

Conference Academic Success in Higher Education

PORTO • 7-8 **APRIL** 2022

PROCEEDINGS BOOK

Alexandra R. Costa Amélia Caldeira Gustavo R. Alves









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HONOR COMMITTEE

(Chair) António Vega, School of Engineering, Polytechnic of Porto Ana María Castañón García, University of Léon Carlos Vaz de Carvalho, School of Engineering, Polytechnic of Porto Leandro da Silva Almeida, Institute of Education, University of Minho Matthias Ludwig, Goethe University Frankfurt, Germany Paula Peres, Accounting and Business School, Polytechnic of Porto Rui M. Lima, University of Minho

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MESSAGE FROM THE HONOR COMMITTEE CHAIR



Antonio Vega

Dear participants of CASHE 2022,

Three years have passed since the first edition of this conference. Three long years in which the world changed radically. We went through a global pandemic that changed habits, behaviors, ways of working and even of living. Nothing will be like before.

Higher education went through a time of constant and immediate challenges. We had to change the paradigms without time for reflection. Adaptation was the word that best represents the response that both institutions and teachers gave to these troubled times. And I think we passed this subject with distinction. We were able to transform ourselves, and with resilience, manage to minimize the impact of COVID 19 on the teaching-learning process.

The students also underwent an adaptation process. Sadly, many of them lost their experiences as students in a new cycle of their lives. But they also managed to overcome the difficulties and continue with their academic career.

And all this with recourse to new technologies and the implementation of pedagogical practices adapted to new media. This is the reason that brings us to these conferences, to learn about and discuss matters related to the academic success of our students and our institutions. We will try, with due humility, to answer the challenges that we foresee for the near future, knowing that predictions will not coincide with the speed at which changes occur.

I wish you a good reading.

MESSAGE FROM THE SCIENTIFIC COMMITTEE CHAIR



Gustavo R. Alves

Dear participants of the CASHE 2022 conference edition,

First, we would like to acknowledge all those authors who submitted their contributions to the CASHE conference. We received a total of 19 submissions (short and long papers) which were double-blind reviewed by the scientific committee members. Long papers were reviewed by three members while short papers were reviewed by two members. Contributions evaluated with a score higher than 10 (in a 20-points scale) were accepted, while those failing to meet this threshold were rejected. As a result, the scientific program of the CASHE 2022 edition includes 12 presentations, which represents an acceptance ratio of 63% (i.e., a rejection rate of 37%). These contributions will be presented in 3 technical sessions. One of these sessions gathers the contributions which have been signaled as candidates for the best paper award, providing an opportunity for the jury to assess the presentations in parallel with the technical quality already evaluated by the reviewers.

The conference program also includes one invited thematic session, two invited keynotes, and two roundtables, besides the traditional opening and closure sessions, the last one also including the delivery of the best paper award.

The invited thematic session, organized by Leandro Almeida, from the Education Research Centre of the University of Minho, addresses the topic of "Improving success in Higher Education". The invited keynotes will be delivered by Diana Mesquita, from the Portuguese Catholic University, and by Juarez Bento da Silva, from the Federal University of Santa Catarina, Brazil. Diana Mesquita addresses the topic "Do you feel students' resistance to active learning? Possibilities to the teaching practice" and Juarez Bento Silva addresses the topic "Academic trajectory linked to research and extension: the experience of the Laboratory of Remote Experimentation of the Federal University of Santa Catarina". The first roundtable will debate the contribution of Research Centers to the academic success of students who engage in R&D activities. The second roundtable will debate the impact of double degrees and internationalization in academic success, gathering Rectors from several Federal Institutes of Brazil, in a session moderated by Antonio Vega y de la Fuente, Vice-President of ISEP.

To conclude, I would like to thank the entire Scientific Committee, and each member individually, for their contribution to the scientific quality of the event, translated into a careful review of the submissions received and the feedback given to the authors.

Finally, I hope all CASHE2022 participants may enjoy the event to the fullest, interacting in it for the improvement of Academic Success in Higher Education.

Gustavo R. Alves

Gustavo R. Alves Chair of the Scientific Committee CASHE 2022

MESSAGE FROM THE ORGANIZING COMMITTEE



The CASHE 2022 Organizing Committee welcomes all those who, in person or online, join us in this space for reflection and debate on the students' academic success of Higher Education.

Academic Success in Higher Education 2022 is the second edition of a conference promoted and organized by Instituto Superior de Engenharia do Porto. Jornadas do Sucesso Académico (Academic Success Journeys) in April 2017 were the motto for the first Academic Success in Higher Education conference (CASHE) that happened in February 2019. The aim of these events is to bring together professors, researchers and students around the discussion of Academic Success of Higher Education students. It is a forum to discuss and exchange new ideas, novel results, work in progress, and experiences.

The concern with the conditions that promote student success has followed the evolution of Higher Education throughout history. In recent years, this concern has become particularly relevant, namely as a result of technological developments and especially the COVID-19 pandemic situation.

In this conference, which takes place for the second time in Porto, Portugal, we bring together professors, researchers, and students who, in a cooperative way, share knowledge, challenges and experiences around the theme of students' academic success of higher education.

Welcome to CASHE 22.

SCHOOL OF ENGINEERING, POLYTECHNIC OF PORTO (ISEP)



ISEP is a trademark of engineering education and innovation. Since 1852, we have been pioneering the training and specialisation of engineers with a strong and entrepreneurial mind-set.

Our academic community combines ambitious and dynamic people, who believe in the potential of innovation and technology to promote a sustainable development. **More than 6200 students and 500 faculty & staff** work motivated by the promise that engineering moves the world and create opportunities.

Students benefit from an excellent learning environment, a prestigious faculty and quality infrastructures. By exploring EUR-ACE and CDIO international best practices, we are creating opportunities for students to connect to the real-world and develop academic projects with companies and research groups.

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BACHELORS DEGREES (BSc)

(3 years * 180 ECTS units)

- Automotive Engineering
- Biomedical Engineering
- Bioresources
- Chemical Engineering*
- Civil Engineering*
- Electrical and Computer Engineering*
- Electrical Engineering Power Systems*
- Geotechnical and Geoenvironmental Engineering*
- Industrial Management and Engineering
- Informatics Engineering*
- Mechanical Engineering*
- Systems Engineering

*Quality European seal awarded in Portugal by the Engineers Professional Association

MASTERS DEGREES (MSc)

(2 years * 120 ECTS units)

- Bioresources
- Chemical Engineering*
- Civil Engineering
- Electrical and Computer Engineering*
- Electrical Engineering Power Systems*
- Development Practice
- Geotechnical and Geoenvironmental Engineering*
- Industrial Management and Engineering
- Informatics Engineering*
- Mechanical Engineering*
- Medical Computing and Instrumentation Engineering
- Sustainable Energies

*Quality European seal awarded in Portugal by the Engineers Professional Association

ACADEMIC PROGRAMMES IN ENGLISH

- Informatics Engineering (BSc and MSc)
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- Sustainable Energies (MSc)
- Electrical Engineering Power Systems (MSc)
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*Any other course requires 15 or more international students to enrol for a certain subject for it to be taught in English. It is also possible to welcome students to do a tailored project or a thesis, which can also be worked in English.

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At ISEP we have over 20 postgraduate courses, which are taught after work hours, in order to support the specialisation of professional engineers among other areas, also to develop high-performance teams.

Whether it is to change the professional area or just for the interest of those who want to learn more, the ISEP's postgraduate courses are a safe investment to get new added-value skills for the labour market.

Find more about these programmes at our website (www.isep.ipp.pt) or contact the Academic Office of ISEP (info-sa@isep.ipp.pt).

CASHE 2022 PROGRAMME

THURSDAY, 7th APRIL **CONFERENCE REGISTRATION** 9:00 Registration desk 9:30 OPENING SESSION · Sala de Atos (Building E) Antonio Vega, Gustavo R. Alves and Amélia Caldeira 9:45 INVITED SPEAKER 1 (presented by Gustavo R. Alves) JUAREZ BENTO DA SILVA ACADEMIC TRAJECTORY LINKED TO RESEARCH AND EXTENSION: THE EXPERIENCE OF THE LABORATORY OF REMOTE EXPERIMENTATION OF THE FEDERAL UNIVERSITY OF SANTA CATARINA. 10:30 SESSION 1 - SUBMITTED TALKS (chair Amélia Caldeira) MEASURING TEACHING SELF-EFFICACY IN PANDEMIC TIMES: A PRELIMINARY VALIDATION STUDY AMONG PORTUGUESE TEACHERS. Diana Aguiar Vieira, Sara Lima and Viviana Meirinhos PUBLISHING AND PRESENTING STUDENTS' RESEARCH: THE COMPUTER ENGINEERING SYMPOSIUM CASE. Piedade Carvalho, Nuno Morgado, Emanuel Silva, Sérgio Moreira, José Avelino, Marílio Cardoso, Dulce Mota and Constantino Martins MATHEMATICAL MODELING AND SIMULATION OF THE PENDULUM PHYSICAL SYSTEM IN MATHEMATICS LEARNING. José Magalhães, Floriano Viseu and Paula Mendes Martins 11:15 Coffee Break 11:40 SESSION 2 - SUBMITTED TALKS (chair José Rodrigues) THE USE OF A CLASSIFICATION TREE TO ANALYZE THE RELATIONSHIP BE-TWEEN SATISFACTION WITH STUDIES AND ENGAGEMENT IN UNIVERSITY DROPOUT. Celia Galve-González, Antonio Cervero, Elena Blanco, Jorge Maluenda-Albornoz and Ana B. Bernardo PRACTICE-ORIENTED APPROACH FOR TEACHING-LED **RESEARCH IN LOGISTICS.** Reinhold Schodl and Sandra Eitle MATHEMATICAL MODELING AND SIMULATION OF THE PHYSICAL SYSTEM OF PULLEYS IN MATHEMATICAL LEARNING. José Magalhães, Floriano Viseu and Paula Mendes Martins MATHEMATICAL MODELING AND SIMULATION OF AN PHOTOVOLTAIC PANEL SYSTEM IN GEOGEBRA AND ARDUINO.

José Magalhães

12:20 Lunch Time

14:30 ROUND TABLE 1 (moderated by Alexandra Araújo)

THE ROLE OF RESEARCH CENTERS IN PROMOTING ACADEMIC SUCCESS OF HIGHER EDUCATION STUDENTS.

CIETI - Center for Innovation in Engineering and Industrial Technology.
GECAD - Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development.
GILT - Graphics Interaction Learning Technologies.
GRAQ - Chemical Reactions and Analysis Group.
LEMA - Mathematical Engineering Laboratory

15:45 Coffee Break

16:00 SIMPOSIUM (Coordinator Leandro Almeida)

IMPROVE STUDENTS' SUCCESS IN HIGHER EUCATION CHALLENGING CONTEXTS

ADAPTING AS I GO: AN ANALYSIS OF THE RELATIONSHIP BETWEEN ACADEMIC EXPECTATIONS, SELF-EFFICACY AND ADAPTATION TO HIGHER EDUCATION. *Mafalda Campos & Francisco Peixoto.*

SUCCESS FACTORS IN LEARNING DURING PANDEMIC REMOTE CLASSES. Andréia Osti & Leandro S. Almeida.

PROMOTING ADAPTATION AND SUCCESS OF FIRST-YEAR STUDENTS. Joana R. Casanova, Maria Alfredo Moreira, Alexandra Gomes, & Leandro S. Almeida.

PROFESSIONAL IDENTITY DEVELOPMENT IN THE TRANSITION TO THE LABOUR MARKET: PERCEPTIONS OF GRADUATES. *Liliana Paulos, Sandra T. Valadas, & Leandro S. Almeida.*

FRIDAY, 8th APRIL

CONFERENCE REGISTRATION

8:45 Registration desk

9:00 ROUND TABLE 2 (moderated by Antonio Vega)

CONTRIBUTION OF DOUBLE DEGREES TO ACADEMIC SUCCESS

Deborah Santesso Bonnas

Dean Instituto Federal do Triângulo Mineiro (IFTM) and Vice-President of CONIF (Council of Deans of Federal Institutes of Brazil)

Oneida Irigon

Dean Instituto Federal de Goiás (IFG) and Coordenator of Chamber of International Relations of CONIF

Carlos Guedes

Dean of Instituto Federal de Alagoas (IFAL)

Jaime Cavalcante Alves Dean Instituto Federal do Amazonas (IFAM)

Carlos Mauro

Founder of CLOO Behaviral Insights Unit

10:00 SESSION 3 - SUBMITTED TALKS / BEST PAPER AWARD (chair Ana Moura)

EDUCATION FOR SUSTAINABLE DEVELOPMENT: ENGINEERING STUDENT SUCCESS WITH EPS@ISEP. Benedita Malheiro, Pedro Guedes, Abel J. Duarte, Manuel F. Silva, Paulo Ferreira

PROMOTING STUDENT'S SUCCESS THROUGH INTERNATIONAL COMPETITION ENGAGEMENT. *Filomena Soares, Ana Paula Lopes*

USING ORIGAMI IN MATHEMATICS EDUCATION. Michael Kleine, Judith Huget

PBL AS AN INTEGRATION ACTIVITY FOR NEW ENGINEERING STUDENTS AT ISEP. José Magalhães, Teresa Costa, Alberto Pinto and Christopher Sá

STUDENTS' PERCEPTION OF TBL CLASSROOM: A CASE STUDY FOR A PORTUGUESE SCHOOL OF ENGINEERING. Marina Sousa, Maria Cunha and José Salgado Rodrigues.

11:15 Coffee Break

11:40 INVITED SPEAKER 2 (presented by Antonio Vega)

DIANA MESQUITA

DO YOU FEEL STUDENTS' RESISTANCE TO ACTIVE LEARNING? POSSIBILITIES TO THE TEACHING PRACTICE.

12:25 CLOSING SESSION

Antonio Vega, Gustavo R. Alves, Juarez Bento da Silva and Diana Mesquita



KEYNOTE SPEAKERS AND PRESENTATIONS







KEYNOTE SPEAKERS AND PRESENTATIONS



Juarez Bento da Silva

ACADEMIC TRAJECTORY LINKED TO RESEARCH AND EXTENSION: THE EXPERIENCE OF THE LABORATORY OF REMOTE EXPERIMENTATION OF THE FEDERAL UNIVERSITY OF SANTA CATARINA

The lecture will focus on the research and extension actions carried out by RExLab throughout its 25 years of activities, mainly on the attraction and training strategies of scholarship holders. Throughout these years, RExLab has hosted a total of 200 scholars from the most diverse educational levels, that is, Basic Education, with high school scholars, to post-doctoral fellows.

RExLab seeks to value the work of Scientific Initiation scholarship holders (SI), assigning them relevant activities and protagonism in research and extension projects, as well as in the scientific production of the nucleus. The active participation of the scholarship holders in the projects offers them the opportunity to know a whole network of researchers in which RExLab is inserted, whether they are students or teachers. This networking has been shown to be important, for example, to provide exchange opportunities for scholarship holders, in addition to providing contact with researchers and research projects coordinated by experienced professors, in Brazil and abroad. This conjuncture certainly brings various advantages of SI in the curricula, in professional growth and in the academic maturation of the participating students.

SHORT CV

Juarez Bento da Silva holds a degree in Business Administration at the Pontificia Universidade Católica do Rio Grande do Sul (1991), a Master's in Computer Science at the Universidade Federal de Santa Catarina (2002), a PhD in Engineering and Knowledge Management at the Universidade Federal de Santa Catarina (2007) and a Post-Doctorate at the Instituto Superior de Engenharia do Porto, Portugal (2016). He is currently an Associate Professor at the Universidade Federal de Santa Catarina, where he works as a professor in the undergraduate courses in Information and Communication Technologies and in the Graduate Program in ICT, where he is also sub-coordinator. He is member of the Remote Experimentation Laboratory (RExLab) research group, where he is coordinator. He has about 150 publications of articles in journals, books and book chapters. Regarding research and extension projects, these are primarily aimed at the integration of technologies in education, with the development and availability of virtual and remote laboratories being one of the main lines of action.



Mesquita

DO YOU FEEL STUDENTS' RESISTANCE TO ACTIVE LEARNING? POSSIBILITIES TO THE TEACHING PRACTICE

Much has been written about the use of active learning in Higher Education, highlighting its benefits. The research also shows that teachers' adoption of active learning has been slow. The most common barriers identified concern student resistance which can be understood as 'any negative behavioural or attitudinal response to a teaching practice that could discourage instructors from using active learning' (Andrews et al., 2020, p.143). This talk aims to explore possibilities to the teaching practice, in order to mitigate students' resistance to active learning.

SHORT CV

Diana Mesquita is currently an invited Assistant Professor at the Universidade Católica Portuguesa, Faculty of Education and Psychology, Porto, Portugal. She holds a PhD in Educational Sciences, specialized in Curriculum Development from University of Minho, Portugal. She delivered more than 60 workshops dedicated to teacher training in Portugal, Brazil, Colombia, Russia and Thailand. She participated in several national and international projects, organized more than 20 national and international conferences and has around 80 publications of articles in international journals, book chapters and scientific events. Her research interests include active learning, project-based learning, teacher professional development, curriculum innovation, higher education and engineering education. She is a member of the Portuguese Society of Educational Sciences (SPCE) and of the Portuguese Society for Engineering Education (SPEE). She is also a scientific reviewer in several leading journals, such as the European Journal of Teacher Education (Routledge) and Journal of Engineering Education (Wiley).



ROUND TABLES







ROUND TABLE 1

THE ROLE OF RESEARCH CENTERS IN PROMOTING ACADEMIC SUCCESS OF HIGHER EDUCATION STUDENTS.

Alexandra Araújo (Coordinator)

R&D Centres

CIETI

Center for Innovation in Engineering and Industrial Technology *Gustavo R. Alves*

GECAD

Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development. *Goreti Marreiros*

GILT

Graphics Interaction Learning Technologies. Nuno Escudeiro

GRAQ Chemical Reactions and Analysis Group. *Hendrikus Nouws*

LEMA

Mathematical Engineering Laboratory Manuel Cruz

ROUND TABLE 2

CONTRIBUTION OF DOUBLE DEGREES TO ACADEMIC SUCCESS.

Antonio Vega (Coordinator)

Invitees

Deborah Santesso Bonnas Dean Instituto Federal do Triângulo Mineiro (IFTM) and Vice-President of CONIF (Council of Deans of Federal Institutes of Brazil)

Oneida Irigon Dean Instituto Federal de Goiás (IFG) and Coordenator of Chamber of International Relations of CONIF

Carlos Guedes Dean of Instituto Federal de Alagoas (IFAL)

Jaime Cavalcante Alves Dean Instituto Federal do Amazonas (IFAM)

Carlos Mauro Founder of CLOO Behaviral Insights Unit



SIMPOSIUM





SIMPOSIUM

IMPROVE STUDENTS' SUCCESS IN HIGHER EUCATION CHALLENGING CONTEXTS

Leandro S. Almeida (Coordinator)

There are many challenges facing Higher Education today, some of which are equally challenging for its students. Social pressures to change in teaching practices or the diversity of students entering this level of education have modified attitudes of self-isolation or some elitism on the part of institutions and their teaching staff. The new demands for a more professional training, the diversity of students, the changes in the methods of teaching and learning, which have been developed in recent pandemic conditions, for example, demand more attention to the academic processes with ensure the permanence, success and employability of graduates. With this objective, this symposium was organized by integrating four communications.

ADAPTING AS I GO: AN ANALYSIS OF THE RELATIONSHIP BETWEEN ACADEMIC EXPECTATIONS, SELF-EFFICACY AND ADAPTATION TO HIGHER EDUCATION

Mafalda Campos & Francisco Peixoto

ISPA - Instituto Universitário | Centro de Investigação em Educação (CIE-ISPA)

Transition to higher education is increasingly becoming a more common stage in young adulthood. Positive academic experiences are benefic for students and can lead to the development of professionals and citizens that contribute in a positive way to society. Therefore, it is necessary to study and understand what contributes for a good adaptation to higher education. This study resorted to a Portuguese sample of college students and aimed to assess, through structural equation modeling, a model describing the relationship between academic expectations, self-efficacy and adaptation to higher education. With a longitudinal design, the Questionnaire for Academic Expectations (T1 and T3), Self-Efficacy in Higher Education Scale (T2 and T3), and the Questionnaire for Higher Education Adaptation (T2 and T3) were applied. With previous scale validation, the model revealed a good fit correlating general indices of the variables mentioned, noticing specifically that expectations and self-efficacy mutually influenced each other from 1st to 2nd year. Also, a mediation model was tested where a full mediation role of self-efficacy was observed for the relationship between academic expectations and higher education adaptation. Results and limitations are discussed, and some future directions are suggested.

SUCCESS FACTORS IN LEARNING DURING PANDEMIC REMOTE CLASSES

Andréia Osti & Leandro S. Almeida UNESP & Instituto de Educação, Universidade do Minho

This presentation analyses success factors in Brazilian college students in the context of remote classes due to the pandemic. Specifically, it was investigated under what conditions the students were able to follow the classes in a virtual way, considering the material conditions, as well as the space and time available for the study. A sample of 800 Brazilian university students from different courses was considered. Data collection was carried out in the form of an online invitation sent by e-mail and with a link to access the questionnaire. The results indicate that 76% were living with their families and that 77.9% were able to carry out online classes normally and that they had all the resources, such as good quality internet and notebook. Of these, 85.6% had individual space to study or only shared a room, which was one of the main factors for success, since they were able to have privacy and better organize themselves with academic activities. These results make it possible to infer that for this group of students, the success factor was the result of home conditions, especially having specific space and time dedicated to studies, which depended on the understanding and support of family members to respect their study needs and their own organization in terms of managing and maintaining a study routine. A positive factor highlighted by students in online classes was the fact that classes are recorded, which allows to watch again to study and ask questions.

PROMOTING ADAPTATION AND SUCCESS OF FIRST-YEAR STUDENTS

Joana R. Casanova, Maria Alfredo Moreira, Alexandra Gomes, & Leandro S. Almeida CIEd & CIEC, Universidade do Minho

The transition of students to higher education involves a wide range of challenges that justify different institutional practices to promote student autonomy and facilitate their academic adaptation. The containment and sanitary conditions associated with COVID-19 have increased these adaptation difficulties, and several preventive programs have been implemented to ensure academic success and prevent student dropout. In this presentation, a support program for first-year students belonging to courses in the field of education is described. The program included three 50/60 minute sessions: the 1st session focused on verbalizing the demands, challenges and difficulties in academic adaptation and on learning and academic achievement. The main results point to the satisfaction of students with the activities of the sessions and with their usefulness to face the challenges of academic adjustment. Students report high levels of satisfaction with their access to and attendance at higher education, but they also report some emotional distress due to the diversity and quantity of academic activities. It is recommended to continue the program with some improvements in its planning taking suggestions from the students themselves.

PROFESSIONAL IDENTITY DEVELOPMENT IN THE TRANSITION TO THE LABOUR MARKET: PERCEPTIONS OF GRADUATES

Liliana Paulos, Sandra T. Valadas, & Leandro S. Almeida CIEd, Universidade do Minho & CEAD, Universidade do Algarve

The present communication focuses on the perceptions of higher education graduates about the development process of their professional identity and has the main aims of identifying the moment(s) at which graduates develop their professional identity; and the factors influencing their formation. Data were collected by means of twenty-four in-depth interviews with graduates from two Portuguese public higher education institutions, from various scientific areas, and who have been in the labour market for at least 18 months. Content analysis was performed, and the main a posteriori categories emerged: (i) before entering Higher Education (subcategories: contact with reference people and with the environment: learning and experiences during secondary education); (ii) during Higher Education (subcategories: curricular content and activities; extracurricular activities and internships); (iii) entry into the labour market (subcategories: social comparison; recognition of others significands). Results show that graduates' identification with a profession is a continuous process that begins before the transition to the Higher Education and extends throughout higher education and during the professional practice. Socio-institutional factors influencing the professional identity formation were also identified: social and environmental, school, and academic influences, on-the-job learning, social comparison, and recognition of others significant.



SUBMITTED TALKS







EDUCATION FOR SUSTAINABLE DEVELOPMENT: ENGINEERING STUDENT SUCCESS WITH EPS@ISEP

Benedita Malheiro^{1,2}, Pedro Guedes^{1,2}, Abel J. Duarte^{1,3}, Manuel F. Silva^{1,2}, Paulo Ferreira¹

¹School of Engineering, Polytechnic of Porto, Porto, Portugal, {mbm,pbg,ajd,mss,pdf}@isep.ipp.pt ²INESC TEC, Porto, Portugal ³REQUIMTE, School of Engineering, Polytechnic Institute of Porto, Porto, Portugal

Abstract. Motivation is the key to academic success. In the case of engineering, autonomous project teamwork guided by ethics and sustainability concerns acts as a major student motivator. Moreover, it empowers students to become lifelong learners and agents of sustainable development. Engineering schools can thus address simultaneously these two essential education goals – learning and academic success – by challenging students to find innovative, sustainable solutions in a learner-centred set-up. This paper describes how the European Project Semester (EPS), a capstone engineering programme offered by the Instituto Superior de Engenharia do Porto (ISEP), combines challenge-based learning, ethics and sustainability-driven problem-solving, and international multidisciplinary teamwork to achieve both goals.

Key words: Academic Success, Challenge-Based Learning, Engineering Education for Sustainable Development, European Project Semester, Multicultural and Multidisciplinary Teamwork, Project-Based Learning, Problem Solving.

INTRODUCTION

Educational literature has long identified strong correlations between student motivation and academic success (Haughery *et al.*, 2019). Academic success, which implies successful learning, involves academic achievement, satisfaction, attainment of learning outcomes, persistence, career success, acquisition of skills and competencies (York *et al.*, 2015).

To promote academic success among engineering undergraduates, programmes need to attract, motivate, and revolve around the learner. In this context, capstone design projects emerge as a promising learning framework. Specifically, assessment surveys have shown that: (*i*) students rank capstone activities highly (Lopatto, 2009); and (*ii*) undergraduate research programmes bring clear benefits for participating students (Fechheimer *et al.*, 2011). Moreover, to further motivate students, project briefs must address individual, social or planetary problems students relate with, be open-ended to promote innovation, and constitute meaningful challenges for students, namely, related to sustainable development. This idea of using active learning strategies, namely, challenge-based learning, to support integrative approaches to sustainability in higher education is advanced by several researchers, *e.g.*, Leal Filho *et al.* (2016) and Martínez Casanovas *et al.*, (2021).

This is the case of the European Project Semester (EPS), a semester-long student-centred engineering capstone programme (Duarte *et al.*, 2020). EPS integrates challenge-based learning with multicultural and multidisciplinary teamwork as well as challenges students to solve real problems following ethics and sustainability driven practices (Nylund & Malheiro, 2022). As such, it aims to motivate engineering students to become active proficient learners and future agents of sustainable change, promoting academic, personal,

and social success. To prove such claim, the current contribution analyses the programme in terms of the academic achievement of the 228 alumni.

This document is organized in five additional sections. Section two presents the background; Section three engineering education for sustainable development and learner motivation; Section four the EPS concept and its implementation at ISEP; Section five analyses the academic success within EPS@ISEP; and Section six draws the conclusion.

BACKGROUND

The continuous demographic growth, associated with the rising expectations of populations, have placed unparalleled challenges to the planet. Pollution and depletion of resources such as water, soil or air, place enormous pressure on all habitats, leading to the extinction of species and the proliferation of others, irreversibly unbalancing the entire planet.

In 1972, the United Nations held the first world conference to address the impact of human activities in the environment. But it was not until two decades later, in Rio de Janeiro, that more than half of the world countries were able to commit to the preservation of the environment in the "Rio Declaration on Environment and Development", often shortened to "Rio Declaration" (United Nations, 1992). The fate of humanity could no longer be separated from that of the environment. Applications of the Rio Declaration were generic and quite ambitious, being difficult to implement. More recently, the United Nations launched a series of 17 sustainable development goals, with implementation starting in 2016, achievable in 15 years, with the principle of "leaving no one behind" (United Nations, 2022). These 17 goals relate to poverty, inequality, climate, environmental degradation, prosperity, peace, and justice. The achievement of these goals contributes to a more sustainable world.

The UNESCO report on engineering for sustainable development highlights the crucial role of engineering in achieving the sustainable development goals (UNESCO, 2021). Engineers are vital in addressing basic human needs such as alleviating poverty, supplying clean water and energy, responding to natural hazards, constructing resilient infrastructure, and bridging the development divide, among many other actions, leaving no one behind (UNESCO, 2021). Nonetheless, the question is how can engineers coordinate and apply appropriate practices and ethics to ensure they are living up to these goals (World Engineering Day, 2021). According to Kemp (2006), technological innovation can be a useful tool for achieving sustainable development. Therefore, making technology students aware of sustainability boundaries and tools is an important educational task for higher education. Developing sustainability competencies amongst graduates is particularly critical to the development of sustainability literacy and for students to become positive change agents in their workplace and personal lives (Sipos, 2008 in Cebrián *et al.*, 2019).

ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT

Education for Sustainable Development (ESD) aims to train future leaders to become responsible managers of the common resources considering the environment, economics, and equity (Radhakrishnan, 2018). There is a consensus regarding the adoption of student-centred approaches to tackle engineering ESD: UNESCO declares that active learning methodologies foster the acquisition of the sustainable development competencies required

to achieve the 2030 Agenda (UNESCO, 2021); Takala & Korhonen-Yrjänheikki (2019) state that collaborative learning, open dialogue, and innovation are at the heart of ESD; and Tejedor Papell *et al.* (2021) refer that challenge driven education can bridge engineering and sustainability. Specifically, in challenge driven education, students work on real-life and often real-time challenges affecting society and industry. The students address open-ended, ill-defined problems that can have multiple solutions to position ideas, innovations and decision making in the forefront of the learning process. Particularly, the design of sustainable solutions and exploration of alternatives requires sound scientific and technological knowledge as well as openness to innovative ideas. To explore as many possibilities as possible, the student is stimulated to research, plan, and debate, collaborating with and championing his/her team (Warburton, 2003).

The integration of ESD into engineering degrees contributes to the development of skills related to sustainability, such as critical and creative thinking, problem solving, capability to act, collaborative competence and systemic thinking (Segalàs & Sánchez-Carracedo, 2020). In this respect, Takala & Korhonen-Yrjänheikki (2019) identify as key engineering ESD competencies holistic understanding, communication and collaboration skills, ability and willingness for critical and reflective thinking, creativity, innovativeness, and entrepreneurship. Considering capstone programmes, Malheiro *et al.* (2019) propose the 4C2S framework to analyse the contributions made by a capstone programme to the critical professional competencies. These include thinking and problem solving, effective communication, collaboration and team building, and creativity and innovation— known as the four C—as well as socio-professional ethics and sustainable development-oriented practices—referred as the two S. 4C2S maps the aims, learning processes, and mandatory deliverables of capstone programs to the development of these six core competencies.

LEARNING FRAMEWORK

EPS was designed by Arvid Andersen in 1995 to prepare engineering undergraduates to become global professionals. This learner-centred programme adopts project-based learning, multicultural and multidisciplinary teamwork, and promotes learning autonomy and responsibility. The aim is to develop sound scientific and technical competencies together with interpersonal skills, such as intercultural and interdisciplinary communication and teamwork, preparing engineering undergraduates to work in international teams and solve multidisciplinary problems. The teams are always multicultural and multidisciplinary, guaranteeing interaction between four to six students from distinct cultures and fields of study. According to Arvid Andersen (2004), EPS prepares engineering students to work in a global environment, to co-operate, to communicate and to compete. EPS is currently offered by a network of nineteen universities, called EPS providers, located in twelve European countries (European Project Semester, 2022). This is the case of Instituto Superior de Engenharia do Porto (ISEP), which runs EPS in the spring semester for more than a decade.

The programme corresponds to 30 European Credit Transfer System Units (ECTU) distributed by six modules: Project Management and Teamwork (2 ECTU), Marketing and Communication (2 ECTU), Foreign Language (2 ECTU), Energy and Sustainable Development (2 ECTU), Ethics and Deontology (2 ECTU) and 20 ECTU assigned for the Project module. At the core of this framework is the Project module. It challenges teams to find innovative sustainability-driven solutions for real problems (Silva *et al.*, 2018).

Projects briefs always gravitate around sustainability. Regardless of the nature of the problem, all projects must follow ethics and sustainability-driven design and development practices. Nonetheless, multiple projects related to sustainability have been developed, mainly addressing food production, smart cities, and robotics. The teams must consider the ethical, social, economic, and environmental impact of the designed solutions, namely, in terms of resources, materials and components used in the prototype, product, packaging, production, logistics, and marketing.

ACADEMIC SUCCESS

The current analysis uses historical data from the cohort of 228 international engineering, business and design students who participated in EPS@ISEP between 2011 and 2021. These students were organized in 45 teams of four to six, comprising several nationalities, fields of study and Belbin team role profiles. The teams choose 45 project briefs addressing problems directly related to sustainability (58 %) as well as to other (42 %) areas (Table 1).

Table 1: Problems addressed by developed projects.

Problem Area	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Sustainability	0	2	2	2	4	3	3	3	3	3	1
Other	2	2	1	3	1	2	1	1	1	3	2

In the analysed period, two students did not complete the programme and, as such, were not classified, resulting in an overall success rate of 99 %. Figure 1 displays the grade histogram of the classified students (left) and the average project grade per problem area (right). The comparison between the average grades of EPS@ISEP (77 $\% \pm 10$ %) and ISEP students (71 $\% \pm 7$ %) on the sixth semester shows the higher achievement and motivation of EPS@ISEP students. The difference between the average grade of sustainability-related projects (79 $\% \pm 5$ %) and that of other projects (81 $\% \pm 4$ %) is not relevant.



Figure 1: Individual grade histogram (left) and average project grade per problem area (right).

Finally, to determine the extent to which a project addressing a non-sustainability related problem follows sustainable design and development practices, the 4C2S analysis framework was applied to the Pet Tracker project developed in 2013. The results showed it fostered the desired 4C2S competencies in the team members, namely the much-sought combination of soft, hard, ethics and sustainability related skills (Malheiro *et al.*, 2019).

CONCLUSION

In EPS@ISEP, academic success and learning emerge from motivating and focusing on the learner. To do so, it adopts student-centred learning strategies; proposes real problems students relate with; exposes students to multicultural and multidisciplinary teamwork; and challenges students to find innovative solutions supported by ethical decision-making and sustainability-driven design.

The 4C2S capstone analysis framework, the achieved success rate and the grades obtained by the students attest that this combination promotes academic success, autonomous learning, and essential professional skills. Finally, this work suggests the need to identify and collect motivational indicators, namely to assess the influence on academic success of prior knowledge, cultural and personality traits as well as personal and professional projects.

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MATHEMATICAL MODELING AND SIMULATION OF THE PENDULUM PHYSICAL SYSTEM IN MATHEMATICS LEARNING

José Magalhães¹, Floriano Viseu² and Paula Mendes Martins⁴

¹DMA-School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>idm@isep.ipp.pt</u> ²CIEd-University of Minho, Braga, Portugal, <u>fviseu@ie.uminho.pt</u> ³DMAT– University of Minho, Braga, Portugal, <u>pmendes@math.uminho.pt</u>

Abstract. In the CDIO model and EUR-ACE certification, project development experiences providing team activities are foreseen since the 1st year of engineering courses. In order to evaluate the contribution of PBL activities in the learning of mathematical content, a multidisciplinary project was carried out in an engineering degree at School of the Porto Polytechnic (ISEP), which involved the construction and simulation based on the physical model of the concept of pendulum. To understand the meaning of the PBL task in the learning of mathematical contents from the students' perspective, we adopted a qualitative approach, collecting data from reports written by the students and their public oral presentations. We present the stages of the task development, the results obtained by the students and their public soft their perceptions of the PBL accomplishment. The results indicate that students recognize the usefulness of carrying out projects in their academic training and to prepare professional future.

Key words: Learning; PBL; CDIO; Simulation; Modeling; Mathematics; GeoGebra.

INTRODUCTION

Project activities in a project-based learning (PBL) methodology starting in the 1st year of engineering courses can be an integrating factor for new students. The existence of these activities is advocated in the CDIO model (Crawley et al., 2007) and in the EUR-ACE degree recognition system (Malmqvist, 2009), in which the students should be trained to develop skills in solving technical problems, carrying out projects and developing research activities, considering communication, leadership and ethical principles.

In the academic year 2013/14, the course coordinator of Mathematics Laboratories I (LMAT1) proposed to the 1st year students of the Electric Power Systems degree to carry out a project involving mathematical modelling and simulation of a system based on the physics of the "Pendulum" and the creation of an experimental physical prototype. The goals of carrying out this activity together with two other Curricular units (CU's), Mathematical (MATE1) and Working Methods in Engineering (MTENG), were: to develop mathematical calculation capabilities; to stimulate problem modelling and simulation; to write a written report and oral communicate results; to manage the project and integrate students in work teams. The results of this type of PBL activity, integrated with other curricular units, involving learning contents of the last ones, proved to be motivating and learning enhancing for students.

THEORETICAL FRAMEWORK

In learning mathematical concepts, especially in higher education, the design of tasks should make sense in the activities of students (motivation). In mathematics, in particular, one can

characterise some tasks that involve problem solving and project-based learning (PBL) methodology as shown on the diagram in Figure 1.



Figure 1: PBL-based mathematical learning activities.

These PBL-based activities provide advantages and a better learning experience for students. **Mathematical modelling** (Silva, 1994) consists of a cycle composed with a set of steps as shown in Figure 2.



Figure 2: Mathematical modelling cycle (Silva, 1994).

Mathematical modelling enables the transformation of a real situation into a mathematical situation (Biembengut & Hein, 2000). The experience combined with objects properties models and technological ways constitutes a mathematical simulation (Bellemain, Bellemain & Gitirana, 2006). Simulation is a good support in mathematical learning (Figure 3).



Figure 3: Advantages of mathematical simulation (Bornatto, 2002)

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METHODOLOGY AND GOALS

To fulfil the aim of the study, a teaching experience, based on PBL, was implemented with 81 students of the 1st year of the degree in Electrical Power Systems Engineering (LESEE), in the curricular unit of Mathematics Laboratories I (LMAT1) together with two other curricular units of the 1st year, Mathematics I (MATE1) and Working Methods in Engineering (MTENG). The integrate project "Pendulum" is a mathematical project inserted in a physics and engineering context, in which mathematical modelling and simulation of a pendulum by a software (GeoGebra) and the physical implementation of a prototype are used. The project was composed by four tasks: Task 1, elaboration of a simulator in software for the Simple Pendulum; Task 2, elaboration of a simulator for the power series of functions and with application to the physical models under study; Task 3, physical implementation and programming of its simulation in GeoGebra; Task 4, elaboration of a report and public oral presentation of its results.

In view of the project requirements, students delivered, in two stages, preliminary written responses to parts of the project and subsequently a final report. These written documents were analysed at each of these delivery stages and their deficiencies were communicated to the students to correct them. Afterwards, the students made a public presentation of the project results and showed the physical prototypes they made. The information presented in this paper is derived from the collected data of students reports and public presentations.

RESULTS

This section describes the main tasks proposed to students and exemplifies solutions created by the professor and students in response to those tasks.

Task 1 - Simulating the Simple Pendulum

With Task 1 the learning of parametric and trigonometric functions was intended. The physical system constituted by a simple pendulum without friction forces to considered and the example built by the professor is represented in Figure 4.



Figure 4: Applet, in Geogebra, to simulate the pendulum model (Professor).

Following the answer given by a group of students, to simulate the pendulum model in GeoGebra applet the user can vary its length, initial mass position angle and the value of the acceleration of gravity, as illustrated in Figure 5.



Figure 5: Applet, in GeoGebra, to simulate the pendulum model (Student).

The simulator allowed supported the students' answers to a set of mathematical questions in the physical context of the pendulum, such as: Visualisation of the pendulum movement; Determination of gravity acceleration in situations of different location of the pendulum; Providing specifications for the construction of a classical pendulum clock.

Task 2- Simulator for power series of functions with application to the pendulum

In Task 2 it was intended the construction of an applet in Geogebra that allows the user to find a polynomial approximation to a function f(x). It was possible type f(x), select the order of the polynomial n, the centre of the series a and a point x1 to analyse the approximation. The images in Figure 6 show an applet built by the professor and the group of students, respectively, in response to the request.



Figure 6: Geogebra Applet about Taylor series.

The development of the Taylor series simulator supported students in: understanding the concepts of function series; helping them to answer questions in the mathematical and physical context, such as, through Taylor approximations, determining the numerical value of \sqrt{e} , visualising approximations of the pendulum angle $\theta(t)$ or gauging the movement of a pendulum clock through the frames of a photographic system.

Task 3 - Physical implementation of a system that makes use of the Pendulum

This task 3 aimed at the physical construction of a system including the pendulum(s) and a computer simulation of all or part of its functioning, as shown in the images in Figure 7 of the teacher's simulator (a) and an example constructed by a group of students (b) during their public oral presentation of results.



Figure 7: Public presentation by a group of students of the pendulum project task.

This same group mentioned during their presentation that,

... Physics was always present. Without Physics, we probably wouldn't have been able to answer all the questions in the Project task. We think that there was a strong articulation between the programmatic contents, interconnection and this type of training is an added value to our course. This way we learn in different contexts, and it helps us to assimilate the theorical concepts. MTENG unit was important in helping us to write reports, make oral presentations, and in time and resource management. The project preparation work, interconnection of different units and teamwork gave us useful skills for the future in the labour market.

Task 4 - Elaboration of a report and public presentation of its results

This activity culminated in a written project report and a public oral presentation of the project results by the students. Figure 8 shows some examples of prototypes and moments of public oral presentations made by other student groups.



Figure 8: Public presentations by student groups on the pendulum project task.

Students recognise the acquisition of new learning skills with the completion of a PBL task:

With this work, we were able to improve our management and project implementation skills. What we learned in the project allowed us to gain a new perspective on manipulating formulas with GeoGebra and have a better understanding of applying mathematics to a real situation.

In the comments of the student groups was noticeable that carrying out the PBL-type tasks provided them with good motivation for learning.
CONCLUSIONS

The project is by excellence a task that allows integrating multidisciplinary transversal skills - Mathematics, Physics and Engineering - of working in a social context (team) in engineering students and integrating new students (Magalhaes et al, 2018). With the project task, students performed mathematical activities of mathematical modelling (Biembengut & Hein, 2000) and simulation of physical processes that can contribute to enhance more meaningful mathematical learning. The project task promoted the construction of mathematical and physical knowledge related to the project theme, as advocated in the CDIO standards (Crawley et al., 2007; Malmqvist, 2009) and the EUR-ACE outcomes (Malmqvist, 2009). Most of the transversal competences listed were recognised by the students, such as project management, writing the final report and oral communication of results. This fact is a consequence of the fact that the project involved other curricular units that reinforced these transversal components. Regarding GeoGebra software, it facilitates the rapid elaboration of simulations and the construction of dynamic applets, develops intuition and visualisation skills.

With the completion of this project task, the students highlight the consolidation of knowledge about the topics studied, particularly the Taylor series, and knowledge of Physics. Students recognise that this type of project-based task brings them additional learning motivation due to the fact that it is integrated with several curricular units. The motivation factor derives from the inclusion of real physical contexts, from being a practical activity of developing software simulators and real prototypes, carried out cooperatively among the group elements. Students identified that the activities developed during the project contributed to the acquisition of skills that will be useful to them in their professional future. Not everything about this PBL activity should be positive and, as such, it will be analysed in future work, based on the analysis of interviews and questionnaires answered by these and future students.

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PBL AS AN INTEGRATION ACTIVITY FOR NEW ENGINEERING STUDENTS AT ISEP

José Magalhães¹, Teresa Costa¹, Alberto Pinto¹ and Christopher Sá¹

¹School of Engineering, Polytechnic of Porto, Portugal jdm@isep.ipp.pt; mco@isep.ipp.pt; apo@isep.ipp.pt; cas@isep.ipp.pt;

Abstract. Integration of new students in higher education needs Project-Based Learning (PBL) challenges with social interaction as recommended by CDIO (Conceiving, Designing, Implementing, and Operating) initiative and EUR-ACE label. Engineering Lab I is a unit of the Systems Engineering degree at School of Engineering - Polytechnic of Porto (ISEP) which uses this PBL-based teaching and learning methodology during the first 4 weeks of the 1st semester. To fulfil the aims of the project most students use the existing free web platform Wix to create a web page, Adobe premiere for video edition, Google Forms for surveys, and PowerPoint for oral presentations. From students' reports, it is written that this type of learning strategy motivates them to learn and 88% confirmed the importance of this unit in student integration on the class, campus, and city. Moreover they acquire a set of ethical and social skills such as teamwork, research, inter and intragroup communication that will be useful for the future job.

Key words: Engineering Education, PBL, CDIO, EUR-ACE, Group Activity, Communication.

INTRODUCTION

New students entering higher education always have a period of adaptation because of new habits, community, physical space. However, it is not always easy and sometimes they find it difficult to adapt (Santos, 2001), which will imply learning failure. This maladaptation has its origin in many factors, among these there are the working rhythm, time management, family distance and higher number of students per class (Bento, 2008). To reduce these difficulties, it is important that teachers from first semester give a motivation boost using a different teaching method. A strategy that involves commitment, communication, new technologies, not clinging to usual motto "everything before was good, the students were better, everything worked better, education was good" (Zabalza, 2005, p. 89).

The ISEP's Degree in Systems Engineering (LES) intends to use a learning methodology based on some of the CDIO requirements as Crawley, Malmqvist, Östlund & Brodeu, 2007, namely the inclusion of integrative projects in different areas of engineering and the cooperative work among students. Accordingly, it was decided to introduce in its 1st year curricular plan the unit Engineering Lab I (LENG1), which takes the PBL methodology as its educational principle. Students attend this unit during the first 4 initial weeks of the course, without the coexistence of other subjects, and must carry out two small challenges where they show personal, interpersonal, and multidisciplinary easy skills. The first of these challenges fully serves the acquisition of soft skills and the second, more comprehensive, aims to create the first prototype involving some electronics and its respective low code use.

This work describes the implementation of the first challenge or microproject since 2016/17 till 2020/21 and gives examples of some of the activities carried out. It is also added the students' point of view and measures to improve to help for a better integration of the new students.

THEORETICAL FRAMEWORK

Project-based learning (PBL) is a trend expressed in the intentions of various engineering teaching programmes (Crawley, Malmqvist & al., 2007; Masson, Miranda & al., 2012). The implementation of a problem/project allows students to acquire scientific and technological knowledge, time management, including environmental and social issues like sustainability, communication, teamwork, self-evaluation and peer evaluation, etc.; valuing attitudes of ethics, responsibility towards colleagues, community and society. In the PBL methodology, the teacher's role will be that of a learning 'coach', making students aware of what they already know and what they need to learn, motivating them to search for information. It is up to the students to take responsibility for their own learning.

ISEP has aligned the learning methodologies in the units of its Courses based on the requirements defined in the CDIO educational initiative. This model includes standards of good practice in education and foresees the existence of project activities, normally in integrative units with student teams and in environments that simulate professional activity (Chowdhury, Bhaduri & Murzi, 2021). The learning environment should lead to a practice based on the design in which students should be directly involved. Problem solving should not emphasise the passive transmission of information, but involve students in manipulating, applying, analysing, and evaluating ideas. These indicators suggest that students discuss what they are learning with each other and with others.

METHODOLOGY

In LENG1, since 2016/17 till 2020/21, a teaching and learning methodology based on PBL was implemented and applied to students entering the 1st semester of LES degree. In this unit, students' integration begins with a plenary session where it is described and explained the main topics of the course (mission, curricular plan, schedule, training opportunities, Erasmus mobility and examples of student successes). Then it is asked a personal presentation of each student to the group, which includes where he comes from, what he likes and dislikes on his free time (music, sport, ...) and what are his course expectations. This short information is crucial to have an opinion and decide who they will choose for a 4-member group to work with.

After this introduction, the unit is explained with a framework, purposes and objectives, programme, most important studying material and tools, evaluation, final classification formula and schedule outcomes. Each group is assigned with one research topic, entitled "Top 4/5", requiring 4/5 characteristics that must be developed. The aims are fundamentally: (i) integration of students into the LES community, ISEP campus and Porto city; (ii) use of a free internet tool to build a website and free software to make a video; (iii) use of Excel to make 3 demonstration graphics; (iv) oral and panel presentation techniques; (v) soft skills workshops.

This document presents the results obtained by one group of students assigned with the topic "Integration tips for new students in LES degree" and considers their written report (Yin, 2003) and their website built and public presentation slides.

RESULTS

The 4-member group with the topic "Integration tips for new students in LES degree" started their activity by searching the Web for their theme. Teacher gave simple-to-use tools to build a free website and introduce freeware Apps to edit and create a video and to make a public survey. Students managed their work assigning tasks to each other: some learned how to use the free tools to build the website, others immersed in the free software to edit/record videos, also others developed criteria (Table 1) to give a good answer to the assigned topic.

Year	Criteria
2016/17	- Student tutors
	- Academic events
	- Psych-pedagogical support
	- Mentorship program
	- Academic sports
2017/18	- Building spaces
	- Working in group
	- People around ISEP
	- Academic Processes
2019/20	- Course dinners
	- Academic parties
	- Sports activities
	- Older students
2021/22	- Praxis
	- Integration tips
	- LENG1
	- Older students

Table 1: Criteria chosen by each group in responding to the assigned theme of the first project.

Most students used the existing free web platform Wix to create their websites because it easy to manipulate and did not require any programming skills. They used the existing templates because they were easy to customize, allowed them to insert videos, links to social networks and surveys. Other frequent tools were Adobe premiere for video edition, Google Forms for surveys, and PowerPoint for oral presentation (Figure 1).



Figure 1 - Most used tools for video edition, surveys, and oral presentation

In the 2017/18 edition, the group of students created a class survey to understand the needs of the new student and then created an Android App (Figure 2).



Figure 2: Interface of the Android App built by a students' group (2017/18).

The App allows students to understand the bureaucratic procedures for inscription, pay the academic fees, make a transference between other ISEP courses just by clicking on different object buttons (Figure 3).



Figure 3: Features of the App built (students' group of 2017/18).

The developed Website (https://sistemas017018.wixsite.com/integracaoacademica) informs us about the existence of the different physical building spaces in ISEP, presents incentives for new students to meet other people and integrates the user in the ISEP community (Figure 4). After finishing the App this students' group applied to an internal Financial Program Support, and as a result, one of the students obtained a monetary scholarship to upgrade the App for iPhone (iOS).



Figure 4: Integration tips featured by the 2017/18 group.

The 2019/20 group of students built a free website and made a class survey to collect feedback from their colleagues about what they would find most important to improve in the integration of new students. The most relevant results are summarised in Figure 5.



Figure 5: Results of the survey conducted by the 2019/20 group of students.

Building on the results of the survey this group concluded:

"60% of the 60 interviewed pupils preferred the Course Dinners to increase their integration, followed by Academic Parties with 17%, Sports Activities with 13% and lastly the help by Older Students with just 10%. Thus, we conclude that a new student integrates better with Course Dinners"... (https://nunoedgarmartins.wixsite.com/dicasparanovosalunos/inquerito).

This group, besides Sports, suggests that integration also comes with the support of older students or through a mentoring programme:

"The week before classes start, we suggest that new students should come to Campus and meet older students, who can guide them in this new space. This advice can be allied with the initiative already implemented in an experimental phase of the mentoring program. In this case, the new student must set а mentor to guide him in the first weeks. (https://nunoedgarmartins.wixsite.com/dicasparanovosalunos)

In the website developed by a 2021/22 group of students, it is stated that in addition to the importance of the students' social activities LENG1 unit is also an integration help:

"LENG 1 subject promotes self-directed learning and the integration of students into a class and work group. It is a good start for introvert students, who feel affected by the change of environment, and for adapt to the new learning style"

(https://1210716.wixsite.com/integracao-na-les)

This group of students launched a survey to the class and the responses (Figure 6) showed without doubt the importance of LENG1 in integrating new students.



Figure 6: Survey answers of the 2021/22 group of students.

CONCLUSIONS

In summary, the groups of students managed to carry out their 1st microproject in 9 days, managed to learn the free editing tools to build websites and videos in Wix and Adobe Premiere, to create a presentation in PowerPoint, to make a survey in Google Forms and, finally to resume and integrate data in 3 Excel graphics.

From a social point of view, students related intra and inter-group, exchanged knowledge, collaborated in web research, web surveys, video interviews and this reinforced their integration in the course, school, and city.

Results of this project permitted to conclude that students acquire research skills, co-work abilities and can integrate in the class, course and ISEP communities and spaces. From students' reports, it was concluded that this type of strategy motivates them to learn and work as a team with 88% of the class confirming the importance of this unit to integrate them.

In terms of future perspectives, this unit will continue to consolidate the experience/methodology and to make a deeper analysis in the collection of data and subsequent analysis of its surveys responses to regard skills and motivations acquired.

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PROMOTING STUDENT'S SUCCESS THROUGH INTERNATIONAL COMPETITION ENGAGEMENT

Filomena Soares¹, Ana Paula Lopes²

¹CEOS.PP / ISCAP / P.PORTO, Porto, Portugal, <u>fbsoares@iscap.ipp.pt</u> ²CEOS.PP / ISCAP / P.PORTO, Porto, Portugal, <u>aplopes@iscap.ipp.pt</u>

Abstract. The Erasmus+ Project "EngiMath – Mathematics on-line learning model in Engineering education", is joint venture that gathered seven HEI from six European countries: Estonia, Ireland, Poland, Portugal, Romania and Spain. The project core and aim were to build an on-line course on basic Mathematic subjects that ground the specific area of engineering mathematics. In this sense, partner Institutions have developed a shared platform for students and academics in Introduction to Linear Algebra and engineering applications. A mathematics on-line learning model was created, available and open-access in seven distinct languages. As established in the project proposal, a Students' Competition was set, within the online course context and framework, to bring international dimension to the engaged students' studies. This competition took advantage of the natural students' appetence to "gamming" format activities and was one of the Project major successes, despite all pandemic restrictions the partner actors had to deal with.

Key words: Mathematics, Online learning, Competition, Gamification, Multinational cooperation, Erasmus+, Technology enhanced learning.

COMPETITION FRAMEWORK AND OBJECTIVES

In 2018, six Hight Education Institutions (HEI), namely: TTK University of Applied Sciences (Coordinator – Estonia), Letterkenny Institute of Technology (Ireland), Polytechnika Koszalinska (Poland), Polytechnic Institute of Porto - Porto Accounting and Business School (Portugal), Technical University of Cluj-Napoca (Romania), Universitat Polytechnica De Catalunya (Spain – on the 3rd Year of the project) and University of the Basque Country - UPV/EHU (Spain – only on the two first years of the project), embraced a collaborative Erasmus+ Project, under the Key Action - Cooperation for innovation and the exchange of good practices.

This project has developed an online course, in seven different languages (Catalan, English, Estonian, Polish, Portuguese, Romanian and Spanish), with a constant and anchor believe that any learning system needs to be perceived as useful. Students must feel that by using it they improve either their academic or job performance or it adds value or comfort to their learning process. For the system to be easily accepted by learners, they must perceive its usage as being free of effort. The course must be easy to navigate and use and it should require less mental and physical effort from the part of the learner (Idemudia et al., 2019).

In the EngiMath framework (Uukkivi et al., 2019), the Students' Competition (SC) proposal was planned and approved as a Learning/Teaching/Training activity (LTT), coordinated and fully organized by the Portuguese partner team. This competition tried to benefit from the expected students' appetence to "gamming" format activities (Lopes, 2017), with a clear objective of a good "reward" at the end – an internationalization opportunity for the three best students per partner institution. Besides trying to raise student motivation, this

competition intended to promote and support possible student exchanges as well as to help to recognize that Mathematics plays a key role in the formation of an individual, developing and enhancing logical and deductive reasoning (Cresswell & Speelman, 2020). This competition was sequentially developed on-line through all on-line the EngiMath courses, in TTK Moodle platform. Information and Communications Technologies (ICT), such as collaborative workspaces, live streaming, videoconferencing, social media, among others, were used to prepare, develop and support the competition phases.

In the initial segment of the SC took advantage of the pilot stages of the Engimath course (Labanova et al., 2021), students were required to complete a predetermined sequence of tasks within the course online platform. Based on the global task score, three students were chosen, by each partner, as "country representatives" for the final and multinational SC part. This Multinational Final of the SC was planned in a face-to-face format and would have taken place at the Portuguese partner's facilities, combining a short period of physical mobility (7 days – only including students) for the three finalist students from each partner institution, with virtual mobility predefined moments for all other participants, to complement and extend the learning outcomes of physical mobility.

Given the COVID-19 restrictions at that time, the competition "in person" plan had to be shifted to an entirely online distinct format, which led to significant changes in all the contest logistic and operative matters.

PARTICIPANTS ORGANIZATION AND FINAL COMPETITION PHASES

As already mentioned, the SC Final embraced 18 contestant students (3 from each partner institution and from 6 different European countries). Eighteen "anonymized" accounts in TTK Moodle were specifically created for this purpose, distinguished by the first letter that connected the "account" to the respective partner institution/city/country (for instance, in the Portuguese case: P1, P2 and P3 were the acronyms for the three Porto students). These Moodle accounts were randomly distributed among the eighteen competitors in the first competition day. SC was developed on three independent phases, each of which with two, or more, stages, in a total of seven challenges to be solved against the clock, namely:

- Phase 1 Competition in International Groups Stage 1 with 6 groups (X1 T1/L1/K1, X2 P1/C1/B1, Y1 T2/K2/C2, Y2 L2/P2/B2, Z1 T3/P3/B3 and Z2 L3/K3/C3), Stages 2 and 3 with 3 groups (X X1/X2, Y Y1/Y2 and Z Z1/Z2)
- Phase 2 Competition between partner countries Stages 1 and 2 6 groups
- Phase 3 Individual competition Stage 1 and 2 18 individual competitors

Competition Scoring Rules and Computation

Each challenge was graded on a scale from 0 to 150 points assigned as follows:

<u>Time Factor</u> – 50 points for the first correct submitted answer (if incorrect these points were lost!) – for the upcoming correct submissions these points were reduced at a rate of 1 point per 5 minutes (continuously measured – 2 decimal places).

<u>Answer Presentation Factor</u> – 100 points (20 points for the correct answer and 80 points attributed to the Problem-Solving Presentation Quality where 60 were for Reasoning scheme/Formal resolution and 20 for the Clarity of the proposed resolution).

The final individual score was obtained by adding the respective group results from the 1^{st} and 2^{nd} Phase (3+2 stages) with the individual score from the last one (2 stages). With a possible score of 150 per stage, the maximum achievable score was 1050 (7x150).

This grading scheme was communicated to all participants, via email (bcc), in the week before the event, along with several other information, remarks and tips and "warm up" problem, with a step by step proposed solution.

Students' Competition Agenda

SC was held from June 28th to July 2nd (Monday to Friday) with all the individual competitors, as well as their respective tutors/supervisors working from home.

Monday	v - June 28th	
	09:00 - 09:30	Welcome all - Introduction to Competition Program
	09:30 - 11:15	Partners Presentation – Institution and Students Team
		Student Competitors Identification
		Estonian Team Members - T1 /T2 /T3
		 Ireland Team Members - L1/L2/L3
	11.15 - 11.30	 Polish Team Members - K1/K2/K3
	11.10 11.00	 Portuguese Team Members - P1/P2/P3
		Romanian Team Members - C1/C2/C3
		 Snanish Team Members - B1/B2/B3
	11.30 - 12.00	Brain storming – Students time
	12:00 - 14:00	LUNCH BREAK)
	12.00 - 14.00 14.00 - 16.00	Phase 1 – STACE 1 – 6 International Groups
	16.00	Submission deadline for Ph1/St1
Tuesday	- June 29th	Submission dedunie for Firipsei
Tucsuuy	09.00 - 12.00	Phase 1 – STACE 2 – 3 International Groups
	12:00 - 14:00	LUNCH BREAK)
	14:00 - 16:00	Phase 1 – STAGE 3 – 3 International Groups
	16:00	Submission deadline for Ph1/St2 and Ph1/St3
Wednes	day - June 30th	
	09:00 - 12:00	Phase 2 – STAGE 1 – 6 National Groups
	12:00 - 14:00	LUNCH BREAK)
	14:00 - 16:00	Phase 2 – STAGE 2 – 6 National Groups
	16:00	Submission deadline for Ph2/St1 and Ph2/St2
Thursda	y - July 1st	
	09:00 - 12:00	Phase 3 – STAGE 1 – 18 individual competitors
	12:00 - 14:00	LUNCH BREAK)
	14:00 - 16:00	Phase 3 – STAGE 2 – 18 individual competitors
	16:00	Submission deadline for Ph3/St1 and Ph3/St2
Friday -	July 2nd	
		Final Meetings
	09:00 - 12:00	 Students Moment – Erasmus exchange opportunities
		Results Compilation and Analysis - "place your bets"
	12:00 - 14:00	LUNCH BREAK)
		Closing Session – "bets" results
	14:00 - 16:00	COMPETITION Award Ceremony – Winner / Runner-up / Second
		runner-up (3 distinct prices) by Project Partner

Table 1 – SC Final Schedule

COMPETITION RESULTS

In the following figures (Fig. 1 and 2) the results from all the seven stages are presented. Despite not having a specific prize, the winner team from each competition phase was publicised in the closing ceremony (see Fig. 4 to 6).

During these 4 competition days, at 16:00 (Lisbon time) the Portuguese team downloaded all student's submissions from TTK Moodle, a proceed with a "double blind" answer correction, after which an arithmetic mean was taken for the score given to the Problem-Solving Presentation Quality (from a maximum of 80). If the correct answer was given students got more 20 points (or less, if not 100% correct). The score given to the submission time factor was computed, decreasing from the 50 points attributed to the first submission with a correct answer (according to the aforementioned scoring system description). All this scoring procedure of the submitted answers was carried out daily, in order to allow the presentation of all the results on the last day of the competition.

Reference of the second			GI	ol	50		Re	25	u	P.PORTO
months (c)		Ph1 - St1	Ph1-St2	Ph1 - St3	Ph2 - St1	Ph2 - St2	Ph3 - St1	Ph3 - St2	FINAL	
CO Part		June 28th	June 29th	June 29th	June 30th	June 30th	July 1st	July 2st	July 2nd	
	B1 - Spain	104,8	130	104,2	137	139,6	146,8	144	906	
	B2 - Spain	120,6	121,4	90,4	137	139,6	146,8	143,4	899	UPC BARCELONATECH
	B3 - Spain	97,4	116,4	100	137	139,6	98,4	80	769	*
	C1 - Romania	104,8	130	104,2	118,2	82,8	125,6	129	795	16 I
	62 - Romania	105	121,4	90,4	118,2	82,8	106,8	116,6	741	
Engi	Math Garmania	35	116,4	100	118,2	82,8	92	122,4	667	
Engr		90,8	130	104,2	132	125	135,2	97,4	815	lyite 💶
	C2 - Ireland	120,6	121,4	90,4	132	125	137,4	71,6	798	LYLL 🔛
	L3 - Holand	35	116,4	100	132	125	107,2	0	516	
	K1 - Poland	90,8	130	104,2	127,6	137,2	99,8	95	785	
	K2 - Poland	105	121,4	90,4	127,6	137,2	139,2	127,2	040	
	R3 - Poland	35	116,4	100	127,6	137,2	66,6	83,6	847	SALIN'
	P1 - Portugal	104,8	130	104,2	149	131,2	86,8	110,8		
	P1 - Portugal	120,6	121,4	90,4	149	131,2	67,4	96		
WIE	T1. Estonia	97,4	116,4	100	149	131,2	150	150	711	
4	T2 - Estonia	90,8	130	104,2	69,2	126,4	120,6	/0	764	
	T3 - Estonia	97.4	121,4	90,4	69,2	126,4	143.6	132,4	759	
		51,4	110,4	100	03,2	120,4	243,0	100,2		Co-Bunded by the Examinate Programmer of the Company Union

Figure 1. SC Results



Figure 2. SC Podium

GROUP B

276,6

GROUP P

280,2

0 🥛

GROUP K

264,8



Figure 3. Phase 1 Results





Figure 4. Phase 2 Results

Figure 5. Phase 2 Results

Participants' Feedback

Twelve participating students and three teachers answered a feedback survey that was given to them at the end of the competition. The collected feedback was mostly descriptive and in the form of answers to open ended questions.

All respondents were either satisfied or very satisfied with all the aspects of the competition: the event in general (Median =6 on a scale of 1 to 6), the communication with the organizers (Median =6 on a scale of 1 to 6), the challenges that were solved during the competition (Median =6 on a scale of 1 to 6), the unfolding of the event (Median =6 on a scale of 1 to 6).

Students enjoyed working in an international setting and interacting with students from other universities. Some even made new friends during the competition and got information about other universities and countries. The students liked the challenges and the communication during the event. They appreciated the format of the competition and the flexibility of the schedule and tools that they were allowed to use to solve the challenges. The teachers appreciated the format of the competition and the well thought out content and considered it very professionally organized. Although the participants considered the competition to be well organized, some improvements were suggested. The most frequent suggestion was that the competition be held face to face. Some had some problems with the communication channels that were eventually resolved.

Final Comments

In Mathematics particular area and interrelated subjects, it is important to support and develop activities in a wide variety of ways, contributing to a broad "mathematical coexistence", trying to deconstruct prejudices and misconceptions. The gaming and ludic format of this Competition allowed the development of activities in a relaxed and friendly environment, despite the relative pressure of time and all the constraints arising from its forced implementation in a fully online format and remote performance. It was gratifying for the organizing Portuguese team to have such positive feedback. It will certainly be an activity to be repeated in future European or even national projects.

Acknowledgements

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USING ORIGAMI IN MATHEMATICS EDUCATION

Michael Kleine¹, Judith Huget¹

¹University of Bielefeld, Institute of Didactic Mathematics (IDM), Bielefeld. Germany, <u>michael.kleine@uni-bielefeld.de</u>

Abstract. Paper folding in mathematics education has a long tradition: to this day teachers use paper folding to promote mathematical knowledge in the classroom. But many mathematical activities have also fallen into oblivion. The purpose of this paper is to shift the focus back to the creation of learning environments with enactive work. Using Origami can be a central aspect for this purpose.

Key words: Origami, argumentation, enactive work, learning environment

LOOKING BACK: ORGAMI AND ITS TRADITION

Origami (jap. for oru - folding and kami - paper) emphasises the art of paper folding by using only one piece of paper for creating forms and figures. This kind of paper folding has strong roots in mathematical education: At the beginning of the 19th century Fröbel establised a set of ten basic forms and activities that determined learning in kindergarten. One of these main activities was paper folding. Froebel picked up a tradition of paper folding: Activities can be characterized by folding of diagonals, central lines and repeated angle bisections. In contrast to that, paper folding in Asian tradition was more filigree and also more flexible as it was not oriented towards these restrictions (Hatori 2011). Both traditions have increasingly intermingled and influenced each other. One characteristic of both traditions is that the folding possibilities and sequences of a figure are varied and not uniform. Everyone interested in paper folding will find a folding process, which is suitable for every individual.

LOOKING FORWARD: ORGAMI AND MATHEMATICS EDUCATION

For a long time, paper folding and mathematical activities seemed to be reserved for experts. In the last years, an increasing number of authors have taken paper folding and considered creating ideas for teaching mathematics. Especially the book by Haga (2008) was certainly an essential starting point to explore mathematical possibilities and discoveries through paper folding. The teaching possibilities are both concerning content as well as processuals. The procedural requirements include subject-specific, as well as interdisciplinary processes:

(1) Instruction on the accuracy of a haptic process: Folding itself is unfamiliar to many learners. The paper can be used in the same way as the use of – for example – a compass as a technical skill in mathematics education. In order for folding figures to succeed, care must be done carefully.

(2) Communication of the folding process: The folding process can be described in different ways, namely through pictures, videos, in short descriptions, or verbally. It is always important to specify the folding through mathematical language to obtain clear fold lines.

(3) Discover mathematical relations: In the folding figure or in the folding pattern often obvious structures are recognized or considered. The processes consists of mathematical up to mathematical argumentation.

To illustrate the processes, we take a deeper look to an example in figure 1: The folding of a windmill is one of the basis foldings of Froebel. You can find various ways for folding.



Figure 1: Froebels' windmill (Kleine & Fast 2016, p. 3))

Looking at the folding pattern in figure 2a) you can recognize many different aspects: The existing squares or the parquetry of isosceles right-angled triangles come into mind. Perhaps you can see different similar triangles and squares. Take a deeper look at the squares in the pattern, then rectangles can be identified, parallelograms, and (symmetrical) trapezoids can be discovered. However, once they are discovered, then numerous figures in different sizes can be seen. Students and pupils must also first learn to sharpen their eye for such structures.



Figure 2: (a) Folding pattern and (b) theorem of intersecting lines of the windmill (Kleine & Fast 2016, p. 3-4))

Conceptual possibilities for paper folding in mathematics education

Paper folding offers different possibilities for teaching mathematics:

(1) Concept understanding. Mathematical concepts should encompass for a whole class of mathematical objects. Thereby one can certainly distinguish two types of concept formation: (a) concepts, which are obtained by construction, and (b) concepts, which are derived from a network of concepts. In the purpose of this topic, the construction is certainly in the center of attendance. If one considers the development of concepts in the sense of Vollrath (2001), on the one hand, a learning level can be characterized as an intuitive approach: mathematical phenomena are recognized and examples are generated. On the other hand, a concept is carrier of properties and characteristics. Let us consider for these two aspects the following two examples.

Example 1: The concepts of parallel and orthogonal: The position relations "parallel" and "orthogonal" of two straight lines can be illustrated by the position of folded lines. The common orthogonal line can be used directly as a characterization of two parallel lines. In addition, one obtains from the folding process a "measuring instrument" for right angles.

Example 2: Meaning of congruence: The congruence is becoming a content-related meaning, because figures can be examined by actually matching for an intuitive understanding. This activity shows another conceptual possibility of paper folding:

(2) *Development of argumentation skills*. Through paper folding, the spectrum of argumentation activities is extended. Characteristics of the folded figure and on the other hand argumentations from the folding process can be used directly. This shows an advantage of paper folding: Arguments for mathematical reasons are discovered and verified by examples. If we consider different levels of argumentation by Holland (1996) (table 1), we take the level of demonstrative argumentations and the level of substantive argumentation into account.

1 Level of demonstrative argumentation	2 Level of substantive argumentation	3 Level of formal argumentation
Characteristics: - oral argumentation - unrestricted reference to sketch,models etc. - Argumentation as short as possible, but as detailed as necessary	Characteristics: - written sequence of arguments in own words - insight into general validity of a statement - Sketch can be used for geometric arrangements	<i>Characteristics:</i> - formal representation of a proof in a mathematical sense
Intention for education: - give arguments for validity of an assumption - take up, continue or refute arguments from classmates	Intention for education: - Sequence of arguments - include known theorems - find simple "proof" sequences	Intention for education: - Proof as a sequence of logical arguments - Check proofs for consistency and completeness - compare proofs

 Table 1: Levels of mathematical argumentation (Holland 1996)

On the first level, arguments are being verbalised orally. These skills will be increasingly systematized by writing them down. The paper folding can provide ideas for argumentation and reasoning, which form the basis of a further sequence for a proof. Focussing on the folding pattern of the windmill from the point of the theorem of intersecting lines (figure 2b): The relationship between the change of the area at this theorem is often difficult for pupils to understand. The parquetry of the folding pattern with the isosceles-rectangular triangles offers a suitable starting point for the discovery: For k = 1 the area is $A_1 = 1$ (triangle), for k = 2 you have $A_2 = 4$ (triangles), for k = 3 then $A_3 = 9$ (triangles) and so on (figure 2b). It may not become as difficult to continue these relations and make assumptions for the relations in general. The generalization is executed outside paper folding.

(3) *Deepening of mathematical relations and structures*. Mathematics can be described as a science that investigates the relations and structures between (mathematical) objects. These structures are not always visible for students and are often difficult to understand. Paper folding offers a possibility for a differentiation of pupils. Two illustrative examples:

Example 1: Relationship between symmetry. The relations between different kinds of symmetry and the reduction of a connection of axis reflections is very often not into account of pupils. If focussing again at the folding pattern of the windmill again, one can discover relations and structures. In Fig. 3 the idea is illustrated, how to replace a point reflection by a double axis reflection at two straight lines. The intersecting point of the symmetrical lines is the center of point symmetry, the angle of intersection of the straight lines is exactly half as large as the angle of rotation. The large number of symmetrical figures in the folding pattern allows these considerations, which can also be examined for parallel symmetry. The paper folding is a starting point for argumentation, which can be verified outside of the folded figures.



Figure 3: Point symmetry as a connection between axis symmetry (Kleine & Fast 2016, p. 6))

Example 2: The theorem of Pythagoras in a general understanding. A visual introduction to the Pythagorean Theorem is illustrated with squares. But this representation is only a "convenient" form of this theorem, which is valid for all similar figures to the sides of a right-angled triangle. Consider again the folding pattern of the windmill and use the above mentioned parquetry. In the representation of figure 4a) one recognizes that it is a challenge, if the square of the hypotenuse is placed on the on the other side than usual. The representation with other similar figures shows a deeper connection behind it (figure 4b, c). Students and pupils can discover on a folded example a deeper relation between the theorem.



Figure 4: The Pythagorean theorem with similar figures: (a) squares, (b) triangles, (c) trapezoids/ parallelograms (Kleine & Fast 2016, p. 5))

(4) *Training and diagnostical aspects.* The example of the windmill should illustrate the investigation of mathematical relations. The activities can also be used to get deeper informations about pupils' structure of argumentations and thinking. A possible starting question could be: "Here you see the folding pattern of the windmill. Write down as many mathematical relations." For a diagnosis of pupils skills you can distinguish between different levels: Argumentation and discover relations based on (a) simple figures, such as

squares and rectangles; (b) triangles, trapezoids, and composite figures; (c) statements and relations about areas, congruent triangles, Pythagorean Theorem etc..

Hereby a diagnosis of mathematical skills is possible. For this, it is of course necessary that the windmill has not been dealt with in class before.

OUTLOOK

The previous explanations show that paper folding activities offer numerous opportunities to build and promote mathematical competencies and skills. On the one hand, paper folding offers possibilities of a haptic and aesthetic access to mathematical concepts and contexts. On the other hand, paper folding offers development and building up mathematical competencies, to promote mathematical thinking and use folded objects for differentiation or diagnosis. The folding patterns are not connected to superficial actions. Moreover, the aim of paper folding is a systematic discovery und understanding. This is an aspect that is emphasized by many authors, but it often is not mapped out by student related activities. As a summary of this paper, it is a need to execute these activities in classrooms.

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STUDENTS' PERCEPTION OF TBL CLASSROOM: A CASE STUDY FOR A PORTUGUESE SCHOOL OF ENGINEERING

Marina Sousa¹, Maria Cunha² and José Salgado Rodrigues¹

¹School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>mas@isep.ipp.pt</u> ²School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>mzc@isep.ipp.pt</u> ¹School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>jar@isep.ipp.pt</u>

Abstract. This study aims to make a knowledge contribution of the impact of the use of the TBL – Team Based Learning – approach on higher education, and in STEM areas in particular. The results of TBL use presented were worked trought a management curricular unit in an engineering degree course at ISEP. This approach was proposed and used in classes throughout the semester, and at the end the students responded to a survey about the impact of TBL. The results obtained indicate a good reaction of the students, especially in relation to their learning and group work. It was also observed the preference for multimedia study materials and some difficulty of the students in systematizing the study before and after classes. Thus, the conclusions suggest the validity of the TBL approach in higher education courses with students from STEM areas, as well as some of its limitations.

Key words: Higher education, Team Based Learning, STEM, Active learning, Students' perceptions

1. INTRODUCTION

STEM (science, technology, engineering and mathematics) education research provides compelling evidence that active-learning classes improve the overall learning of students (Freeman et al., 2014). TBL is one of STEM's education frameworks. The benefits of team learning include increased achievement, motivation, and greater retention of concepts learned.

Currently, several higher education institutions have been betting on active methodologies as part of teaching practices. Innovative, they are increasingly present in the daily life of this higher education institutions, being part of the routine of thousands of university students worldwide (Eddy & Hogan, 2014).

Team Based Learning

One team learning pedagogy is team-based learning (TBL), a structured course design that combines individual preparation with collaborative problem-solving. But also, group work among students that can collaborate a lot for richer learning, creating interesting pedagogical processes at all levels of education, from kindergarten to graduation (Freeman et al., 2014).

Team-based learning (TBL) was initially developed in the 70s in the United States and its main goal was to improve learning processes for large classes of students. This pedagogical approach was first used in classes of administration courses in American universities and was then disseminated and applied in several undergraduate courses.

According to researchers in the area of higher education, team-based learning has some characteristics that differentiate it from other teaching strategies directed to small groups,

such as problem-based learning and peer learning (Parmelee, Michaelsen, Cook, & Hudes, 2012).

For Sweet & Michaelsen (2012), TBL benefits students in order to stimulate the defense of authentic positions; participation in best practice approaches that motivate students to persist; moreover, as the TBL exploits the strength of teams, teachers provide activities that require power to decision that would be difficult for individual students.

Studies on TBL report on their results, the effects on performance of the students with the methodology attendance: engagement, students' attitudes towards work in group, student satisfaction with their experience and team synergy (Beatty, Kelley, Metzger, Bellebaum, & McAuley, 2009; Clark, Nguyen, Bray, & Levine, 2008; Koles, Stolfi, Borges, Nelson, & Parmelee, 2010; Shankar & Roopa, 2009).

For Gullo, Ha, & Cook (2015), TBL contributes to the development of collaborative work skills, in addition to arousing interest in the search for information, making the student responsible for his or her own learning and that of his/her colleagues.

In addition, the findings of Silva, Colle, Cavichioli, & Souza (2018), shows that use of TBL gave students the strengthening and understanding of the process of learning, especially, in the development of personal, interpersonal and communication matters. According to the authors, evolution was perceived as a stimulus to the exercise of doubt, interaction, conflict resolution, motivation and defense of opinions.

2. MATERIALS AND METHODS

2.1 Course design

At the beginning of the semester, the functioning of the TBL classes was explained in detail to the students and highlighted the advantages of the method in the learning process. The curricular unit was organized in major themes related to Organizations Management: Planning, Organization, Control, Direction, Marketing, Financial and Operations, and in complementary topics such as Social responsibility, Circular economy, Productivity, and Industry 4.0, during a total of 15 weeks. In each week the curricular unit had 4 hours of contact classes: 2 hours online and the other 2 hours face to face. Figure 1 illustrates the pedagogical practice implemented according to the phases of the TBL (Ruder, Maier, & Simkins, 2021). Each week had a readiness assurance test (RAT), available to students on the Moodle platform.



Figure 1. Drawing of the sequential phases of each TBL class.

In the first 2 teaching hours (online regime) the RAT was applied. For the individual readiness assurance (iRAT), that allows students to evaluate their prior preparation, were allocated between 10 to 15 minutes of the class and students were asked to take note of their answers (tRAT). After iRAT, students discussed the same group of questions (tRAT) during a period of 30 to 45 minutes and consensualized a group response. After the group discussion, each group submits the answers in the VoxVote e-application, which showed the results allowing teachers to correct errors and clarify concepts. In the second block of 2 hours (face to face), the groups discussed a case study of greater complexity related to the theme worked in the RAT and then applied the concepts to an organization chosen by them.

For the constitution of the groups, teachers used the questionnaire for evaluating learning styles developed by Kolb & Kolb (2012). Students were distributed in groups of 5 to 7 elements (Kibble, Bellew, Asmar, & Barkley, 2016).

The diversity of styles in each group was the main criterion for the constitution of the groups, since it emphasizes complementarity and pluralism in the way students think (Kyprianidou, Demetriadis, Tsiatsos, & Pombortsis, 2012). This groups remained the same throughout the semester and in the two blocks of classes (Ruder et al., 2021).

2.2 Procedures

The aim of this study is to evaluate the perception of the students' reaction to the application of TBL methodology, in the curricular unit of Organizations Management, using a quantitative methodology. For this purpose, an 8-item questionnaire was developed by the authors, based on the available literature (Aljaraideh, 2019; Guffey, Parrish, & Williams, 2021; Jaime, Tramontt, Gabe, Reis, & Maia, 2019; Vasan, DeFouw, & Compton, 2009). The authors decided to use a five-point Likert scale: 1-totally disagree, 2-disagree, 3-neither agree nor disagree, 4-agree and 5-totally agree. A set of questions were added with the aim to better understand how each student studies and works individually and in groups. The questionnaire was previously tested by members of the school community and their suggestions were incorporated into the final version of the questionnaire. The study was carried out at the School of Engineering of the Polytechnic Institute of Porto at the end of the first semester of the 2021/2022 school year. The participants are first-year students of the undergraduate course in Electrotechnical Engineering and Computers. The questionnaire was made available through an online tool and before the evaluation of the curricular unit. Prior to the distribution of the questionnaire, the objectives of the study were explained, and voluntary participation was guaranteed. It was also informed that all information would be treated in a pseudonymized manner and used solely for statistical purposes.

2.3 Sample

After data collection and validation, it was released and processed in the Statistical Package for Social Sciences (SPSS) version 26.0 for Windows. A reliability analysis of the scale was performed, obtaining a Cronbach's Alpha value of 0.86, a value that is within reference values (Cortina, 1993). This course has 227 students, and 58% participated in the study. Table 1 shows the overall characteristics of the sample.

Table 1. Demographic composition of the sample, in percentage. (N=131).

Student-worker		Ge	nder	Age	
Yes	19.1	Female	7.1	18 to 21 years old	86.3
		Male	92.8	22 to 25 years old	6.9
No	80.9	N/A	0.1	26 to 29 years old	0.8
				30 or more	6.1

The analysis of the previous table shows that the sample consists mainly of non-working students, male and aged 18 to 21 years. This group of students attends a set of six subjects with a total of 26 hours per week. Of this set of subjects only Management of Organizations. with 4 hours per week, used the TBL methodology. It should be noted that the classes of all disciplines took place in a mixed regime, the classes of theoretical nature on an online basis and the theoretical-practical or laboratory classes, in a face-to-face regime.

3. RESULTS AND DISCUSSION

Table 2 shows the descriptive statistics for the questionnaire items about the reaction to TBL methodology. All items obtained higher scores than the intermediate value of the scale, a result that seems to indicate that most students had a positive perception of the method in use. The students significantly value the provided TBL opportunity to communicate more with colleagues than in exhibition classes, a result that can also be explained by the current pandemic situation (Cicha, Rizun, Rutecka, & Strzelecki, 2021). They also state that the use of RAT, both in the individual and in the group format, contributed to the learning process and that it helped them to prepare for the moments of evaluation of the curricular unit. The items with the highest number of answers "I do not agree or disagree" are related to the way students felt during the classes, the level of motivation to participate in these classes in relation to traditional classes and the perception of the advantages they would have for applying the methodology to other disciplines.

These results can be explained by the fact that TBL is a pedagogical practice considerably different from the practices of the other subjects they attend, because it is the first time that students use this methodology and because it a disruptive situation in relation to the work habits that students acquired in secondary education.

Table 2. Means and standard deviations of the students' perceptions of TBL, items are ranked in a descending order by mean (N=131).

Item	Mode	Mean	Sum	SD
TBL classes gave me more opportunity to communicate with colleagues	4	3.78	495	1.09
The discussion of the questionnaire (RAT) in group allowed me to				
correct errors and improve the understanding of the curricular unit subjects	4	3.57	468	1.07
The individual resolution of the questionnaire (RAT) helped me learning the subjects of the curricular unit	4	3.47	454	0.99
I felt more comfortable in a TBL class than in a traditional (exhibition class)	3	3.34	438	1.11
The TBL classes helped me prepare for the evaluation of the curricular unit	4	3.24	425	1.05
I would like to take TBL classes in more curricular units	3	3.15	412	1.25

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TBL classes helped me to better understand the subjects of the curricular unit	4	3.15	412	1.14
TBL classes motivated me more than traditional (exhibition classes)	3	3.05	400	1.16

The following tables show the complementary questions results of descriptive statistics. These issues allow a deeper understanding of student's involvement, not only in the methodology adopted but also in their own involvement with the course and discipline. They provide even greater clarity regarding the learning tools that have been made available. The available study materials consisted of a set of texts prepared by the teachers, in which short videos were introduced to illustrate some more complex concepts. Students had to study weekly a text with an average dimension of 5000 words. The results show that the materials fit their method of study, but they preferred to have more videos to study than texts (table 3).

Table 3. Means and standard deviations of the students' perceptions of study materials, items are ranked in a descending order by mean (N=131).

Item	Mode	Mean	Sum	SD
The study materials available on moodle are suitable for my study method	4	3.52	461	1.04
I like studying by videos more than reading texts	4	3.50	458	1.11

A central issue for the success of TBL is the prior materials study before class realization (Sannathimmappa, Nambiar, Aravindakshan, & Kumar, 2022). The results show that only about 43% (sum of answers I totally agree and agree) of the students regularly studied the materials before classes. Tomas, Evans, Doyle, & Skamp (2019) found an identical result and identified the lack of time, lack of motivation and inability to manage the individual study as the main explanations for the non-compliance with this task. It should be noted that the students did not feel comfortable during classes in which they had not had the previous study and that they did not acquire the habit of consolidating the study of the contents of the discipline after classes (table 4).

Table 4. Means and standard deviations of the students' perceptions of individual work, items are ranked in a descending order by mean (N=131).

Item	Mode	Mean	Sum	SD
When I didn't study the materials available on Moodle, I felt uncomfortable in TBL classes	4	3.46	453	1.05
I regularly studied the materials available in the Moodle before the TBL class was held	4	3.15	412	1.07
Often, after the TBL class, I reviewed the study materials available on Moodle	3	2.84	372	1.15

Finally, questions were asked to assess the perception of the efficiency of group work, another critical success factor of the TBL (table 5). Students need to have teamwork skills, be able to have a collaborative attitude towards the group and learn from others (Kibble et al., 2016). The groups had the dimension suggested in the literature, between 5 and 7 elements, with diversity in the way they perceit and process the information in order to enhance the discussion and motivation for learning. The results show that the group training technique led to a integration high level and the students claim to have had a collaborative

attitude towards the group. However, this motivation is low when it comes to discussing the RAT, this result can be explained by the lack of study of the materials available above.

Table 5. Means and standard deviations of the students' perceptions of teamwork, items are ranked in a descending order by mean (N=131).

Item	Mode	Mean	Sum	SD
I felt integrated into my working group	4	4.10	537	0.867
I had a collaborative attitude in the discussions of the questionnaire (RAT) with my group	4	3.87	507	0.91
I learn better working in groups than working alone	4	3.50	459	0.97
My group has shown to be motivated to discuss the questionnaire (RAT)	4	3.18	417	1.12

4. CONCLUSIONS

A limitation of this study was its use of a pedagogical approach (TBL - Team Based Learning) different from the traditional one, with students who were having the first contact with higher education, and in the context of a pandemic. This context meant that half of the classes took place online, sometimes with large groups of students (between 80 and 100 students) giving a limite to the possibility of interaction between teachers and students. The students' perception of the TBL may be different if the classes are all face-to-face. The results obtained suggested a positive reaction of the students to the use of the TBL approach Management classes, of the 1st year of the Undergraduate course in Electrotechnical and Computer Engineering of the School of Engineering of the Polytechnic Institute of Porto. In their responses to the survey, students highlight aspects such as the opportunity to communicate more with colleagues in the group or a better understanding of the subjects (table2). Interestingly, when faced with the general question of whether The TBL contributed to better learning, the students' response was clearly more neutral. The impact of TBL in preparing for the evaluation also revealed a positive trend. However, students did not show a clear preference for the use of TBL in other subjects or for the advantages of TBL over the traditional exhibition approach.

In line with previous studies (Tomas, Evans, Doyle, & Skamp, 2019), one of the difficulties pointed out by the students in this pedagogical approach was the management and systematization of their study, namely the preparation before and after classes, as well as the discomfort they felt when they did not prepare classes (table 4). Teachers involved, tried to mitigate this difficulty by elaborating study materials that included multimedia elements, which were valued by students (table 3).

The establishment of groups of students with diverse learning styles (Kyprianidou, Demetriadis, Tsiatsos, & Pombortsis, 2012) contributed to the success of this pedagogical experience, depending on the good work environment that the students reported (table 5).

The authors are able to conclude that, in line with previous studies, the data collected point to the effectiveness of the use of TBL in engineering courses, although with due care in the preparation of activities to be carried out in classes, in the preparation of dynamic study materials and in the balanced constitution of groups.

It will also be interesting to continue to monitor the results of the use of TBL in engineering courses, particularly in the context of fully face-to-face classes.

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MEASURING TEACHING SELF-EFFICACY IN PANDEMIC TIMES: A PRELIMINARY VALIDATION STUDY AMONG PORTUGUESE TEACHERS

Diana Aguiar Vieira¹, Sara Lima² & Viviana Meirinhos¹

¹ISCAP/Instituto Politécnico Porto, Centro de Estudos Organizacionais e Sociais, Porto, Portugal, dianavieira@iscap.ppt.pt

²CESPU/IPSN-Instituto Politécnico da Saúde do Norte, Instituto de Investigação e Formação Avançada em Ciências e Tecnologias da Saúde, Paredes, Portugal, sara.lima@ipsn.cespu.pt

Abstract. This study presents two original instruments to evaluate teaching self-efficacy. The Teaching Self-Efficacy Inventory (TSEI) addresses common tasks and challenges teachers face, whether in face-to-face or online teaching format. The 25 TSEI items ask teachers to rate their self-efficacy on online teaching against face-to-face format. The second questionnaire - Self-Efficacy for online teaching (SEOT) - is composed of 5 items that tap teachers` perceived confidence in dealing with technological and fatigue challenges posed by online teaching. One-hundred-and-fifty higher education teachers completed both TSEI and SEOT. As theoretically anticipated, TSEI exploratory factorial analysis identified five factors that accounted for 66% of the total variance. Additionally, as expected, SEOT factorial analysis resulted in one factor that explained 64% of the total variance. In conclusion, this preliminary study provided support for the validity of both TSEI and SEOT.

Key words: Teacher self-efficacy, online teaching; face-to-face teaching; higher education; self-efficacy; pandemic time; Portugal

INTRODUCTION

Self-efficacy refers to a person's beliefs concerning his or her ability to successfully perform a given task or behaviour (Bandura, 1977; 1997). It is one of the key constructs that underpin Bandura's Social Cognitive Theory (Bandura, 1986). Self-efficacy expectations are particularly useful as it predicts behavioural consequences such as enhancing the probability of taking a given action; quality of one's performance of behaviours in the target domain and persistence in the face of barriers or disconfirming experiences (Bandura, 1977, 1997). Selfefficacy affects performance quality and can make the difference between the approach or avoidance behaviour in the presence of obstacles. Self-efficacy expectations influence whether a person will pursue a given behaviour, with greater self-efficacy increasing the likelihood that an individual will persist until he or she succeeds (Bandura, 1986).

Several studies showed that teacher self-efficacy constitutes an important psychological resource for teachers' skills and students' academic achievement success (e.g. Konig et al., 2020; Lauermann & Konig, 2016). Since the pandemic beginning, we have been witnessing the transition from face-to-face to online teaching worldwide. As stated by Ulum (2021), this transition involved not only technical but also pedagogical and instructive challenges. The tasks and challenges experienced by teachers during the COVID-19 pandemic are the focus of the present study.

As the concept of self-efficacy is used in reference to a specific behavioural domain (Bandura, 1977, 1997), the first task in developing a new self-efficacy measure is to define and carefully delineate the behavioural domain of interest (Betz, 2000); in this case, teaching self-efficacy. Perceived efficacy should be measured having in mind different levels of task difficulty that represent challenges or barriers to a successful performance (Bandura, 2006).

Although there are several instruments to assess teaching self-efficacy in both face-to-face (e.g. DeChenne et al., 2012; Fong et al., 2019; Tschannen-Moran & Woolfolk-Hoy, 2001) and online environments (e.g. Robinia & Anderson, 2010) it seems important to develop self-efficacy measures in the pandemic context as it has brought new teaching challenges (Dolighan & Owen, 2021; Pressley & Ha, 2021). Additionally, as far as our knowledge, there are no such instruments in the Portuguese context. Based on the above conceptual framework, the purpose of the present study is to evaluate the psychometric qualities of two original instruments developed for measuring teaching self-efficacy.

Method

Participants

The participants consisted of a total of 150 higher education teachers (67% females) from North to South of Portugal (63% from the Northern region). Participants age range varied from 24 to 65 years old (Mean age = 49; SD = 9). Demographic data also revealed that 24% of participants had 10 years or less of teaching experience, 26% between 11 and 20 years teaching experience, 37% between 21 and 30 years of teaching experience and 13% more than 31 years of teaching experience.

Instruments

Instrument development procedures. The process items generation that would represent the skills, tasks and challenges required by teaching included two steps. First, we did a literature review on existing measures of teaching skills as well as teacher self-efficacy (e.g. Fong et al., 2019; Tschannen-Moran & Woolfolk-Hoy, 2001) and online environments (e.g. Robinia & Anderson, 2010). Subsequently, we sent the initial 15 items questionnaire to ten teachers, asking for their perception of clarity of instruction, items adequacy and further challenges or difficulties experienced while teaching in pandemic times. After content analysis on this material, we identified two broad categories. One category included tasks and challenges previous to the pandemic outbreak but was identified by teachers as difficult to adapt to the online context. The other category was exclusively related to online teaching experience and included new teaching challenges brought by the pandemic. These two categories resulted in two different instruments described below and developed in the Portuguese language.

Teaching Self-Efficacy Inventory (TSEI; Vieira & Lima, 2022). This inventory is composed of 25 self-efficacy items that followed the recommendations provided by Bandura (2006) to develop self-efficacy instruments. Items reflected five themes that emerged from the previous content analysis procedure. Four of the emerged themes were also identified in previous studies (e.g. Robinia & Anderson, 2010; Tschannen-Moran & Woolfolk-Hoy, 2001)

such as student engagement (sample item: "*Encourage student participation during classes*"), classroom management (sample item: "*Control disruptive student behavior during classes*"), assessment (sample item: "*Avoid situations of fraud in moments of evaluation*"), instructional planning and administrative tasks (sample item: "*Manage the time needed for timely class preparation*"). However, teacher well-being was a new theme that emerged from the instrument development procedures (sample item: "*Manage physical fatigue caused by classes*"). TSEI instructions ask teachers to indicate their perceived confidence in several teaching activities comparing face-to-face against online teaching. Answers followed a five Likert-type scale ranging from (1) "much less" to (5) "much more" skilled.

Self-efficacy for online teaching (SEOT; Vieira & Lima, 2022). This instrument is composed of 5 self-efficacy items aimed at assessing teachers' perceptions about their skill to perform several online specific teaching skills (sample item: *"Solve technological problems that may arise during assessments"*). Answers followed a five Likert-type scale ranging from (1) "nothing" to (5) "totally" skilled.

Procedures

Data collection included information on the aim of the study and assurance of confidentiality was guaranteed. Participation was voluntary and after providing informed consent the online questionnaire was made available to be answered. Data were submitted to exploratory data analysis in the IBM SPSS program (v.26).

Results

The Teaching Self-Efficacy Inventory (TSEI) 25 items were submitted to exploratory factor analysis and principal component analysis as the extraction method. KMO value was .88 which is considered adequate for factorial analysis (Hair et al., 2006; Kaiser, 1974; Tabachnick & Fidell, 2007). Based on the criterion of eigenvalues greater than 1 and the examination of the scree plot (Stevens, 1992), a five-factor solution was submitted to varimax rotation. The solution obtained was considered meaningful and items loading at least .40 on one of the factors were retained. However, taking into consideration theoretical criteria, four cross-loading items were allocated to the most adequate theoretical factor instead of considering the higher loading value. The final instrument retained the initial twenty-five items distributed by five dimensions and the total inventory accounted for 66% of the variance.

The first factor "Student engagement" consisted of 7 items that accounted for 19% of the total variance. Items analysis suggest that this factor assesses teachers perceived confidence in engaging students (e.g. "Getting students attention in class"). The second factor "Teacher well-being" is composed of 5 items that accounted for 14 % of the total variance. One sample item is "Manage physical fatigue caused by classes". The third factor named "Instructional planning and administrative tasks" consists of 4 items that accounted for 13%. One sample item is "Preparing classes activities". Subsequently, two factors are untitled "Classroom Management" and "Assessment" each accounting for 10 % of the total variance and composed of 4 and 5 items, respectively. The dimensions "classroom management" and

"Assessment" include items such as "Getting students to follow class rules" and "Prevent fraud in assessment moments", respectively.

To evaluate the internal consistency reliability of the Teaching Self-Efficacy Inventory (TSEI), a Cronbach` Alpha was computed. TSEI showed strong internal consistency reliability, with a coefficient alpha of .96. This analysis was also undertaken with each factor separately and the results also showed good internal consistency reliability (see Walsh & Betz, 1995) for all factors (F1=.87, F2=.86, F3=.76, F4=.80 and, F5=.76).

The Self-efficacy for online teaching (SEOT) was also submitted to exploratory factorial analysis. As expected SEOT is composed of one dimension and accounts for 64% of the total variance. The Cronbach` Alpha value was .86.

Discussion

The present study involved the development and preliminary validation of the Teaching Self-Efficacy Inventory (TSEI) and Self-Efficacy for Online Teaching (SEOT). Given that research on this area has been limited, our study contributes to two original and promising tools for the assessment of teaching self-efficacy among higher education teachers. TSEI allows measuring self-efficacy perceptions of teachers related to tasks and challenges that are present both in face-to-face and online teaching contexts. On the other hand, SEOT allows to specifically assess online teaching self-efficacy.

One limitation of the present study is related to the small sample size. Future research should further examine TSEI and SEOT adequacy through confirmatory factor analysis among independent and larger samples. Moreover, different types of validity such as convergent and discriminant validity should be addressed in future studies.

In conclusion, the present study contributes to the assessment of perceived Teaching Self-Efficacy and Self-Efficacy for Online Teaching. In general, results provided support for the reliability and validity of both TSEI and SEOT instruments. Further research may provide information regarding their usefulness to research and applied settings.

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PUBLISHING AND PRESENTING STUDENTS' RESEARCH: THE COMPUTER ENGINEERING SYMPOSIUM CASE

<u>Piedade Carvalho¹</u>, Nuno Morgado², Emanuel Silva³, Sérgio Moreira⁴, José Avelino⁵, Marílio Cardoso⁶, Dulce Mota⁷ and Constantino Martins⁸

¹School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>pbc@isep.ipp.pt</u>
 ²School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>nvm@isep.ipp.pt</u>
 ³School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>ecs@isep.ipp.pt</u>
 ⁴School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>sjm@isep.ipp.pt</u>
 ⁵School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>ism@isep.ipp.pt</u>
 ⁶School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>ism@isep.ipp.pt</u>
 ⁷School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>mdm@isep.ipp.pt</u>
 ⁸School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>acm@isep.ipp.pt</u>

Abstract. In the last three years the Events Committee of the Department of Informatics (CEDEI) of the School of Engineering of the Polytechnic Institute of Porto (ISEP), has been holding a Symposium for graduate, Masters, and Doctoral students in computer engineering in two modalities – in person and online. Students, along with their supervisors, are challenged to submit a scientific paper in one of three formats: full paper, short paper, or poster. This Symposium, although aimed at ISEP computer engineering students, includes students, professors, and specialists from similar areas, both national and foreign, encouraging the acquisition of skills in scientific writing along with publishing, sharing and exchanging experiences. This paper presents the process, model, resources, implementation, and results of the Symposium, throughout its first three editions. The results show the value and usefulness of an event designed mainly for higher education students, providing a friendly ecosystem for the dissemination of academic work with a scientific nature. It also allows participants to make connections with national and international experts in the field and receive constructive feedback on the academic project. The model described in this paper have been applied with good results and can be used to encourage future in person or online academic Symposiums.

Key words: academic Symposium, scientific paper, higher education, easychair.

INTRODUCTION

The Computer Engineering Symposium (SEI) is an academical-scientific event that aims to encourage students of computer engineering and similar areas in the practice of writing and publishing technical-scientific papers.

The purpose is to offer students an event focused on the development of technical-scientific competences, of communication and presentation, much sought after by the market.

The Symposium is organized annually by the Events Committee of the Department of Informatics Engineering (DEI) of the School of Engineering of the Polytechnic Institute of Porto (ISEP). In each edition of the Symposium, students are challenged to submit technical-scientific papers in one of the three formats – Full Paper, Short Paper or Poster - applying and following a set of phases and requirements. As a result, in 2019 36 papers were submitted to SEI19, in 2020 29 papers were submitted, and in 2021 43 papers were submitted.

For DEI, the Symposium is considered one more training offered to students to complement their academic training, publicize, and promote students' academic work and promote internationalization. The Symposium aims to provide students with skills in the dissemination of technical-scientific works, such as writing of projects carried out, the operation of the entire process and the stages of submission of a technical-scientific paper to a Symposium, awareness of the peer review process, and aspects of communication and intercultural relations or English language.

In this paper, it is presented three years of Symposium experiences fostering a general outline for others who may be interested in planning their own academic-scientific Symposium. This event provides an opportunity for academics, speakers and sponsors to exchange knowledge and experiences forming an ideal ecosystem to encourage collaboration among them.

This paper includes the following sections: introduction, the publication process, SEI model, results, evaluation, future work and conclusions.

THE PUBLICATION PROCESS

The publication process was structured in the following sequence of steps: (1) Formats of papers, (2) Call for papers, (3) Acceptance of papers submissions, (4) Papers evaluation and (5) Papers publication. The methodology adopted was as follows:

- 1. Formats of papers Three types of papers are allowed: Full paper (must describe completed work with results and discussion, between 6 and 8 A4 pages), Short paper (must describe work in progress, but with preliminary results relevant to be discussed, between 4 and 5 A4 pages) and Poster (must describe work in progress including, preferably, some preliminary results, no more than 2 A4 pages).
- 2. Call for papers E-mails are sent to undergraduate and Master's finalist students, inviting them to promote their work and share it in a scientific paper format. The idea that the publication of the work is a mechanism for valuing the curriculum vitae and the portfolio is reinforced. At the same time, invitations are sent to professors who supervise or have supervised project and internship work (PESTI) and Master's theses (TMDEI), to encourage their supervisees to publish completed or ongoing work. The call for papers is disseminated in national and foreign higher education institutions, by the publication and sharing on institutional and personal social media and by using email lists. In addition, a web site is available with up-to-date information on the different stages of the Symposium [Martins et al., 2021a].
- 3. Acceptance or rejection of papers submissions papers must be written according to the rules defined by the event's organization. To assist in this task, templates with the desired style and formatting are available. Documents must be submitted on the Easychair online platform for integrated management.
- 4. Papers evaluation Papers are sent for review by a scientific technical committee (CTC). The CTC is made up of professors and researchers, specialists in the field of informatics. All papers are subject to blind review by at least two reviewers. Each reviewer writes a textual report with comments and suggestions for improvement and fills in a grid containing a set of 11 criteria that must be rated on a scale from 0 (not relevant) to 5 (excellent). The criteria for evaluation are as follows: Relevance of the topics to this conference, Structure of the paper, Standard of English/Portuguese, Adequacy of the abstract as a description of the paper, Adequacy and number of keywords/key phrases, Adequacy of the research method /study, Review of literature properly provided and

critically analysed, Relevance and clarity of drawings, graphs and tables, Results and findings adequately reported, Discussion and conclusions, and List of references, properly and correctly cited. In addition to these criteria, the reviewer makes an overall assessment about the paper and assigns his personal recommendation, on a scale of -1 (reject) to 3 (strong accept).

Based on the respective classification grids, each paper is assigned one of the following three decisions: (i) accepted (with no/minor/major revisions), (ii) accepted, but for a smaller format (Full paper to Short paper or Poster, or Short paper to Poster) or (iii) rejected.

- i. the paper presents quality and relevance to the event and complies with the category it is applying for (Full paper, Short paper or Poster).
- ii. the paper does not have the expected density or depth for the category to which it is applying. According to pre-defined criteria, the jury informs the authors that it will accept the paper if it is adapted to a more synthetic format, that is, Short paper or Poster.
- iii. the paper does not have sufficient relevance for the event or does not comply with the defined rules and is rejected.

The final decision is sent to the authors, accompanied by the reviewers' report and the classification grid. Authors must correct the paper to incorporate the improvement suggestions proposed by the reviewers.

5. Publication – The final step is to make the content of the paper public. In an initial phase, the paper is orally presented to the public attending the Symposium. For Full Paper, Short Paper and Poster, the presentations have a dedicated time between 10 to 15 minutes, followed by 5 minutes for discussion. Subsequently, all accepted papers and posters are compiled and published in a proceedings book, with ISBN [Martins et al., 2019] [Martins et al., 2021].

SEI MODEL

The SEI is an academic Symposium in the field of computer engineering and related knowledge areas, held annually at the School of Engineering (ISEP) of Polytechnic Institute of Porto in Portugal. Revised by university lecturers, it is dedicated to the dissemination of current research and academic work carried out by graduate, Master's, and Doctoral students.

Students strive to be successful in publishing. Both the peer and revision feedback contribute to that goal. This feedback will not only help authors identify areas for improvement in their submission but will also help them better understand the process for achieving publication success. Once published, SEI aims to provide a platform for authors to showcase their work in two different ways. On the one hand, publicly presenting the work carried out at an event, and on the other hand, publishing a scientific paper in the Symposium Proceedings Book (see Fig. 1).

The Symposium is looking for original contents across diverse disciplines in the computer engineering domain. The content of the Symposium varies from applied research to theoretical research.

As regards the execution process, some of them are manual whereas others are semiautomated or full automated through easychair platform. Manuscript submission, peer review and publication are supported by easychair. Concerning the administrative steps (eg., enrolment form creation, paper review grid, proceeding book conception, etc.), they are manually executed.



Figure 1: SEI model.

The Symposium follows a double-blind policy where the author's identity is not revealed to reviewers and vice versa.

RESULTS

By itself, the Symposium is helpful for DEI's students, Master, and bachelor's degree, as it allows an exchange of experiences, discussion, and dissemination of knowledge, either through the projects presented by the students or through the talks of the invited speakers around Education as well as the business world.

Another positive impact is the initiation of students to the production of scientific publications for the dissemination of research works, projects and innovation activities carried out in the field of Computer Engineering, or similar areas, and covering different themes.

SEI'19 was the kick-off of this initiative and attracted a relevant number of authors. Maybe due to the Covid-19 pandemic the SEI'20 edition was below the expectations, mainly in the number of students and submissions. But, on the last edition, SEI'21 had a greater quantity of papers submitted, resulting more publications (Tab. 1).

Symposium Year	Papers submitted	Papers published	Student authors	Institutions
2021	43	36	48	5
2020	29	26	31	6
2019	36	26	37	7
Total	108	88	-	-

Table 1: Numbers from the first 3 editions of SEI.
Despite the increase of the number of student authors, it has been a challenge to motivate them to write scientific papers, perhaps due to lack of time, as most of them are already employed full-time.

By the analysis of satisfaction surveys, requested from 62 participants among professors and students (Fig. 2), it can be inferred that a correct path is being followed since most answers are either good or very good.



Figure 2: Overall results of satisfaction surveys.

In every edition, all the accepted papers are published in the proceedings book with an ISBN [Martins et al., 2019] [Martins et al., 2020] [Martins et al., 2021].

Despite the Covid-19 pandemic, which has affected the planet in the last 2 years, the Symposium was forced to move from an in-person to an online model, bringing a wider range of participants in SEI'21, which can be seen as a relevant asset.

EVALUATION

Even though the limited data analytics produced through the three SEI editions, the success of this event is finally beginning to be recognized. The number of published papers has been increasing without decreasing the degree of demand for evaluation.

However, the range of different institutions did not increase as desired. It is difficult to figure out a real reason for that, but the Covid-19 is not certainly free from responsibilities. In general, professors had to deal with very complicated situations to adapt to the online or hybrid teaching modality, making it impossible to dedicate themselves to other activities, for example, motivating students to write scientific papers. This can also be applied to DEI professors.

FUTURE WORK

Professors play a key role in the whole process to motivate more students writing scientific papers to publish their academic work. Without them, students will hardly be able to accomplish this very difficult challenge (Recker, 2013). To put this idea into practice, it would be of great importance to ask students to submit a paper to SEI in the context of an end of graduation project. Likewise, Masters and Doctoral students can also have an

opportunity to start writing papers and consequently get proper feedback on the research work they are carrying out.

As far as companies are concerned, it is intended to create a more dynamic process of interaction, leading to more collaborations not only during the Symposium but also creating other small events where they can participate in our department.

Likewise, it is intended to broaden the participation of other national and international institutions by promoting the participation of their students in the SEI.

Finally, some efforts need to be made in relation to the SEI website and related support tools to assist in the submission of papers, communication between authors, reviewers, and all regular committees of this type of event. The first step has already been taken with the creation of a dedicated website for the management of DEI commission events [Ribeiro and Carvalho, 2022], within the scope of the computer engineering degree project. Despite having already implemented some features, it is not yet finished nor is it in operation.

CONCLUSION

In the set of these three editions carried out, it is possible to realize that the SEI has fulfilled the proposed objectives. Several dimensions can be addressed.

First, the authors, who are mainly students, are able to share their academic work and professional experiences, to make themselves known in both the Academy and business companies, these ones playing the role of speakers and sponsors. Furthermore, students that published in the proceedings book have a proper certificate.

Second, companies are becoming more and more aware of the importance of participating in these kinds of events to let know their activities and to capture future engineers.

Finally, this event increases the national and international visibility of the school contributing this way to capture students from different levels of education.

As point out before, there is room to evolve and innovate. Diverse lines of action were established, in respect to software tools, interaction between students and professors, broader the collaboration of institutions of education, companies and sponsors.

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THE USE OF A CLASSIFICATION TREE TO ANALYZE THE RELATIONSHIP BETWEEN SATISFACTION WITH STUDIES AND ENGAGEMENT IN UNIVERSITY DROPOUT

<u>Celia Galve-González</u>¹, Antonio Cervero¹, Elena Blanco¹, Jorge Maluenda-Albornoz² and Ana B. Bernardo¹

¹Departament of Psychology of the University of Oviedo, Asturias, España, <u>galvecelia@uniovi.es</u>, <u>cerveroantonio@uniovi.es</u>, U0264675@uniovi.es, <u>bernardoana@uniovi.es</u> ²Faculty of Psychology, University of San Sebastián, Concepción, Chile, jorge.maluenda@uss.cl

University dropout is a phenomenon of growing interest due to the high financial costs that it involves for both families and states. Various variables have been studied in order to understand why this problem occurs. Satisfaction with the degree choice or engagement with the studies is some of the variables that are most important when studying the dropout intention. Therefore, the objective of this study was to analyze the extent to which the intention to drop out of university courses is predicted by satisfaction and engagement with the course. We performed descriptive analyses and a classification tree on a sample of 587 students from a university in the north of Spain. We saw a relationship between the variables studied and the intention to drop out. In conclusion, there is no single variable for understanding the phenomenon of university dropout, but several variables that interact within a holistic model.

Key words: higher education; intention to drop out; satisfaction; engagement; expectations; permanence; classification tree.

INTRODUCTION

In recent years there has been an increase all over the world of the number of studies related to university dropout in response to the negative consequences that could affect the student, the family, the educational community, and society in general (Castro-López et al., 2021). In fact, according to the Spanish government (Ministry of Universities, 2021), university dropout affects 30.5% of the students in our country. These figures are worrying, since Spain has a much higher dropout rate than other European countries.

Determining the causes of university dropout is not a simple task, because, as various studies have reported, there is no single variable to predict why it happens. Nowadays, different models have emerged based on specific factors within the educational process. Nevertheless, research based on a single specific factor has been overtaken by interactionist models (Tinto, 1975) which are focused on the relationship of each of psychological, academic, sociological, economic and organizational variables in order to weigh their importance in the decision to drop out.

In this sense, one of the most commonly studied variables in relation to dropping out of university studies is satisfaction with the degree choice. On the one hand, research such as that of Bethencourt et al. (2008) show us that certain psychological characteristics of

university students are important in the completion of their studies. Seems to be that "the persistence to finish the degree despite the obstacles" or "satisfaction with the degree choice" are guarantees of academic success, an essential variable that influence the intention to drop out.

On the other hand, engagement with the course is other variable related to the intention to drop out of the university studies. Engagement is understood as the set of manifestations of motivation by students arising from the satisfaction of needs for competence, autonomy, and relationships in the learning context (Fredricks et al., 2016). For Schaufeli and Bakker (2003), engagement refers to a more persistent and influential affective-cognitive state that is not focused on a particular behavior. In this sense, research such as that of Núñez et al. (2013) showed that those students who receive instruction on self-regulation learning strategies have greater engagement and better academic performance, constructs that highlight the consideration of the individual's active role in their teaching-learning process, in addition to being related to the intention to drop out as a predictor of student retention according to recent research (Truta et al., 2018).

For all of the above, the main objective of the present study was to analyze the extent to which the intention to drop out of university is predicted by satisfaction with the course being done and course engagement.

MATERIALS AND METHODS

Participants

A sample of 587 students from a Spanish university participated in the study. Most were women (77.0%) in the first two years of various degree courses (i.e., psychology, speech therapy, early childhood education, primary education, social work, accounting and finance and business administration). Most of the students were aged 18 to 19 years old (M = 19.12; SD = 3.26). A quarter (26.9%) of the participants had at some point thought about changing course and 25.9% had considered dropping out. Participants were identified and selected via non-probabilistic snowball-type sampling.

Instruments

An ad hoc questionnaire was created to collect personal and sociodemographic variables (sex, age, university, among others), students' intention to drop out, course satisfaction and student academic engagement. For Intention to drop out, participants were asked whether they had ever intended to drop out of university altogether, to which they gave dichotomous responses (1 = No, 2 = Yes). Satisfaction was measured by two items from the satisfaction block in the Questionnaire for dropping out of university (Tuero et al., 2018). Responses were given on a five-point scale (1 = Totally disagree to 5 = Totally agree). Student Engagement was measured by the 17 items from the Utrecht Work Engagement Scale (UWES-S; Schaufeli and Bakker, 2003), adapted to university students. Responses were given on a six-point scale (1 = Never to 6 = Always). Examples of items include "I forget everything that happens around me when I am absorbed with my studies".

Procedure and Data Analysis

The Responsible Research and Innovation Subcommittee of the Research Ethics Committee of the University of Oviedo gave approval, allowing the necessary permits to be obtained for the study. Recruitment of participants was randomized in an ex-post fact study and teachers were asked to collaborate. Following that, the students completed online the questionnaire using Google Forms. We carried out data analysis using SPSS v.24, performing descriptive analysis and classification trees.

RESULTS

Considering the above, we validate a model (Table 1) by using classification tree analysis to allow us determining the most influential variables. The analysis shows a 78.9% chance of success in the permanence option, considering this as the opposite of dropout intention. This means a high predictive value for the selected variables as a result of the classification tree (Figure 1). As the tree shows, the variable that best predicts dropout intention is being excited about the career ($\chi 2 = 115,903$; p < .001; df = 2), 91.3% of the students are classified as having 'no dropout intention', which falls to 45.8% in the case of those students who never or rarely express this feeling with the item. However, at a second level, there is another variable that seem to function as a modulating element. This is the satisfaction with the degree choice and compensates to some extent those how value negatively being excited about the degree (values sometimes, never or rarely), since among those who score this variable positively (>3) ($\chi 2 = 11.177$; p = .002; df = 1), there is still a lower probability of dropout (42.0%).

	Risk	
Estimate	.211	
Standard error	.017	





Figure 1: Classification tree relating to the intention of dropping out from university.

DISCUSSIONS AND CONCLUSIONS

Dropout theories in higher education have highlighted the importance of considering the interaction between multiple variables. Within this holistic approach, academic and social variables have been of great importance in the recent years. The model resulting from the classification tree confirms the importance of the satisfaction with the degree choice, but also with engagement. This two variables are important in the study of university dropout, as well as we saw in studies such as Bethencourt et al. (2008), Castro-López et al. (2021) and Truta et al. (2018).

We can conclude that university dropout is a phenomenon of growing interest in current research. However, it is still necessary to continue to study it in more depth since there are multiple variables that interact with each other to predict it. Thus, although we found that satisfaction with the course and student engagement are variables that serve to predict whether students intend to drop out or not, there is still very little research into them that considers each of these variables in a single model. The present study provides some results to help continue studying the phenomenon in a much more integrated manner, but it is still necessary for future research to look into it more deeply.

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PRACTICE-ORIENTED APPROACH FOR TEACHING-LED RESEARCH IN LOGISTICS

Reinhold Schodl¹ and Sandra Eitler²

¹University of Applied Sciences BFI Vienna, Austria, reinhold.schodl@fh-vie.ac.at ² University of Applied Sciences BFI Vienna, Austria, sandra.eitler @fh-vie.ac.at

Research-informed teaching is a higher-education approach that links research and teaching. An advanced form is teaching-led research, where students contribute to university research projects by completing work in the pursuit their personal educational goals. This paper presents a practice-based approach that aims to improve the practicability and positive impact of teaching-led research. The focus is on the benefits for both teaching and research, as well as smooth collaboration between researchers and students. The article describes the application of the approach in a logistics master's degree program. This paper is intended to contribute to the successful use of teaching-led research not only in logistics but also in other disciplines.

Key words: research-informed teaching, teaching-led research, logistics, higher education

INTRODUCTION

Research-informed teaching describes the practice of linking research and teaching in higher education. Students can potentially benefit in a variety of ways (Turner et al., 2008). In general, research-informed teaching can promote critical, joined-up thinking and produce a motivating and inspirational learning experience. In addition, students can acquire future-oriented competences that are relevant for later use in their chosen professional field. This is especially important in occupations where the required competencies are subject to rapid change. The logistics sector is a good example of such an environment. Logistics is one of the industries that is being affected most significantly by the megatrend of digitization, as many processes and business models are undergoing major changes. In addition, the industry is facing challenges that are closely linked to a growing awareness of social, environmental, and economic sustainability. These developments are having a substantial impact on the qualifications required by employees, especially for higher-skilled jobs (Zijm & Klumpp, 2017). Therefore, it is not sufficient to teach the qualifications that are currently in demand. Research-informed teaching can help to integrate forward-looking qualifications into the curriculum, since logistics research is by its very nature future-oriented.

Research-informed teaching can be implemented in several ways. Based on the classification of Healey (2005), one possible approach is research-led teaching, where existing research findings generated by a faculty or third parties are incorporated directly into the curriculum. A more advanced form is teaching-led research, where students contribute to the university's research projects with their own work while pursuing their personal educational goals (Harland, 2016). This paper deals with teaching-led research in the field of logistics. Based on experience gained from a logistics master's degree program, this article draws conclusions in answer to the following question: what is a suitable approach to ensure the practicability and positive impact of teaching-led research?

APPROACH AND RESULTS

We can assume that in most cases the success of any form of collaboration is strongly determined by two levers. Everybody involved should benefit and the interaction between all the various parties should be well coordinated. Extending this basic idea to teaching-led research, the aim should be to guarantee that both teaching and research benefit from the collaboration, and that students and researchers work together smoothly. Consequently, when carrying out teaching-led research, there should be a clear understanding of (a) the intended benefits for teaching, (b) the intended benefits for research, and (c) the intended form of collaboration between researchers and students. Ideally, this should be determined at the very beginning of a project using a structured and transparent approach.

This idea was tested in a project that applied teaching-led research in a logistics master's degree program in 2020/21. This paper gives a brief overview of the project, describes the operationalization of a practice-oriented approach, and shows the resulting impact based on students' evaluation of the project. The project focused on urban consolidation centers, a logistics solution which tries to reduce the negative environmental and traffic-related effects of freight transportation in cities, mainly through the consolidation of shipments across customers (Björklund & Johansson, 2018). The students were involved in connection with the following research question: which innovative design options for urban consolidation centers, environment, environment to generate substantial added value for transport service providers, employees, the local economy and residents, as well as the environment? The design options were expected to address trends related to the economy, society and the environment.

Category	Learning outcome	Contribution
Knowledge	Expert knowledge in logistics to independently deal with complex tasks and challenges	Some
	Knowledge from different disciplines required to deal with tasks and challenges in logistics	Small
	The ability to incorporate newly acquired knowledge in the further development of logistics	Some
Skills	Gather knowledge and findings from different disciplines, critically reflect on them and incorporate them in own activities	Substantial
	Discover new findings from practical work and from the theoretical approach and use them for innovations	Substantial
	Develop the strategy of complex projects, functional areas and/or companies	None
	Examine the performances and results of projects, functional areas and/or companies, assess them, draw conclusions from them and make necessary amendments	None
	Communicate views to relevant actors, act as a moderator and state reasons for decisions	Some
Competence	Lead complex projects, functional areas and/or companies independently and take on responsibility for decision-making	None
	Monitor the implementation of the strategy, intervene to take control and, if necessary, draw consequences for content and staff	None

Table 1: Benefits for teaching

Table 1 shows the intended benefits for teaching in terms of the project's contribution to achieving desired learning outcomes. The table is based on the qualifications defined in the Austrian National Qualifications Framework (BMUK & BMWF, 2011), which is related to the qualifications framework of the European Union.

Table 2 shows the intended benefits for research based on an assessment of the project's contribution to research-related success factors. In particular, the students' open mindset is assumed to play a major role. Part-time students on the master's degree program already have some expertise and work experience, and, at the same time, a relatively low risk of being professionally blinkered.

Success factor	Contribution	
Sufficient work resources	Some	
Heterogeneity of knowledge	Some	
Open mindset of students	Substantial	
Personal development of researchers	Some	
Motivation of new talents for research	Small	

Table 2: Benefits for research

Table 3 outlines the intended forms of collaboration between researchers and students in the project. A responsibility assignment matrix, which is a well-known project management tool (Snyder Stackpole, 2010), was used to define the type of participation associated with the various project roles. There are typically four types of responsibility: responsible (performing the work), accountable (ensuring correct and timely completion), consulted (providing required information), and informed (receiving information on progress). The project presented here comprised three roles: student, lecturer (teaching the course and researching), and researcher. The type of participation is defined for each project task. After defining the project's goals and setting up the teams, the KJ Method – an established creative technique (Scupin, 1997) – was applied to generate ideas in a classroom setting. Then, senior researchers utilized their expertise in logistics to consolidate the results. Next, student groups refined the ideas based on literature research as homework. Subsequently, students evaluated the feasibility and effectiveness of the refined ideas in the classroom. As a final step, senior researchers prepared the results for dissemination and project reporting.

Task	Responsible	Accountable	Consulted	Informed
Define goals	Researcher, lecturer	Researcher	-	-
Set up teams	Lecturer	Researcher	Student	-
Generate ideas	Student, lecturer	Lecturer	Researcher	-
Consolidate ideas	Researcher, lecturer	Researcher	-	-
Refine ideas	Student	Lecturer	-	Researcher
Evaluate ideas	Student, lecturer	Lecturer	Researcher	-
Prepare results	Researcher, lecturer	Researcher	-	-

Table 3: Definition of forms of collaboration

After the project, students took part in an anonymous evaluation in the form of an online questionnaire. On a five-point Likert scale (1=strongly agree, 5=strongly disagree) students stated their level of agreement with the following questions: "Overall, I am satisfied with the course." (AVG=1.25, SD=0.43, n=12); "The teaching methods were well suited to achieving the learning objectives." (AVG=1.23, SD=0.42, n=13); "The course called for independent

thinking and working." (AVG=1.00, SD=0.00, n=13). The following replies were given in response to an open question about the aspects that students particularly liked: participation in a real-life research project; the work done was useful for a real-life project and not only for the course; high practical relevance; open exchange between students and with teaching staff; students' opinions were listened to and each proposed solution was discussed; enabling creativity; and combining existing solutions with new ideas. When asked an open question about where they saw potential for improvements, the students gave the following responses: excursion to enable students to learn more on site; broaden the scope of the study; and application of additional methods. The course was well received by students, and the staff involved assessed the teaching-led research as "a generally inspiring and productive experience".

CONCLUSIONS

It can be hypothesized that proper planning of crucial aspects of teaching-led research from the very beginning of a project plays a significant part in its success. This paper considers the benefits for teaching and research, and effective collaboration between researchers and students to be the crucial aspects. A planning approach for each of these three aspects has been demonstrated. Clearly, a wide variety of important aspects currently under discussion in theory have not been considered. Instead, the emphasis was on simplicity and a high degree of practicability for real-life settings. The evaluation of the project presented here suggests that it was a success, and the approach outlined may have contributed to this. The approach might be of interest for teaching staff who carry out teaching-led research not just in logistics but also in other disciplines.

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MATHEMATICAL MODELLING AND SIMULATION OF THE PHYSICAL SYSTEM OF PULLEYS IN MATHEMATICAL LEARNING

José Magalhães¹, Floriano Viseu² and Paula Mendes Martins³

¹DMA- School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>idm@isep.ipp.pt</u> ²CIEd-University of Minho, Braga, Portugal, <u>fviseu@ie.uminho.pt</u> ³DMAT – University of Minho, Braga, Portugal, <u>pmendes@math.uminho.pt</u>

Abstract. The standards of the CDIO model (Conceiving, Designing, Implementing, and Operating) include the existence of project development experiences that involve different curricular courses and that provide team activities from the 1st year of engineering degrees. In this sense, it was implemented a teaching experience in the engineering degree in Electrical Power Systems at School of Engineering of the Porto Polytechnic (ISEP) based on a multidisciplinary project that involved modulation, simulation and construction of a prototype based on the concept of pulleys. Here we present the phases of the task development, the objectives to be achieved with its realisation, the results obtained by the students and their perceptions about the realization of the Project-based learning (PBL). Here we present the phases of the task development, the objectives to be achieved with its realisation, the results obtained by the students and their perceptions about the realization of the Project-based learning (PBL). Here we present the phases of the task development, the objectives to be achieved with its realisation, the results obtained by the students and their perceptions about the realization of the Project-based learning (PBL). Here we present the phases of the task development, the objectives to be achieved with its realisation, the results obtained by the students and their perceptions about the realization of the Project-based learning (PBL) challenge.

Key words: Simulation; Modelling; PBL; CDIO; EUR-ACE; Learning; Mathematics.

INTRODUCTION

From the 1st year of engineering degrees, the existence of project activity is advocated in the CDIO (Concept-Design-Implement-Operate) model (Crawley et al., 2007) and in the EUR-ACE degree recognition system (Malmqvist, 2009). This type of activity allows students to develop skills in technical problem solving, project realisation, research activity development, communication, leadership, and ethical principles.

THEORETICAL FRAMEWORK

The CDIO educational framework is implemented in various schools worldwide (Figure 1) and approved 12 standards to describe CDIO programmes in 2004 (Malmqvist, 2009).



Figure 1: CDIO Organisation Diagram (www.cdio.org).

These norms include "Design-Implement Experiences": it demands the realization of complex projects in teams and in an environment that simulates professional activity; there should be activities of this type already in the 1st year of the course; the projects have to be "fitted" into Curricular Units (CUs), usually integrative CUs; It is intended an organized curriculum based on courses that support each other; based on design-build projects developed by students; active and experimental learning.

Project-based learning (PBL) (Masson et al., 2012): application (growing) in Engineering degrees; it involves problem or research situations based on real problems; it allows students to acquire scientific and technological knowledge, including environmental and social issues (Figure 2).



Figure 2: Features of the PBL activity.

PBL develops students' skills in: carrying out projects; problem solving; communication; teamwork; self and peer assessment; values attitudes of ethics, responsibility towards colleagues and society.

Mathematical modelling is a model-building process that transforms a real situation into a mathematical situation (Biembengut & Hein, 2000; Blum, 2002), according to the cycle represented in Figure 3.



Figure 3: Mathematical modelling cycle (Takaci & Budinski, 2013, adapted)

The modelling method is based on problematization, observation of phenomena, management of doubts about them and the construction of a mathematical model that expresses the relationships between the quantities observed.

Simulators can take many forms, be presented in different fields of knowledge, and can have the following characteristics: they are exploratory learning environments; they are discovery spaces where students can manipulate, explore and experiment, developing their skills and taste for discovering the objects of the simulated world; they allow limited simulations of real-world phenomena. In this domain, **GeoGebra** is a freely distributed algebraic and dynamic geometry computer software, with good characteristics to be used in a classroom environment; it allows constructions to be performed dynamically.

METHODOLOGY AND GOALS

In the school year 2014/15, the unit Mathematics Laboratories I (LMAT1) of the first year of Electrical Power Systems degree from ISEP, followed the CDIO model along with the CUs of Mathematics I (MATE1) and Working Methods in Engineering (MTENG). A Project was developed involving mathematical modelling and simulation of a system based on the physics of the "Pulleys" and the creation of an experimental physical prototype. The project was composed of four tasks with the objectives of this activity were: to develop mathematical calculation skills; to stimulate problem modelling and simulation; to build reports and communicate results in public; project management and student integration in work teams.

Students delivered, in two stages, preliminary written answers to parts of the project and then a final report. These written documents were analysed at each of these delivery phases and the students were informed of their deficiencies in order to correct them. Afterwards, the students made a public presentation of the project results and showed the physical prototypes they made. The information presented in this paper is the result of data collected from the students' reports and public oral presentations.

RESULTS

This section describes the main tasks proposed to students and exemplifies solutions created by the professor and students in response to them. In **Task 1** it was asked to build an applet, in GeoGebra, to simulate a model with one, two and three pulleys, where the user could vary the length of the wire L, radius, positions and masses of the pulleys, the values of the mass M or the force F1 (Figure 4).



Figure 4: Modelling and simulation of the physical model of the pulleys

The simulator allowed students to answer a set of questions for different conditions in the physical context of pulleys, such as: visualisation of the motion of the pulleys; determination of forces to maintain the equilibrium of the system; determination of velocities of the pulleys motion and angles relative to these conditions.

The goal of **Task 2** was the elaboration of the Taylor series simulator (Figure 5a) that allowed to support the students: in the understanding of the conception of function series; to help them in the answers to the questions in the mathematical and physical context of the pulleys. **Task 3** aimed at the physical construction of a system including the pulley(s) to analyse its functioning and **Task 4** was the public presentation of results as shown in the pictures in Figure 5b) with final prototypes by some groups of students. In the comments of the student groups, it was perceptible that the accomplishment of the tasks of this PBL type provided them with a good motivation for learning.



Figure 5: Public presentations of student groups' results in the pulleys project task.

CONCLUSIONS

The project was, par excellence, a task that allows engineering students integrating multidisciplinary transversal skills - Mathematics, Physics and Engineering - of working in a social context (team) and integrating new students (Magalhães et al, 2018). Modelling and simulation of physical processes are tasks that contribute to enhance more meaningful engineering learning, as advocated by Malmqvist, Edström et al. (2020). As advocated in the CDIO standards (Crawley et al., 2007; Malmqvist, 2009), in the project task most transversal skills were recognised by the students, such as project management, report writing and oral communication of results. Regarding GeoGebra software, it facilitates the rapid development of simulations and the construction of dynamic applets, develops intuition and visualisation skills.

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MATHEMATICAL MODELLING AND SIMULATION OF AN PHOTOVOLTAIC PANEL SYSTEM IN GEOGEBRA AND ARDUINO

José Magalhães¹

¹School of Engineering, Polytechnic of Porto, Porto, Portugal, <u>jdm@isep.ipp.pt</u>

Abstract. Project development experiences in different curricular units are included in the CDIO (Conceiving, Designing, Implementing, and Operating) model standards and it is suggested that they start in the 1st year of engineering courses in order to provide team activities. In this sense, in the engineering degree in Electrical Power Systems at School of Engineering of the Porto Polytechnic (ISEP) it was proposed to the 1st year students a multidisciplinary project that included modulation, mathematical simulation and construction of a prototype of a photovoltaic system using the Arduino electronic platform. They are presented the phases of the task development, the objectives to be reached with its realization and the results obtained by the students.

Key words: Simulation; Modelling; PBL; CDIO; Arduino; Learning; Mathematics.

INTRODUCTION

Project activities from the 1st year of engineering degrees are an integral factor for new students on courses. The existence of project activity is advocated in the CDIO (Conceiving, Designing, Implementing, and Operating) model (Crawley et al., 2007) and in the EUR-ACE degree recognition system (Malmqvist, 2009) from the first year of engineering courses. In addition to the factor of integrating new students in the course, this type of activity allows students to develop skills in solving technical problems, carrying out projects, developing research activities and communication.

THEORETICAL FRAMEWORK

In student learning in higher engineering education, it is essential that problem-solving activities are involved (Masson et al., 2012) and, therefore, **project-based learning** (PBL) methodologies are applied. PBL is centred on student activity: Be at the centre of the search for knowledge; Take responsibility for their own learning; Activities are developed in groups; The learning process is active and cooperative. The teacher has the role of learning 'coach': making students aware of what they know; what they need to learn; motivating them to search for information; working in teams and listening to other opinions.

Mathematical modelling and simulation are important activities in engineering students' learning (Malmqvist., Edström et al., 2020). **Modelling** is the process of obtaining mathematical models that represent a real-world situation (Biembengut and Hein, 2000), which requires solutions and decisions coming from mathematics (Figure 1).



Figure 1: Mathematical modelling cycle (Cai et al, 2014, p. 17).

This cyclical process is consistent with many real-world problems are modelled and promotes a shift in the teaching of traditional mathematics towards a multidisciplinary approach. Modelling provides a learning environment based on research and investigation, in which the process of mathematical simulation contributes significantly to reflections. Hence the need for simulators, because they are discovery spaces where students can manipulate, explore and experiment, developing their skills and taste for discovering the objects of the simulated world and allow simulations of real-world phenomena. In this sense, the use of GeoGebra software can be an option, because it is an algebraic and dynamic geometry computer program, of free distribution, with good characteristics to be used in a classroom environment and allows to perform constructions dynamically.

METHODOLOGY AND GOALS

By the standards of the CDIO model, the curricular unit of Mathematics Laboratories I proposed to the 1st year students of the Electric Energy Systems degree, 2016/17, the realization of a project - Solar House and Mathematics - that involved mathematical modelling and simulation and application of electronics (Arduino) based on a photovoltaic energy generation system and the creation of an experimental physical prototype.

By this project task it was intended that the students would gain learning skills about: energy efficiency of a house and the respective improvement in energy classification; operation and application of photovoltaic panels in the context of Energy Systems; operation of the microcontroller based on Arduino Uno and various sensors applied to the movement of a photovoltaic panel in the monitoring of a spotlight; programming in Arduino/C. In terms of mathematics, the students were expected to perform a dynamic mathematical simulation of a solar panel rotation system using GeoGebra; learn mathematical concepts of 3D geometry (points, lines and planes); study of multivariable functions (implicit and parametric); numerical calculation of equation resolution using the numerical methods of successive bisections and Newton. With the support of the curricular unit of work methods in Engineering (MTENG), that the students improve their capacities for written reports and public presentation of results.

RESULTS

This section describes the main tasks proposed to students and exemplifies solutions created by the professor and students in response to them.

In **task 1** we intended to model and simulate in GeoGebra a physical system consisting of a rotating photovoltaic panel placed on a house, as shown in figure 2.



Figure 2: Simulation (GeoGebra) of the rotating photovoltaic system on a house.

The simulator built by the students allowed them to support their answers to questions related to the Sun's motion curve in parametric form. Some of the questions involved solving equations numerically and through some of the methods studied during the lessons, such as, method of successive bisections, simple iterative and Newton's method.

Task 2 aimed to build a prototype in Arduino with the movement of a photovoltaic panel on a house to learn programming and electronics concepts (Figure 3).



Figure 3: Schematic and electronic construction of the rotating photovoltaic system.

Task 3 was the public presentation of results and the final prototypes, as shown in the pictures in figure 4 by some groups of students. In the comments of the student groups, it was perceptible that the realization of this kind of PBL tasks provided them with a good motivation for learning.



Figure 4: Public presentations of the prototypes of some student groups in the project task.

CONCLUSIONS

The project is by excellence a task that allows integrating multidisciplinary transversal skills - Mathematics, Physics and Engineering - of working in a social context (team) in engineering students and integrating new students (Magalhães et al, 2018). Modelling and simulation of physical processes are tasks that contribute to enhance more meaningful engineering learning, as argued by Malmqvist, Edström et al. (2020). Regarding GeoGebra software, it facilitates the rapid elaboration of simulations and the construction of dynamic applets, develops intuition and visualisation skills. The existence of curricular units such as Mathematics Laboratories facilitates the use of mathematical software and perform by student's simulations of engineering systems.

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