers shift from face-to-face to a distance learning, the drastic change in the education system, was a huge challenge for the teachers that have been forced to completely change the concept of teaching in a few days. This concern is also evident in the study by Crawford *et al.* that assesses the Covid-19 pedagogy responses of 20 countries' higher education, in terms of types of responses undertaken and assess the agility of higher education in preparing for the pandemic [7]. In this context, three teachers who have adapted their teaching methods and resources, as most of the teachers, invested a great part of their time learning, adapting, and testing new remote learning systems through different tools and testing new forms to evaluate the students. At this stage, the authors felt that it was the time to evaluate how the students felt during their first semester in this new reality. To assess the effect of the drastic shift from face-to-face to full remote education, a study was carried out in three curricular units (CU), namely Applied Chemistry, Transfer Phenomena II and Process Optimization. These CU are part of the curriculum of three different levels of education (professional higher technical, graduate and master) in a Polytechnic Institute of Portugal. The same digital methodologies were used in the three CU. An anonymous questionnaire (16 questions) was prepared to evaluate the students' perception of the digital resources' efficiency used in their learning. The students' profile was obtained in the first three questions: degree, age, and previous digital habits. Three questions assessed students' perception of the CUs implementation during the semester. The next questions assessed the digital tools used for synchronous learning (2 questions) and asynchronous learning (4 questions). The methodologies used for the assessment and grading of student learning were approached in one question. The final 4 questions were about the students' global assessment of the CU. It was found that 66% of the students already used social media for studying. Of all the digital tools (used for the first time), the ones with detailed (step-by-step) exercises solutions were considered, the most relevant (written-77%, videos-83%), and the ones that should be reinforced (written-77%, videos-86%). Most students considered using explanatory PowerPoint as appropriate, tools such as Whiteboard and videos as extra-appropriate. When asked to compare their learning throughout this semester, with previous semesters, less than 4% of the students gave a negative evaluation. As for the global results of the student's grades, they were no higher than in previous years, which corresponds to the overall result of the survey, but they were no worse, which could be expected given the atypical situation experienced. It is our expectation that this experience will allow to use digital tools even being in a pandemic context and take advantage of it.**

Keywords— higher education, digital resources, remote learning

ACKNOWLEDGMENT

The authors would like to acknowledge all the students who answered the questionnaire, also the additional training given by the Polytechnic Institute of Setúbal.

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Sharing Remote Teaching and Research Experiences - SaRTRE

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***Abstract*— In response to the contingency measures applied in Portugal to contain COVID-19, the Pedagogical Council (PC) of Instituto Superior Técnico (Técnico) created a platform with guidelines for remote Teaching, Supervision and Research. The platform included a website, a forum, and a training program.**

The methodology to develop the platform included the identification of the Técnico community needs, gather of the online best teaching and learning practices among the Técnico community, define the structure of the website, creation of the forum and define the training program.

For the identification of the Técnico community needs the PC had regular meetings with the courses coordinators where they presented their major challenges in the global uncertainty. The gather of the best teaching and learning practices involved the creation of a temporary commission was created with a group of teachers with experience in online platforms and two students' members of the PC. This commission created a series of contents regarding the online tools already used in Técnico, identifying the main characteristics of each platform, and created tutorials (manuals and videos). With the information gathered by the commission, a website was created to address the challenges of the faculty, researchers and students for remote Teaching, Supervision and Research, including best practices for remote classes, namely theoretical, problems and laboratory classes, the recording of classes and doubts schedule; a specific section for students was created to provide recommendations of students before and during an assessment; a dedicated section with recommendations to be adopted in remote learning for students with special educational needs.

Parallel to the website a private forum was developed to allow Técnico faculty and research staff share their teaching, supervision, and research experiences. The Técnico courses are very diverse in terms of subject and dimension, and the forum allowed the community to informally share their experiences and what works and what doesn't for their classes.

The general faculty community (around 800 people) had no or little experience with online teaching tools, and one of the objectives of the platform was to develop specific training in all the online tools. These training sessions were very appreciated by the community and in average 200 people participated in each of the sessions.

Now the platform is a reference for the Técnico community in online teaching and learning practice and tools. And the training program has been extended to other needs of the community as "How to teach laboratory classes in a pandemic".

Keywords—remote teaching; methodologies; glossary; website; forum

ACKNOWLEDGMENT

The authors would like to acknowledge to the Remote Education Working Committee: Alexandra Moutinho, Ana Moura Santos, António Rito Silva, Beatriz Isidro, Bernardo Matos, Carlos Santos Silva, Carlos Baleizão, Daniel Gonçalves, David Matos, Henrique Matos, João Nuno Silva and Moisés Pinto.

And the staff that collaborated with the contents of the website: Alexandra Pontes, Alexandre Francisco, Amaro Rica da Silva, Ana Mourão, António Rodrigues, Daniel Cacho Gonçalves, Francisco Aveiro, Helena Borges, Isabel Gonçalves, João Marques, Jorge Matias, Fernando Mira da Silva, Leonor Moura, Luís Santos Castro, Luís Cruz, Luís Oliveira e Silva and Rodrigo Cunha.

Gender Balance at Técnico

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Abstract— **The United Nations (UN) defined in 2015 seventeen sustainable development goals (SDGs) to transform the world to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere by 2030 [1]. These SDGs were adopted by all UN Member States, i.e. 193 countries. The achievement of a peaceful, prosperous and sustainable world cannot be obtained without gender equality, which is a fundamental human right [2]. Reducing gender inequality promotes economic growth, progress and innovation because workforce development cannot be attainable without the full involvement and engagement of women [3]. The European Community (EU) demand for science, technology, engineering and maths (STEM) skills is increasing, and the STEM female graduates are not growing accordingly [4]. So, the involvement of women in STEM is crucial to job-rich recovery and growth in the EU. Instituto Superior Técnico (Técnico) is the largest school of Architecture, Engineering, Science and Technology in Portugal, enrolling over 11.000 students. Técnico has 26% female professors but only 17% became full professors and continue to have great difficulties in getting the most prestigious positions. To overcome this imbalance a more female-friendly engineering school is needed. The number of female students has been increasing, but there is still a long way to go since in this last 5 years there have been only 28% of female students enrolled per year, even though they represent almost 1/3 of Técnico graduates each year, in the last five years. To overcome these inequalities the group Gender Balance@Técnico was created in 2016 with the main goal of promoting female recruitment in Técnico among students, staff, researchers, and professors and the wellbeing of female workers at Técnico. The work program is divided into five major areas: internal and external information and communication, work-life balance, parenting protection and family assistance, equal access to employment in terms of recruitment and selection, performance evaluation and career progression. Several activities were developed under these areas. Some examples of the activities carried out by the group are post-parenting leave for the faculty, the Prize Maria de Lourdes Pintasilgo to promote two alumnae yearly, the organization of the *"Engenheiras por um dia"* (Engineers for a day) and several internal communication activities to give awareness in the Técnico community. A webpage was created to include all the activities promoted in Técnico under the gender balance thematic with information on the group's action plan, events, news among others: genderbalance.tecnico.ulisboa.pt**

Keywords— *gender balance; activities; action plan*

ACKNOWLEDGMENT

The authors wish to acknowledge the support of all members of the group Gender Balance@Técnico: Isabel Trancoso, Inês Lynce, Joana Lobo Antunes, Marija Vranic, Fernando Mira da Silva, Carolina Ferreira, Carla Patrocínio, Marta Fajardo, André Pires, Rui Mendes and the two students Carolina Santos and Miguel Almeida.

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PART II – ABSTRACTS OF PAPERS

[3] RETHINKING CURRICULUM DEVELOPMENT THROUGH DESIGN THINKING

Rogério Duarte (Escola Superior de Tecnologia de Setúbal - Instituto Politécnico de Setúbal), Ângela Lacerda Nobre (Escola Superior de Ciências Empresariais, Instituto Politécnico de Setúbal), Fernando Pimentel (Escola Superior de Tecnologia de Setúbal - Instituto Politécnico de Setúbal) and Marc Jacquinet (Universidade Aberta)

Abstract. Higher education institutions must be aware of the transformations that occur in societies in order to innovate and to offer revised educational curricula. Design Thinking is a tool that helps to foster innovation in business contexts. Could this methodology be used in higher education for curriculum development? The present article considers this question by presenting the Design Thinking methodology, establishing links with outcome based education, constructive alignment principles, and discussing the context specific to higher education institutions.

Keywords: design thinking, curriculum development, outcome based education, constructive alignment, innovation, higher education

[6] ANT AND ENGINEERING EDUCATION

Jose Figueiredo (CEG-IST, Instituto Superior Tecnico, Universidade de Lisboa)

Abstract. Formal engineering education is a situated process enacted by motivation and enrolment of actors, usually using different materials, framed in exploratory ways. Inscribing technologic design and development in the use of artefacts produced is a basic concern and pushes us to sociotechnical ambiences and sustainability. We think Actor-Network Theory provides a framework that contributes to our understanding of complexity inscribed in the relations and mutual influences that emerge between actors in learning spaces. Using narrative, and exploring ANT concepts we circulate in learning spaces, observing and deciding about the ways we can explore to enact knowledge creation and learning. Our results are exploratory but they contribute to provide a different look into educational fields. We believe it is an innovative look, adapted and consistent with an extension (extended work) to this specific area of knowledge – engineering education.

Keywords: Actor Network Theory, engineering design, learning processes

[8] SETTING UP EDUCATIONAL ESCAPE GAMES: LESSONS LEARNED IN A HIGHER EDUCATION SETTING

Ana Moura Santos (Instituto Superior Técnico, University of Lisbon/CEAFEL), Luís Costa (Programa de Engenharia de Sistemas e Computação Coppe/UFRJ, Brazil), Sofia Sá (Instituto Superior Técnico, University of Lisbon) and Luísa Coheur (Instituto Superior Técnico, University of Lisbon/INESC-ID)

Abstract. Educational Escape Games are active learning strategies, as students solve problems related with the curriculum content to "escape" from the physical place where they are "locked". This paper describes the implementation of two Escape Games aimed at Computer Science undergraduate students, at Instituto Superior Técnico, University of Lisbon. The procedure followed to create the games is presented and both activities are described and evaluated. Also, tips for teachers willing to build similar Educational Escape Games are suggested. Our goal was to understand: a) if students are motivated to this kind of learning experience; b) if students are aware of the possible learning gains when participating in these activities; c) if students do, effectively, feel that they have learned something; d) which are the achievements of this kind of activities (perceived by the teachers). Considering the feedback given by students, they do engage in this kind of activity, are aware of the learning gains and do feel it was a fruitful learning experience. In addition, and despite being timeconsuming, this activity was considered a success by the teaching staff/organizing team.

Keywords: Higher Education pedagogy, active learning, Educational Escape Games, transversal skills

Acknowledgment. This work was supported by the Pedagogical Council of Instituto Superior Técnico, through "Projeto 5647 - escapulSTe?" that sponsored the scholarship student responsible for the online registration platform. This work was also supported by national funds through Fundação para a Ciência e a Tecnologia (FCT), under grants with references UIDB/50021/2020 (INESC-ID multi-annual funding).

[17] AN EVOLUTION MODEL FOR REMOTE AND VIRTUAL LABS

Raul Cordeiro (ISEP e EST-IPS), Gustavo Alves (ISEP) and José Fonseca (FCT - UNL)

Abstract. A graphical model that describes and anticipates the evolution of remote and virtual laboratory systems and networks is proposed. The model was built considering the "remote past" and the "recent past", to make a projection about the future evolution, in each of the development lines that persist today. The verification of the proposed model considers some remote and virtual labs networks and systems that have existed and / or still exist today and translating their history through graphs that show the evolution of the system affected by different variables, states, flows, processes and results defined on the dynamic model and also a specific sub-model for the kernel of the main model.

Keywords: Remote and Virtual Laboratories, Energetic coupling, Structural coupling, System Model

Acknowledgment. The authors would like to acknowledge the partial support provided by Fundação para a Ciência e Tecnologia (FCT) through Grants UIDB/04730/2020 and UIDB/00066/2020.

[21] THE PREDICTIVE MODEL OF INDUSTRIAL EMPLOYABILITY (PMIE) – ENABLING EMPLOYEES TO EFFECTIVELY PERFORM FUTURE PRODUCTION WORK

Amelie Metzmacher (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University), Syrina Beierle (Chair of Management Accounting, RWTH Aachen University), Ina Heine (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University), Peter Letmathe (Chair of Management Accounting, RWTH Aachen University) and Robert Heinrich Schmitt (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University)

Abstract. This paper highlights the development and operationalization of the Predictive Model of Industrial Employability (PMIE). The overarching objective of this model is to enable both shopfloor employees and production engineers to find or maintain employment in a VUCA (Volatile, Uncertain, Complex, and Ambiguous) industrial working world. The PMIE consists of the construct "Industrial Employability", and incorporates dependent variables that are consolidated within the four dimensions "Occupational and Technological Expertise", "Adaptability", "Social Skills", and "Self-Management". The model also contains antecedents as independent variables that influence a person's employability. On the micro-level, these antecedents represent individual factors; on the meso-level, the antecedents are determined by the organization; and on the macro-level, they are determined by sociopolitical factors. In order to validate and quantify the qualitative model, the PMIE will be applied in the form of a questionnaire study to companies within the automotive and machine tools industries as well as to unemployed persons who have previously worked in these industries. The PMIE aims at helping both the European labor market in general and specific organizations to identify the antecedents that need to be addressed in order to improve employability.

Keywords: Employability, Industry 4.0, KSAOs, Competences, The future of production work

Acknowledgment. The research presented in this paper has been carried out within the research project "PreModIE – Predictive Model of Industrial Employability" (Project number 406934476). The authors gratefully acknowledge the support of the German National Science Foundation (Deutsche Forschungsgemeinschaft DFG).

[22] TEACHERS LEARN AND IMPROVE THE MATHEMATICS FOR FUTURE ENGINEERS: RECOGNITION OF GEOMETRIC FIGURES IN LINEAR ALGEBRA

Cristina M.R. Caridade (IPC-ISEC)

Abstract. Matrices and geometry are important content taught in mathematics to students in their first year of engineering. Students have some difficulties in this matter. Can geometry applied to real cases help students to learn Linear Algebra better? Does the application of geometry in digital images increase students' motivation in these contents? Thus, it was proposed to the students a project where geometry and digital images are combined providing an opportunity for students to improve their knowledge and skills in an intuitive and visual way. It is concluded that this type of learning enriches teaching practices, transmitting the syllabus in a more targeted and precise manner, improving motivation and stimulation of knowledge in mathematics.

Keywords: Teaching strategies, significant learning, improve mathematics, information technology, engineering

[31] LEARNING ENGINEERING CONTENTS FROM DIFFERENT COURSES THROUGH A HANDS-ON ACTIVITY TEAMWORK

Anabela Alves (ALGORITMI Research Centre, Dept. of Production Systems, University of Minho) and Filomena Soares (ALGORITMI Research Centre, Dept. of Industrial Electronics, University of Minho)

Abstract. Frequently students have difficulties in relating and integrating learning content from different topics in a problem solving challenge. In order to tackle this issue the authors carried out a conjoint initiative in giving a common project to the Integrated Master of Industrial Engineering and Management (IEM) students in the School of Engineering of University of Minho. Production Systems Organization I and Process Control and Automation are curricular units taught in the 3rd year of these engineering students. Although with different content they have a common point: both refer to design production systems and/or design industrial applications to be integrated in the production systems, reducing waste and production time. The goal was to challenge students to develop project work that included as a main result a hands-on activity developed in the class where they simulate a virtual or real-world automated production line. They designed production cells to yield manufactured goods through a previously defined operating mode, including automated production subsystem components such as transport and supply mechanisms. Students worked in teams with seven to ten members in each. The assessment process included a public presentation, with the real-time presentation of the production cell/line simulation, and work documentation, namely, video, PowerPoint presentation, simulations, poster and web page. After a first experience which revealed positive outcomes, the authors repeated the experience concluding that it is worth to continue investing in such integrated activities.

Keywords: Teaching/Learning experience, Students' perceptions, Production Systems and Automation, Hands-on

[32] TEACHING ETHICS TO ENGINEERING STUDENTS: CASE STUDIES.

Alfredo Soeiro (University of Porto) and Luis Adriano Oliveira (Universidadde de Coimbra)

Abstract. Two case studies are presented and discussed as a means of implementing the teaching of ethics in two different contexts of engineering activity: scientific research and daily practice. One case study is related to the discipline of "Research Methodologies" for students of MSc and PhD degrees in the Initiative "Energy for Sustainability" (EfS) at the University of Coimbra, Portugal. The second case study presented is related to the discipline of Construction Management of a master degree in Civil Engineering. The methodology applied during the teaching component comprises the description of Deontology and of Ethics. Professional engineering standards and practices are also presented and discussed. Problems with issues involving ethical decisions in construction management are described. Students are invited to discuss and to present their points of view. Groups are formed and discussions about conclusions of the group and global debates take place. Disagreements or agreements are presented by each one supported by a rationale. Students are then faced with a methodology to support decision making in situations with an ethical essence. The methodology does not present a unique solution but addresses the ethical problem under three perspectives. The perspectives for ethical analysis are called reversibility, disclosure and impact.

Keywords: Ethics d, Deontology, Reversibility, Disclosure, Ethical dilemma, Active learning

Acknowledgment. First author expresses to professors Joaquim Sarmento, Joaquim Sampaio and José Novais Barbosa, from University of Porto, and to professor Giuliani Augusti, from University of Roma, the excellent examples and the profitable discussions and insights about teaching Ethics in Engineering.

[35] TEACHING METHODOLOGIES FOR NEW INFORMATION TECHNOLOGIES

João Catarino (College of Business Administration, Polytechnic Institute of Setúbal)

Abstract. New Information Technologies is a course whose curriculum was developed to fill the need of teaching students with more recent and emerging topics in information technologies. The novelty is the approach taken to group in a single course numerous loosely related subjects and a hybrid problem-based learning teaching methodology. Preliminary empirical evidence encourages us to continue pursuing this approach and we believe that our experiences may help other teachers designing their courses' teaching methodology.

Keywords: information technologies, hybrid problem-based learning, curriculum development

[36] FLIPPED CLASSROOM AS A MATHEMATICS LEARNING SPACE FOR PART-TIME STUDENTS

Júlia Justino (Instituto Politécnico de Setúbal) and Silviano Rafael (Instituto Politécnico de Setúbal)

Abstract. This paper presents a study developed in the implementation of flipped learning approach in a Mathematics course unit of an evening higher education degree, mostly attended by student workers. The pedagogical model based on flipped learning combined with active learning techniques, which complements the acquisition of mathematical scientific skills with autonomy, teamwork, mutual help and critical thinking, is described. Outcomes of the implementation of this pedagogical model are also presented and discussed.

Keywords: flipped learning approach, flipped classroom, student-centered techniques, active learning

[37] DO DEMOGRAPHIC FACTORS AFFECT ACADEMIC OUTCOMES? A MASTER ENGINEERING COURSE ANALYSIS

Isabel M. João (ISEL-Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa.CEG-IST,Instituto Superior Tecnico,UL) and João M. Silva (ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa. CQE, Instituto Superior Técnico, UL)

Abstract. The main objective of this study is to address the demographic characteristics of the engineering students enrolled in a master course to explore their effect in the academic outcomes. Variables such as gender, age, nationality and type of previous academic graduation were studied to predict their potential impact upon academic outcomes. The total number of enrolled students in the first four years of the recent master course was retrospectivelly examined. Descriptive statistics were used to summarize the collected data. The chi-square test was applied to evaluate the statistical significance of the demographic variables on response variables related to academic outputs such as average grades of the completed curricular units in the master course, number of ECTS achieved and grade of the master final work. The results of the study are meaningful as they contribute to understanding the impact of demographic diversity in the academic outcomes of a study program for an engineering master's degree course and can assist the coordination team to outline actions to develop in the future taking into account the analysis carried out.

Keywords: Higher education, engineering education, academic outcomes, demographic diversity

[41] PREFERENCES FOR STUDYING MATERIALS: WHAT HAS COVID-19 CHANGED

Luis Coelho (Polytechnic Institute of Porto), Sara Reis (Polytechnic Institute of Porto) and Fátima Coelho (Polytechnic Institute of Porto)

Abstract. In a multimodal world the contact time between the teacher and the students is not always sufficient to ensure the effectiveness of the learning process. For the assimilation of concepts, students often endeavor on a search for the materials that best suit their learning needs. With the application of new technologies in teaching, study materials and support platforms are increasingly abundant and diverse. Additionally, recommendation algorithms overwhelm students with several options, sometimes hard to resist and select, especially after the COVID-19 restrictions, where the amount of connected time as increased. In this context, it is important for the teacher, to know which methods and materials the students use when they are autonomously developing their knowledge and skills. A survey was conducted within a group of engineering students at a Portuguese higher education institution with the main goal of characterizing the study habits and the materials that students. The obtained results are here reported and analyzed and compared with previous results from pre-pandemic study.

Keywords: Teaching Material, Survey, Engineering

Acknowledgment. The authors would like to acknowledge the financial support provided by the Foundation for Science and Technology Project, FCT UIDB/04730/2020.

[45] PROFILING ECE STUDENTS THROUGH HORIZONTAL SKILLS

Joao Sequeira (Instituto Superior Técnico)

Abstract. The paper discusses an experiment on the profiling of Electrical and Computer Engineering (ECE) MSc students by requesting them to engage in activities requiring strong horizontal skills. The data was obtained during an introductory course (in the first semester of the programme).
The conclusions obtained, based on grades obtained over a four year period, suggest that current generations of university freshmen are still unprepared to operate outside of their comfort zone namely when facing unexpected conditions.
The findings also support a claim that students tend to engage in poorly effective communication, both among themselves and with the teachers.

Keywords: ECE, Student Profile, Student maturity, Horizontal skills

Acknowledgment. Work partially supported by project LARSyS-FCT Project UIDB/50009/2020.

[53] APPLE PIE TO APOLLO 13: THE NEED TO REFOCUS ENGINEERING ETHICS WITH DEONTOLOGICAL ELEMENTS, SIMILAR TO MEDICAL ETHICS

Domhnall Ó Sioradáin (TU Dublin)

Abstract. Abstract— On the 50th anniversary of Apollo 13, it is instructive to address the myth of the resourceful and brilliant NASA engineers who saved the crew from certain death. The reality is that was those same goal-orientated engineers who caused the problem in the first place.

This paper examines the nature of engineering ethics, taking the example of the US engineers code of ethics, and showing how its consequentialist foundation leads to problems such as that of Apollo 13 and subsequentially the space shuttles Challenger and Columbia. A single accident could be seen as unfortunate; three suggests a failure of an ethical code to protect human life.

The main frameworks in moral philosophy are consequentialist (outcome-focused) and deontological (duty-focused). This paper puts forward the proposition that both the general psychological outlook of engineers, and the nature of the profession, put heavy emphasis on outcomes (in other words are consequentialist), and need to be balanced by elements of a deontological ethical framework that focus foremost on duty.

Keywords: engineering ethics, moral philosophy, deontological

[54] WOMEN AND STEM: A METHODOLOGY FOR STUDYING FACTORS AFFECTING ATTRACTIVITY

Rita Pereira (ISEL-Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa.), Cristina Borges (ISEL-Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa.), Isabel M. João (ISEL-Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa.CEG-IST,Instituto Superior Tecnico,UL), Bill Williams (CEG-IST, Instituto Superior Técnico, Universidade de Lisboa, Portugal TUDublin, Ireland), Fernanda Coutinho Coutinho (Coimbra Polytechnic - ISEC, Coimbra, Portugal; ISR - University of Coimbra, Coimbra, Portugal), Celina P. Leão (ALGORITMI Centre, Department of Production and System, School of Engineering, University of Minho, Guimarães, Portugal), Filomena Soares (fsoares@dei.uminho.pt), Gilberto Vaz (Coimbra Polytechnic - ISEC, Coimbra, Portugal ADAI-LAETA, University of Coimbra, Coimbra, Portugal), Maria João Meireles (CIETI (Center for Innovation in Engineering and Industrial Technology), ISEP, Polytechnic of Porto, Porto, Portugal) and João Carlos Cunha (Coimbra Polytechnic - ISEC, Coimbra, Portugal)

Abstract. A research group formed with several higher education institutions (HEIs) came together with a common objective: study the factors that influence the choice of female students in STEM programs like engineering and technological courses. This paper reports on the motivation that guided female students to STEM courses and the methodology to be used by different HEIs. It also includes operationalization challenges founded in the different HEIs and expected outcomes. This work is in the initial phase of methodology implementation in the various HEIs. The study is relevant, allowing to understand what drives female students to STEM courses and their perception about 1st year difficulties in the course and institution. Also, it will contribute to improve procedures and methodologies applied to 1st year students in general and enhance motivation for new strategies to attract new female students.

Keywords: STEM, gender, engineering programs, collaborative work

[56] CIVIL PROTECTION ENGINEERING IN A DIGITAL AND VUCA WORLD

Manuel Ribeiro (Instituto Superior de Educação e Ciências de Lisboa (ISEC Lisboa)), Paulo Gil Martins (Instituto Superior de Educação e Ciências de Lisboa (ISEC Lisboa)) and Ana Paula Oliveira (Instituto Superior de Educação e Ciências de Lisboa (ISEC Lisboa))

Abstract. This article discusses the relations that derive from the interventional action of civil protection activity in today's societies that, as is known, are defined by the existence of a panoply of risks, increasingly complex, uncertain and ambiguous. To this end, a contextualization of the socio-technical characteristics of postmodern societies is presented, based on the concept of the global risk society. At the same time, the ambivalent importance of Information and Communication Technologies (ICT) and the digital society in communication and informational processes is highlighted, as contributory mechanisms for greater security volatility, with repercussions on the definition, organization, preparation and operationalization of actions of civil protection. In this domain, and subsequently, the strategies and operational models to be followed in the area of Civil Protection Engineering (CPE) training are addressed, establishing a relationship with what is considered to be public policies in this matter. For this purpose, and as a proposal, a short range of essential requirements for the consecration and affirmation of CPE is presented, as an essential technical and scientific area, as a transversal discipline of improving a safety culture and increasing the resilience of current societies.

Keywords: Civil Protection Engineering, World risk society, ICT, Public policies

[57] AN EXPERIENCE OF USING KAHOOT! WHILE GOING ONLINE

Sofia Cruz (Faculty of Engineering of the University of Porto), António Coelho (Faculty of Engineering of the University of Porto), Diana Urbano (Faculty of Engineering of the University of Porto) and João Pedro Pêgo (Faculty of Engineering of the University of Porto)

Abstract. This report describes a preliminary study that took place during the second semester of the school year 2019-2020, where suddenly classes had to be held online due to COVID 19 pandemic. Kahoot! a gamified application was used in some of the problem-solving classes of an undergraduate physics course of the integrated masters of the Electrical and Computers Engineering program. The quizzes applied covered rigid body dynamics and thermodynamics, both contents included in the syllabus of the course. The study was planned prior to the pandemic and the necessary adjustments of teaching online altered the goals. A simple analysis of the data obtained with the Kahoot! quizzes is performed and the results are discussed in the context of the positive and negative effects of "going online".

Keywords: 'Kahoot!', 'problem-solving', 'online classes', 'student engagement', 'performance', 'feedback'

[58] ENGINEERING EDUCATION IN A CONTEXT OF VUCA

João M. Fernandes (Universidade do Minho) and Paulo Afonso (Universidade do Minho)

Abstract. We live in contexts of higher volatility, uncertainty, complexity, and ambiguity (VUCA). In such contexts, higher education must promote active learning approaches where the responsibility of learning is focused on students, enhancing their competencies and ability to be competitive in the market, after their studies. But, such educational strategies encompass many issues, questions and challenges, both for teachers and students. This article presents and discusses the main changes that have been introduced in a course that promotes entrepreneurship in the field of software engineering. The promotion of entrepreneurship within universities requires effective teaching paradigms which need to be constantly adapting and evolving particularly in the current VUCA context. The PSE course is analyzed according to two distinct VUCA angles: (1) how the course can be adapted to satisfy the expectations of students, and (2) how the course can provide opportunities for students to learn how to behave in a VUCA context.

Keywords: VUCA, active learning, technology stewardship, IT tools, entrepreneurship

Acknowledgment. This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

[60] COMPUTER ASSISTED TEACHING TO IMPROVE THE GLOBAL UNDERSTANDING OF SYNCHRONOUS GENERATORS IN ENERGY ENGINEERING DEGREES

Juan P. Torreglosa (University of Huelva) and F. J. Ruiz-Rodriguez (University of Huelva)

Abstract. Courses on synchronous generators are part of energy engineering undergraduate programs throughout the world. However, according to the currently scientific literature, understanding of the way synchronous generators operate presents difficulties for students, leading to high failure rates. This study proposes the use of computer assisted teaching to improve the global understanding of synchronous generators. Specifically, the library SymspowerSystems of MATLAB was used to observe and verify the performance of a synchronous machine when connected to an infinite electrical network. In order to assess the effectiveness of the proposed methodology, two groups of students were evaluated; the control group, according to the traditional teaching methodology, and the experimental group, utilizing complementary computer assisted simulations. Both groups were evaluated using the same final test, with the results analyzed via a contrast of the means. The results show that the participants of the experimental group significantly outperformed those in the control group in all three of the dimensions under analysis: theory, problems and total.

Keywords: Energy engineering, Grid tied synchronous generators, Simulation, Undergraduate

[64] THE STUDENTS' INTEGRATION IN PANDEMIC TIMES: MIEIC.ONBOARD 2020/2021

Bruno Lima (INESC TEC and Faculty of Engineering, University of Porto) and António J. Araújo (INESC TEC and Faculty of Engineering, University of Porto)

Abstract. The 2020/2021 academic year started full of uncertainties for new students of higher education in Portugal. The restrictions imposed by the COVID-19 pandemic, the fears of a new lockdown, all coupled with the well-known challenges that a university student faces in his first year, made this year a particularly challenging year in terms of the students' integration.
In this paper, we present how the mentoring programme of the Integrated Master in Informatics and Computing Engineering at the Faculty of Engineering of the University of Porto adapted to help the integration of first-year students in the university environment under the pandemic.

Keywords: Integration, Pandemic, Mentoring Programme

[66] PEDAGOGICAL INNOVATION IN PANDEMIC TIMES: THE EXPERIENCE OF A MICROPROCESSOR PROGRAMMING COURSE

Bruno Lima (INESC TEC and Faculty of Engineering, University of Porto), Daniel Granhão (INESC TEC and Faculty of Engineering, University of Porto), António J. Araújo (INESC TEC and Faculty of Engineering, University of Porto) and João Canas Ferreira (INESC TEC and Faculty of Engineering, University of Porto)

Abstract. The 2019/2020 academic year will always be remembered due to the impact of the COVID-19 pandemic. For the first time in recent history, countries closed schools, forcing teachers and students to quickly adapt to online teaching. This sudden and imposed change to a teaching method that was completely different from the one we were used to, brought several challenges and opportunities at the pedagogical level.
In this paper, we describe our experience as teachers of a microprocessors programming course of the Master in (omitted due to blind review).
Our approach comprised changes to the evaluation plan, which became more distributed, as well as improvements to communication between students and teachers through the use of Slack.
We found that the introduced changes not only were very well accepted by the students, but also led to the best exam attendance and average final grade in the last 10 years of the course's history.

Keywords: pedagogical innovation, pandemic, evaluation

[67] THE IMPACT OF THE COVID-19 PANDEMIC IN A MATHEMATICS SUBJECT

Ana Júlia Viamonte (LEMA, Department of Mathematics, ISEP, P.Porto), António Sousa (LEMA, Department of Mathematics, ISEP, P.Porto), Roque Luís (SYSTEC, Department of Mathematics, ISEP, P.Porto) and Marta Ferreira (Department of Mathematics, ISEP, P.Porto)

Abstract. This paper describes the main changes verified on the compulsory digital transition of teaching and learning in a mathematics curricular unit during the second semester of 2019-2020 academic year under COVID-19 pandemic. We highlighted the implementation process of online teaching-learning modes, including all procedures and practices that had been reshaped face to the new circumstances. Particular attention is paid to the main difficulties felt by the students and the teaching team in the adaptation phase to the new reality of distance learning.

The analysis of outputs regarding the previous years and the comparison with the last assessment outputs lead us to conclude that the whole implementation has allowed mitigating an unfavourable scenario for educational success, in particular, the great social change in the student's lives.

We also present the conclusions regarding the students inquiries, which were passed anonymously at the end of the semester, where both quantitative and qualitative approach to study the perceptions of students about the online teaching-learning modes.

As we can see from the answers to this questionnaire, the students missed the face-to-face classes and the contact with teachers and colleagues. They also felt difficulties in the changes that were made in the assessment with a view to moving to the online regime, but they also felt that the course as a whole went well, as evidenced by the success rate. Comparing the success rate with the ones from previous years, it's shown that it decreases a little, although the drop is residual.

Keywords: Digital Education, Mathematics Teaching, Online Learning, Remote Assessment

Acknowledgment. This work was partially supported by LEMA-ISEP.

[71] HOW WE TURNED FULLY DIGITAL DUE TO COVID-19: TWO CONTROL ENGINEERING TEACHING EXPERIENCES

Paulo Moura Oliveira (UTAD University) and Filomena Soares (University of Minho)

Abstract. While living in a digital era, both teachers and students of Engineering Courses were not ready for the drastic change associated with the Covid-19 first confinement (March 2020). This forced change from a presential mode to a fully on-line mode provided teaching/leaning difficulties as well as new opportunities. Moreover, as most engineering courses require laboratory practice, on-line teaching raised additional challenges. This paper reports two different experiences in two different Control Engineering university courses in the North of Portugal. The goal is to share some learning tools that are particularly relevant in the pandemic time we are living: pocket-sized laboratory kits that students can easily take home and experience real-world control contents; an open Mural that can serve as an exchange of knowledge. Perceptions received both from students and lecturers regarding these two experiments are presented.

Keywords: TCLab, Padlet, Control Engineering Education, Arduino, Teaching Experiences

Acknowledgment. The authors would like to express their acknowledgment to all students who agreed to collaborate in this study. This work is financed by National Funds through the Portuguese funding agency, FCT - Fundação para a Ciência e a Tecnologia, within project UIDB/50014/2020.

[72] ELECTRONICS EDUCATION DURING THE COVID-19 PANDEMIC: THE USE OF A CAD FRAMEWORK IN DISTANCE LEARNING ASSIGNMENTS

Francisco Campos (Instituto Superior de Engenharia de Lisboa)

Abstract. Computer-aided design (CAD) software is a fundamental engineering tool that is often integrated into educational programs, including those for electronics. When the COVID-19 pandemic spread worldwide in 2020, an introductory electronics course at our Institution had to be reformulated due to restrictions on holding face-to-face classes. In this scenario, traditional lab tasks were replaced by computer-based assignments that students worked on using CAD software. This paper introduces the software framework used for this purpose, which has the two features considered necessary to closely replicate a practical experiment: i) the ability to mimic breadboard circuit prototyping activities and ii) the ability to simulate the prototyped circuits. In order to enhance students' motivation for the educational activities, the assignments proposed in our course have focused on robotics applications for several years. This was conveniently accounted for by combining simulation of electronic circuits with robotics simulation. In this way, we can be reproduce the embodiment of the electronic circuits and the interaction with an external environment that take place in a real experiment. The paper describes the proposed software framework, gives examples of its use, and reports on students' results for first distance learning semester using the framework.

Keywords: electronics education, distance learning, circuit simulation, educational robotics, robot simulation

[73] DESIGNING MATHS INTERACTIVE LESSONS

Ana Moura Santos (Instituto Superior Técnico, University of Lisbon) and Domenico Brunetto (Politecnico di Milano)

Abstract. In this article, we report a set of student-centred lessons that may inspire higher education teachers to structure interactive lessons for first-year Maths courses in Science, Technology, Engineering, Architecture and Maths (STEAM) programs. In particular, we want to address difficulties first year students often meet when making connections between syntactic and semantic dimensions in learning mathematical concepts, especially in Linear Algebra topics. The specific goal of this paper is to present and discuss how a teacher can make it work in the particular, but relevant, case of a linear transformation. This topic is a pivotal subject in every Linear Algebra standard course and has many recent applications, such as computer graphics. We describe the teaching-learning experience and the results of the first pilot study, which has involved circa 100 undergraduate Architecture students from Politecnico di Milano. The group of students is heterogeneous, both in terms of knowledge background and attitudes towards Maths, which makes the lesson design challenging. The main findings of this article, together with a previous one on the planned activities, underline how a student-centred strategy, based on asynchronous activities and synchronous class discussion, allows misconceptions to emerge and be addressed immediately.

Keywords: student-centred activities, open educational resources, Linear Algebra syllabus, linear transformations, Architecture students, STEAM higher education

[74] THE STRUCTURE OF INFORMATION IN THE INTERNATIONALIZATION PROCESSES OF UNIVERSITIES

Domingos Manuel Machado Costa (Universidade do Minho), Fernando Romero (Universidade do Minho), Senhorinha Teixeira (Universidade do Minho) and Carla Rocha (Universidade do Minho)

Abstract. In this work we were interested in the relation between internationalization of universities and the information demands associated with it. The internationalization process of universities is accompanied by a process of dissemination of information, which fulfills several purposes. The aim of this work was to evaluate, in a systematic way, the international indicators and rankings that are proposed in the literature and that are used by the higher education institutions, and to propose an information model based on that analysis. The research methodology was based on a literature review, documental analysis, informal interviews and observation of events related to internationalization of universities. An exercise of compilation, analysis and synthesis of indicators of the internationalization process of universities resulted in the proposal of a structure of information that includes the most common used indicators, and that can be related to the various perspectives that drive the internationalization process. The structure can be used to guide the process of construction of models of information by universities, particularly in the process of design of web pages, which is nowadays a preferred vehicle of information dissemination from the part of the universities and of information gathering from the part of entities interested in universities.

Keywords: universities, internationalization, information

Acknowledgements. This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

[76] STUDYING ENGINEERING ABROAD: INTERSECTIONALITY AND STUDENT SUPPORT

Shannon Chance (TU Dublin & UCL), Bill Williams (TU Dublin & IST) and Inês Direito (UCL Centre for Engineering Education)

Abstract. What is it like to study engineering in Ireland when you are female and you come from somewhere far away, in the Middle East, which has different social customs and norms? What is your lived experience? What aspects of the experience are common to Middle Eastern women across your course? As education researchers, we aim to understand the essence of the experience these women have had studying engineering in Ireland—what life has been like for them and what unique challenges they have faced that may be invisible to us as instructors. This article reports preliminary analysis of 13 interviews conducted with eight women from Oman and Kuwait over their first three years studying engineering in Ireland. It is geared toward educators—teachers, administrative staff, and support providers—who want to better understand the experiences and perspectives of international students. The paper culminates with advice distilled from literature and our own analyses regarding how to support students working in groups, with an eye toward helping international students achieve success and feel supported and included.

Keywords: women, diversity, nontraditional students, student development, international students

Acknowledgment. Funding to support this study was provided by two Marie Sklodowska-Curie Actions (MSCA) from the European Union: (1) FP7-PEOPLE-2013-IIF, Project 629388, Project: REESP, "Re-Engineering Europe's STEM Pipeline", and (2) H2020-MSCA-IF-2016, Project 747069, Project: DesignEng, "Designing Engineers: Harnessing the Power of Design Projects to Spur Cognitive and Epistemological Development of STEM Students". While portions of this text previously appeared in publications by Chance and Williams [11, 12, 13], this paper synthesizes and extends our prior work.

[77] MOTIVATING FEMALE STUDENTS FOR ENGINEERING COURSES

Rita Pereira (Instituto Superior de Engenharia de Lisboa), Cristina Borges (Instituto Superior de Engenharia de Lisboa) and Eduarda Pinto Ferreira (Instituto Superior de Engenharia do Porto)

Abstract. Worldwide initiatives for promoting motivation in female students for engineering courses are taking place in a regular form. Those initiatives are directed to different age groups and scholar levels. This paper addresses a methodology that was developed in Portugal to allow custom actions for motivating female students to those courses that historically rises them less interest. A workshop with different engineering universities and polytechnic institutions from Portugal, Brazil and Mozambique took place allowing to generate a network and a list of proposed actions. From this list each institution selected one or more actions to be implemented in their own institution. The workshop named "Good practices network for motivating female students to engineering courses" was the kick-off for this initiative. Detailed methodology and future working plan are here detailed.

Keywords: women, Engineering Education, Motivation

[79] A SURVEY ABOUT GENDER DIVERSITY IN A MORE GENDER-BALANCED IT FIRM

André Santos (ISCTE-IUL), Joana Alexandre (ISCTE-IUL) and Fabiane Meireles (Truewind)

Abstract. We present a case study of Truewind, a mid-size IT consulting company whose distribution of employees is significantly more gender-balanced than the norm. Whereas worldwide employment of women in the ICT sector hardly reaches 20%, women make up almost one third of the developers of the main office of this company. We conducted a case study to gain an understanding of which factors are perceived to contribute to such a gender distribution, and how its employees see it as an advantage. A survey revealed that, independently of gender, employees value gender diversity, pointing out advantages on teamwork, organizational climate, and critical thinking. Further, we collected factors that contribute to the retention of women, which in great part refer to organizational climate and work conditions. Our study reinforces the evidence that gender diversity carries benefits to ICT companies, confirming results of previous studies.

Keywords: gender diversity, ICT, software engineering, survey

Acknowledgment. We thank the anonymous Truewind employees that accepted to collaborate in this study.

[83] OVERCOMING CRISIS: A PORTRAIT OF THE ADAPTATION OF ENGINEERING PROFESSORS TO REMOTE TEACHING IN CHILE

Juan Ross (Universidad de Chile), Nicolás Bravo (Universidad de Chile) and Juan Solis (Universidad de Chile)

Abstract. Lately, Chile has been struck with two significant events that have made its citizens rethink and adapt their worldview and activities in various dimensions. The recent social outbreak and the COVID-19 pandemic have impacted almost any institution, and public higher education is no exception. Emergency remote teaching has arrived and professors have made all the possible efforts to deliver a quality education given the limitations. In this article, we portray teachers' experience belonging to the FCFM, one of the most prestigious Chilean engineering and science schools. We implemented two surveys, one on each semester of the year 2020, to understand their main difficulties, concerns, and appreciations. Frequencies and regression analyses were conducted. Results show that teachers' experience has improved through the year. The gained experience in the first semester has made them adapt their ways of teaching, design a better course and enhance their interaction with students through a combination of synchronous and asynchronous strategies.

Keywords: Educational Adaptation Process, Virtual Modality Evaluation, Chilean Experience, Engineering and Science, Higher Education during COVID-19

[86] THE USE OF SIMULATION AND COLLABORATIVE TOOLS IN TEACHING MANAGEMENT TO ENGINEERING STUDENTS

João Gustavo de Matos (INESC-ID, Instituto Superior Técnico, Universidade de Lisboa), João Oliveira Soares (CEG-IST, Instituto Superior Técnico, Universidade de Lisboa), Ana Catarina Kaizeler (DEG-IST, Instituto Superior Técnico, Universidade de Lisboa), Ana Sara Costa (CEG-IST, Instituto Superior Técnico, Universidade de Lisboa) and José Gonçalves Pinto (DEG-IST, Instituto Superior Técnico, Universidade de Lisboa)

Abstract. The current pandemic crisis has brought about the need to use digital and distance learning tools to ensure the involvement of students and their participation in classes and academic work. In this article we present the tools used in the Management course at Instituto Superior Técnico involving, namely, simulation through management games, clickers and collaborative techniques useful to manage the large size of student classes. Subsequently, we discuss the results of using these tools in the new pandemic context, concluding that this situation has highlighted some of its characteristics that will continue to be useful in the future and correspond to greater student involvement and to a greater adaptation to different learning rhythms by the students.

Keywords: management education, gamification, management games, collaborative tools

[87] DO FUTURE ENGINEERS TRUST COBOTS?

Ana Pinto (University of Coimbra), Paulo Nogueira Ramos (University of Coimbra), Carla Carvalho (University of Coimbra) and Cristovão Silva (University of Coimbra)

Abstract. We live in a complex and uncertain reality where technology such as robotics will mostly augment its market size. This evolution will impact future engineers in their professional lives. Increasing trust in their interaction with collaborative robots also known as cobots is relevant to decrease uncertainty in our volatile, uncertain, complex, and ambiguous (VUCA) world. This research aimed to analyze the extent to which different higher education courses (mechanical engineering, industrial engineering and management, and management) differ with respect to the degree of general trust and its dimensions (perceived risk, benevolence, competence, and reciprocity) in Human-Robot Interaction (HRI). A sample of 290 Portuguese higher education students replied to a "Human Robot Trust Scale", that showed adequate validity and reliability. In order to test our hypotheses an analysis of variance (ANOVA) was conducted. Results showed that there are significant differences between groups regarding general trust - mechanical engineering students show more trust in HRI compared to engineering and industrial management students and management students. About the dimensions of trust, there are significant differences concerning perceived risk, benevolence, and competence, but not in relation to reciprocity. Practical implications, study limitations and clues for future research will be presented.

Keywords: trust, collaborative robots (cobots), engineering, students, human-robot interaction

[89] ETHICS AS PATHWAY TO SUSTAINABILITY AND SOCIAL BALANCE

Jose Figueiredo (CEGIST, IST, Universidade de Lisboa)

Abstract. People interested in teaching ethics to university students usually know about ethics, about ethic principles, ethics schools of thought, ethic paradigms, and they are normally able to provide a solid conceptual background on ethics. The problem usually arises on how they are going to do it, how they are going to teach. Teaching, top-down, unidirectional, ethic principles, and ethical rules, or facilitating the way students absorb facts and create knowledge, how they learn, through discussions, negotiations and decisions. The main difference between the two approaches, the two strategies, is about how knowledge is produced, how do we create and develop knowledge. We think knowledge is produced inside ourselves and for ourselves, and knowledge is what allows us to act. We take ethics as a specific form of knowledge, that is, we create and improve our ethics behaviour the same way we improve and expand our knowledge. Further ethics is about small things, as it is about huge and transcendent things. But maybe, in order to learn, we need to address these two categories of situations with different strategies. In fact, we define a way to coop with small things, things from our everyday life, and another to deal with more difficult things, the ones the happen more singularly, and usually with stronger consequences. It is about these intricate labyrinths of behaviour that we explore our research, defining pathways to navigate actual circumstances as they happen.

Keywords: ethical education, promote ethics behaviour, learning approach, model one, model two

[90] USING A VALID GAME-BASED LEARNING ACTIVITY TO PRACTICE COMMUNICATION COMPETENCIES ONLINE

Sofia Sá (Instituto Superior Técnico) and Mariana Leandro Cruz (Delft University of Technology)

Abstract. Due to the covid-19 pandemic, several universities have changed to remote teaching. Instituto Superior Técnico (IST) was no exception and a communication activity already given in a face-to-face environment was adapted to be implemented in a remote setting. During this activity, 310 Master engineering students of IST participated in this activity via Zoom. The aim of this study was to compared the differences between the face-to-face setting to the remote format. A scoring rubric was used to analyze the performance of students' communication competencies in the activity, and a self-assessment questionnaire was used to study the perceptions of students' communication competencies, their areas of improvement and the usefulness of the activity according to them. The findings showed that the activity is effective in both face-to-face and remote settings, with the following advantages of the remote implementation: less noise in the rooms, more organization, better time management, fewer constraints during the reflection moment, and benefits from the use of digital tools. The lessons learned by the authors in the remote adaptation of the activity can be used by other educators in the implementation of remote teaching.

Keywords: Communication competencies, Game-based learning, Active learning, Remote teaching

Acknowledgments. The authors would like to thank all the IST students who participated in this study.

[92] ETHICAL SKILLS NEEDED BY ENGINEERS TO FACE FUTURE'S CHALLENGES

Fátima Monteiro (ISEC)

Abstract. Engineering practice has a high impact on contemporary society. The international scientific publication recognizes a broad consensus on the need to incorporate ethical education in engineering courses as essential. It is also noted that the way to incorporate and promote it, as well as the skills to be acquired, is not consensual, this being an area with a research deficit, especially on the skills to be acquired. In view of this, the present study aims to investigate what ethics skills are required for engineering graduates in the face of the challenges of the future. To this end, it was considered necessary to identify which ethical competences are necessary for engineering graduates recognized in scientific research in the area. The competences identified have the common point of helping to face and find ethical and responsible solutions to the challenge of sustainability. But there is also a strong focus on promoting professional and ethical responsibility, understanding the role of engineering in society and raising awareness of the negative consequences of technology.

Keywords: ethical education, engineering education, ethic skills, challenges of the future

[94] METACOGNITIVE CHALLENGES TO SUPPORT SELF-REFLECTION OF STUDENTS IN ONLINE SOFTWARE ENGINEERING EDUCATION

Daniela Pedrosa (Universidade de Aveiro & CIDTFF; Universidade de Trás-os-Montes e Alto Douro), Mário Madureira Fontes (PUCSP), Tânia Araújo (Universidade de Aveiro), Ceres Morais (INESC TEC), Teresa Bettencourt (Universidade de Aveiro & CIDTFF), Pedro Pestana (Universidade Aberta), Leonel Morgado (INESC TEC / Universidade Aberta) and José Cravino (UTAD & CIDTFF)

Abstract. Software engineering education is challenging, requiring students to develop technical knowledge and advanced cognitive and behavioral skills, particularly in the transition from the initial level to the proficient. In distance learning, the hurdles are greater because students are required greater autonomy, adopting strategies of self and co-regulation of learning. Facing these challenges, the SimProgramming approach has been transposed into the context of DL (e-SimProgramming). In the second iteration of e-SimProgramming implementation (2019/2020), one of the adaptations made was the inclusion of metacognitive challenges (MC) with the aim of promoting students' self-reflection on their learning process. This work explains the adaptation process and the design of the two types of MC implemented. We adopted a qualitative and quantitative exploratory methodology: 1) descriptive analysis of the evolution of MC submission throughout the semester, to identify the regularity and completion with the MC submission deadlines and their relationship with the success achieved by students and 2) analysis of students' perceptions of MC. The results showed that there is a positive correlation between high MC submission and success achieved, greater interest and involvement of students in type 2 MC (focused on the syllabus) and positive perceptions of students about MC. In future work, it is necessary to make some adjustments to the instructional design on the SCRL support.

Keywords: Metacognition, e-learning, Computer Science, Self-regulated learning, Learning strategies

Acknowledgments. Daniela Pedrosa wishes to thank Fundacão para a Ciência e Tecnologia (FCT) and CIDTFF (UID/CED/00194/2019) – Universidade de Aveiro, Portugal, for Stimulus of Scientific Employment – CEECIND/00986/2017 Individual Support 2017. This work was financially supported by National Funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., under project PTDC/CED-EDG/30040/2017.
We would like to thank all the students and teachers who collaborated on this research.

[96] EVOLUTION OF ENGINEERING EDUCATION RESEARCH IN PORTUGAL AND SPAIN: A SCIENTOMETRIC STUDY

Andrew Valentine (University of Queensland) and Bill Williams (Setubal Polytechnic Institute; CEGIST University of Lisbon; TUDublin)

Abstract. This paper contributes to the growing body of work that analyses the growth of engineering education research (EER) as a global field of inquiry. It uses a computer-aided process to compare the evolution of EER in Portugal and Spain. This is achieved by extracting the names of the Portuguese and Spanish authors that published in a sample of 12 different journals in the years 2018 and 2019 and then carrying out a computer-curated scientometric analysis of their complete publishing careers in both specialised engineering fields and in EER.
For a sample of 50 Portuguese and 285 Spanish authors we present data taken from 14,121 publications that allow us to show the percentage of their publications that are educationally focused and how this in turn impacts their h-index. We also calculate how early in their career they published their first educational paper. Differences between researchers active in the field of EER from Portugal and Spain are identified, the most notable being the tendency for a large number of Spanish authors to publish in specific EER journals and we suggest possible explanations for the findings.

Keywords: Students with Special Needs, inclusive higher education, physical and digital accessibility, didactic videos, special needs employability

[99] TÉCNICO2122: RETHINKING ENGINEERING EDUCATION AT IST

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Abstract. This paper summarizes the work of CAMEPP, the IST Commission that was charged in 2018 with the analysis of pedagogical practice at IST, as well as of the curricula of its first and second cycle degrees. As a consequence of this work, IST changed significantly the curricular structure of its degrees and pedagogical methods, with a new design that will begin its implementation in 2021/22.

Keywords: higher education, engineering, educational model, learning, teaching

Acknowledgment. The members of CAMEPP gratefully acknowledge the collaboration of the IST community during the preparation of its report, whose main conclusions are summarized here. Student Groups, Administrative Offices, Departments, Degree Coordinators, the Pedagogical and Scientific Councils, all gave fundamental support and contributed ideas and opinions that greatly helped to guide the work of CAMEPP. We would like to highlight the role of the Presidents of the Management Council, Scientific Council and Pedagogical Council, Professors Arlindo Oliveira, Luís Oliveira e Silva, and Raquel Aires-Barros, respectively. We also acknowledge the collaboration of the Student VicePresident of the Pedagogical Council, Nuno Guerreiro, and the Science and Technology Management grant holder Liliana Freitas.

[100] ENGINEERING THE FUTURE: TRANSVERSAL SKILLS IN ENGINEERING DOCTORAL EDUCATION

Helena Martins (Universidade Lusófona de Humanidades e Tecnologias, ESE + CEOS.PP), Ana Freitas (Universidade do Porto, FEUP), Ines Direito (University College London) and Ana Salgado (Instituto Politécnico do Porto, ESS + ESE-P.Frassinetti)

Abstract. Over the last decade there has been a significant increase in doctoral students and researchers in Engineering. Entry-level skills for these academic positions are often mostly technical and frequently associated with profiles that thrive in analytical and frequently solitary tasks in laboratorial environments. However, success in doctoral programs and research careers is highly dependent on competencies that are both intrapersonal (e.g. time management, self-regulation, emotional intelligence, resilience) and interpersonal (e.g. teamworking, communication, negotiation, etc). Since the employment landscape for doctoral graduates has significantly changed due to the reduction in the number of research and professorship positions within universities, the transition from academia to industry has been gaining more attention from the Engineering Education community. Despite this, many studies point out that the competencies developed in Portuguese doctoral programs do not motivate nor prepare PhD graduates for a career outside academia and also don't match industry requirements in terms of competencies needed to thrive in such environments. In response, assessment reports and policy papers have been highlighting the need to rethink doctoral programs curricula in order to prepare engineering graduates for their future careers both in academia and industry. The basis for this has been advocated in the development of a specific skill set of transversal competencies. With this study, we intended to identify the transversal skills clusters that result from engineering doctoral education literature, make engineering researchers and managers aware of the importance of transversal skills, identify potential gaps in the literature and avenues for future research. In order to have a broad overview of the transversal competencies of PhD candidates in engineering, a preliminary bibliometric analysis of 2756 papers published in the last two decades was conducted using VOSviewer. The results show evidence of literature clusters related to 1) necessary skills for successfully concluding the PhD program; 2) the shift from the academic world to the labor market; 3) interpersonal competencies. In the discussion of the results, the authors: 1) advocate the emergency for HEIs to develop institutional strategies that contemplate formal opportunities to develop transversal skills during the doctoral path and ensure employability prospects for PhD candidates; b) propose the use of a framework of competencies for PhD candidates in engineering that may orientate the implementation of such institutional strategies and also help candidates to transfer such skills to industry/business in the transition from academia to industry.

Keywords: doctoral education, engineering, soft skills, transversal competencies, transition to industry, VOSviewer

[102] VIENA: A MULTIDISCIPLINARY PLATFORM FOR EDUCATION

Francisco Ferreira da Silva (Técnico Lisboa), Bruno M. A. Tibério (Técnico Lisboa), Miguel A. C. Gameiro (Técnico Lisboa), João F. P. Fernandes (Técnico Lisboa) and P. J. da Costa Branco (Técnico Lisboa)

Abstract. This article is to present the Veículo Inteligente Elétrico de Navegação Autónoma (VIENA) project - (Intelligent Electric Vehicle with Autonomous Driving) - a project made by students, for students. The project scope is to be a multidisciplinary platform for the Electrical and Computer Engineering (ECE) course at Técnico Lisboa to grasp important aspects and concepts that can only be obtained by a practical implementation. Since the objective of this project is to make a semi to a fully autonomous electric car, every aspect of the ECE course applies here: electrical circuitry development, sensor implementation, low and high levels of communication, low and high-level programming, power train design, including battery and electric motor system, and all the control aspects required to make all these parts function as one, as well as for the speed control and autonomous driving. The main goal is to show the work developed so far and how this project contributed to knowledge and curriculum of the students that worked in the project, voluntary, in their master's thesis, or through scholarships.

Keywords: VIENA, Project, Student, Electric Car, Autonomous

Acknowledgment. The VIENA project would never come to be what it is today and what it will become in the future if it were not because of the help of several persons and institutions. First and foremost, to all the students who voluntarily helped this project in several manners, giving their time and soul to take the first steps in the project. To Maxime de Changy and Sebastian Jorres, for the first studies in the dynamic characteristics of the car; to Nicola Tertullian, who did considerable work in integrating the power train of the vehicle, being with us for the first outdoor testing of the car, and for being its first driver! To Filipe Neves for helping us with the car's mechanical parts, such as maintaining the brakes, the side windows, and several other small but important contributions. To Andre Antunes, former FST member, took his time to come to the lab with us and enlightened us on how the CAN connection with the inverter worked. To Pedro Costa, former FST member, for his valuable knowledge to get us started with the parts supplied by the FST team and many suggestions for problems that arose. His experience saved us valuable time in the solutions for those problems. Andre Agostinho, a former FST member, developed the low voltage BMS system and did the groundwork for the FoxBMS system, integrating the old battery system with this new one.

Now for the groups and institutions that helped us. To the entire Formula Student Teams, from 2018 until today, that helped us with a lot of knowledge, and by supplying us with the equipment and material, we needed from the very start to make this project viable. Our deepest gratitude and that this implicit partnership will continue with the new teams in the future.

To the Center of Intelligent Systems (CSI), of the Mechanical Engineering Institute - IDMEC, for being our supporters from the start. Their great financial support helped us progress to purchase the new systems to implement in the car.

[103] ENHANCING ENGINEERING STUDENTS' PROJECT MANAGEMENT SKILLS IN THE MIDDLE OF THE COVID-19 PANDEMIC: AN ONLINE PROJECT-BASED LEARNING EXPERIENCE

Gonçalo Cruz (University of Trás-os-Montes and Alto Douro), Caroline Dominguez (University of Trás-os-Montes and Alto Douro) and Adelaide Cerveira (University of Trás-os-Montes and Alto Douro)

Abstract. Teaching project management and industrial optimization to engineering students require real-world experiences in which they can explicitly integrate, apply and develop work-ready skills, such as critical thinking, communication, and teamwork. This paper presents an exploratory case study research describing an online Project-based Learning (PjBL) experience aimed at tackling the challenge of decreasing the ecological footprint in the university campus generated by the local commutation of students from university-home and/or home-university. The experience was implemented with 9 participating students enrolled in the Industrial Management I course, part of the Mechanical Engineering Master programme at the University of Trás-os-Montes and Alto Douro (UTAD), Portugal, from February to June 2020, in the middle of the COVID-19 pandemic. We firstly describe the course in terms of the key driving question, the learning goals, the educational activities, the collaboration among students, the scaffolding technologies, and the tangible artefacts produced. We further discuss the preliminary results of the study from a post, self-completion questionnaire of students' perceptions about the experience, as well as from the final tangible artefact - a carpooling model proposal for the UTAD student community. Finally, we outline implications for the teaching practice as well as some concerns that need to be addressed in future course editions.

Keywords: mechanical engineering, industrial management, project management, project-based learning, engineering education

[104] INNOVATIVE TEACHING/LEARNING METHODOLOGIES IN CONTROL, AUTOMATION AND ROBOTICS: A SHORT REVIEW

Ricardo Afonso (Engineering School - University of Minho), Filomena Soares (Centro Algoritmi - Engineering School - University of Minho) and Paulo Moura Oliveira (UTAD-University of Trás-os-Montes and Alto Douro, ECT)

Abstract. Innovative teaching-learning methodologies in the fields of Control, Automation and Robotics are of great interest to researchers, educators and students. Nowadays there is a wide range of technological options available that can be used to improve learning and motivate students in their knowledge acquisition and skills development. Concepts such as Pocket-Sized Labs, Virtual and Remote Labs, as well as Web-Based Learning, are increasingly included in the teaching-learning processes, where students are expected to acquire their knowledge as active and central elements in the entire process. This article focuses on the review of various teaching-learning methodologies in the fields of Control, Automation and Robotics, taking several aspects into account: the portability and low cost of devices and applications, the possibility of autonomous and distance learning and centering of the learning process in the student. The conclusions drawn allow us to state that it is possible to apply innovative, effective and motivating methodologies with tools, devices and applications that are both low-cost and easy to access. It can also be inferred that the future of teaching demands a radical departure from the traditional methodologies, as well as taking advantage of technologies and students' skills to use and put them into practice.

Keywords: Arduino, Pocket-sized labs, Virtual and remote labs, Learning-by-doing, Hands-on, Web-based learning, Android

Acknowledgment. This work has been supported by FCT – Fundação para a Ciência e Tecnologia, within the R&D Unit Project Scope: UIDB/00319/2020.

[105] MODDING MODERN BOARD GAMES FOR E-LEARNING: A COLLABORATIVE PLANNING EXERCISE ABOUT DEINDUSTRIALIZATION

Micael Sousa Sousa (University of Coimbra)

Abstract. The paper describes an experience of applying analog games in online educational environments as a way to respond to the pandemic restrictions. Combing these games with online collaborative tools like Zoom and Google Drive allows to transform them into serious game tools. The experience happened during a class to teach collaborative decision making, part of the environmental engineering master's degree course of the Nova University of Lisbon. The invited teacher acted as the facilitator of the serious game approach. The facilitator presented students with the challenge to create, debate, and deliberate proposals about urban renewal in a city passing by a deindustrialization process. Through this game-based method, players had a pleasant experience and reached the intended game and lesson goals.

Keywords: Board games, Collaboration, E-learning, Serious games, Spatial Planning

[106] TEACHING AND LEARNING DURING ONE YEAR OF THE PANDEMIC AT TÉCNICO LISBOA

Filipa David (Instituto Superior Técnico), Maria Teresa Peña (Instituto Superior Técnico), Maria Raquel Aires Barros (Instituto Superior Técnico), Maria Beatriz Silva (Instituto Superior Técnico), Marta Graça (Instituto Superior Técnico) and António Rodrigues (Instituto Superior Técnico)

Abstract. The way Higher Education Institutions reply to the COVID-19 pandemic by moving their activities to digital platforms accelerated the large-scale implementation of remote learning methods, using alternative forms of teaching and academic assessment. Técnico reacted promptly and in the 2nd semester of 2019/2020 adopted emergency distance learning, providing students and teachers with the necessary tools to continue their teaching and learning activities. This new reality led to implementation of new measures to monitor teaching and learning at Técnico, along with the existing integrated system for quality assurance of course units. The monitoring process continued into the 1st semester of 2020/2021 as well as the teaching adaptations arising from the pandemic situation. Fortunately, the flexibility, adaptability and resilience of all the community, teachers and students, allowed to carry out successfully both semesters marked by a big change. The surveys discussed here show that the perception of the students is that remote teaching enhanced the pedagogical performance of the teachers and improved the organization of the courses. On the other hand, students signaled the effects of lacking communication to the teachers and also between the students themselves.

Keywords: remote teaching and learning, digital methods, higher education, quality assurance, pandemic

Acknowledgment. The authors wish to acknowledge the support and the efforts involved of Francisca Simões (former Vice-President and student representative of CP) and Professor Carlos Santos Silva (current Vice-President of CP). Besides these, the authors cannot fail to acknowledge the support of all the professionals of Técnico's staff, students and teachers that contributed somehow to the pursuing of interests and improvement of academic performance of the School's students and teachers.

[107] PEDAGOGICAL INNOVATION PROJECTS AT TÉCNICO

Maria Beatriz Silva (Instituto Superior Técnico), António Rodrigues (Instituto Superior Técnico), Luís Oliveira E Silva (Instituto Superior Técnico) and Raquel Aires Barros (Instituto Superior Técnico)

Abstract. Recent technological developments and rapid social changes have brought new challenges to engineering education in the 21st century. To better prepare young engineers to be able to anticipate, take part and respond to the future challenges of our society, Instituto Superior Técnico launched a process of analysis and reflection on its teaching model and pedagogical practices. The Pedagogical Innovation Projects (PIP) emerged in this context and are intended to support teachers in the development of new formats and innovative teaching methods, encouraging the inclusion of new technologies and skills in curricular units, which play increasingly large roles in the world of work, such as collaborative project work and digital technologies.

Keywords: innovation, pedagogy, teaching projects

Acknowledgment. The authors wish to acknowledge the support of:
- Participants and candidates of the PIP
- The jury of all the PIP editions
- Patrícia Rosado Pinto, NOVA Doctoral School
- Manuel João Dias, University of Minho
- Telma Baptista from the Design and Multimedia Unit of Técnico

[110] PEER OBSERVATION PROJECT AT THE UNIVERSITY OF LISBON – IMPLEMENTATION AND MANAGEMENT

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Abstract. The "Observar e Aprender" Project (Observing and Learning – O&L) is a peer-observation program for the teaching community in Universidade de Lisboa. The project aims to promote spaces for experimentation and support of the Universidade de Lisboa teachers, constituting itself as an interdisciplinary training forum. This paper presents the project, its main results and management activities.

Keywords: peer-observation, higher education, forum, feedback

Acknowledgment. The authors wish to acknowledge the support of:
• João Pedro Pêgo and Ana Mouraz from U. Porto, coordinators of the project "De Par em Par";
• Our colleagues from the O&L project Coordination Team: Luísa Louro and Miguel Mourato (ISA), Maria Henriques Ribeiro (FF), Luís Tinoca and Marta Almeida (IE);
• Ambassadors of the O&L project
• All the participants in the O&L project

[111] OBSERVING CLASSES AT TÉCNICO (2010-2019): DO OBSERVATIONS IMPACT ON THE QUALITY OF TEACHING?

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Abstract. The main objective of the observation of classes project is to promote and improve the pedagogical skills of professors and their professional development. This paper refers to three existing contexts of observation and aims to understand how the class observation process is reflected in the pedagogical performance of teachers over time, using the Quality of Curricular Units (QUC) results in order to provide details about the performance of the teachers in a certain semester. This study focuses on the universe of more than 700 teachers evaluated by QUC, from 2010/2011 to 2019/2020 at Técnico. The statistical analysis demonstrates evidence that there are differences between the pedagogical performance of teachers over the years, namely with an emphasis on moments after the observation of classes has occurred. Qualitative results from the feedback meetings, after every observation process, reveal that class observations are seen as an appropriate means to promote the quality of teaching and the pedagogical development of teachers. More work needs to be done in this area, on the one hand to continue monitoring the professors' achievements and their performance over the years at Técnico, and on the other hand, to identify other variables that influence the pedagogical skills of professors, assessing and improving the positive impact of the classroom observations done by non peer professionals.

Keywords: classes observation, higher education, feedback, quality assurance, teaching skills

Acknowledgment. The authors would like to aknowledge the Pedagogical and Scientific Council of Técnico, namely Prof. Raquel Aires de Barros and Prof. Luís O. Silva for their support and encouragement regarding the Observation of Classes.

[112] THE RELEVANCE OF PROMOTING SELF-REGULATED LEARNING AND MOTIVATION IN A SUPERCOMPLEX HIGHER EDUCATION LANDSCAPE

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Abstract. Higher Education suffered great changes from the 70's until the present, especially in Europe, trying to keep pace with collective challenges. Universities are, therefore, immersed in a super-complex world, partly aggravated by their own contribution. New complexities lead to new solutions, such as the worldwide rising relevance of soft skills in higher education. Psychological Theories, in particular SRL and motivational theories offer new pathways to support change and development. An example of a Portuguese Engineering School is here explored to highlight soft skills potential in a volatile, uncertain, complex and ambiguous world.

Keywords: self-regulated learning, teaching, self-regulation, motivation, development, soft skills, higher education, engineering education, VUCA

Acknowledgment. Isabel Gonçalves would like to thank Raquel Barros and Luís O. Silva for believing, for trusting and for always encouraging the work of the NDA team. A warm greeting is also due to Beatriz Silva for being a special friend, an amazing tutor and an excellent teacher.

Title
SHAPING ENGINEERING EDUCATION FOR THE 21ST CENTURY
Book of Abstracts of the 4th International Conference of the
Portuguese Society for Engineering Education

Editors
Raquel Aires Barros, Alexandra Moutinho, Ana Moura Santos, António Rodrigues,
Beatriz Silva, Isabel Gonçalves, Leonor Moura, Pedro Brogueira

1st Edition – June 2021