

Engineering Education: New Challenges, New Approaches

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ABSTRACT

Teachers must aid students develop 21st century skills providing them with rich learning experiences, as related as possible to their future professional practices. The sudden transition to an e-learning environment due to the COVID19 pandemic is the focus of the works presented. A good diversification of teaching approaches such as PBL, teamwork, gamification or the integration of complementary resources is tackled. Teachers' concern about students' perception, and development of professional competences is present in all works. Some works not only describe experiences that were useful to students learning but also in developing solutions, engendering a bridge between academia and the professional world.

CCS CONCEPTS

• **Applied Computing**; • **Physical Sciences and Engineering**; • **Education**;

KEYWORDS

Engineering Education, PBL Engineering Experiences, Emerging Technologies in Teaching, Online Teaching and Learning in Engineering

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1 INTRODUCTION

Twenty-first century engineers need to present themselves not only technically qualified, but also socially confident. During their education students are expected to develop different competences in several areas of expertise, while in parallel develop social and personal skills such as creativity, critical thinking, communication, teamwork, leadership, proactivity, and so on [1-7].

Teachers must act as facilitators in this arduous work and provide them with rich learning experiences, as related as possible to their future professional practices [8-10]. There are so many aspects to be concerned. Engineering is, by heart, an area where students need to get their hands on handling experimental devices. Experimentation work plays a great part in their syllabus and is of major importance

in most engineering degrees [11]. There is so much we can do online with the use of remote labs, simulators, videos, etc. As literature points out, students still need to gain sensibility handling those apparatus themselves, evolving by making mistakes, by figuring out the big picture and mobilize their learning in order to solve the problem [12-13].

How may teachers replace those accomplishments students still need to achieve in distance learning? On the other hand, there is the question of how to assess students' learning in such a different learning environment. The question goes deeper than how to make online exams. If we recognise students work is triggered by the way they are assessed, then the real question should be how to potentiate their work by diversifying the assessment strategies. Our goal must be as close as possible as it was previously, that is, to provide students learning situations which allow them to develop scientific, technical and social competences [8, 14]. So, tasks and assessment must also be aligned with this. The real question should be how to do it in order to assess student actual progress. Another angle that needs urgent addressing is the way online classes are carried out. It is certainly clear they cannot be delivered using exactly the same resources and procedures. Even the more traditional lectures need to be adapted to this online era. Some teachers might be more proactive and innovative and by sharing their experiences may motivate others to experiment and improve their own.

As engineering teachers, we motivate students to become experts with consolidated scientific and technological learning. In parallel we state they have to develop ability to adapt to new situations and competence of using those knowledges to make a difference. More than ever, we must practice what we preach.

2 ENGINEERING EDUCATION: NEW CHALLENGES, NEW APPROACHES

Traditionally this special track concern students' competences when arriving the labour market and the identification of teaching practices that might help students cope better with those challenges [15-20]. Since last year we are experiencing the most defiant demand which forced a change in our practice all over the world. Unfortunately discussing the constraints brought by COVID19 has become a cliché. However, it is necessary to discuss it internationally and conferences present themselves as privileged forums to disseminate good practices and help us win this educational battle. So, this year we welcomed empirical experiences about re-invented teaching practices that show some examples of how to address this challenge and aid students to learn, while continuing developing the necessary competences. The sharing of such experiences might aid other teachers to refine and improve their own. This generation of students may be stigmatized by this pandemic, so it is also important to understand their point of view of how teachers can help them overcome this. This track aims enhancing the discussion

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around Engineering Education especially concerned on empirical practices meant to help teachers and students cope with this new challenge.

3 CONTRIBUTIONS

This year's contributions to the special track in Engineering Education – New Challenges, New Approaches at TEEM'21 shared new learning experiences, some of them using new methodologies or resources during a demanding e-learning period due to COVID19. Based on PBL approaches, teamwork, gamification or the integration of videos or simulations in the course resources. Students' perception, development and professional competences are also tackled.

3.1 Incorporating authentic learning experiences in the Degree in Agro-Food Engineering

This work reports a pedagogical experience on the 4th year degree course "Engineering of Food Industry III", within 7 students working in groups. Teachers proposed students an authentic learning experience – prepare an innovative project that satisfies the requirements of the University-Business Transfer Programme – to motivate, challenge and help them to develop the necessary competencies required by the labour-market.

Teachers' continuous feedback, guidance and tutoring, acting as facilitators of the process, played a crucial role in students' success. The dynamic of the groups also had an important contribution in the final result. Students got more confident, improved their attitude and found the project very interesting, motivating and challenging.

3.2 When industry meets Education 4.0: What do Computer Science companies need from Higher Education?

This work presents an exploratory research (using the input of several Computer Science companies, from 5 countries) which main goal was to identify the required skills that graduates in this field should have at the end of their academic path and the current gaps still existing in these HE students' training. The two main gaps identified were graduates' lack of soft skills and challenges to applying theoretical knowledge to different practical contexts.

To overcome these gaps, according to authors, is crucial that academic content and teaching methods (including assessment) should be debated. Plus, a close collaboration between companies and HE institutions, through company work placements during students' studies as well as experts from the companies deliver certain bits of contents within the degree may also contribute to "produce" highly skilled, competent and successful CS graduates.

3.3 Incorporating Team-Based Learning into a Fluid Mechanics Module: First Insights

This work describes the impact of using a Team-Based Learning (TBL) methodology in a module of a Fluid Mechanics 2nd year course in a Chemical Engineering degree. In the former course editions as well as in the remaining modules of this course edition, traditional teaching methodologies were used. Taking into account

students' grades and their perception of the TBL methodology usage (collected through a questionnaire) the authors conclude students' grades in this module (using TBL) show in average a positive tendency when compared to the grades of the previous year equivalent module. Still TBL was the least students' preferred methodology.

The study, including the assessment tools and the obtained results are detailed presented, which may be useful to other teachers.

3.4 Engineering capstone project as a service-learning activity: A case study in Geomatics degree

This article presents an innovative topic related to the application of a service-learning approach. Specifically, it develops a case of the roadway project carried out by students of the Geomatics Engineering Degree in a Spanish university.

The teaching and learning methodology Service-Learning (SL) reported in this article allow students to solve a real life problem, very relevant for the community. Furthermore, with this capstone project many skills and competences acquired in the degree were developed with the use of instruments and software packages, which will continue to be used throughout professional life. Working with real life and complex problems is very important for future professionals as they require communicating with the community. To sum up, this paper combines the relevance of capstone projects as the culminating experience of engineering students, and the importance of focusing on real-world application, to be better prepared for their professional life.

3.5 Control charts based on MATLAB statistical and visualization tools as a compatible with e-learning methodology in the context of quality control

This work reports an interesting teaching approach, using Matlab in the context of quality control for engineering students. The activity was created considering the possibility of e-learning, in which all the needed files to the autonomous work of the student can be uploaded to the LMS platform. The learning activity is based on the generation of different random datasets. Three different real situations are addressed based on the nature of the data: one case of a fully statistically controlled process, one case of a process with a violation in the variability, and finally, one case of a process with violation either in the centring and variability. Within the framework of a pilot study, the perceptions of the students involved in the trial is reported given in a 5-points Likert scale. The activity was perceived by the students as useful and scalable.

3.6 Based-on simulation training on ventilation calculation for the reduction of occupational risk of SARS-CoV-2 infection

This article addresses a new methodological approach for undergraduate engineering students to learn the industrial hygiene requirements for the prevention of sars-cov-2 virus infection in the workplace. The teaching proposal also develops the critical sense to design ventilation systems in accordance with the standards that

minimize the biological risk. Thus, a learning activity is proposed in which three different initial ventilation requirements hypothesis are considered to calculate the necessary ventilation in the workplace. Subsequently, a simulation is carried out to obtain the probability of contagion in each of them and, in this way, to obtain information to make adequate decisions in the risk occupational prevention field.

In this activity, advanced concepts of ventilation facilities have been combined with contents of the field of industrial hygiene so that the student is able to model different risk situations based on different initial requirements for the quantification of the ventilation needed to reduce risks extracted from the normative and the literature. The students may realize that depending on the initial requirements and the geometry of the workplace, forced ventilation may or may not be necessary, so they will develop the critical sense in terms of the need to establish adequate calculation conditions to avoid the risk of contagion in the workplace to the maximum.

3.7 Manufacturing of a mechanical respirator valve in the context of e-learning methodology

This paper presents a project-based learning methodology (PBL) applied on an e-learning course in manufacturing process engineering. The students were proposed to design the manufacture process of a mechanical respirator valve for medical use, namely in covid cases. The paper describes the methodology and an analysis of the results of a questionnaire filled by the students. The issue is a very actual one, derived from the recent covid issues and represents an interesting adaptation of academia to the ongoing world problems. The paper fits perfectly into the new challenges of education in engineering, namely in the current covid-19 pandemic environment.

3.8 Crowd Orchestration - An EPS@ISEP 2021 Project (80)

This paper describes the different stages of an experience in the framework of The European Project Semester (EPS), a multicultural and multidisciplinary project-based learning semester offered by a network of providers, including the Polytechnic of Porto (ISEP). During the academic year 2020/2021, five EPS@ISEP students from different areas of studies and European countries teamed up to create a Crowd Orchestration solution for large outdoor festivals. To this end, the team designed a product called "ScanGo" with several features, such as real time alerts about the number of people in predefined areas, suggestion of alternative activities within the event or indication of the best route to go from one stage to another. This way, "ScanGo" also intends to minimise the effects of the undergoing pandemic, allowing people to safely experience open air festivals. This paper can be very inspiring and useful.

3.9 Reporting and Analysis of a Teaching Experience in Confinement Time

This work reports on the didactical strategies adopted in a 1st year Physics course, in (forced emergency) remote learning in the 2019/2020 academic year, during the COVID pandemic. From day to

night, teachers had to adopt their methodologies in a course in the field of electricity, with a laboratory component and more than 300 enrolled students. The head teacher decided to create a YouTube channel and prepared and made available a total of 25 short explanatory videos covering all the topics of the course (besides the "normal" material, such as the exercises, theoretical classes slides, etc., available via MOODLE).

3.10 Games: The Motivation in Engineering Education

Gamification – the use of games as educational tools in classes – is a powerful tool to motivate students and engage them in learning, being very appropriate for remote education. This work describes the inclusion of 7 games, one per week, in an 8 weeks' course addressing the topic "Information and Communication Technologies in Education". The games were selected according to the learning objectives of the course, each of them covering a different subtopic.

Authors conclude that the proposed educational games challenged students and increased their involvement having a positive impact in their success. Still, to take the most of it, game design must include multiple game mechanisms and be in accordance with the pedagogical context in which they are used.

4 FINAL REMARKS

This years' contributions were more focused on teachers' efforts to overcome the difficult situation COVID19 brought overnight and induced teachers to come up with new forms of developing students' competences in e-learning environments. Teacher' main concerns were students' involvement, collaboration with colleagues in teamwork, autonomy, and in making decisions. Students' perceptions were also taken in most of the presented works, showing teachers care for students' satisfaction and involvement in the learning process. The diversification of the presented solutions and the importance teachers gave to rich learning experiences allowed for the continuing of competences developing, close to their future profession. Some works not only describe experiences that were useful to students learning but also in developing solutions to aid specific areas deal with COVID19 strains, narrowing the bridge between academia and the professional world.

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