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Cross-cultural Collaborative Online International Learning via Problem-based Learning

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Abstract– In the current context, international companies require engineers who collaborate remotely with people from other cultures. Developing these skills at university level is very important for future professionals, as they will have a differentiator with respect to their peers. This research paper presents the design and implementation of a cross-cultural Collaborative Online International Learning based on Problem-based Learning between two universities on different continents. The formality of the research method, the design of the COIL+PBL activity, and its deployment are described. The case study was modeling and automatic control of an electronic process, at the simulation level. The mixed-type research approach included the disciplinary performance of the students, but also their opinion. This cross-cultural COIL experience is very valuable within the efforts of universities to graduate professionals with a global vision.

Keywords—Collaborative Online International Learning, Cross-cultural, Engineering Education, Problem-based Learning, Modeling and Automated Control Systems

I. Introduction

It is becoming more and more common to work in multinational companies where projects are developed from a remote interaction perspective and where professionals from different parts of the world participate in the same team. This scenario requires engineers with the ability to collaborate remotely with peers from different cultures, possibly with different native languages, and who are in different time zones. Regardless of these cultural, linguistic, and geographic differences, team members must collaborate appropriately to achieve the common goal. These skills could be developed over time, by participating in work teams, but it is desirable that, upon graduation, professionals already have these credentials.

From the perspective of having face-to-face and in-person interactions, developing these cross-cultural soft skills from the school years would require a large financial budget and considerable logistic effort. For most educational institutions, it is very complicated, with their own resources, to move a group of students to another country to have an international and cross-cultural experience. It is not only the cost of travel expenses, food, and lodging for the students and the tutors who will accompany them, but also the scheduling of activities, the impact on other courses in the same academic period, and other logistical aspects. In this context, Information and Communication Technologies (ICT) emerge as a platform that allows international cross-cultural activities to be carried out, as will be reviewed later.

Modern universities are spaces where paradigms are broken in the teaching-learning process and where educational approaches are at the forefront. Today's world is global and multicultural and to respond to these needs, in 2004, in a higher education institution, the Collaborative Online International Learning (COIL) educational approach was proposed. It was there, at the State University of New York, United States, where the first COIL activities were reported, to connect students from different parts of the world and coincide in an academic course. Since then, multiple instances of COIL have been reported, and the educational research work herein will focus on intercultural COIL experiences with engineering students who do not share the same native language.

It is pertinent to briefly describe the main elements of COIL. It must include collaborative work between students from peer institutions. In addition, there should be remote digital technologies to maintain a bridge among participants, i.e. Information and Communication Technologies (ICT). Additionally, the approach expects to be international and could have more impact if it is also cross-cultural. Finally, participants must learn something and formalize the COIL, that is, it must have a direct relationship with an academic course for all parties involved [1].

To increase the relevance of the COIL within a university engineering curriculum, the aim is to solve a relevant problem that corresponds to reality and that students perceive the future value of what they are doing in the COIL. The Problem Based Learning (PBL) technique has been successfully applied in these cases. An example of reported COIL+PBL is in [2].

The COIL educational approach can be applied, complemented with PBL, to develop digital interaction skills at a distance with peers from different cultures where a common problem must be solved. Universities can contribute to developing these skills by strategically combining teachers, digital communication tools and an institutional support platform. On the one hand, teachers with an openness to carrying out this type of international experiences are required; as well as an ICT infrastructure that supports virtual classrooms with audio and video. These two elements are sufficient to carry out COIL activities, but if the institution dedicates an entity/office to help the teaching team with the administrative and technological part, better results can be obtained [3].

The COIL learning approach has Collaborative Learning (CL) embedded in it. The impact of this teaching technique that has been applied in conjunction with PBL should not be overlooked. CL is a student-centered didactic technique that requires collaborating in small teams to perform learning sequences, acquire knowledge, develop competencies on specific topics, and achieve a common goal [4]. Furthermore, CL expects that team members share and discuss individual learning to develop some previously defined competencies [5]. COIL could be viewed as a type of CL with the specific features: online and international.

Following the implementation of the Bologna Process, European universities have developed robust networks of collaboration, significantly enhancing cross-border academic cooperation. A notable example is the Erasmus+ Virtual Exchange program, which has facilitated intercultural learning experiences through online platforms. This initiative enables students and educators across Europe and the Southern Mediterranean to engage in structured, technology-enabled dialogues that promote mutual understanding and global competencies [6]. Such programs provide a valuable reference framework for the development of inclusive and scalable Global Shared Learning (GSL) models in diverse academic contexts.

The contribution of this research is the design and implementation of a cross-cultural COIL/CBL activity for engineering students. The activity was designed by teachers from Ferhat Abbas University in Algeria and Tecnológico de Monterrey in Mexico. It was applied to students from these same universities who were presented with the problem of modeling and automatic control of an electronic system. Additional elements around COIL+PBL are the cultural difference between both countries and the fact that English was used as a means of communication, a language that is not the first language in either case. To the best of the authors' knowledge, there is no previously reported COIL experience structured in the specific terms and pedagogical framework described in this article. While GSL has been explored in various forms, this work introduces a unique implementation that combines cross-institutional collaboration, discipline-specific content, and student-centered active learning strategies. This highlights the originality and relevance of the presented approach.

II. METHODOLOGY

This section delves into the structure and formality of the exploratory research effort and the focal point COIL+PBL. The conceptualization of this research includes the conditions that triggered the inquiry. Later, the research problem and scope are defined. Furthermore, the action plan defines participants, instruments, workflow diagram, and a detailed description of the deployed COIL activity.

A. Academic Team, Collaboration Opportunity and Objectives

The teaching team consisted of two professors from a university in Algeria and one professor from a university in Mexico. The professors had a personal interest in collaborating in a joint international activity. When reviewing options, they found that both institutions taught a course on control engineering with similar objectives and topics; additionally, both courses were taught practically at the same time of year. It should be noted that there was previous experience of collaboration among professors, but without the participation of students. This previous collaboration triggered the work presented here.

Control Systems Design is the name of the course at both universities. At the Mexican university, it is taught to third-year engineering students, and at the Algerian university, it is taught in fourth-year engineering. In both cases, the objective of the course is the analysis and design of control systems, with simulation work. In general, the topics cover closed-loop theory, revision of different control strategies, application of automated approaches to design self-driven systems, and their further validation.

B. Research Problem and Scope

This investigation could be classified as applied research [7] with an experimental and descriptive scope [8]. The purpose was to generate preliminary findings that could contribute to an exploratory driving hypothesis. The problem is defined in the framework of a society that demands recently graduated professionals able to work collaboratively with team members from a different culture and physically located in other countries, who may not even share the same language as their first language. Therefore, professionals are required to graduate with a certain degree of advancement in these skills.

The research technique was mixed-type. Both quantitative and qualitative methods were of the same importance. The quantitative approach was analyzed with the deliverables of the students related to the disciplinary activity, while the qualitative elements focused on the comments of the participants about the implemented COIL activity, mainly during the initial and final stages of the COIL activity. Having both ways allowed to develop a broader understanding of the studied phenomenon.

From a disciplinary perspective, the activity was related to the United Nations Sustainable Development Goal 9. Automated systems in industry seek to increase productivity and safety. However, designing automated systems that meet some metrics (performance criteria) could also contribute to sustainable industrial processes by enriching processes using a cross-cultural approach. These elements are found to be transversal among the targets and indicators of the United Nations Sustainable Development Goal (SDG) 9. This SDG has the following description: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

C. Participants

In total, 56 students participated in the COIL activity. During COIL (November to December 2023), 32 students were enrolled in the graduate program in Industrial and Process Automation at Ferhat Abbas University, Algeria, with an age range of 21 to 24 years. The other segment of participants consisted of 24 students from the 3rd year of mechatronics engineering at Tecnológico de Monterrey, Mexico: with an age range between 20 and 22 years. The ages of all students are considered during the period of the activity. Moreover, the participants who lived the experiment were not selected from an initial universe, and no one was left out of the experiment. In both universities, the total number of students enrolled in the control design courses and their professors were part of the COIL activity.

D. Instruments

Data collection was done through examining records (the students' deliverables in teams) and through student comments in the Icebreaker and reflection activities that were done individually. In the Icebreaker stage, the deliverable was the PADLET (a virtual wall post comments), and in the disciplinary and reflection stage, the deliverables were two reports and one video. The first report described the modeling of the electronic system and the second report the design and validation of the control loop. Both reports included disciplinary conclusions. In addition to summarizing the entire design, the video included reflection information for having participated in the COIL. In addition, the other deliverable of the reflection stage was a second closing PADLET.

E. Workflow Diagram and Calendar

As part of the research process, a general action plan represented by a workflow diagram is included. The short descriptions on the left side of the diagram are labels indicating the main activity carried out during each of the stages of the diagram, separated by the dashed horizontal lines. The text aligned to the same horizontal lines is the output of the previous stage, which was used as the input for the next stage. The right side lists the time periods during which the activities in the diagram were carried out. Fig. 1 provides a summarized representation of all COIL activities performed.

The research work included the International Joint Collaboration (IJC) efforts and later the COIL. The first edition of the activity was executed in 2022 and was called the IJC. In general terms, it included the elements of a COIL, but did not have the endorsement of the administrative team that validates the realization of COILs in one of the participating universities. With the findings of the first application and by formally considering the COIL protocol, the activity was improved to comply with the COIL guidelines and the participating students were awarded a badge. The badge was obtained by students from both universities with a minimum score of 80/100 in the COIL activity. These stages and more information about them are shown in Fig. 1. Furthermore, both courses had the same name and purpose, Design of Control Systems. There was an 8-hour difference between the time zones; therefore, the synchronous sessions considered this fact.

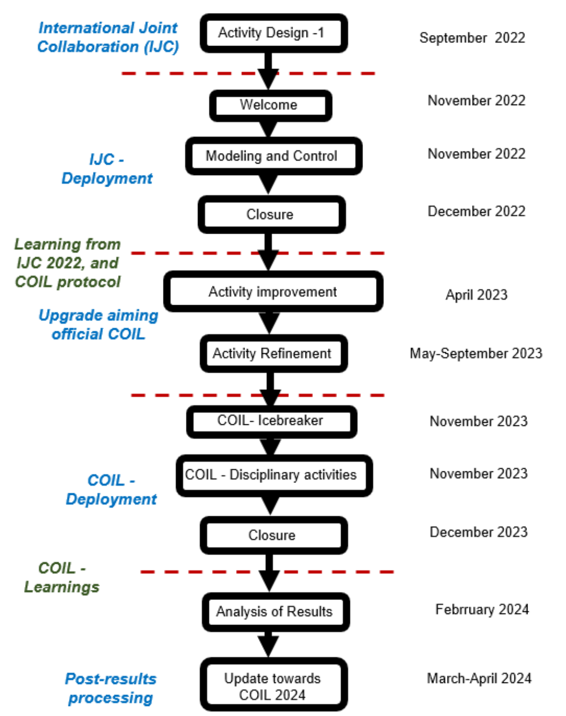


Fig. 1 Research Workflow Diagram and the Approximated Calendar

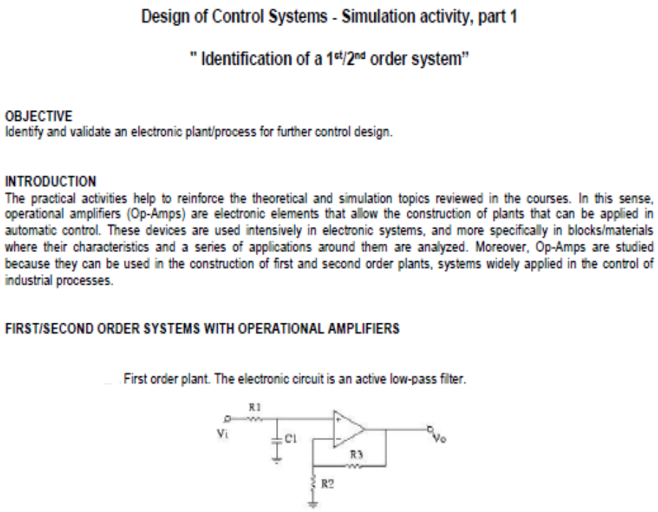
F. COIL activity in Detail

The COIL activity consisted of three stages distributed in four synchronous sessions. The first session was introductory to the COIL, and to perform the Icebreaker activity. The second phase consisted of two sessions where the students focused on the disciplinary activities: the modeling of the electronic system and the design of the automatic control for said system. The third phase was a reflection activity by the students and a closing message by the teaching team. All sessions were carried out with the ZOOM technological tool to carry out remote sessions in real time. Of the 100% of the COIL grade, the majority consisted of the disciplinary activity and the rest was divided between Icebreaker and Reflection.

The first synchronous session was the start of the COIL and the introductory activities. In a plenary session, the teaching team introduced itself, welcomed the students, and explained the dynamics of the overall activity and of each of the 3 parts of the COIL. This description included the general assessment, the ICTs to be used, the means of communication between students, and a detailed description of each stage of the COIL.

After the introduction, the teams, previously defined by the teaching team, were shared and the Icebreaker activity was carried out. Due to the number of participants from each university, the teams were made up of 2 or 3 people; one person from Mexico and one or two people from Algeria. Each team went to a breakout room and for approximately 45 minutes they performed the Icebreaker activity. During this timeframe, they introduced themselves and shared information. The outcome of this activity was presented in the PADLET. On this virtual wall, the students introduced themselves and their peers from the partner university, and some scholars added representative images.

The disciplinary part consisted of two parts. The first was to identify the system, and the second part was to design the controller and verify the automated control system. This information was provided in two documents. Figures 2 to 4 show extracts from the documents; description and deliverables.



Design of Control Systems - Simulation activity, part 1

" Identification of a 1st/2nd order system"

OBJECTIVE
Identify and validate an electronic plant/process for further control design.

INTRODUCTION
The practical activities help to reinforce the theoretical and simulation topics reviewed in the courses. In this sense, operational amplifiers (Op-Amps) are electronic elements that allow the construction of plants that can be applied in automatic control. These devices are used intensively in electronic systems, and more specifically in blocks/materials where their characteristics and a series of applications around them are analyzed. Moreover, Op-Amps are studied because they can be used in the construction of first and second order plants, systems widely applied in the control of industrial processes.

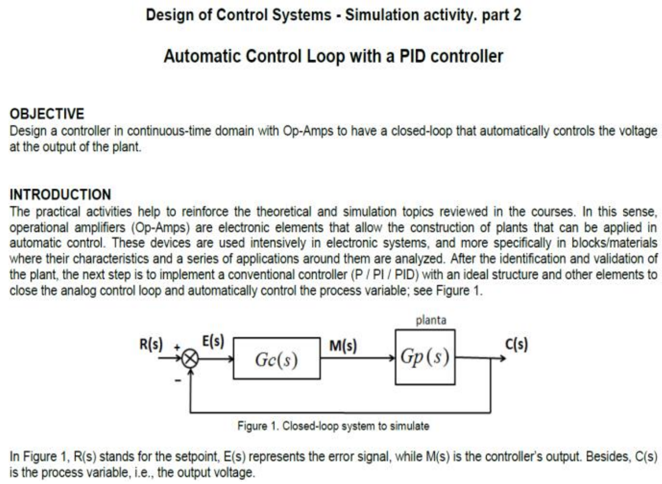
FIRST/SECOND ORDER SYSTEMS WITH OPERATIONAL AMPLIFIERS

First order plant. The electronic circuit is an active low-pass filter.

Fig. 2 An extract of Simulation Activity, part 1. Identification

During the course activities, students used specialized simulation software. In FALSTAD, a free online simulator, they emulated the real system and obtained data to identify the system. The data collected was stored in a plain text file and loaded into MATLAB. There, they designed the control system. In the end, they returned to FALSTAD to validate the performance of the closed-loop control system.

The closing stage was a student reflection. The reflection was included in the deliverables; report and video; and, in a closing PADLET. In addition, in the closing synchronous session, some students shared their reflections in the plenary session, and the teaching team closed with their final comments. The later stage included evaluating the students' performance and reflection by the teaching team



Design of Control Systems - Simulation activity. part 2

Automatic Control Loop with a PID controller

OBJECTIVE
Design a controller in continuous-time domain with Op-Amps to have a closed-loop that automatically controls the voltage at the output of the plant.

INTRODUCTION
The practical activities help to reinforce the theoretical and simulation topics reviewed in the courses. In this sense, operational amplifiers (Op-Amps) are electronic elements that allow the construction of plants that can be applied in automatic control. These devices are used intensively in electronic systems, and more specifically in blocks/materials where their characteristics and a series of applications around them are analyzed. After the identification and validation of the plant, the next step is to implement a conventional controller (P / PI / PID) with an ideal structure and other elements to close the analog control loop and automatically control the process variable; see Figure 1.

Figure 1. Closed-loop system to simulate

In Figure 1, R(s) stands for the setpoint, E(s) represents the error signal, while M(s) is the controller's output. Besides, C(s) is the process variable, i.e., the output voltage.

Fig. 3 An extract of Simulation Activity, part 2. Controller Design

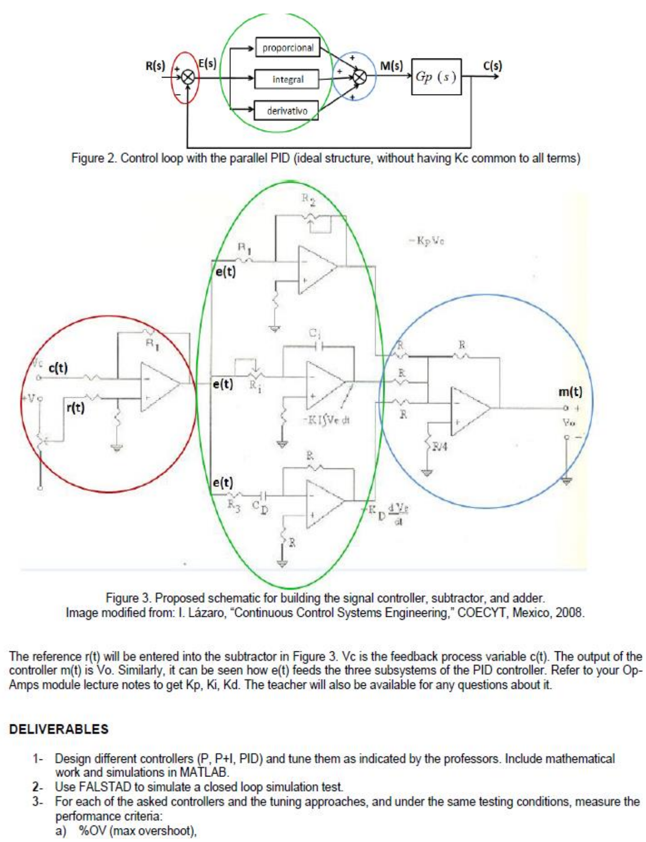


Figure 2. Control loop with the parallel PID (ideal structure, without having Kc common to all terms)

Figure 3. Proposed schematic for building the signal controller, subtractor, and adder.
Image modified from: I. Lázaro, "Continuous Control Systems Engineering," COECYT, Mexico, 2008.

The reference r(t) will be entered into the subtractor in Figure 3. Vc is the feedback process variable c(t). The output of the controller m(t) is Vo. Similarly, it can be seen how e(t) feeds the three subsystems of the PID controller. Refer to your Op-Amps module lecture notes to get Kp, Ki, Kd. The teacher will also be available for any questions about it.

DELIVERABLES

1- Design different controllers (P, P+I, PID) and tune them as indicated by the professors. Include mathematical work and simulations in MATLAB.
2- Use FALSTAD to simulate a closed loop simulation test.
3- For each of the asked controllers and the tuning approaches, and under the same testing conditions, measure the performance criteria:
   a) %OV (max overshoot),

Fig. 4 An extract of Simulation Activity, part 2. The closed-loop system and Deliverables per team

III. Students Results

This section describes the student deliveries. First, the Icebreaker PADLET, then the disciplinary assignment of modeling and automatic control design, and finally, the comments on the video and the reflection PADLET. Fig. 5 shows parts of the Icebreaker assignment deliverable. It exhibits where students introduce themselves. Fig. 6 is also an extract of the PADLET, but it depicts how students present to their international peers. In addition, note in the activity´s title that TEC refers to Tecnológico de Monterrey and FAU indicates Ferhat Abbas University.

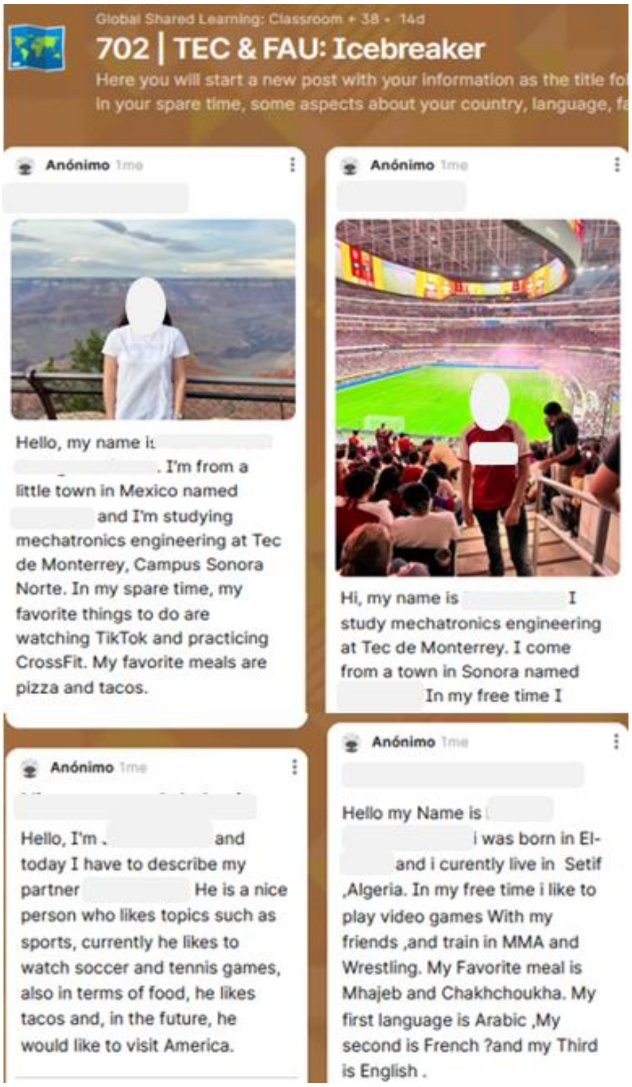


Fig. 5 Icebreaker PADLET. Students introduce themselves

The disciplinary output consisted of two reports and a video. Evidence of the videos made by the students is shown in Figures 7 to 9. As part of the video rubric, students were required to always appear in the video. In addition, they were asked to show interaction during the video.

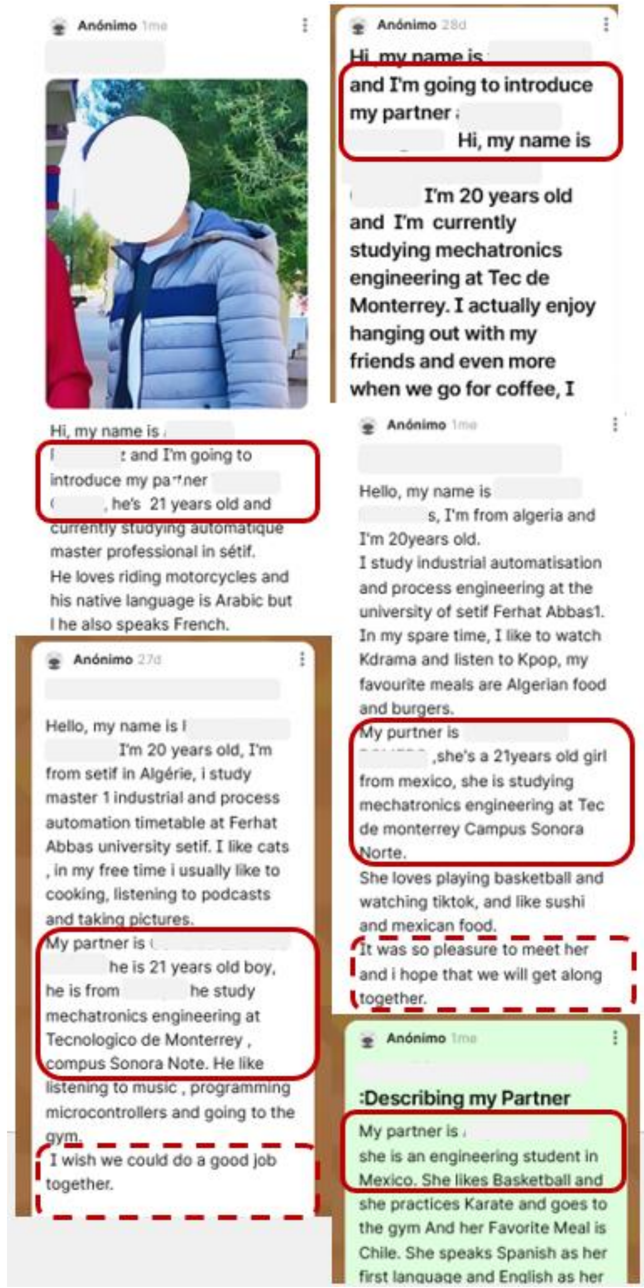


Fig. 6 Icebreaker PADLET. Students introduce their peers (enclosed text in solid lines). Besides, students express their desire to have positive collaboration with their peers (enclosed text in dashed lines)

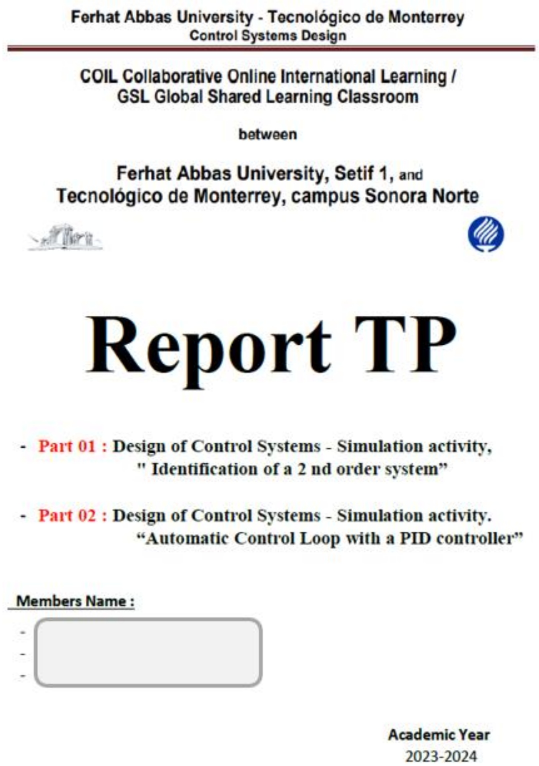
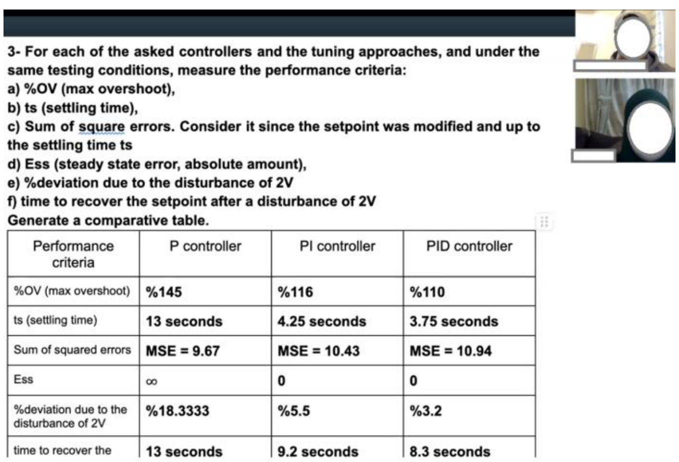


Fig. 7 Cover page of a written report



Performance criteria	P controller	PI controller	PID controller
%OV (max overshoot)	%145	%116	%110
ts (settling time)	13 seconds	4.25 seconds	3.75 seconds
Sum of squared errors	MSE = 9.67	MSE = 10.43	MSE = 10.94
Ess	∞	0	0
%deviation due to the disturbance of 2V	%18.3333	%5.5	%3.2
time to recover the	13 seconds	9.2 seconds	8.3 seconds

Fig. 8 Video screenshot where students explain performance criteria

The reflection deliverable is a closing PADLET which students comment on their COIL experience. Fig. 10 shows some of the comments posted on the Reflection PADLET.

Fig. 9 Video screenshot where students explain the caried out activity

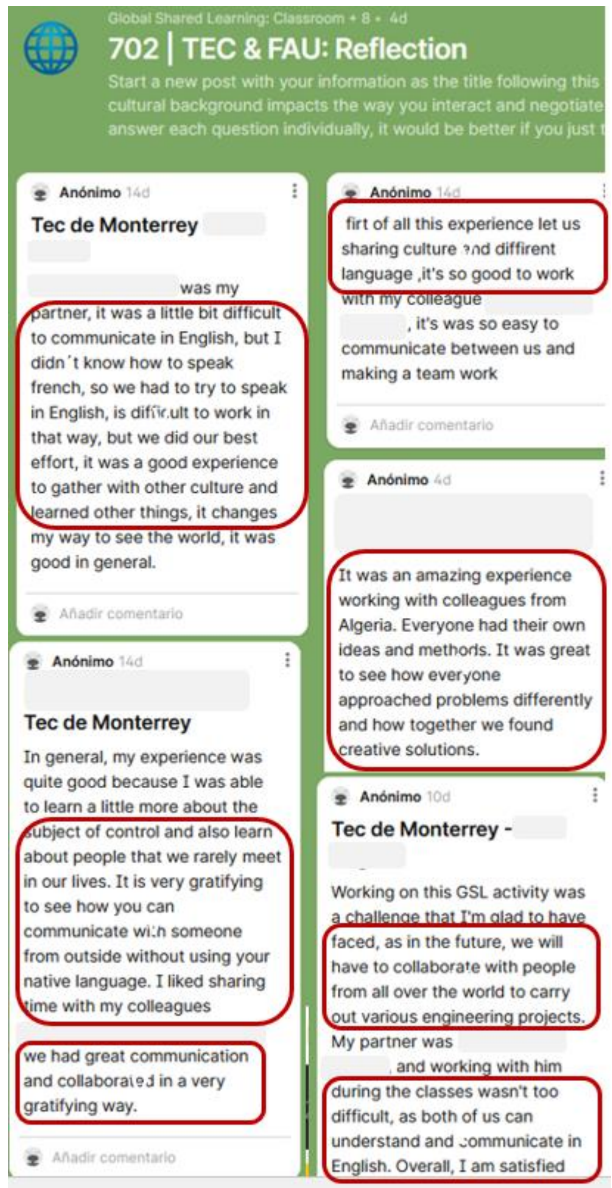


Fig. 10 Part of the Reflection PADLET. Red boxes indicate cultural and language issues during the COIL, team achievements, and the importance of these activities in their professional life.

IV. Conclusions and Further Work

The design and implementation of a cross-cultural COIL+PBL activity between students from two universities located on different continents was achieved. More than the disciplinary part, the focus was on allowing students to work remotely with people from another culture, another native language, and significant time differences. Despite the differences, they had to find a way to communicate and agree on how to work towards a common goal. In the end, the students greatly valued this international experience because they appreciated the soft skills they developed.

In addition to the quantitative results, the quantitative results highlight the value of this activity for the students. Considering their comments on the Icebreaker and Reflection activities, their motivation to interact with people from other cultures is observed, and in the end, they are grateful for the opportunity to make friends in another part of the world. These positive comments on their participation motivate the teachers to review the comments and improve the activity to continue implementing it at the next opportunity.

This manuscript presents part of the research work. The purpose is to present the most relevant aspects of the process that allow identifying the contribution and, in general, all the research effort, its complexity, and the innovative elements. The planned further work will focus on the more in-depth development of the research methodology, the design process, the deployment, and the analysis of the results.

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