A collaborative learning approach for an engineering research project development during Colombia lockdown

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***Abstract*– The social restrictions imposed by the Covid-19 pandemic generate severe changes in the everyday activities of the world. University education was no stranger to this reality. This situation forced the search for different strategies to guarantee the quality and continuity of the various academic activities. This project explores the use of a collaborative work methodology used with the help of communication and information technologies to develop a research project. The selected project was the improvement of a racing drone structure. A collaborative approach during the project development presumed exciting and promising results from the technical and teaching views.**

***Keywords*—Collaborative learning; research; project development; E-learning; Virtual learning.**

I. Introduction

Educational and research activities at universities are commonly developed employing traditional methods whereby classrooms, real experiments, and laboratories play a crucial role, as studied and presented in [1, 2]. However, thanks to information and communication technologies (ICT), innovative approaches have been established in recent years, leaving the possibility for these activities to be conducted beyond the campus boundaries.

The governmental actions to contain the spread of the COVID-19 disease introduce requirements for social isolation. The cessation of face-to-face events impacted the entire structure of society and our daily activities [3], including university education, where the most traditional forms of teaching have been obliterated. Nearly 82 percent of students worldwide had their institutions closed entirely or partially during the more restrictive time [4].

The implementation of appropriate and innovative strategies is one of the variables that may influence the success of the teaching and learning process. Different approaches have been explored in the literature to be employed during learning experiences [5] online and offline. Furthermore, digital transformation (DT) has become a significant trend in recent years [6], fostering dramatic changes in society due to the popularity, implementation and use of ICT technologies [7]. This reality has not gone unnoticed by educational institutions.

E-learning is a crucial component of DT, involving electronic educational technology in learning and teaching. It can disseminate knowledge in various formats and covers multiple applications and procedures. The quality of e-learning education is determined by many factors, including the instructional methods used, preparation, involvement, and participants' attitude.

Move to E-learning approaches affects the routine operation of the institutions with significant influence on the entire academic activities [8, 9]. Nonpresential activities are considered challenging, especially in developing countries [10, 11]. A lack of online learning abilities and expertise rendered the educational process much less effective, resulting in low student engagement.

According to socio-constructivist and cultural viewpoints, rather than being created, knowledge is constructed, and learning results from interactions with their surroundings [12]. Collaborative learning (CL) refers to a teaching approach in which two or more students of varying abilities collaborate in small groups through interaction to achieve a common goal [13]. The theories of social interdependence, cognitive growth, and behavioral learning are the basis of collaborative learning [14]. This pedagogical strategy has been extensively employed in traditional and non-traditional scenarios throughout different disciplines with numerous benefits [15], such as encouraging social interaction and learning, promoting critical thinking, and the active involvement of the students in the learning process [16].

Zhang and Cui [15] relate that CL success has a relationship with the learning goals, motivation, and enhancement, involving five crucial components: "Positive interdependence; Individual accountability, Promotive interaction; Social skills training, and; Group processing." The technologically mediated collaborative learning processes are influenced by the learning environment, the workgroup, and the characteristics of social interaction [12].

Different studies [17 - 19] that analyze the perception of faculty and students about the teaching processes assisted by information technologies during the pandemic are available in the literature. However, studies contemplating the development of research projects for undergraduate students were not found.

This work presents a case study of a collaborative learning strategy for students' research project development during the digital attendance scenario. The document's

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structure is the following: The methodology is shown in section 2, the case study results and discussions are highlighted in section 3, and the conclusions are presented in section 4.

II. METHOD

This manuscript has been developed from a case study employing an undergraduate research project. The project was developed under a collaborative learning methodology during the technology-assisted learning modes period. The objective was to analyze the method's effectiveness associated with fulfilling the project's goals and observing the student's development through their feedback, impressions, perception, and reflections related to the learning experience.

Relevant data for the analysis are associated with the dynamics of the group and the individual behaviors of the participants, covering activities such as the task division, roles, cooperation, affective atmosphere, and engagement. The information was collected using non-formal interviews, group discussions, and details shared during social interaction. The idea was that students voluntarily give their feelings about the collaborative work.

The CL strategy was selected considering its advantages in encouraging social interactions. With direct effects that benefit academic achievements and its capacity to reduce nervousness and anxiety. University students could present problems due to the stress and limitations of the pandemic. Another reported achievement of the CL is that it encourages scholars to search for aid and accept coaching from others and cultivates favorable attitudes toward the learning process. These factors may significantly impact their academic performance, social relationships, and future professional and personal opportunities.

Technologically mediated collaborative learning processes are influenced by different factors such as the learning environment, the workgroup, and the social interaction characteristics.

The first step in implementing a collaborative learning method is to form a learning group. However, different concepts about the ideal size of the workgroup were found in the literature [20, 21]. Some experts feel that as the number of members in a group grows, efficiency will rise; some researchers, on the other hand, have the opposite viewpoint. Therefore, one of the essential procedures in CL is group creation. Having enough and adequate participants in a learning group promotes good collaborative interactions and are necessary for achieving satisfactory learning results. Next, a computer-supported environment needs to be carefully chosen as a communication tool for the activities with the work team of professors and students. After that, the group developed the research activities, and some performance criteria were defined. Finally, the participants' impressions were collected as a qualitative evaluation of the experience.

III. THE CASE

At Universidad Pontificia Bolivariana (UPB), during the Covid-19 lockdown, the activities were suspended for a short period. After that time, academic tasks were adapted and modeled to occur by employing E-learning approaches and ICT-assisted attendance. The goals during these transformations were to ensure continuity at all levels of educational activities and organize practical remote learning activities.

During the experience, a formal collaborative learning group was employed. Eight (8) undergraduates from different levels of the program and two (2) professors from the aeronautical engineering program who had previously engaged in research activities were invited to participate in the experience. The research working group was formed based on joint investigation interests.

Students participate in small-group tasks where they share their knowledge and expertise in collaborative learning with professors acting as facilitators in the education process.

Microsoft Teams was selected as a tool for the collaborative learning process between the different software and platforms available as a virtual education environment. The app was planned to be employed by local, remote, and distributed workgroups and is considered a hub for teamwork [22]. It integrates different resources in a single platform showing good communication, sharing, and interaction capabilities that work following the educational methodology and the tasks to be developed. Furthermore, thanks to mobile devices, the app can be used at any time or location, supporting synchronous and asynchronous activities. This help maintains engagement, participation, and interaction at any time or place.

As a strategy to improve students' perception, stimulate their sense of belonging and simulate the physical meeting spaces that existed before the pandemic, a virtual space was created within the app, dedicated exclusively to this activity—Fig. 1, shows an image of the collaborative learning space.

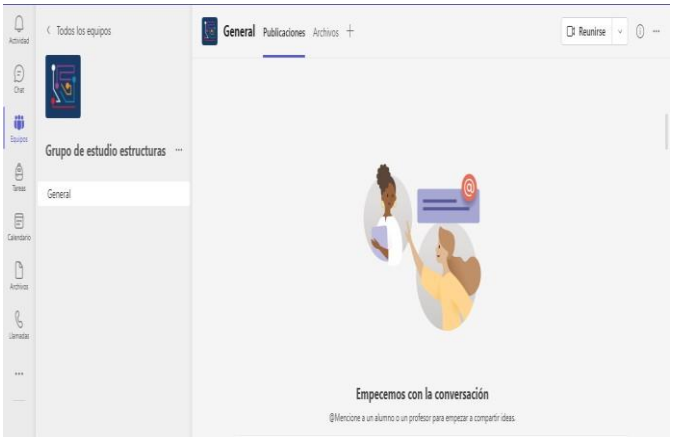

Fig. 1 Microsoft Teams Collaborative learning space

Different tools can be employed in the collaborative space to promote interaction and learning between forums, collaborative annotations, collaborative authoring, meetings, multimedia, and information sharing.

After defining the workgroup and the learning space, the professors present different research proposals to review, discuss and analyze to select the one to be developed during the activity. Among the objectives expected in the various propositions presented was to encourage applying the knowledge acquired during the program's courses to solve a real problem.

The proposed goal of the research project was to improve the performance of the drone. First, it started considering previous concepts of aerodynamics, performance, and operation of similar vehicles. After that, the factors with the most significant influence on performance were listed. From the list, the vehicle structure weight was selected for its relevance. Therefore, the chosen work proposal consisted of a methodology to improve a structural section's strength/weight ratio of a crewless aerial vehicle through topological optimization methodologies. The selected vehicle was the Drone "Eachine Aurora 100" presented in Fig. 2.

Fig. 2 "Eachine Aurora 100" [20]

The vehicle was initially designed to participate in racing competitions. In this kind of race, pilots fly drones outfitted with cameras while wearing goggles that stream the live video feed, giving them the sensation of being inside the drone. The objective is to complete a problematic racecourse in the shortest amount of time feasible while staying ahead of the other competitors in the heat. [24].

The project was developed for eight weeks in a computer-supported environment. It served as an evaluation project for further developments to improve the effectiveness of E-learning approaches applied to research activities.

An activities schedule was proposed during the project development, including some synchronous meetings and asynchronous activities. The communication space was always available to advocate, encourage, and facilitate the communication through discussion, argumentation, and reflection upon the tasks to achieve deeper information processing.

A semi-structured exploratory questionnaire was created to analyze the perception of the investigative experience. The feedback form was developed with the support of a literature review and informal interactions with students currently enrolled in the activity. The main elements asked of the participants were related to research performance improvements and learning effectiveness applicability of the methodology used.

IV. Results

As one of the technical results of the project, a proceeding was presented during the third meeting of research, development, and innovation in the aeronautical sector organized by the aeronautical authority of Colombia. The document and presentation were titled "*Metodología De Obtención De Elementos Estructurales Para Aeronaves No Tripuladas Utilizando Optimización Topológica*" [25]. They highlighted the structural optimization techniques used during the development and the technical results related to reducing the weight of the obtained structure. Furthermore, other results of the learning experience through a collaborative approach were presented in this document for its communication. There were grouped into technical results and learning results.

A. Technical results

The first step during the process was to obtain a digital representation of the drone. For this proposal, commercial CAD software was employed. The digital model of the drone is presented in Fig. 3. This digital representation was used as input for the finite element analysis process and structural optimization. All team members had prior skills in using Computer-Aided Design software that had been acquired during the initial stages of their academic training process.

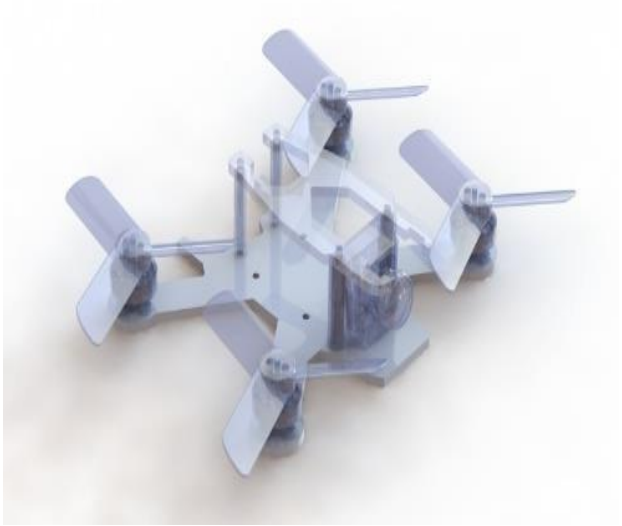

Fig. 3 General isometric view of the "Eachine Aurora 100"

As the next step during the process, an optimization process was conducted with the objective of reducing the weight of the structure. To accomplish it, a Topology Optimization (TO) process was conducted. TO employs a mathematical method that optimizes the material layout through variations in the component geometry for a specific set of loads while maintaining its adequate mechanical resistance to fulfill the function for which it was designed. To carry out this optimization, a percentual weight reduction objective must be selected, and some sections of the structure must be restricted according to its manufacture and operation. The goal of the TO process, in this case, was a forty percent (40%) reduction in the unnamed aircraft structure mass. During a typical topological optimization process, Finite Element Analysis (FEA) was employed to identify the load condition of the structure under optimization. The use of topological optimization has been widely spread in the industry, especially in aerospace components, including drones and unmanned aerial vehicles. The selection and use of topological optimization techniques are beyond the scope of this document, but it is possible to find enough information about it in the literature [26-27]. The structure resulting from the TO process is presented in Fig. 4.

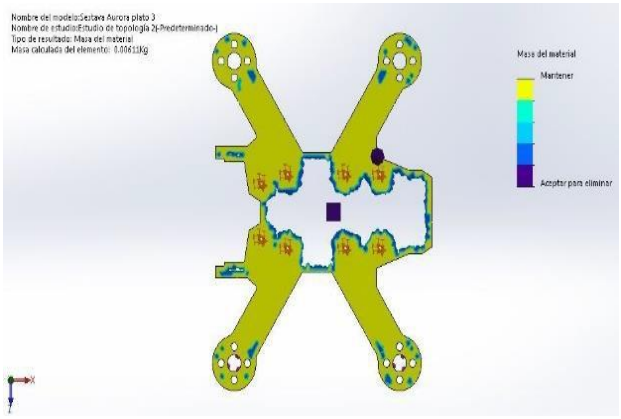

Fig. 4 Structural analysis with a target mass of 40% [25].

In Fig. 4, it is possible to observe the geometry generated autonomously by the optimization process selected and employed. However, some alterations to the structure were required to avoid structural problems due to the presence of fatigue during the continuous operation of the vehicle. Fatigue analysis was not carried out during this optimization stage.

The model was rebuilt considering a cleaner surface to avoid possible stress concentrations and harmonize the design generated by topological optimization. However, some increase in weight due to the design fix appears. In Fig. 5, the harmonizing design was presented.

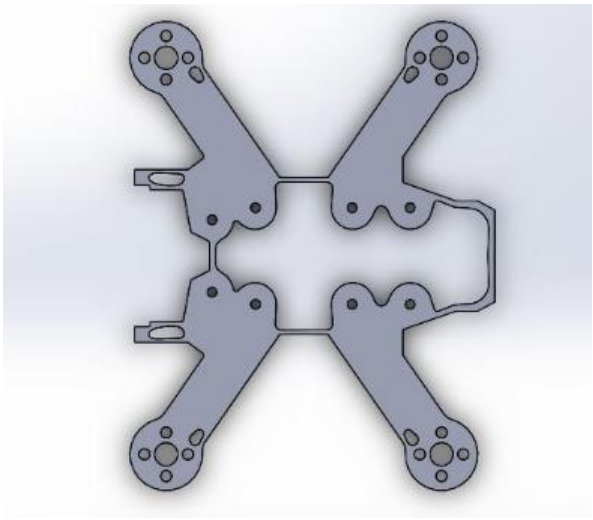

Fig. 5 Unnamed aircraft harmonized s structural design [25].

From the point of view of the technical goal of the process, the experience was considered successful. Nevertheless, some additional analyzes and improvements can be developed in later stages. Fig. 6 presents a digital model of the final assembly of the unnamed racing vehicle with the modified structure through a topological optimization process.

Fig. 4 Proposed final assembly.

In order to have a more realistic experience, the final designed structure was manufactured employing a 3D printing machine that employs a Fused deposition technique. The combination of additive manufacturing techniques and TO has shown great potential for diverse applications. The manufacturing process was conducted during a less restrictive social distance period on the university facilities and was followed by the team members through streaming. Fig. 6 presents the 3D printed component.

Fig. 6 3D printed structure.

B. *Learning results*

The results of the learning process and the general experience perception are presented based on the information provided by the participants through unstructured interviews.

At the beginning of the process, the students believed that teamwork during the e-learning condition was complex. The complexity is primarily related to the necessity to overcome obstacles such as individuality and the tradition of carrying out activities in an outdated way. Some additional problems associated with obtaining successful interactions between team members appear too during the project begins. In problematics moments, the professor plays a crucial role. The responsibility is to demonstrate how the information exchange could be conducted and stimulate the students to explain their ideas and ask questions to obtain a deeper discussion.

A shift in the teacher's role from traditional transmissive attitudes to supporting and facilitating individual and group learning processes was critical. Good instructional decisions were crucial and needed to be combined in active and passive ways. In some cases, the principal needs to monitor the activities to understand how students interact and resolve problems or intervene when necessary.

The group initially expresses skepticism toward the collaborative effort, assuming that not all members will endeavor to contribute equally to common goals. However, during the project's development, the concept changed, and work planning acted as an essential tool for determining individual tasks. Despite the initial resistance, most responses of the team members were optimistic.

The virtual space at Teams app allows fruitful and constructive discussion, this element working hand in hand with the encouragement to share inspiration or excitement strikes at any time of day or night, preventing good ideas from being forgotten. However, when the group started to apply the app, numerous challenging situations were discovered where the potential for interaction and cooperation was not fully realized, either because the environments did not provide the essential tools or because they were not used.

Previous experience with social media and mobile communication allows a more natural touch in the generated space for the collaborative work turning this interaction space into a thriving learning zone.

The absence of intelligent assignment design and issues with communication and management of learning activities can be more challenging to overcome than the technical components of the programs or platforms used in some circumstances.

The involved students develop better attitudes towards the professors and the research activities in an e-learning environment.

Students report that valuable knowledge was developed primarily by the group's immediate feedback, questions, and comments during the discussions, even for members less active in the debate.

Students believed that group cohesion, communication capacity, and responsible action had increased during the procedure. They identify that responsibility and dedication are two prerequisites for autonomous work, which must be adjusted to group members' availability in terms of personal duties.

IV. Conclusions

In the near future, one of the most significant purposes of education will be to equip students to enthusiastically participate in an interconnected society where information will be the primary resource for personal, social, and economic development.

Using a collaborative learning approach to develop a research project during the digital attendance scenario caused by the social restriction of the Covid-19 pandemic was proven successful.

The students' learning results show promise with significant improvements in their social and technical skills.

The professor's support and attitude toward the students were crucial elements in achieving the project's proposed objectives.

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