Learning Experience Design in Engineering Education

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Abstract Interaction experiences with students are considered as one of the key aspects to achieve an effective digital transformation in higher education classrooms. This paper presents some successful experiences carried out at the School of Industrial and Civil Engineering at the University of Las Palmas de Gran Canaria. Specifically, in "Las Cocinas" workshop, a working and cooperative learning space in which open educational practices are achieved through the implementation of the methodologies Maker Education and Students as Partners. Students from different educational levels work on the development of social innovation projects alongside other members of the university community and external collaborators. They participate in co-creative processes for designing learning experiences, both for other university students or different educational levels. The usage of digital manufacturing technologies as well as other content development and management technologies, are essential in a quality engineering education since both and soft skills are put into practice.

Keywords Maker Education, Soft Skills, Open Education Practices, Learning Experiences Design

Introduction

Digital transformation is not just about incorporating technology into an organisation, but also about using it effectively to achieve its mission and purpose from a strategic approach. People must be the main protagonists in the digital transformation process of any institution, and especially in those dedicated to education, with technology being the way to facilitate educational processes. Only with this strategic approach will be possible to achieve a change in the organisational model

that incorporates the appropriate technologies at the service of educational methodologies. This will make possible to design innovative and high-quality actions and experiences that will stimulate the cultural change needed to achieve an effective digital transformation. The collaboration of all of those involved, especially students and teachers, to reflect on and be aware of their needs and abilities, are key aspects for the correct implementation of this process of digital transformation in university classrooms. Learners, as end-users, must be at the centre of decision-making. (Ameneiro & Verdú, 2022).

Digital transformation does not mean that all educational processes must be online. Blended or hybrid methodologies bring out the best of face-to-face teaching and online learning. Teachers can use digital designing tools to create interactive and enriched learning materials. The learner can prepare these contents autonomously and asynchronously in virtual classrooms. Face-to-face time in classrooms or laboratories can be devoted to active learning, which facilitates the student´s participation and interaction. In this way, practical and social skills that are more complex to deal with in virtual environments are also addressed. In the current context, with the continuous and accelerated emergence of new technologies that can be applied to the field of education, such as artificial intelligence, the metaverse, virtual reality, among others, new types of interaction between face-to-face and virtual models will emerge. Universities must prepare students to face a digitalised and constantly changing technological environment, both in their personal and professional fields (Gómez-Cardosa, 2022).

Interaction with students is recognised as one of the weakest points of digital transformation at universities (Ameneiro & Verdú, 2022). It is in this area that this work is oriented, and particularly in the usage of methodologies that encourage participation, collaboration and openness to different actors, such as students, teachers, researchers, companies and institutions, within what is called Open Education Practices (Cronin & MacLaren, 2018). They constitute experiences of great value for Engineering Education, which is characterised by the transmission of knowledge, principles and skills related to the professional practice of engineering, integrating research and education. Engineering is one of the STEAM disciplines that have proven to be essential for the progress and development of societies, in a context of globalised competitiveness where numerous employment opportunities are opening up (Pedreño Muñoz, 2016). There is a need to question whether the current way of educating and motivating students in these disciplines is adequate. This is a priority area for Engineering Education Research (EER), which is defined as a research that focuses on how engineering students can acquire the skills they need to be successful professionals (Bernhard, 2015). Recently, a new academic discipline has emerged known as Learning Engineering, which focuses on the practical application of learning sciences through engineering design and learner-centred methodologies, relies on technology in order to more effectively implement innovative, flexible, adaptive and personalised learning experiences, and seeks to create a more efficient and sustainable learning ecosystem (Kolodner, 2023).

The Educational Innovation Group *Ingeniería de Fabricación* (GIEIF) of the University of Las Palmas de Gran Canaria (ULPGC) has developed an educational

innovation project in the School of Industrial and Civil Engineering (EIIC), between 2019 and 2022, called "Applying Engineering for Learning in the EIIC". The main objective of this project was to improve the learning of the school's students by identifying their entry profile, studying the actual learning experience, developing a plan for attracting and retaining new students and creating new learning experiences. To this end, it has implemented open educational practices in the development of co-creative processes with students to design new learning experiences through Maker Education. An outstanding result of this project was that it gave rise to another complementary educational research project called "Transversal Competences from the EIIC for its social ecosystem". Both projects have been running in parallel since 2021, generating valuable synergies between them, which are presented throughout this work.

Methodologies

The following is a brief description of some of the methodologies used in the aforementioned projects, where both quantitative and qualitative impact assessment tools were used in several of the experiences described in the following section.

The Students as Partners (SaP) methodology in the teaching-learning process involves students and the broader university community collaborating to achieve shared educational objectives, benefiting from working and learning together. It involves a reciprocal process in which all participants have the opportunity to contribute equally, though not necessarily in the same way, to conceptualisation, decision-making, implementation, research or curricular or pedagogical analysis. It is process-oriented rather than outcome-oriented, and is based on the principles of respect, reciprocity and shared responsibility for learning and teaching. The SaP methodology can encompass a wide variety of educational practices, all characterized by a repositioning of the roles of all participants, working collectively to enhance the learning experience, making them co-learners, co-trainers, co-investigators and co-creators of these educational practices (Mercer-Mapstone et al., 2022).

Learning Experience Design (LXD) is a design discipline that focuses on creating powerful learning experiences. It is distinguished from other disciplines by its unique focus on learning from a holistic, comprehensive and interdisciplinary perspective. The aim is to ensure that the learning journey is enjoyable, engaging, relevant and formative. This creative process enables work in situations with a high level of initial uncertainty and yields clear and detailed results. The focus is on the student or learner and the objectives or outcomes of their learning. The learning process must integrate the learner's voice and interact with them in a shared development process. It should consider the realities, behaviours, and preferences of learners, including the learning environment. LXD uses design engineering methodologies that involve identifying the problem to be solved and understanding the individuals who will be experiencing it. The experience is then collaboratively

created, integrating various perspectives. Following this, the experience is prototyped at an appropriate level of detail and scale. A pilot experience is tested to verify whether the intended learning objective has been achieved. Finally, after reviewing the results and making any necessary improvements, the learning experience is launched (Schmidt & Huang, 2022).

The Maker Education methodology is the application in the educational field of the values of the Maker movement, originated outside of the education sector, but has since been incorporated into all levels of education, and it encourages participation in STEAM design and engineering activities from an early age (Sang & Simpson, 2019). The use of Maker Education is based on learning by doing through experiences that enhance learning in three ways. Firstly, they foster a collaborative community that shares information, knowledge, and ideas, facilitating peer learning and teamwork. Secondly, they encourage problem-solving, student flexibility, curiosity, and experiential learning, which increase learning and its relevance. Thirdly, students can access new spaces for creation that are open and equipped with tools not typically available in the classroom (James et al., 2019). These are collaborative spaces for digital manufacturing, commonly known as Makerspaces, Fablabs or STEAM-labs. The primary focus of these spaces is not on the physical location or equipment, but rather on fostering the interaction and cooperation in co-creation processes that involve problem-solving and participation in meaningful projects. These spaces provide individuals with the opportunity to develop technical skills related to the use of technologies, as well as soft skills in design and critical thinking, stimulating creativity, communication, emotional intelligence, teamwork, ethics and professionalism, among others (Sanabria-Z et al., 2020).

Results and discussion

The GIEIF has prior experience in applying the SaP methodology for the creation and management of content through the development of interactive teaching materials, converting some of them into open educational resources (Hernández-Castellano et al., 2020). In the 2019/20 academic year, the decision to apply this methodology to tutorial action was made at the EIIC. This coincided with the modification of the syllabus for the Degree in Industrial Design and Product Development Engineering (IDIDP), which was being worked on at that time.

Two Bachelor Thesis (TFG) were proposed for this degree, one of which aimed at defining a collaborative workspace to meet the historical demand of students in this degree. This demand included having an open space to carry out various academic activities required in different subjects, as well as the opportunity to develop related personal initiatives. This is how the Industrial Design Engineering workshop, “Las Cocinas”, is born. The definition of “Las Cocinas” workshop resulted from a collaborative process with 4th year IDIDP students, led by one of their classmates who was working on his TFG, and it was ultimately realised and inaugurated

in October 2020. The workshop was implemented with the indispensable collaboration of several students who had taken the External Practices (PE) course and recent graduates of the same degree. They voluntarily contributed their time and effort in a context of global uncertainty. This is a clear example of the students' commitment, involvement, and exercise of responsibility in improving their learning. The workshop is equipped with both digital manufacturing technologies, conventional equipment, and manual tools. It provides a collaborative space for students to materialise their ideas and projects with the support of other members of the university community. The Circular Maker Movement Ecosystem was defined through a Master's thesis (TFM) developed by the same student. It was decided to frame the activities to be developed in "Las Cocinas" with a spirit of openness that invites the participation of other external collaborators, such as professionals, companies, and various institutions. This space has successfully established a learning ecosystem that facilitates interaction between students from diverse educational backgrounds. This ecosystem supports the development of various training activities and social innovation projects, which are requested by different stakeholders, both within and outside the university community. We have enhanced our students' learning experiences through non-formal and informal educational activities. These activities have strengthened their connection with the social environment of the EIIC. "Las Cocinas" currently offers a virtual classroom for collaborative work in Moodle and its own website (www.lascocinas.eiic.ulpgc.es). Students can access training resources related to the available tools and technologies, as well as information about the activities and projects developed in the workshop. These practices are open and involve students as valuable partners in the teaching-learning process, which is the essence of the SaP methodology.

The other TFG is aimed at evaluating the learning experience perceived by IDIDP students, highlighting some key aspects, such as the students' sense of belonging to the school and the institution. It also identified the need to understand the profile of the students who accessed the school. To achieve this, a specific questionnaire was designed to be used during the welcome day for incoming students. This questionnaire had several blocks of questions to extract socio-demographic information, university entrance qualifications and studies, interests and hobbies, motivation for selecting the degree and university, and self-assessment of transversal competences. Additionally, the questionnaire includes the Honey-Alonso learning style preference assessment test (Freiberg Hoffman & Fernández Liporace, 2013). The questionnaire's main objective was to gather pertinent and valuable information for the EIIC and its educators. This would enable us to gain a better understanding of incoming students and adapt teaching activities to achieve improved learning outcomes. In September 2021, the EIIC administered this questionnaire for the first time to all degree programs. The questionnaire obtained relevant and varied information on the average university entrance qualifications, the main motivations for pursuing the degrees, and the interests and hobbies of the students. The perceived mastery of transversal competences was generally at a medium-high level, with more homogeneous results.

Small differences were observed in the preferred learning styles among most degrees, except for IDIDP, which showed greater differences. Repeating this analysis in subsequent years to draw reliable conclusions is recommended. The sample size

for IDIDP students was 143, which represents more than 90% of the new students entering this degree, and for the other degrees was 238, which represents approximately 25% of the total accumulated in the academic years 2021/22, 2022/23, and 2023/24. The results suggest that students in the IDIDP degree exhibit a preference for Active learning style, which are above average among other degrees. Similarly, there is a slight preference for Reflective learning style. However, and to a greater extent, for the Theoretical and Pragmatic learning styles are below average. These results align with many teachers´ perceptions, who have taught in both IDIDP and other degrees offered by EIIC. This could be one of the reasons for the lower results obtained in this degree in some subjects common to other degrees and would support the hypothesis that an appropriate contextualisation of the teaching activities for these subjects could improve these results. The development of specific, interactive and adaptive teaching materials for these subjects, which take into account the characteristics of different learning styles, could have a very positive impact on their results.

To continue analysing the learning experience of IDIDP students, it was deemed necessary to propose another TFG for the same degree. This TFG is oriented towards the application of the educational Design Thinking methodology (Panke, 2019), and involves group dynamics with students from each course of the degree. A face-to-face collective experience was organised based on the principles of participatory design. A working group of twenty volunteer students, five from each course, was formed. The students who were invited to participate were committed and actively involved in the degree. The aim of the activity was to identify the actual learning experience, assess the degree of satisfaction, and recognise any existing needs. Canvas-type panels were elaborated together with a scale to quantify the level of satisfaction. Both individual and group evaluations were considered to improve the reliability of the results. The study addressed various aspects of the university experience, including students relationships, both among themselves and with the wider university community, classroom and outdoor spaces, subject content and teaching styles, transversal competences, and emotional bonds. The purpose was to evaluate the degree of belonging to the degree programme, the school, and the university.

The author of the TFG directed and facilitated the experience to ensure that teacher involvement did not hinder student participation. Prior to the face-to-face activity, a virtual pre-activity was conducted using a digital whiteboard application where students introduced themselves to one another. Participants were required to submit a photograph of themselves, along with an identifying element and a list of three things they enjoy. The face-to-face session was designed to be engaging and to hold the attention of all participants throughout the approximately two-hour and a half session, which took place in a spacious room with tables arranged in a circle to facilitate interaction between course groups. An introduction was provided to clarify the objectives, indicate the benefits of participation, establish a climate of psychological safety, encourage reflection and emotional expression, and remind participants of the rules of respect for all opinions. The concept of the learning experience was presented and initial participation was encouraged through a quick round of self-introductions. This was followed by the first block of questions with few minutes to respond and interact with the group members, synthesising the ideas

on stickers on the corresponding Canvas panel. Each block concluded with another few minutes for a global discussion of the four groups. The session ended with a few minutes to summarise the overall conclusions about the experience and its usefulness. The activity was deemed successful based on the feedback provided by the students in the final questionnaire. They appreciated the opportunity to express themselves and be heard, which helped improve their learning experience. Upon analysing the information provided in the different thematic blocks, most of them received a good or acceptable rating, but there is still considerable room for improvement. The highest-rated aspects of the degree were the general vision of the degree, relationships between students, transversal competences acquired, and overall sense of belonging to IDIDP. The lowest-rated aspects were the sense of belonging to the school and ULPGC, as well as the contents and teaching methodologies in certain courses. The ratings for relationships between students and teachers, as well as the spaces in the EIIC, were average.

One issue raised by students regarding their first year was the need for more specific design content and increased opportunities to interact with final year students in practical activities. To address this demand, a specific experience was proposed and it was determined that the most suitable subject for this experience was Aesthetics and Industrial Design. The idea was accepted by the lecturer of the subject, and fourth-year students completing their PE at “Las Cocinas” workshop planned and led a practical activity in small groups. The goal of the activity was to demonstrate to first-year students how to complement basic knowledge in design with digital manufacturing technologies, from the early stages of the new product development process. The pilot experience took place during the academic year 2020/21 and received positive feedback from students who completed the standardised CEQ questionnaire (Wilson et al., 1997) used to assess teaching quality. This experience has been continued in subsequent academic years, indicating its sustainability and transferability to other subjects within the same degree program.

Another successful example of learning experience design is the consolidation of flipped learning model in laboratory practices. This model was implemented in the subject of Product Development Technologies in the 4th year of IDIDP. The virtual classroom of the subject contains interactive didactic materials that students must work on before attending the face-to-face laboratory session. The didactic materials were developed by students who had previously studied the subject under the guidance of the teaching team. These materials have been highly valued, as have the dynamics of the face-to-face sessions that encourage interaction between students. After completing the laboratory practice, students are required to produce a narrated video report that is no longer than two minutes. The report should demonstrate their communicative competence and ability to synthesize relevant information. This will enable teachers to assess the extent to which the learning objectives for the laboratory practice have been achieved (Hernández-Castellano et al., 2021).

In the spirit of opening up new collaboration activities between the EIIC and its social ecosystem, “Las Cocinas" workshop has proposed various types of training activities for students from other ULPGC faculties, as well as for entrepreneurs and external professionals. The workshop has also conducted maker activities to promote STEAM vocations among students from different educational levels. An example of this is the project ‘Get Closer to Engineering’, which was offered to all

secondary schools in the Canary Islands with the collaboration of the Education Department of the Canary Islands Government. Practical and participatory experiences were designed for different branches of engineering to play a fundamental role in achieving the Sustainable Development Goals. The students collaborated with their teachers from various subjects on a course project related to controlling invasive plant species in the Canary Islands. At the end of the course, a session called "Young Engineers" was organised, in which all the centres met in the EIIC Assembly Hall for the joint presentation of the work carried out. A third of these institutes opted to join the IDIDP programme and took part in a complementary pilot programme at "Las Cocinas" workshop, led by EIIC students. They actively participated in the use of digital manufacturing technologies, such as 3D scanning, 3D printing, and laser cutting. According to the CEQ activity evaluation questionnaire, secondary school students expressed a high level of satisfaction. They particularly appreciated the interaction with EIIC student collaborators and the support tutorials available on the school's website (Narganes-Pineda et al., 2023).

Besides, a social innovation project was developed through collaboration between the co-edu educational research project and another equivalent project called "Development of Inclusive Teaching Materials in the Field of Geography". The project involved designing and manufacturing three-dimensional haptic models and textured sheets with Braille information. Twelve IDIDP students participated in this project during their PE at "Las Cocinas" workshop. Some of them even developed it as their TFG. Working in interdisciplinary teams to develop professional projects that meet social needs has allowed individuals to apply technical skills acquired during their degree, as well as develop soft skills in communication, organization, and cooperation. This is a clear example of the application of service-learning methodology to address social needs, where students have learned to use various digital technologies (*Participación de la Escuela en las V Jornadas de Aprendizaje-Servicio de Canarias – Escuela de Ingenierías Industriales y Civiles ULPGC*, 2023).

Conclusions

This contribution claims that the experiences described can facilitate the digital transformation process in the classroom, without which the digital transformation in higher education institutions would not be completed. The implementation of various methodologies that encourage interaction between teachers and students has been key to achieving a peer learning ecosystem in "Las Cocinas" workshop. The EIIC has experienced a positive impact on its social environment due to certain results that have been obtained.

The use of digital technologies to better understand new students and evaluate their satisfaction with the experiences offered can provide valuable information for centres to make strategic decisions. Hybrid models, which combine face-to-face and online activities, enable students to learn in a digitalised context while also

developing hard and soft skills. The latter are increasingly in demand on nowadays labour market, so acquiring these skills will enhance students' employability.

Students are the best ambassadors for universities when they spread the word about the rewarding learning experiences they have received. More attention should be paid to these dissemination activities of our students in order to give as true picture as possible of the good work being done in higher education institutions. This is the only way to survive in an increasingly globalised and competitive industry.

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