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Incorporating Collaborative Online International Learning (COIL) into Common Practices for Architects and Building Engineers

Sara Gutiérrez-González
University of Burgos, Spain

Claudia Elena Coello-Torres
University of Piura, Perú

Lourdes Alameda Cuenca-Romero, Verónica Calderón Carpintero and Alba Rodrigo Bravo
University of Burgos, Spain

Abstract. Higher education institutions and educators must provide their students with the opportunity to have global, intercultural, and collaborative experiences that will enable them to solve specific problems in different socio-cultural contexts. Industry 4.0 provides a very suitable context in which to carry out these experiences from home, thus contributing to the wider goals of environmental sustainability and global availability. This work analyzes students' experiences and engagement when involved in collaborative online international learning (COIL), aimed at establishing how pluricultural competence can be digitally developed in the field of architecture at university level. The experiment was carried out as part of the assessments for first year undergraduate students enrolled in a bachelor's degree in architecture in Piura, Peru and postgraduate students enrolled in a master's degree in inspection, rehabilitation, and energy efficiency in Burgos, Spain. Results show that the experience motivated participants, with 48% responding that they were very satisfied, 38% extremely satisfied, and 14% moderately satisfied. The study's findings confirm that pluricultural competence among students can be enhanced by using virtual cooperation. The learning experience offered participants the chance to boost their confidence and communication skills and to take part in a new learning environment as well as to exchange knowledge with international peers, thereby preparing them to form part of a global environment.

Keywords: architecture; cultural backgrounds; energetic efficiency; inclusive education; online international learning

1. Introduction

The Covid-19 pandemic forced the international academic community to explore new ways of teaching and learning, including virtual and online education (Harris et al., 2021). This has created an opportunity to rethink education pathways and integrate e-learning, favoring new intercultural experiences (Cotoman et al., 2022; Medina-Guillen et al., 2021). Globalization as a process for creating a global economy that is more integrated and interdependent is one of the factors that will reduce barriers worldwide (Agnew & Kahn, 2014). Global education and technology contribute towards students' experiential learning – if it is well applied and well used (Nava-Aguirre et al., 2019). At educational level, higher education is on a global horizon, in which the different actors involved must work collaboratively to achieve comprehensive academic enrichment (Adefila et al., 2021). Many universities can integrate new collaboration with international universities and cooperate in different programs. They hereby take advantage of technology in students' motivation and engagement and communication encouragement in the learning process (Mestre-Segarra & Ruiz-Garrido, 2022) as well as improve the employability of their students in the job market (Chandrasekaran et al., 2021).

Collaborative online international learning (COIL) is an innovative pedagogical methodology providing students with the opportunity to interact with international peers (Rubin & Guth, 2015). COIL projects typically involve two or more instructors from different countries and students from different language and cultural backgrounds, jointly carrying out an activity to communicate and collaborate online (Ingram et al., 2021; Pouromid, 2019). The initial objective of this type of initiative (knowledge exchange between students from different educational systems) is increased by the greater possibilities of educational internationalization that it provides for the students involved. To facilitate and promote student involvement in COIL learning activities, the use of e-resources, such as surveys, forums, etc., is essential. In this way, a second learning process materializes – that of using the different electronic tools (Cole, 2009; Harandi, 2015). The curriculum vitae of students who take part in this type of international activities is enriched, now including increased opportunities in the search for employment (Munoz-Escalona et al., 2022).

Built into the context of internationalization of higher education, COIL can prove very useful in promoting intercultural competence as well as other perspectives in the architectural and building engineering sector in other fields. Several COIL experiences are carried out in the field of higher education in science, technology, engineering, and mathematics (STEM) degrees. The work of Munoz-Escalona et al. (2022) in this field is particularly noteworthy. The work analyzes a COIL activity for second and third year students of mechanical engineering and industrial design degrees, with the aim of promoting aspects such as global manufacturing and reverse engineering. In a study carried out by Appiah-Kubi and Annan (2020), technological engineering students participated in an eight-week COIL program with materials engineering students from different language and geographical regions, establishing a standard pattern group to compare results between the standard methodology and the COIL methodology. For their

part, researchers from the Tecnológico de Monterrey, Mexico and the University of San Francisco de Quito, Ecuador implemented the COIL methodology in the subjects of microbiology and biotechnology. They carried out a biotechnological challenge, in which students put into practice the theoretical knowledge acquired, their negotiation skills, teamwork, and leadership in a multicultural and international environment (Álvarez-Barreto et al., 2022). In the field of architecture, research has been conducted on the integration of construction technology in architectural design through different virtual, intercultural, and cooperative learning environments in an architectural project. The research findings suggest that many students consider the conventional design studio to be disconnected from reality and that learning with practical application helps to provide a deeper understanding of construction processes (Kostopoulos, 2022).

In all of the above experiments, the international development of an effective learning system was noted. This was seen to provide students with an overseas study experience without them having to leave home, thereby enabling them to internationalize their curriculum vitae as a tool to promote intercultural competences and international perspectives while enhancing their abilities to grow as responsible global citizens. This paper analyzes the experience through a COIL activity as part of the assessment for undergraduate students of architecture in Piura, Peru and master's students in inspection, rehabilitation, and energy efficiency in Burgos, Spain in the courses of Introduction to Architecture, and Energy Efficiency, respectively. The selected topic was an assignment on "Energy Efficiency in Buildings", where students analyzed technical aspects in buildings in the two countries: climatology, architectural design, materials, and energy performance. Specifically, this research addressed the following questions:

- Research Question 1: What impact does the COIL method have on preparing architecture and building engineering students to be part of a global environment at the higher education level?
- Research Question 2: How did the Spanish and Peruvian students perceive the online communication experience and relate it to the development of pluricultural competence and motivation?
- Research Question 3: What are the benefits of COIL in degrees in the field of architecture?

2. Methodology

2.1 Methodological Approach

The aim of creating an international learning experience was to provide students from different universities and countries with cultural competence and to offer a global perspective in the field of architecture and sustainable building engineering. The COIL approach was used as a key element to meet the study objectives (Engeness, 2021). This interactive social learning reduces potential barriers to learning, including institutional affiliations, sociocultural background, and individual learning limitations (Polyakova & Galstyan-Sargsyan, 2021).

The learning objectives of the COIL experience were to:

1. Facilitate an understanding and appreciation of cultural differences between Peru and Spain.
2. Build intercultural communication skills via interviewing.

3. Acquire digital communication competences by connecting students from one country with a different culture.
4. Develop cultural sensitivity so as to better understand individuals from another culture and thereby attain cultural competence.
5. Learn about architectural techniques and to understand energy efficiency in different countries that have a sharp contrast in terms of their climatology.

2.2 Project Participants

In this work, two lecturers from Spain and Peru met to create and design a COIL experience in the fields of architecture and energy efficiency. Emphasis was placed on the student collaborative process aimed at creating shared experiences as well as understanding of architectural and construction aspects in very differing locations. A total of 43 students from the two institutions participated during the spring of 2021. Of these participants, 40 were undergraduate students from the University of Piura, Peru and 3 were graduate students from the University of Burgos, Spain (Table 1).

Table 1: Number of undergraduate and postgraduate students involved in the study

	Participants (n)	
Module	**Piura (Peru)**	**Burgos (Spain)**
Introduction to Architecture (Degree)	40	
Energy Efficiency (Master's degree)		3

The lecturers developed a collaborative project where students would use technology to communicate and exchange cultural and experiential aspects while they process and move through the learning material together.

2.3 COIL Program Implementation

The experience was carried out in three different stages: icebreaker, comparison and analysis, and collaboration (Meza Morón, 2018). Each stage lasted two weeks, with the whole program lasting a total of six weeks (Figure 1).

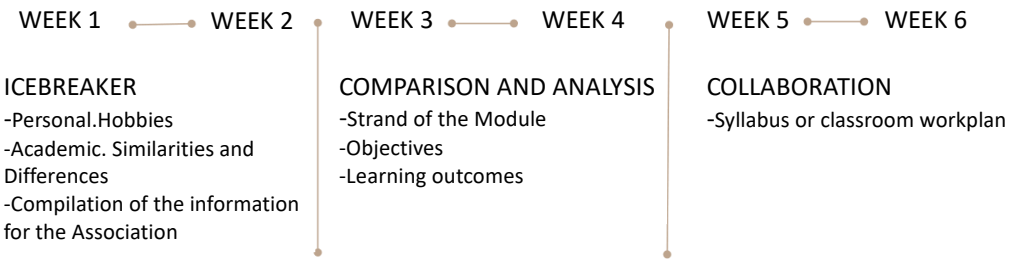

Figure 1: Program planning

2.3.1 Project tools and contents

Due to the time difference between the two participating countries (seven hours), and since it was not possible for all participants to work at the same time, an asynchronous mode of communication was chosen. The IT tools employed to carry out the experience were the Miro: The Visual Collaboration Platform for

Every Team online collaborative platform (Tucker et al., 2021) and the Zoom video call platform due to its efficacy, convenience, and immediate feedback. During the first stage (icebreaker), the Miro online collaborative platform was used as a working tool. In addition to the Miro platform used in the first stage, an online virtual classroom form was used at each university for the second and third stages (comparison and analysis; collaboration). Students at the University of Piura (Peru) used the Udep virtual platform and students at the University of Burgos (Spain) used the UBU virtual platform, of which the content management system (CMS) is Moodle.

The topic selected for the activity was an assignment on Energy Efficiency in Buildings, where students had to analyze and discuss four different aspects of this topic in buildings located in the two different countries. The four aspects were: i) climatology, ii) architectural design, iii) materials, and iv) thermal energy performance. Students of the Energy Efficiency module at the University of Burgos (Spain) focused specifically on analyzing the energy performance of buildings at the two locations. Conversely, students of the University of Piura (Peru) had to recognize in these two buildings the concepts learned in the Introduction to Architecture course, finding similarities and convergences.

The actions to be carried out were established through periodic coordination. The aim was to gain student development in the collaborative construction of knowledge concerning the analysis of architectural and energy-related aspects that responded to the specific context of each city – Burgos, in Spain and Piura, in Peru. Each task responded to the academic level of the group in question and was carried out asynchronously, ending with a presentation in which the results were presented via video call. A challenge arose when implementing the COIL program in the two courses, due to the considerable difference in age and level of knowledge of the two student groups.

2.3.2 Limitation of the COIL program implementation

From the beginning of the project, certain limitations had to be considered in its implementation. The first was the age difference between the two student groups. The course in Energy Efficiency at the University of Burgos is taken in the first year of the master's degree, while the course in Introduction to Architecture is taken in the first year of the bachelor's degree. The second limitation was the significant difference between the number of students in Piura and Burgos (40:3). The third limitation was the day on which the course is taught (which is different at the two institutions).

2.3.3 Workplan and goals of the different stages of the program

Data collection methods: The data collection method is shown in the workplan through the definition of the learning outcomes in the different stages of the project. The workplan and goals of the different stages of the program (see Table 2) were coordinated by the lecturers of the two courses. All the activities were available to students through Moodle. This offered a log-in history with user tracking and provided students with feedback on the process at all times.

Once the experience was completed, a simple, voluntary, and anonymous survey was carried out, which required all students to answer five questions. In four of the questions, the Likert scale was used, consisting of five response options, of which two are negative, one intermediate, and two positive.

Table 2: Workplan and goals of the program

Stage	Week	Task/activity	Learning outcomes
1. Icebreaker	1	Students introduce themselves and get to know each other	- Understanding the structure of working groups - Handling and working on the platform
	2	Students answer questions of a more academic and professional nature from their peers	- Boosting trust between students - Recognizing similarities and differences between the two student profiles
2. Comparison and analysis	3	Sharing of local knowledge or realities on the chosen topic	- Understanding the convergences and parallels with respect to the architectural aspects of each location, putting into practice the concepts reviewed in class: context, technique, and architectural typologies
	4	Analysis of the information obtained in week 3	- Summarizing the information needed to develop the final product, following a pre-established presentation format
3. Collaboration	5	Joint product development and final delivery	- Presenting a final document in which students reflect on the relationship between the concepts learnt, applied to the architectural aspects of each locality - Answering questions on the video made by students of the other university
	6	Sharing intercultural experience	- Sharing the results of the experience – collected in the form – between the two institutions

The first stage – icebreaker – was aimed at integrating the groups of students and their interaction. The objective was to build trust between the students so as to recognize similarities and differences between the different profiles present. To achieve this, the students – guided by their lecturers and motivated by the type of work to be done – put forward their proposal in a dynamic of communication and association that represents a real socio-communicative experience. Each student answered specific questions indicating what they do in their free time, why they chose this profession, where they would like to work in the future, which university class they belong to, and what expectations they have concerning this intercultural experience. This stage also served as an introduction to mastering and using the Miro platform. This digital platform served as a flexible space for

shared information, and allowed feedback from students by their being able to access it in real time or asynchronously (Figure 2).

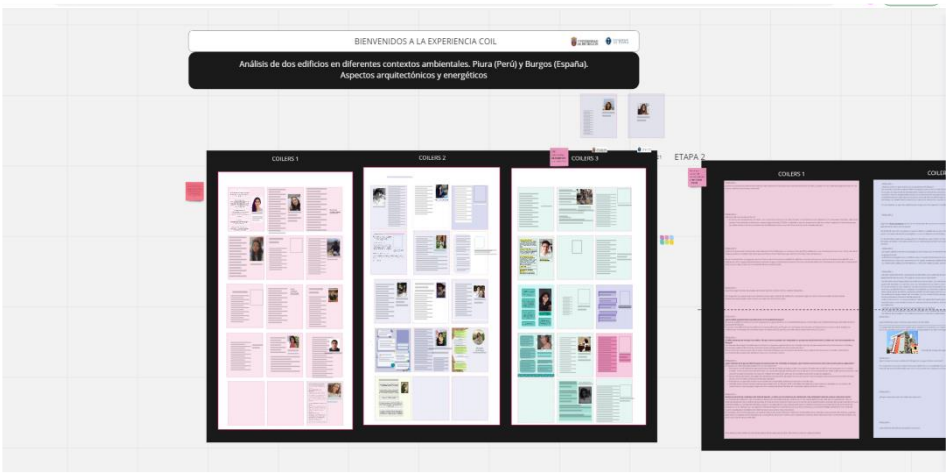

Figure 2: Screenshot of the first stage (icebreaker) on the Miro platform

The second stage – comparison and analysis – corresponding to the third and fourth weeks, involved understanding and sharing the convergences and parallels with respect to the architectural aspects of each locality. Students from Piura put into practice the concepts reviewed in class, such as context, technique, and architectural typologies, while students from Burgos sought to learn about the construction techniques and energy solutions used in Piura (Figure 3).

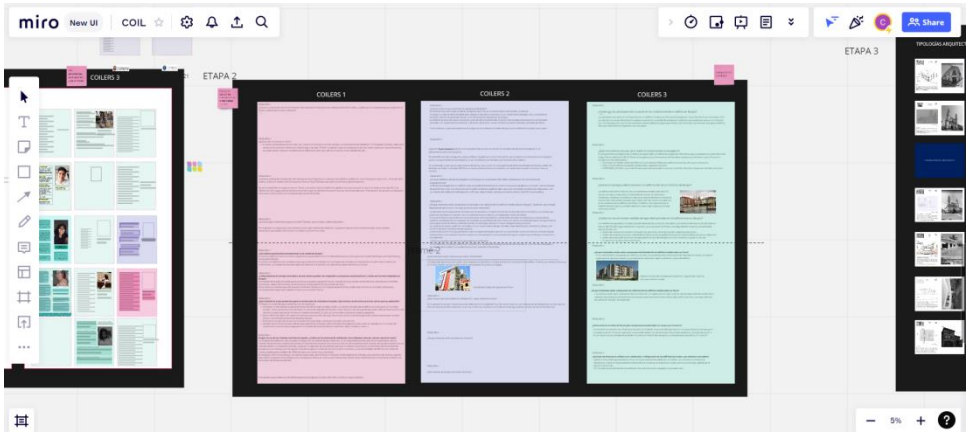

Figure 3: Screenshot of the second stage (comparison and analysis) on the Miro platform

The specific goals of this second stage were for students to learn about and differentiate the climatology of the Piura area from that of Burgos, and to analyze the most common architectural typologies in the area and the materials used in the building of envelopes. To do this, students from the two countries answered specific questions to help them gather information. After information was collected, the information obtained in week 3 was analyzed in order to summarize the information needed to develop the final product, following a pre-established presentation format.

The third and last stage of the experience was the collaboration stage. The architectural and energy inferences of the study carried out were jointly drawn up. These inferences were expressed in a final document in which the students reflected on the relationship between the concepts learnt, applied to the architectural aspects of each locality. These were presented orally in a virtual meeting via Zoom (Figure 4).

Figure 4: Screenshot of the third phase (collaboration) on the Zoom platform

Evaluation: Evaluation of the learning outcomes was carried out through the findings obtained in the third stage by appraising a final document which reflects on the relationship between the concepts learnt and applied to the architectural aspects of each locality. Additional appraisal was conducted by interpreting the responses to the questionnaires addressing student satisfaction.

3. Results

3.1 Results from the Findings Obtained in the Third Stage

For the students taking the Introduction to Architecture course, a former student of the University of Piura Program in Architecture oversaw the preparation of the exposition. In the presentation, each of the concepts learned during the semester was shown, and which focus on providing students with learning tools of analytical and project value. For this, the most representative works of each concept applied to the analysis of an architectural work, were shared.

The topics dealt with included order and architectural system, scale and proportion, geometry, and structure, among other topics. However, the topic in

which the students carried out the most in-depth analysis was construction techniques. Local constructions were taken as reference architecture, prominent among which were the vernacular and typical construction technique of the town of Piura, which, due to its geographical location, is subject to a desert climate, high temperatures, and rainy season.

One of the constructions analyzed was the San Lucas de Colán Church, the oldest preserved church in all of the Americas, and which is in an area where the desert and ocean converge. It consists of some Solomonic columns that were at first made up of two towers covered with thatch. The gabled roof is supported by a uniform framework of sticks in the form of trusses. The low ceiling is woven from totora reeds and tied with wild cane. On the outside, it is covered with mud cake, which is a mixture of clay, earth, rice straw, guano, and water. The structure of the building is made with limestone quarry, a common material in the area where the building is located. The students concluded that with local techniques it is possible to achieve architecture that transcends time and which responds to the area's climatic conditions.

Another construction analyzed was the Casa Hacienda Sojo, located in the province of Sullana, Peru. The building is built with materials such as wood and plaster. Reed, adobe, and marble are also used throughout its construction. Quincha is used as a construction system – a typical construction technique of the area. Quincha is a traditional technique used to execute partition walls. It consists of a structure formed by a framework of wood or reed, with a filling of earth mixed with vegetable fibers. This technique responds to the high temperatures that are characteristic of the Piura desert and provides thermal comfort, which is essential in the area.

The technique used to construct schools in the urban area of the city of Piura was also analyzed. Schools built in the traditional way were chosen, with a construction system of concrete columns and beams, brick partitions, and tarrajeadas (plastering with cement mortar). The block configuration is of the pavilion type with large longitudinal windows that allow cross-ventilation, and which are strategically located so that the sun does not hit directly. On the roofs, clay tiles are installed in the direction of the rainfall that allow the rain to run off in the rainy seasons. What the students learnt was how, through the configuration of the building blocks, the direction of the wind can be used to ventilate the rooms and to illuminate them without high radiation impacting the interior.

A sustainable-housing module was also studied. This is a project proposed by students from the University of Piura. The project very accurately reflects the coexistence and harmony of technical, handmade, and traditional self-construction techniques in Piura together with modern construction techniques. Materials typical of the area are used, such as thatch, cane, mats, eucalyptus wood, mud, and ruminant manure for impermeability, and above all, the local people themselves participate in constructing the housing. It was important for the students to highlight how the local construction technique can be used as a response to the city's climate problems, such as the Fenómeno del

Niño Costero, a climate phenomenon produced by the anomalous heating of the sea due to the weakening of the cold air currents that run from south to north along the coasts of the South Pacific.

Other constructions analyzed were the typical beach houses that abound in the coastal zone of Peru, and in which wood, brick, and other light materials are used for the freshness they generate inside. In addition, straw is used for the roof, which gives it an aesthetic that matches the area where it is located. These constructions are raised on large wooden structures, which safeguard the houses against rising tides.

All of these local references that were seen – in addition to the national and international references studied in the course – helped the students to enhance their capacity for analysis and response to local reality. In their position as future architects, they must respond to the needs, problems, and conditions that exist in their environment. The project results were reflected in the drawings by students that showed the themes analyzed in the chosen architectural works.

The work carried out by the students at the University of Burgos consisted of comparing the energy efficiency of a building system located in Piura and the same system located in Burgos. They worked with the LIDER/CALENER Unified Tool Software (HULC) of the Spanish Government Ministry for Ecological Transition and Demographic Challenge. For this, two buildings were modelled, one for Piura and one for Burgos, defining the materials that made up the different construction elements of the thermal enclosure, indicating the installation system (see Figure 5). The buildings modelled consisted of a single-family, two-story house with four bedrooms, a kitchen, and a bathroom.

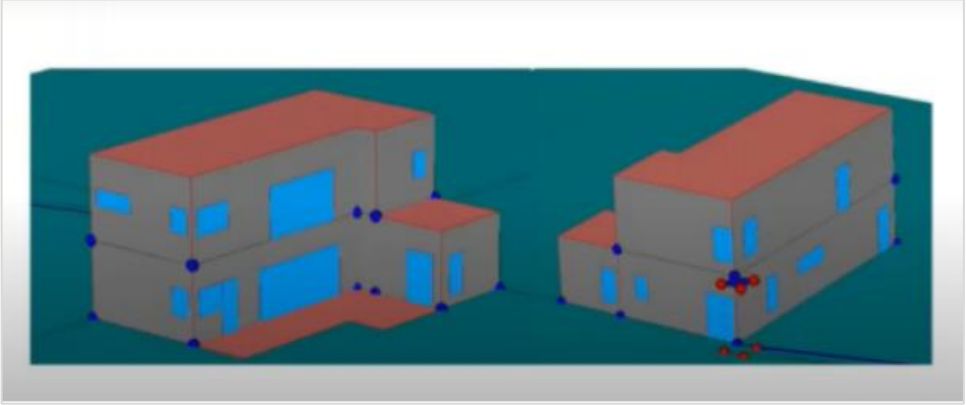

Figure 5: University of Burgos students' building model using HULC software

To obtain information about the materials of the Piura building, the students at the University of Burgos posed a series of questions and doubts to the students of the University of Piura, through Miro. The Piura lecturer acted as moderator to ensure that the technical aspects were properly detailed. The climate typologies of each building were then identified. Given that the program is for national use in Spain, a climatology was sought which resembled Santa Cruz de Tenerife in the Canary Islands, which corresponds to a climate zone α3. One key aspect of the

work was the justification of the importance of Spanish regulations in aspects related to energy efficiency. Such aspects are not taken into consideration in areas such as Piura, which has an average annual temperature of 25.4°C and, initially, no heating requirements. In the questioning phase among the student groups, it was found that energy efficiency aspects were not particularly taken into consideration in Piura. It was therefore decided that the students would explain the rating system through the labelling "Energy rating of the existing building" and the most basic and general concepts of energy efficiency. Once the different parameters were defined, domestic hot water (DHW) consumption was calculated, as was the energy demand. Finally, the energy rating was determined.

In the comparison between the two buildings, the following conclusions were reached. First, the overall thermal transmittance value of the building in Piura was amply met, even though the materials that make up the envelope are thinner and have higher thermal conductivity than those used in the envelope of the building in Burgos. However, in the city of Burgos, this value is complied with to the limit, entailing a significant investment in insulating materials. Second, in the study, the students detailed one case of a heating installation in each location. In Piura, a mixed heating and DHW system, ventilation equipment, and renewable energies through solar panels for DHW heating were considered. In Piura, the installation of thermoelectric equipment, air conditioning equipment, and ventilation equipment was considered.

Subsequently, the energy rating was compared between the two sites (see Figure 6).

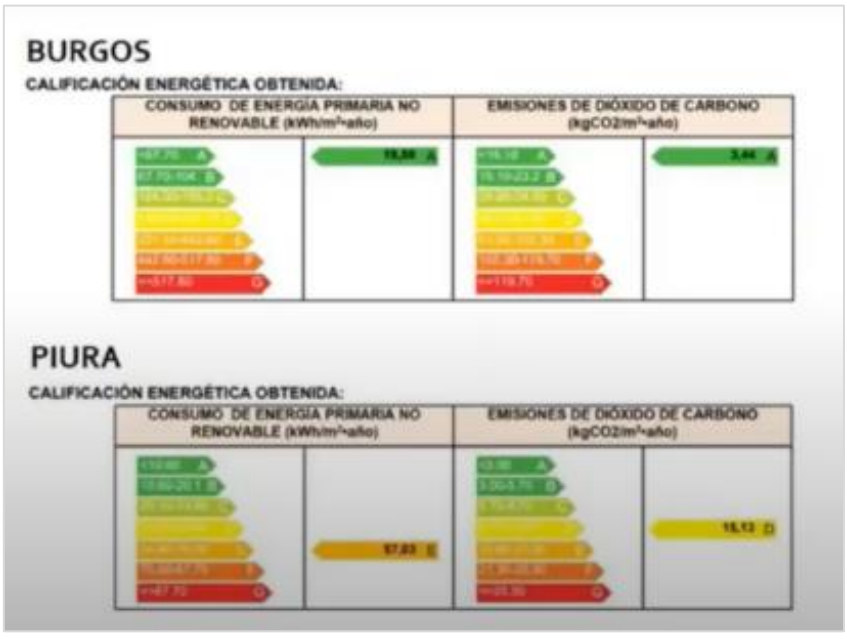

Figure 6: Energy efficiency rating of the buildings in the two countries

The students from the University of Burgos concluded that the use of renewable energies and more efficient systems helps to achieve better energy rating values, regardless of whether the climate zone is more or less adverse.

3.2 Results from the Student Satisfaction Survey

The questionnaire was completed by 49% of the participants. The first question focused on whether it was the first intercultural experience they had had, with 86% indicating that it was (Figure 7).

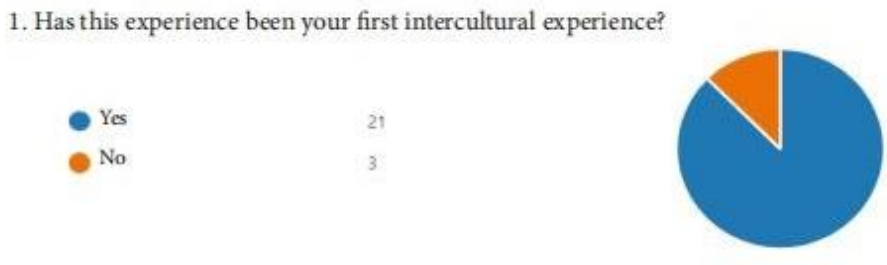

Figure 7: Responses to Question 1: Has this experience been your first intercultural experience?

Question 2 evaluated the respondents' degree of satisfaction concerning the incorporation of the COIL experience in the Introduction to Architecture course. Responses were positive, with 48% indicating that they were very satisfied, 38% extremely satisfied, and 14% moderately satisfied.

The third question sought to determine whether the experience motivated participants to continue and to constantly seek an intercultural exchange in the future. For this question, 24% of the respondents indicated that they were extremely motivated, 71% were very motivated, and 5% were motivated (Figure 8).

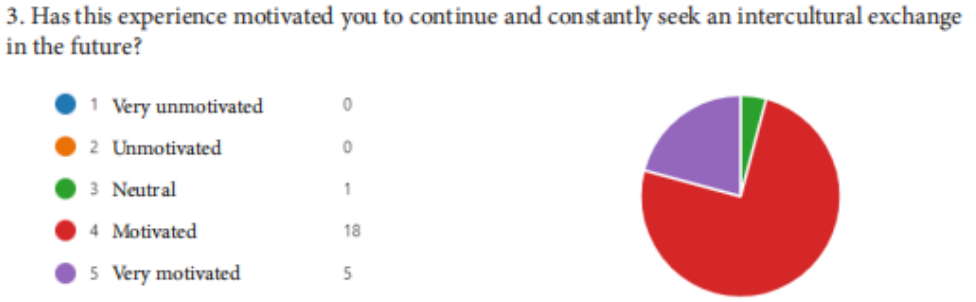

Figure 8: Responses to Question 3: Has this experience motivated you to continue and constantly seek an intercultural exchange in the future?

Question 4 asked whether the respondents' expectations were met by using the course asynchronously (that is, students were able to complete the assignments at different times of the day). For this question, 30% of respondents answered that they were able to do so extremely well. A further 48% responded that it proved very adequate, while 21% considered it to be moderately adequate and 5% not very adequate (Figure 9).

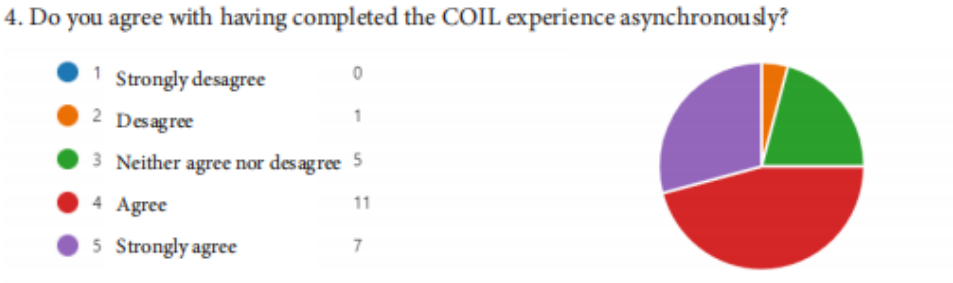

Figure 9: Responses to Question 4: Do you agree with having completed the COIL experience asynchronously?

The last question assessed respondents' degree of satisfaction concerning the presentation of the findings by the students at the two universities. The majority (57%) indicated that they were satisfied, while 5% indicated that they were moderately satisfied and 38% very satisfied (Figure 10).

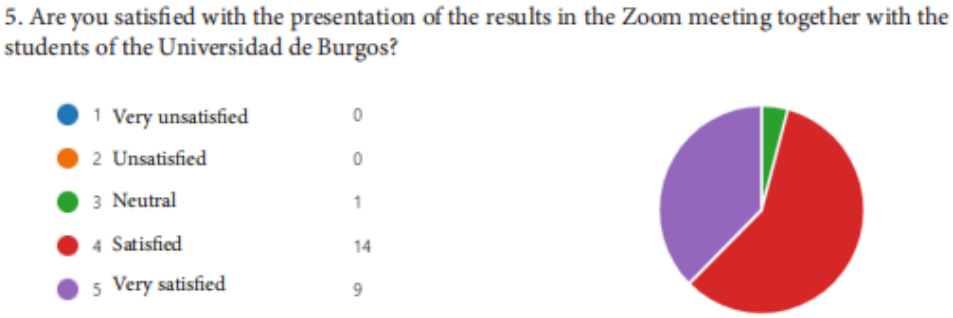

Figure 10: Responses the Question 5: Are you satisfied with the presentation of the results in the Zoom meeting together with the students of the Universidad de Burgos/ Universidad de Piura

4. Discussion

The students from the University of Burgos concluded that the use of renewable energies and more efficient systems helps to achieve better energy rating values, regardless of whether the climate zone is more or less adverse. All the national and international references studied in the course helped the students from Piura to enhance their capacity for analysis and response to the local reality, wherein – as future architects – they will have to respond to the needs, problems, and conditions that exist in their environment. The results were reflected in drawings that showed the themes analyzed in the chosen architectural works.

These results reflect the importance of opening technical conception to other localities and environments that have a different climatology and socio-cultural component. One possible application would be career performance in developing countries, in which students of technological degrees would face the challenge of adapting to the socio-cultural environment in order to carry out building solutions that are different from those of their own environment (Owoha et al., 2022). Moreover, the findings show that tele-collaboration projects in the field of architecture and building engineering are potentially key to developing architects,

helping them to acquire and improve essential skills and attitudes (Ceylan et al., 2020).

Most of the students who responded to the survey showed that they are willing to continue and constantly seek intercultural training for the rest of their professional career and in the future. Other studies in the field of engineering have reported similar results (Loyo Rosales & Gutiérrez, 2022). For the first cycle students of the Introduction to Architecture course, this experience evidenced huge potential as it served as a motivation. It also offers a competitive advantage that will serve as a positive aspect in their curriculum. As for the postgraduate students of the Energy Efficiency course, the COIL experience proved to be of interest as well as very enriching at a personal level. At an academic level, the students highlighted certain key aspects. These included "the opportunity to learn about the construction and energy differences in the buildings of another country", "the differences between the technical terms used in the construction sector between the two countries", and "the openness to other construction systems, with economically and technically sustainable local materials". The online platforms used – such as Zoom, Moodle, and Miro – provided a suitable context in which to carry out the project online. This positive impact of online platforms was mentioned by Bakir et al. (2021), thereby highlighting the qualities that these platforms can offer the educational context (Haridy et al., 2022). However, the students did encounter certain difficulties in the collaborative task, as asynchronous work did not always favor communication between peers. All the difficulties were overcome with the help of the lecturers who acted as mediators between the two groups. In the phase of sharing results synchronously via video call, the students were highly motivated, and a strong bond was established between the two groups. Other studies in which the time difference did not allow for synchronous work to be carried out indicated similar difficulties (Vasquez & Ramos, 2022).

5. Conclusion

Implementing the COIL methodology has proved to be an enriching and positive experience. COIL has allowed students from different countries to share knowledge and skills in educational environments in different contexts, and has improved the internationalization profile of both lecturers and students alike.

The data obtained from the survey completed by the students support the degree of acceptance gained by the collaborative experience. The survey results of the students show that 48% were very satisfied, 38% extremely satisfied, and 14% moderately satisfied. The experience motivated participants to continue and to constantly seek an intercultural exchange in the future. The survey results show that 24% of the respondents were extremely motivated, 71% highly motivated, and 5% motivated.

At the teaching level, the COIL experience opens up an interesting horizon for innovation in new teaching methodologies, which can be put into practice in different courses and in different academic years with the aim of gathering sufficient data to analyze and draw conclusions on the impact of intercultural

collaborative experiences in the field of education – specifically in fields of architecture and building engineering. According to the survey, respondents' expectations were met when using the course asynchronously. In this regard, 33% of respondents indicated it functioned extremely well, 48% very adequately, with 14% considering it to have been moderately adequate. Only 5% indicated that it did not prove to be very adequate.

The COIL experience is key to putting into practice international, interdisciplinary, and inter-university cooperation, which can help to broaden the vision towards the search for a more inclusive education and to reflect on the holistic education of students. This activity afforded a great opportunity for the participating students. They not only strengthened their performance in online communication and the use of technological tools but also met people from another culture, worked collaboratively with them, and developed new skills.

One recommendation to come out of the study concerns the suggestion that the COIL approach may open up new opportunities for the internationalization of curricula in higher education institutions and online academic mobility in the field of architecture and building engineering.

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