PROJECT-BASED LEARNING APPLIED IN THE PANDEMIC SCENARIO. CASE STUDY: FLUID-MECHANICAL ENGINEERING

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Abstract

The pandemic situation due to SARS-Cov-2 obligates to adapt the learning processes in different academic levels. Universitat Politècnica de València (Spain) had to deal with this challenge, where the learning process changed from a face-to-face way to a non-face learning model when the confinement began in March 2020. This caused the need to adapt the teaching process, methods and materials from in-person classes to virtual ones. This contribution shows the adaptation process to face the problems caused by the pandemic and related to the non-face-to-face education through an example in a case study, particularly in the subject called Fluid-Mechanics Engineering. This subject is taught in the third year of the mechanical engineering degree at the Universitat Politècnica de Valencia (Campus of Alcoy). The students enrolled in this subject followed two different teaching procedures and the present research shows how the planning of the subject was adapted when the pandemic situation arose, the different activities developed to adjust to this new context as well as the perception of the students about such an adaptation through the development of an online survey.

Keywords: COVID-19, Project-based-learning, fluid-mechanical engineering, non-face-to-face classes.

1 INTRODUCTION

The world is trying to return to normality after the outbreak caused by COVID-19. The pandemic has affected all contexts. One of them is the education sector. Overnight, people had to stay at home to try to minimise the spread of the virus. So teleworking became the routine for many professionals. This also happened in the educational context, at all academic levels, although this research is based on the higher educational level. In this sense, teachers and students quickly had to change the teaching-learning method from face-to-face to online classes.

According to UNESCO data, at the beginning of April 2020, universities of 185 countries around the world closed, affecting nearly 90% of enrolled students [1]. Based on the data collected by the International Association of Universities, the process of transition from face-to-face classes to an online educational model was particularly difficult and demanding for universities, both in terms of technological needs and the adaptation of evaluation processes [2].

Spanish universities, like all international university systems, suffered directly from the impact of the pandemic and they were able, in a very short period of time, to develop solutions and response mechanisms. In [3] it is shown the COVID-19 timeline in Spain from March to June, 2020. From a social point of view, the universities carried out a general inventory of laboratory material that they donated to their closest environment: hospitals, health centres, residence for the elderly, with the provision of 1.7 million gloves, 75,000 masks, 25,000 gowns, 6,000 individual protection equipment , etc. to alleviate the effects of the lack of these items. From an educational point of view, the university's efforts focused on maintaining quality standards in teaching, in the reactivation of day-to-day activities such as research and knowledge transfer and, last but not least, in staff management (national and international students, administration and services staff and teaching-research staff) [4].

Generally, all the universities from Spain, and particularly Universitat Politècnica de València (UPV), adopted the following actions: (i) recording, as far as possible, the classes so that all students could get access to them at any time in order to deal with connectivity issues and/or family reconciliation problems; (ii) rapid and flexible adaptation of teaching contents and methodologies to the virtual teaching context; (iii) virtual defence of Final Degree, Master's and Doctoral Theses; and (iv) adaptation of the evaluation methodologies to virtual teaching.

This paper describes the adaptation process performed in a particular subject: "Fluid-Mechanics Engineering" taught in the third year of the mechanical engineering degree at UPV (Campus of Alcoy),

based on the previous actions, to guarantee the quality of the teaching-learning process but also the health of all the university community. Moreover, it is worth mentioning that the adaptation procedure was particularly complex since part of the subject used the active methodology of project-based learning (PBL).

The paper is organised as follows. Section 2 describes the methodology that it is, in turn, divided into two main parts. The first one describes the PBL innovation and educational improvement project as the context in which the subject is framed. The second part describes the adaptation procedure in the transition to a virtual teaching model. Section 3 shows the results of the adaptation process. Finally, section 4 provides the main conclusions of the paper.

2 METHODOLOGY

2.1 PBL Innovation and Educational Improvement Project

One of the parts of the subject used the active methodology of PBL. This is due to the fact that the subject participates in a innovation and educational improvement project promoted by UPV whose main objective is to incorporate the PBL methodology collaboratively among different subjects of the last courses of different bachelor degrees [5]. The Campus of Alcoy of UPV has 5 bachelor degrees that have participated in this innovation. Ten different PBL models have been implemented in the academic year 2020-2021. They are the following ones per bachelor degree:

- Industrial Design and Product Development Engineering Degree
  1 Product design project
- Computer Engineering Degree
  2 Programming and data structures and algorithms project [6].
  3 Software engineering project in business contexts [7].
  4 Videogame project [6].
- Business Administration and Management Degree
  5 Financials advice project [8].
- Mechanical Engineering Degree
  6 Engineering model project [9].
  7 Vehicle design and engineering project [10].
  8 Design and calculation of a pressure tank with Solid Works with the use of composite materials project [11].
  9 Design and manufacturing of machines and prototypes project [12].
- Chemical Engineering Degree
  10 Design of an adsorption column for the elimination of colorants in wastewater in the textile industry project [13].

This paper focuses on the project 6, in which the subject Fluid-mechanical engineering participates.

2.2 Adaptation Procedure

The challenge caused by the pandemic situation obligated to use synchronous and asynchronous tools to continue with the lessons. The lessons changed from a face-to-face way to an online model in one day. The proposed methodology tries to keep the initial programming of the subject to not vary significantly due to the new pandemic situation. The main goal was to keep the project-based learning methodology, which the student just started on 1st March 2020. The lessons were master lectures before 14th March, 2020 when the Spanish Government declared the alarm state [14]. The traditional teaching methodology was structured as follow. The professor develops and works the theoretical concepts to build the knowledge basis in the students. In the different face-to-face classes, besides teaching, the professor defines the problem-solving strategies in each of the units. In addition, in the first units the professor supervises students in understanding and analyzing the problem, extracting the data, adopting the resolution methodology and initiating a critical analysis of the solution obtained [15]. The project-based learning methodology was thought to be applied from unit 4 to unit 8, in which students develop

a project applying the learning goals to reach the learning results by different team groups. The teaching concept was focused on teamwork in class and the professor helps students while they work in class.

Once the face-to-face lessons were impossible due to COVID-19, the structure and organization of the lessons had to be modified. In this case, to adapt to the situation, different learning steps were proposed to students (Figure 1).

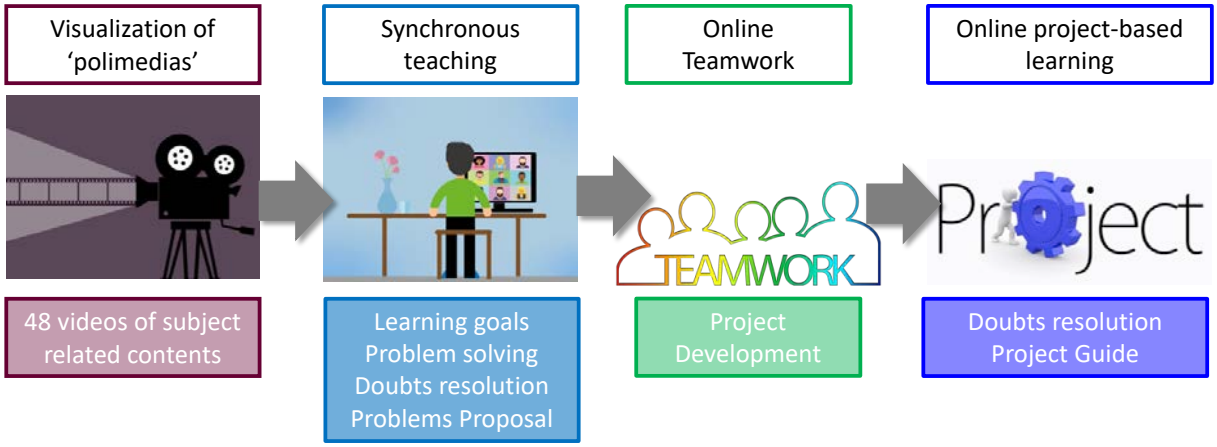

Figure 1. Summary of the adaptation procedure.

1 Visualization of 'polimedias'. Polimedias are explained videos where the professor records a short explanation whose main objective is to reach a specific learning goal [16]. The author of the polimedia has high interactivity with the exposed content. Its duration is between 5 and 10 min. In this situation and to facilitate the students' learning process, the professors developed 48 polimedias, which were considered in the teaching guide of the subject. Each day had a detailed planning that was programmed. Students received an e-mail in which the professors indicated the recommended polimedia for that lesson. Such emails were sent five days before the day of the lesson. It was recommended to see between two or three polimedias, in which students could know, analyze and acquire the main learning results to be used and applied in the following class.

2 Synchronous teaching.Synchronous lessons consist of performing the teaching process when the lesson was programmed. The duration of the synchronous lessons was two hours. In this time, the session was divided into two different phases: synchronous teaching and online teamwork. Synchronous teaching extended around 30 minutes in which the professor enumerated the main learning goals. These were contained in the polimedias, and therefore, this helped students to remember them and they could make questions to solve their doubts. If students do not have any doubts, a short problem was developed and solved, and other problems were proposed so that students can apply the learning results.

3 Online Teamwork. When step 2 was finished, the work was developed applying the active methodology of the project based- learning. In this case, students worked in a team. The team was composed by four people. They had to develop a project in which they should design the pump system as well as the distribution network. The activity analyzed the efficiency indicators related to sustainable development goals [9]. Students had to design the system considering two hypotheses: (i) gravity network where there is a reservoir and it fills using a pump system; and (ii) direct supply using pump systems. The first hypothesis enables the analysis of the influence of the reservoir volume in the pump selection and the second enables the application of the knowledge of the regulation operation curves [17]. Students applied the learning results of each polimedia, which was watched previously in each session. The project was organized to add each week the learning results and it could be developed in 15 sessions.

4 Online project-based-learning session. Moreover, students could develop private sessions in which they could ask doubts and/or present ideas to incorporate into the project.

3 RESULTS

Fluid-mechanical engineering was taught in the third course of Mechanical Engineering Degree at Universitat Politècnica de València (UPV). There were 136 students and they were between 20 and 26

years old. Students were divided into two theory groups and four practical groups at the academic year 2019/2020. When the lessons were online due to pandemic situation, the size of the groups was the same.

The main goal of this research is to know the opinion of the students about the previously defined methodology used during the months of confinement, once that the lessons were finished. Thus, a survey was developed in which different questions were defined according to the different phases of the project development. Figure 2 shows one example of the sizing of a network developed in one of the students' project.

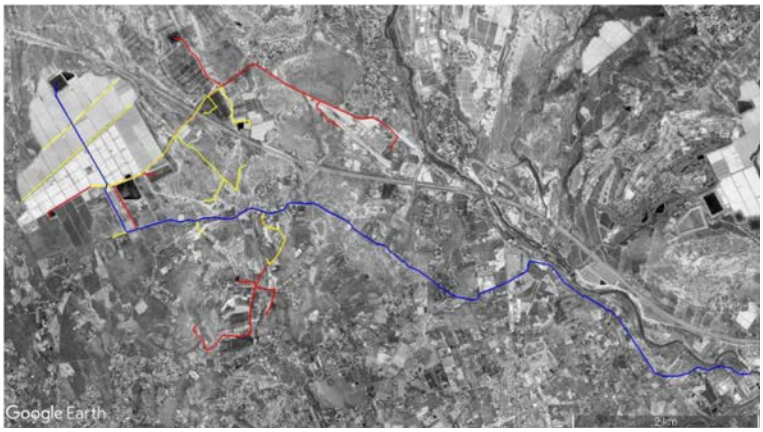

Figure 2. Example of the design project

The survey was answered by 68.9% of the students. Figure 3a shows the answers related to the following question: "What percentage of the available polimedia developed for this subject did you use throughout the course?". The results show that 56 % of the students watched all the polimedia (100%) developed. A 26 % of the students watched between 70 and 99% and the rest of the students played the polimedia with a percentage below 49%. This shows an excellent reception of the students in the use of these interactive educational resources, which can be recorded in the UPV facilities.

Figure 3b shows the acceptance of the students to work using PBL. This methodology was accepted by more than 75% of the students and the learning results were excellent as 84% of the teams reached the proposed learning results. These learning results were evaluated using a rubric, which contains 32 different indicators. These indicators were related to the efficiency of the system, correct design, evaluation of the environmental conditions as well as the presentation of the work (writing, modelling of the models in the used software, budget, among others aspects). To improve the acquisition of the learning results, the evaluation criteria were published in advance. This provided transparency to the evaluation process and allow both professors and students to follow the learning progress. An example of transparency is the so-called rubrics, documents that articulate objectively and equitably the evaluation process, providing feedback to the students during the learning progress. In this sense, competence is evaluated using a rubric.

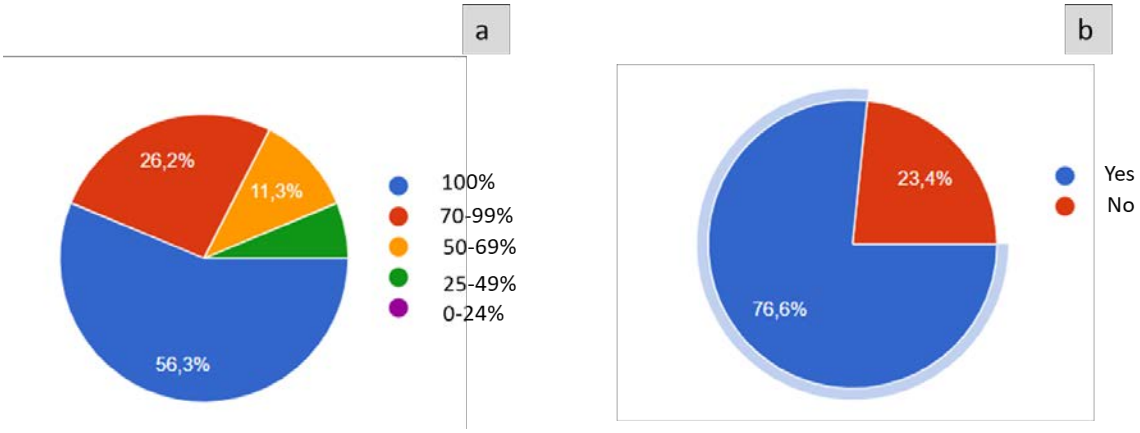

Figure 3. (a) Results of the survey related to polimedia.
(b) Results of the survey related to PBL method

4 CONCLUSIONS

The whole world has experienced and continues to experience a completely unexpected situation caused by the SARS-Cov-2 that has had a major impact on all areas of life. One of them has been the educational context, which has had to take very rapid measures to adapt to this new situation by guaranteeing students teaching process. To this end, alternative procedures to the face-to-face teaching model have had to be defined and implemented in record time.

Most universities have implemented, among other measures, the development of asynchronous educational materials (such as videos, virtual laboratories, etc.) to support the learning process; the recording of online classes so that students can get access to them when required; the use of asynchronous virtual teaching tools to carry out classes and also to communicate with students to resolve questions and doubts. This paper describes the measures adopted in the transition from the face-to-face to the virtual paradigm in a third-year subject taught in the degree of Mechanical Engineering at the Campus of Alcoy in UPV and entitled "Fluid Engineering Mechanics". In face-to-face classes, this subject used methodologies such as master classes and PBL. The new teaching paradigm required adapting these methodologies to a virtual context and this paper describes such an adaptation procedure as well as the results obtained. Both the procedure and the results may serve as examples to be transferred to other subjects or educational contexts.

ACKNOWLEDGEMENTS

This work was supported by the project SISIFO (Development of analytical toolS to characterIze the Sustainability of hydraulic systems Indicators that deFine sustainable development Objectives) PID2020-114781RA-I00 from Spanish State Research Plan Scientific and Technical and Innovation 2017-2020.

This article has been supported by Universitat Politècnica de València, particularly by the Vice-rectorate for Digital Resources and Documentation (Vicerrectorado de Recursos Digitales y Documentación) and Vice-Rectorate for Studies, Quality and Accreditation (Vicerrectorado de Estudios, Calidad y Acreditación) under the Call for Learning + Teaching (Convocatoria A+D2019: Aprendizaje + Docencia. Proyectos de Innovación y Mejora Educativa) and Project Code: A157. The authors would like to acknowledge the support of the Institute of Educational Sciences (Instituto de Ciencias de la Educación), the Evaluation and Monitoring Commission for Educational Innovation and Improvement Projects (Comisión de Evaluación y Seguimiento de Proyectos de Innovación y Mejora Educativa (CESPIME) and Escuela Politécnica Superior de Alcoy.

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