Hybrid Project-Based Learning course approach from face-to-face and remote experiences.

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Abstract. The Covid-19 pandemic challenged students and educators who quickly migrated face-to-face courses to a remote context. Given this challenge, this paper documents the experience of a Project-Based Learning course originally proposed to a face-to-face and adjusted to the remote context. It is a wearable computing course centralizing on mixed reality technologies and user studies evaluation. The adopted methodology is student-centered based on PjBL practices, emphasizing the Human-Computer interaction subject was applied six times, three times face-to-face, and three times remotely between 2019 and 2021. This paper describes the educator's experiences, learnings, and directions for the arrangement of other PjBL courses.

Keywords: Project-Based Learning, Student-Centered Learning, Hybrid learning, Mixed Reality, Wearable Devices, Design Thinking

1 Introduction

The COVID-19 pandemic required new behaviours from students and teachers as social contact was restricted. The isolation lasted for months and forced the beginning of academic activities remotely. Teaching practices using active methodologies were already challenging in the face-to-face model and had adaptations in the remote model.

The active Project-Based Learning (PjBL) [4] methodology stands real problems as the subject for supporting the learners' activities. The author used PjBL in classroom format before the pandemic. The migration to a remote model, which must consider synchronous and asynchronous activities practices and at the same time keep the student at the centre of the learning process, created challenges and course adaptations.

The course presented in this article uses the active Project-Based Learning methodology focused on teaching wearable computing [1] based on technological artifacts of augmented and virtual reality [2]. It uses game-focused development tools, prepares students to carry out user studies [8], user-centered project development, and other contributions to the Human-Computer Interaction context.

This paper aims to present, compare, and discuss teaching practices based on the Project-Based Learning (PjBL) methodology for students of Computer Science and

Control and Automation Engineering courses before and during the COVID-19 pandemic. The specific goals are:

- To introduce the challenges of both modalities
- To describe challenges to migration from in face teaching to remote teaching toward hybrid teaching
- Discuss and list best practices for hybrid PjBL teaching

Importantly, this is not a research project designed to conduct assessments from students' perspectives. Therefore, it is presented from the educator's perspective who conducts the learning process. No information on student opinions and perceptions was captured.

Although the work reports the specific context for the Computing and Engineering course, it is expected that other educators can use the contributions presented in this paper to construct courses focused on PjBL, whatever the format.

The rest of this paper is organized as follows: Section 2 presents concepts related to the content proposed in the course. Section 3 describes information about the proposed course without distinctions about the teaching format. Section 4 describes features of face-to-face teaching. Section 5 presents the particulars of remote learning. Section 6 compares the two formats and presents a hybrid format proposal for conducting the discipline. Finally, Section 7 presents the conclusions.

2 Literature and Concepts Review

This section presents concepts explored in this work. Section 2.1 describes the concepts of wearable computers, augmented and virtual reality, the central technologies applied in the proposed discipline, and described in this work. Section 2.2 presents the active Project-Based Learning (PjBL) [4] methodology used in the proposed course. Section 2.3 introduces Design Thinking [6], the human-centered development method for conducting projects developed by students in the study. Finally, Section 2.4 presents two of the main game development engines. Students use these engines to create their projects during the course.

2.1 Wearable Devices, Augmented Reality and Virtual Reality Concepts

The term wearable computing [12, 13, 14] refers to the possibility of interacting with computer equipment through user-connected devices that have accessory formats used by humans. They are usually applied to health purposes, especially when they are built with the intention of sensing data from the human body. They are valuable for context identification [1] in different application areas. Smartwatches and smartglasses are the most common shapes for wearable devices and both were the gadgets responsible for popularizing wearable equipment and mass adoption. Currently, several companies are investing in wearable equipment towards the consolidation of ubiquitous computing.

Milgram [2] presents the Reality–virtuality continuum scale that deals with the composition of real and virtual objects. Fig. 1 shows the scale introduced by Milgram. Mixed reality corresponds to technologies that join real and virtual components, featuring augmented reality (AR) [15] as the joining of virtual to real components and augmented virtuality (AV) when real-world elements are incorporated into the virtual environment. The concept of virtual reality (VR) [16] occurs when the intention is to remove the individual from the real environment, simulating a new, completely virtual environment. For this reason, virtual reality is not considered in the mixed reality spectrum, as there is no mixing between real and virtual world objects.

Fig. 1. Milgram’s Reality–virtuality continuum [2]

Mixed reality and virtual reality are not concepts strongly linked to wearable computers. However, combining these technologies allows for more pleasant experiences for users. Currently, several companies such as Meta, Microsoft, Google, among others, make investments in the development of hardware and software aimed at these technologies. In addition, the main engines for game development are compatible with these types of equipment. These factors have allowed mixed and virtual reality applications to become accessible to end-users.

2.2 Project-Based Learning (PjBL) Concepts

Active methodologies aim to place students at the centre of the learning process [4]. Naturally, they are based on teaching theories proposed by classical thinkers and reproduce methods and actions for a modern and effective teaching model. The methodology covered in this paper is named Project-Based Learning (PjBL), which is learner-centered, collaborative, and focused on learning through students' development and delivery of an artifact.

Project-Based Learning (PBL) methodology and Problem-Based Learning are usually confusing methodologies because they both have the same acronym[1]. An important distinction between the two methodologies is that Project-Based Learning focuses on developing a product or prototype. In contrast, Problem-Based Learning encourages students to think of solutions to a specific problem that derives from observing a phenomenon or event [5]. Table 1 shows a comparison between both approaches.

[1] Some authors use PjBL and PBL to differentiate both. This is the same standard used in this paper

Table 1. Comparison between Project-Based Learning and Problem-Based Learning.

Project-Based Learning	Problem-Based Learning
Focused on the solution.	Focused on the knowledge.
Students analyse a general problem and propose a solution.	Students analyse a specific question.
Students design and develop a prototype as a possible solution.	Students generate hypotheses that can explain the phenomena or events.
The prototype can be refined by experts, instructors, or pairs.	Students identify follow-up questions
Usually, can apply it along the course in some weeks	Usually, can apply it in short periods where the phenomena or events occur
Easy to merge with other development methods	Appropriated to a deep discussion about the problem discussed by students

According to the characteristics of the proposed course, we chose to use the Project-Based Learning methodology to be applied in the course described in this work. The acronym PjBL used will be referenced to the Project-Based Learning methodology from this point onwards.

Another advantage that favoured the choice of Project-Based Learning was the possibility of mixing project development with human-centered development techniques. The Design Thinking method was chosen in this work and is explained in the next section.

2.3 Design Thinking

Design Thinking is a method for stimulating ideation about human-centered problems that prioritizes collaborative work and involves several multidisciplinary actors in the development process focused on innovative solutions to complex problems [6]. The method is known and adopted both in academia and business and arouses the interest of mainly those who seek innovation to solve their problems. The Design Thinking in this work is divided into five phases described below:

Empathize or immersion. It aims to understand the problem intended to be solved from different points of view and perspectives. It can be performed in two parts being preliminary and depth. Often the process can be carried out through exploratory research followed by field surveys, interviews, and others. The collected data are organized into cards for further analysis at this stage.

Define. This phase aims to analyse the data collected to make the participants understand the problem. Various tools like concept maps, affinity diagrams can be used in this phase.

Ideate. Ideation is when the target audience for the solution is defined and the strategy to be used to solve the problem. Alternatively, it can include end-users of the solution in this phase and the multidisciplinary team that works on the project, allowing for participatory design.

Prototype. This phase represents when ideas start to shape and are prototyped for further evaluation. Although prototyping is in one of the last phases of Design Thinking, in some situations, it is interesting that it is present in the previous phases to enhance the creative process of those involved.

Test. The testing phase corresponds to the validation of the created solution. It must be performed through user tests in search of User Interface (UI) or User Experience (UX) responses in the proposed course context. Some literature does not consider the testing phase a stage of Design Thinking. Others incorporate it into the prototype phase. There can still be another phase in the business environment, which is implementation.

The scope of the proposed course is not to teach the concepts of Design Thinking to students, a fact that by itself demands a specific course. Therefore, the students' project development has been organized into the stages of Design Thinking for didactic purposes and the separation of concepts, particularly human-centered prototyping, and evaluation through user studies.

2.4 Game Engine as Software Development

Unity[2][7] is one of the most famous graphics engines for 2D and 3D game development. It implements the physics of objects and their interactions. Currently, it supports C# language for writing scripts and several file formats such as jpeg, png, and others for two-dimensional objects and fbx, obj, dxf, and dae others for three-dimensional objects. Unreal Engine[3][11] is one of the primary Unity competitors.

Both engines are cross-platform compiling on various platforms such as PC (Windows, Linux, iOS), mobiles (Android and iOS), game consoles such as Xbox, PSX, and recently for augmented reality devices e.g., Microsoft Hololens, or virtual reality, e.g., HTC Vive [4].

Unity and Unreal are very similar, have a fast-learning curve, and are considered productive for building small games. Both platforms have API and SDKs with support for development on the leading augmented and virtual reality equipment available on the market. They also have free versions and free or paid artifact stores.

The choice between the engines turns out to be a personal one, often motivated by the developers' experiences..

2.5 – Tools and Methodologies Justification

Wearable devices, Augmented Reality, and Virtual Reality are the primary research subjects of the author. Furthermore, this is the first time a wearable course has been proposed at the University. As the proposed course focus on wearable systems for human interaction, we decided to use the Design Thinking approach for human-centered design. Design Thinking is one of the most popular methods, has a vast

[2] https://unity.com/
[3] https://www.unrealengine.com/

literature for learners' support, and is widely utilized on the market. For the teaching approach, Project-based learning match better with the Design Thinking approach in this context. Unity is one of the most popular tools for developing wearable extended-reality systems. It has a free academic version and extensive complementary material for study. Students were encouraged to use other tools for their convenience, although the educator was more confident in providing support on the Unity platform.

3 Wearable Computer Based on AR and VR Course

This section presents details of the proposed course used as a basis for the discussion of this article. The section makes no distinction between face-to-face or remote course aspects. Sections 4 and 5 discuss both approaches. It is important to emphasize that the course was offered eight times between 2018 and 2021 for undergraduate and graduate students. This section does not address the particularities, adaptations of each class, and practice evolutions.

3.1 Course Agenda

This section provides details on the proposed course plan. There is no distinction between the concepts covered in face-to-face and remote teaching activities.

There were changes in the activities and forms of assessment in the specific sections to describe the actions of face-to-face and remote teaching activities. The discipline is not mandatory in the course schedule, but it counts as an alternative to the undergraduate conclusion. This means that it is one of the subjects offered to students to choose from to specialize in some area of knowledge. The proposed course was arranged into the following topics:

Presentation of the Concept. This topic covered several concepts of wearable computing. Lessons were organized with subjects on initial conceptions, market numbers and trends, wearable sensors, wearable computing requirements, processing hardware and software, IHC in wearable computing, namely visual and non-visual interfaces, classification, and head-mounted construction displays (HMD) and wearable sensors.

Project Development. This topic covered topics related to hardware and software used to build wearable devices, user-centered development methods, and techniques for evaluating these devices from the perspective of user experience. It is the main reason for using PjBL methodology in the course conduction discussed on Section 3.3. The students' proposed solution should have focused on the development of wearable AR and VR solutions. This approach was chosen because most students have a smartphone that allowed them to the prototype during the course without significant additional acquisitions. In addition, the research and teaching laboratory focused on these technologies supported students through equipment loans. Students could attend the physical space to develop prototyping activities.

User studies with wearable equipment. On the evaluation aspect, the course covers user study techniques based on those generally used by researchers in the field [8] and the ethical factors of studies with people. UI and UX methods and techniques are presented to students in lectures given by the teacher. In addition, students must present/participate in a seminar on the topic, which discusses an article related to UX concepts. Some practices are proposed to students, such as making a test plan and conducting a short users' study during lessons.

Applicability of wearable computers. This topic was proposed to expand to students the various areas that wearable computing has relevance. When we talk about wearable computing, we intrinsically think of solutions that tend to have aspects related to monitoring the conditions of the human body. Although this is an exciting line of research and development that can explore more than that. For instance, wearable computers can better integrate the individual in the production process. Among the topics suggested for the study and presentation of students are those easily found, such as case studies on the use of wearables in sports and health and others not so intuitive as wearable computers applied in smart cities, industry, education, ecological systems. The list was not limited to these suggestions, as students could suggest investigations on other topics.

3.2 PjBL on Proposed Course

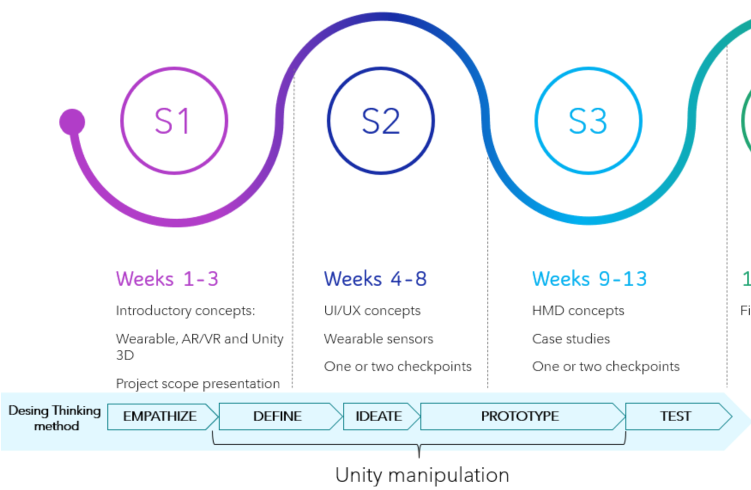

Fig. 1.. Course timeline based on PjBL practices and design thinking method along 14 weeks.

The PjBL practice proposed in this course was presented to students at the very first meeting with the educator. They were introduced to the idea of human-centered development, in particular the Design Thinking method. It is not mandatory that students apply all stages of Design Thinking in this course. The proposal is that they have a vision about the human-centered development process and use some techniques during the project development. PjBL practices must be carried out in groups of 3-5 students according to the number of students enrolled in the course, except when the number of students has been reduced and when each has chosen to develop their project. Each class had a minimum of 3 and a maximum of 5 groups.

The PjBL practice is divided into four stages that must be aligned with the plan proposed in the course. The course takes 15 weeks, and the last one is reserved for students who have lost some evaluative activity for reasonable causes, having the opportunity to recover. Fig. 1 shows a timeline of the occurrence of steps, the content presented to students until that week, and an alignment of the PjBL proposal with the Design Thinking method used as a basis for human-centered development.

The phases of the Design Thinking method are presented to students. Although the Empathize Phase is described to them, students do not always carry out this phase through formal standards, such as persona definition or empathy maps known in the literature. In general, this step is based on statistical data found about the application's target audience. This weak point still needs to be improved for course development.

Unity is the software suggested by the course professor for developing prototype programming activities. It is the tool the teacher supports the students, although it can use other tools or programming languages to build the solution. The only restriction is that the final prototype is an AR or VR application. Although prototyping starts in the second half of S2, the manipulation of the Unity tool still occurs in the Define and Ideate phases of Design Thinking. They are encouraged to think about the proposed solution by exploring free 3D models available in specialized online stores or through assets available in the official Unity store. Steps S1 to S4 are described below:

Stage 1. Problem definition and scope. In this step, the groups should identify a real problem that would allow them to think about how an augmented or virtual reality application could be valuable for solving that problem. At this stage, the students received an example of how to assemble their presentation through the teacher's explanations. The presentation should contain the context, the identified problem, the motivation to solve the problem, the proposal of how they imagine that the AR or VR technology could solve the problem, and a schedule that should align with the partial deliveries proposed by the discipline schedule. To complete this step, it is essential that some concepts of wearable computing, augmented or virtual reality, and notions of Unity 3D are constructed.

Stage 2. Project Development and Checkpoints. This step starts after the teacher provides feedback to students on the proposal presented. The prototype development starts, and the follow-ups are made throughout the course. Checkpoints are the teacher's name, which represented a milestone in the project. The educator planned 3 or 4 checkpoints activities. The groups needed to present the evolution of the project up to that date, problems encountered, and possible contour situations encountered during development. Checkpoint presentations had the partial distribution of the grade assigned to the project. In this way, students maintained their commitment to continuous growth throughout the course. Checkpoint encounters had two primary purposes. 1) The educator had the opportunity to check the project's progress according to the proposed schedule presented by the students and helped manage the project and its risks of failure during the course period. 2) Learning from the experience of colleagues. The presentation of doubts from the groups represented a moment for discussing solutions to the problems encountered. The time was right for the teacher to demonstrate technical solutions to the difficulties encountered, not only for the group he had just presented but also for all the students. Often, the solutions discussed were applied by more than one group as, in general, the challenges and problems are similar. Students must be more fluent with the Unity tool at this stage. Therefore, some tutorials are recommended to students.

Stage 3. UI/UX evaluation. Project evaluation was from the user's perspective. It is not shown in checkpoint activities as it was one of the last activities of the project. Its presentation was restricted to the final presentation stage of the project described in the next section. Before performing it, the students had already had contact with these concepts through an expository class on the content, presentation, and discussion of scientific articles on the topic, and practices related to assessment such as documentation of the test plan and carrying out the evaluation in the classroom about some technology not related to the project proposed by the students. It is noteworthy that the evaluation practices carried out were always among the course students, with didactic purposes, since it was not a research project, so there was no approval of this practice by the local ethics committee. None of the results shown have statistical significance for publication. Students must be familiarized with UI/UX concepts at this stage based on educator lessons and proposed practices It is also worth noting that the checkpoint activities still take place to assess the development of prototypes for each group.

Stage 4. Final presentation. The final presentation of the projects takes place in the last week of class. Groups should prepare slides with an overview of the work and re-present the identified problem, justifying motivation and the achieved result. In addition to this exhibition, students prepare a video focused on the lay public, i.e., external to the computer science community, demonstrating the work carried out in a simple and accessible language. This material is used as a portfolio for the course.

3.3 Complementary Course Activities

Educator demanded from students two other activities as complementary and evaluative activities as methodological support for learning. The presentation of seminars aims to motivate students to make presentations on the topic that the teacher planned to address in a specific class. Typically, nine seminar themes are proposed according to the number of students in the discipline. The themes were presented by groups formed by three or four students or individually. Before the presentation, the professor would select a scientific paper or white paper sent to all students. Next, each group member should choose another article to complement the exhibition. Therefore, three students should present four papers, one suggested and another selected by the members. The manuscripts selected by the teacher and the students should be shared among everyone. The objective was to allow other colleagues to read all the articles before class. The expectation was to encourage discussions in class. A fact that does not happen very often.

The activity adopted consists of presenting the seminars for a maximum of 15 minutes at the beginning of the class. Afterward, the educator presents his material to the class on that same topic to address in greater depth. This dynamic did not happen only in classes where themes were case studies.

Three challenges were activities presented to students at the beginning of the class and should be delivered at the end of it, after 40 minutes. Except for one, the challenge was to build a piece of equipment out of class for a later exhibition. The main objective of the challenges is to take students out of their comfort zones. Generally, students obtained three challenges, namely:

Challenge I is presented in the introductory class to wearable computing (one class before the first Challenge), and students were introduced to rapid prototyping cases and techniques. At the beginning of the Challenge I class, the dynamics used to develop the activity were explained to the students. After the teacher presents the topic, the students should present a solution. The methodology is presented in Fig. 2 and called "Double Team Process"[4]. Usually, the activity instigates the teams' creativity and promotes the participation of everyone, even the timidest. This process develops a brainstorming methodology among the participants and promotes a balance between very creative and less creative students. Furthermore, it strengthens the collaboration between them. The activity is divided into four phases described below.

Phase 1. After presenting the topic, the teacher lets each student think about the solution for five minutes. This first phase is individual, and each student must extract from 3 to 5 ideas described in a few words or short sentences to be used in the next phase.

Phase 2. Students organize themselves into pairs (or a trio if there are odd participants) and repeat the process. This time they have 10 minutes to present their ideas to each other and then select from 3 to 5 among the ones they think are most relevant. Note that this process makes a natural selection of what counts as good ideas.

Phase 3[5]. Two pairs come together, repeating the previous step. This phase lasted 30 minutes, as the quartets had to end the activity with a solution to the problem. As the challenge was rapid prototyping, the students had to prepare a solution prototype. Note that students were not required to prototype wearable equipment in this exercise, despite this being the focus of the discipline. The purpose of this activity was to show students that they were able to build a prototype, even in low fidelity, in less than 100 minutes.

Phase 4. Students should introduce their solutions for all.

[4] A citation explaining the method was not found. It was introduced to the author in 2008 by a Finn.

[5] It can be performed more times depending on the number of students.

The educator presented suggestions for tools that students could use during the challenge. Therefore, he hoped that most of them came prepared, even if they did not know about the problem. They could still take their personal computers and consult the internet about developing their work.

Challenge II aimed to allow students to achieve a user study on some technological device. A seminar presentation on the topic, followed by a lecture by the educator, happened before the challenge started. After explaining user test concepts, the educator summarizes how user tests are performed and some statistical tools commonly used by researchers [8]. For the rest of the class, students could form groups and discuss what they intended to use as an object of evaluation. They were instructed to take the test device and prepare the forms to present results at the end of the class. In other words, students could use tools such as Excel, Google Forms, R to build the results. They should invite at least five people (teacher plus four other students who were not members of the group) to take the test during the challenge. This activity did not require the use of a wearable device. At the end of the class, each group had 10 minutes to present their results.

Challenge III was the one with the highest degree of difficulty. The primary motivation for applying this challenge was finding low-cost AR equipment for use in the classroom during the course. A lesson to the presentation of HMD concepts, construction technologies, and available devices was prepared. A sample of technology suggested is from the paper [9]. The paper demonstrates how to build an AR device using mirrors. Students had contact with a prototype reproduction in the classroom. The challenge for the students was to build something similar, using mirrors and materials that were easily purchased and should be wearable.

4 PjBL Practices and Activities in Face-to-Face Teaching

The subject was offered three times in 2018 and 2019 for undergraduate students in Computer Science. The environment was taught is a classroom with tables and chairs arranged in rows, a blackboard, and an image projector connected to a computer. Alternatively, practical Unity 3D instruction classes could be held in a computer lab containing 20 computers with the software installed for students to use and an image projector connected to the teacher's computer. Some classes included visits to the research laboratory, which contains virtual and augmented reality equipment for the demonstration to students. These pieces of equipment were available for students, although sometimes some prefer to buy low-cost glasses for personal development and continuity of activities after completing the course.

The meetings took place twice a week. The teacher had a Moodle platform configured for the course that was not used to its full potential. The platform was generally only for sending and receiving tasks developed by students. The course did not incorporate written tests, and the evaluations were distributed in 60% of the project, this total being distributed in the activities of proposal presentation, checkpoints, and final presentation. 10% of points were distributed in seminar activities presented by students, and the remaining 30% were distributed in challenge activities.

The course load is 60 hours, with around 10% dedicated to project development activities. In this case, the classes aimed at this activity did not have meetings in the classroom. Instead, the teacher left the subject time free for development, and students could meet him in his office to discuss queries.

5 PjBL Practices and Activities in Remote Teaching

The course was offered three times in 2020 and 2021 to undergraduate students in Computer Science in a remote format, the first of which was singular as it was the first offer of a remote course in a face-to-face course modality, which was eight weeks long. The adaptations should follow suggestions defined by the university's pedagogical team for the adaptation of students and professors, among them the most important:

Lessons should have synchronous and asynchronous activities. Asynchronous activities were when the student did not need to be connected in the same environment and time with the teacher and classmates to perform the tasks. Synchronous activities are those that demand this connection. Also, it is recommended that synchronous activities be recorded to watch students who lost due to lack of power or connection. Alternatively, lectures could be recorded and made available to students to participate asynchronously.

As it is still a face-to-face course, controlling the frequency of students in asynchronous activities was done through the delivery of a summary on that subject since, being asynchronous, the teacher had no control of the moment when each one developed the activity. Synchronous activities were generally carried out through video calling, which allowed for attendance like face-to-face teaching.

Students used their computers and smartphones, or equipment provided by the university for remote use. Smartphones and tablets could be used to attend classes. However, the computer was still essential for the development of practical activities. Laboratory visits were impeded due to the health crisis, and this was one of the most significant losses as the students had no contact with RA/VR equipment such as Microsoft Hololens, Epson Moverio, and HTC VIVE. The apps could be developed to run on students' smartphones. Those who did not have the equipment could develop the application for PC.

Educators went through a course to use Moodle, which had new features made available by the IT and pedagogical staff of the university. The platform already worked as an environment for making educational material available and delivering tasks. Remote learning also became an official environment for teacher x students and students x students communication. The platform also helped so that students could manage their activities.

The challenges created in the on-site discipline were not continued in the remote discipline due to the environment in which the synchronous activities took place. The available tools made the control and management of the task not very simple, so the teacher chose not to do it so that there would not be some injury to the students' learning. This was another weakness concerning remote learning as it did not have a practice that was considered beneficial. The distribution of points after this activity cut was 70% project, 20% for seminars, and 10% for user test planning activities. The latter was inspired by one of the three challenges of face-to-face teaching.

The total course load of the course still is 60 hours, with around 15% being dedicated to project development activities which were part of the asynchronous activities. The teacher made a worksheet available to students with the weekly estimated time to carry out the tasks for better time management. At first, the impression is that the material added to the organization of students.

6 Lesson Learned Toward a Hybrid PjBL Teaching

This section describes some of the PjBL-based course development learning in face-to-face and remote learning.

6.1 Overall Discussion

Table 2. Comparison in face and remote PjBL course.

Tasks/Resource	Face-to-face	Remote	Propose
Project checkpoints	Presented in class.	Students join in a virtual room for the presentation. The best environment for Professor manipulates the Unity and code living and share suggestions to students.	Remote
Final project	In class. Students and the professor could experiment the wearable application delivered	Students should share the app. Not possible to experiment on wearable devices except personal smartphones.	In Face
Proposed Challenges	Occurred in class	Not feasible.	In Face
Seminars	Presented by students	No changes.	Indifferent
Lab	Opportunity to use XR devices	Not possible to use them.	In Face
Expositive lessons	In class. Better for discussions	In the virtual meeting. Opportunity to record for absent students.	Indifferent

The changes caused by social isolation and teaching environments provided us with new experiences and reflections. New ways of learning and teaching were explored. The course proposed and started in 2018 will no longer be able to follow the format in which it was initially applied. The proposal is that what proved to be efficient in synchronous and asynchronous activities, remote or in person, be proposed as a hybrid model for the new normal. For the most part, students and teachers tend to behave with different points of view than they did before the pandemic. It does not make sense that these practices should be disregarded for the possibility of face-to-face feedback as they have evidence of efficiency. On the other hand, it must be considered that the lack of social interaction affects some activities. Therefore, there is a proposal for a hybrid format for the course narrated in this article, which is established on the active Project Based Learning methodology described on next section.

Table 2 summarizes the main points discussed in Sections 5 and 6 and impressions about the proposed model of activities and resources for a hybrid format.

Next sections describe each Task/Resource in detail and provides the main reasons for the proposed scenario.

6.2 - Project Checkpoint

The goal of the project checkpoint is to provide students a moment to present their partial project evolution, discuss the project issues, and for the educator to help them with project decisions when necessary. Each group of students shows their results to the other for 10 minutes. Afterward, the professors and colleagues can provide feedback and share their experiences toward project improvement. The remote environment is a video call tool allowing each participant to share their computer screen and send messages in a chat. This context provides us with a faster and more immersive way to interact with this dynamic. This occurs because students can open their Unity project source code and edit it while receiving feedback. Also, the environment is advantageous for sharing tutorials and guides for introduced issues. Although we can do the same in a classroom, each presenter should physically connect their device to a shared screen in the room. Many changes take away precious time for discussion. Also, the experience of using a video call for sharing screen is more comfortable than a physical shared screen in the room for reading and discussing software source code. For this reason, the remote environment is considered more immersive.

6.3 - Final Project

The presentation of the final project is an opportunity for us to experience what was developed by the students. In particular, this context, the result is directed to a wearable application that uses augmented or virtual reality techniques. However, in the remote model, it is possible to run the final version on a computer but enjoy it as a game. This was the alternative used while working remotely. The face-to-face model gives us the freedom to hold a fair to demonstrate the results, inviting people outside the context of the discipline to provide feedback to students. This type of activity encourages more student participation and enhances the continuity of the project started in the course, often making it the course's final project.

6.4 - Proposed Challenges

There is no viable way to accomplish the proposed challenges in a remote course. The activities are intrinsically dependent on physical contact, done by groups to help with collective learning. While some activities can be adapted for the remote model, the experiences are not the same and can be frustrating. For example, assessment through user studies could be carried out by students with people who live in the same household or remotely. In some cases, students lived alone or with a tiny number of people, or people did not have the profile to perform the tests. The executions were individual, as students from the same group rarely are flatmates, and it was still not possible to have the educator's supervision, a fact that impoverished the exchange of experiences for better learning. For those reasons, on remote courses, the Challenges were cancelled.

6.5 – Seminars and Expositive Lesson

There were no significant impacts on the presentation of seminars in the remote model. The video call tool allows the participants to share their computer screen and audio with everyone present in the virtual room. The most significant damage to this model is that students do not always like to leave their cameras enabled, and this makes visual contact of the educator with the students difficult. Probably, students tend to be more distracted in the remote context with influences from other computational applications. On the other hand, remote classes can be recorded without specific infrastructure demand and later made available to students who could not attend, allowing them to have a better opportunity to learn.

6.6 – Lab

The impossibility of using the physical laboratory through visits, experimentation, and use of equipment for the development of activities had a negative influence on the conduct of the courses. Access to augmented and virtual reality technologies is not simple in the context in which the course is presented due to the costs of the main gadgets available. This means that when students choose to purchase equipment by themselves, it is generally very low-cost equipment, but it will hardly be equipment such as HTC VIVE or Microsoft Hololens, such as those available in the laboratory. During remote teaching, students could not have access to physical equipment due to restrictions imposed by social isolation. The absence of Lab use may have been the most significant loss concerning remote teaching in the context of this course.6.7 - Learning Management System (LMS)

6.7 – Hybrid Course Considerations

What can be seen were students, in large part, with more autonomous characteristics concerning the learning process. Agile methodologies tend to put the student at the centre of the process. It is no different from the PjBL proposal, although the perception is that the remote course showed the student as the protagonist. This protagonism involves the awareness of students about their role, and this has been a difficulty reported by professionals who apply agile methodologies for successful learning [10]. Perhaps this reflects what the students felt when they realized that they were physically alone, even though they were available in terms of digital communication tools and information exchange.

Some challenges need to be faced to do so. First, as feasible as it may seem, some students do not have a remote learning profile with synchronous and asynchronous activities. This may be due to several factors, one of which is the inappropriate home environment. Once again, the study spaces provided by educational institutions (libraries, laboratories, study offices, and others) can be used to carry out tasks in a more autonomous way. The educational institution must also agree to the implementation of a hybrid teaching. This adaptation may not be simple as in some countries. It requires modifications and adaptations in regulations and legislation.

7 Conclusion

The Covid-19 pandemic brings challenges to the learning process. Professors and students who are used to a face-to-face learning environment should meet in a remote setting and adapt to this new way. This paper presented the experience in a Project-Based Learning course for Computer Science undergraduate course before and during the pandemic. The author reported the challenges and lessons learned after migrating an in-face to a remote course. In addition, he proposed a hybrid course from the best practices from both experiences. This paper should reference other professors and teachers in adopting other subject courses toward “new normal”.

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