



# Students' Perceptions Exploring a WebXR Learning Environment

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**Abstract.** The work described in this paper is a case study, which involved 3 computer science teachers and 29 students from secondary school programming course, from 3 high schools. Informed consent was obtained from the students (those of legal age and the rest from their Parents and Guardians). In this initial phase of the course, it is important to know if the students are motivated to learn how to program and model objects, on the other hand it is intend that the students have a learning experience immersed in a 3D environment to evaluate the impact of this strategy in their willingness to learn. To carry out this study, the following research question was formulated: What is the student's perception about learning 3D programming and modelling immersed in a virtual environment? Two questionnaires were applied, a pre-test before the intervention and a post-test, immediately after the intervention. The results proved to be promising, having verified that these environments allow students to collaborate and learn in an intuitive and interactive way.

**Keywords:** Immersive web environments · Programming · 3D object modelling · Collaboration

## 1 Introduction

The emergence of immersive web environments democratizes the access to these sorts of environments and puts an end to some constraints, since the teacher has access to a simple customization technology [1], any teacher from any area or teaching level is able to design and customize an immersive web environment, adapting it to their teaching practice, without having to know how to handle a programming language. This environment runs on a browser, without the need to connect to any other device so that students and teachers are able to share the virtual space and interact with each other.

Interaction, in an immersive web environment, is one of the most important aspects of the interface, since it is related to the computer's ability to detect the users' actions and react to them, modifying the environment [2, 3]. This allows leveraging some skills, at a creativity level, in the replication of real spaces, or the creation of imaginary worlds, using static or moving objects [2] and collaboration, by interacting with others in the creation of these worlds.

Engagement is a process that reflects the quality of the user experience, based on the level of cognitive, temporal and/or emotional dedication employed in the interaction with a digital system" [4]. For the author, engagement is a multidimensional concept and is directly related to student participation during didactic activities. The more engaged with the activity, the greater the motivation to develop it, therefore, the greater the learning effectiveness. There is great concern on the part of interaction designers and developers to create immersive web environments that create and keep users engaged in tasks, otherwise, if the immersive environment does not have the ability to maintain attention and improve the user experience, it tends to be abandoned.

Immersive experiences are engaging and create a sense of presence in students, as if they were part of the virtual world. These experiences are useful to stimulate students' interaction with learning activities and foster collaboration among them. In addition, self-creation and interactivity within immersive environments allow the development of activities close to reality, resembling the practices performed in learning labs [2, 5, 6].

A benefit of using these environments in education, is the possibility to manipulate, visualize and explore the objects in real time using their senses and natural body movements [2]. This type of interface allows the transfer of the student's intuitive knowledge with the physical world, to the virtual world. Traditional virtual learning platforms, such as Moodle or Google's classroom, are usually static and do not allow this type of interaction.

Immersive web environments, such as Mozilla Hubs [7], FrameVR [8], Spatial[9], among others, intuitively allow students and teachers to meet in a three-dimensional space, build rich environments with personalised experiences, converse by voice or text, together or separately, as well as enabling students and teachers to bring the constructs of the virtual world into their real environment through augmented reality.

Immersive web environments may present themselves as ideal for schools to begin exploring and researching the potential of these tools in distance education for experiential learning - not as a substitute, but as a complement. This experiment arises from the willingness of authors/teachers to study the potential and limitations of using this technology in learning activities, and whether it brings benefits for students' learning.

The work presented here was carried out by three computer science teachers and twenty-nine first-year students of the Information Systems Management and Programming course, from three secondary schools, located in different places of the country. We intended to understand if students are motivated to learn how to program and model 3D objects but immersed in a virtual environment.

## 2 Methodology

An investigation always involves a problem, formulated by the researcher, and to which there is no theoretical answer. In qualitative methodology, based on the phenomenological-interpretative paradigm [10], the problem has the important function of focusing the researcher's attention to the phenomenon under analysis, playing a "guide" in the research, because it focuses the research on an area or domain, organises the project by giving it coherence and direction, delimits the study by showing the boundaries, directs the literature review to the central question, provides a reference for the drafting of the project and points to the data that will need to be obtained [11].

For this intervention cycle, the following research question was formulated “What are the student’s perceptions regarding the learning of 3D programming and modelling, immersed in a virtual environment?” To answer the question the following specific objectives were defined:

- To assess whether the student is predisposed to learning how to model 3D objects through programming,
- To assess the students’ perception of their enthusiasm for programming.
- To assess whether students enjoy learning in immersive virtual environments.

Quantitative data were collected through a survey and qualitative data from the video recordings made during the intervention. Notes were also collected (field diary) from the participating teachers/observers [11, 12].

## 2.1 Pedagogical Intervention

In this experience we transposed the “traditional” classroom to an immersive web environment (Fig. 1), using the Mozilla Hubs platform.



**Fig. 1.** Virtual classroom room in the Mozilla Hubs environment

Students were challenged to program their own 3D objects (Fig. 2), using the TinkerCad Platform [13] to develop programming skills required in the curriculum of the Professional Course of Management and Programming of Computer Systems, in the subject of Programming and Information Systems, whose module one “Introduction to Programming and Algorithmics” this module was taught in a distance learning regime, using a learning management platform (Moodle [14]) and the immersive web environment, Hubs by Mozilla, with the following learning objectives:

- Apply instructions and logical sequences in problem solving.
- Learn concepts about programming logic

- Identify the different types of data
- Identify variables and constants
- List and identify arithmetic, relational, and logical operators.



**Fig. 2.** Tinkercad: 3D programming software

The Mozilla Hubs environment is a collaborative web application that allows people to come together in customisable immersive environments, for example for meetings, for learning or simply for virtual socialising, and in which participants can join using virtual reality glasses or by using a computer with a browser. We chose to create a space in this tool that simulated the face-to-face classroom, as students moved into distance education due to the pandemic. The aim was to make them feel as if they were in a typical physical classroom. In this environment two different spaces were personalised; a large room, decorated with a world map, the periodic table, chairs and two whiteboards. In one of the whiteboards the teacher's computer screen was projected, showing the code and explaining its construction, line by line; in the other, the already programmed 3D object was projected. In the second space it was decided to customise six smaller, collaborative breakout rooms (Fig. 3), reserved for group work. These contained a table, six chairs and three boards, one on each wall. On the boards the students shared the monitors of their computers and discussed the solutions as they were programming the 3D objects.



**Fig. 3.** Breakout rooms

TinkerCad, is a free online platform, provided and maintained by Autodesk, which provides a set of online development tools. It allows you to create 3D objects in a very simple and intuitive way, modeling 3D objects using the Codeblocks programming language.

The students being physically in their homes and virtually in the immersive environment, shared their computer screen in the collaborative room. As shown in Fig. 3, two students are interacting with each other, talking, and simultaneously viewing the two screens, where the TinkerCad software is projected.

The experiment ran for three weeks, one fifty-minute lesson per week. In the first lesson, the students attended, in the large room, a short briefing on navigating the Hubs Mozilla environment. They created their avatars and explored for a few minutes all the spaces of the classroom environment. Next, they were invited to sit down to listen to the instructions from the guiding teacher, after settling down and satisfying all their doubts about the environment, the teacher taught the 3D object modelling programming content. For that purpose, he shared his screen inside the 3D immersive environment (most of the students didn't know the block language and had never modelled 3D objects), after the explanation they went to the small rooms to program their objects, in the first class they had to create a table (Fig. 2). On the second lesson, the students showed more mastery and comfort in both navigation and procedures, they questioned less and were more familiar with the environment, so the lesson flowed quite well. In this class, the students entered, immediately went to the large room, and waited for the teacher's words. The teacher presented the lesson objectives, the programming content for the second lesson, demonstrated the code and the modelled object. Then the students went to the collaborative rooms and developed their activity, this time they had to program a rocket. In the third and last class an Easter related activity was proposed, in this class there was no previous explanation, being expected that the students would apply the knowledge acquired previously. The final works exceeded the teachers' expectations, who expected most of the works to be Easter eggs decorated with other geometric shapes, since it would be the easiest approach, however the students used their creativity and ended up creating 3D artifacts with superior quality (Fig. 4), which revealed not only application but also consolidation of knowledge. It was found that they only resorted to the teachers' help, after discussing the solution among themselves and with colleagues from other classrooms.



**Fig. 4.** 3D object programming - Example of an artifact produced by the students

## 2.2 Data Collection Instruments and Techniques

To carry out this experiment, the authors chose indirect observation, using video recordings, survey questionnaires and an unstructured grid to record everything they saw and heard within the immersive environment. The interactions between students and teachers were recorded in 30 video recordings of approximately 3 to 5 min each, these videos were transcribed and analytically processed. Two strategies were developed to capture the video recordings. One camera recorded in the common room, recording the interactions in the large room. The other consisted of creating several camera avatars placing them in the various work rooms (breakout rooms).

Two questionnaires were designed, the first (Q1), was applied in the first class, before the students entered the immersive web environment of Hubs Mozilla and focused on the expectations and prior knowledge of students regarding immersive web environments, programming language and 3D modelling, the second (Q2), was applied in the third class, after the conclusion of the experiment. The questions of the questionnaires were similar, in order to allow the comparison of the students' answers, before and after the intervention. The questionnaires were answered online and consisted of six questions. A 5-level Likert scale (1 - Strongly disagree, 2 - Disagree, 3. No opinion, 4- Agree, 5 - Strongly agree) and a non-mandatory open-ended question were used to collect the student's opinion about the experience. A 5-level Likert scale was chosen, to enable the choice between two levels of negative and two levels of positive answers, and a neutral level, for students who have no, or do not intend to give their opinion.

## 2.3 Results Analysis

### Direct and Indirect Observation

First lesson in the Mozilla Hubs Immersive Web Environment: Students explored the environment, configured their avatar, tested navigation, tried out the features available in the environment (Screen sharing, placing 3D objects, images, videos), entered and left the rooms, looked at the information displayed on the walls and talked to each other. They listened to the teacher's instructions about 3D programming, they organised themselves in teams and went to the breakout rooms; they programmed a table in 3 dimensions, in Tinkercad, the students shared the screen inside the environment and talked amongst themselves; A group of students left and entered the environment, the internet connection was very unstable, so students were disconnected and lost workflow.

Second lesson: More dexterity in handling the platform was observed. The students went to the "big" room as soon as they entered, they focused on the teacher's instructions in a more organized way (they sat on the chairs), they interacted with the teacher, asking questions about programming and 3D modeling, more familiarity with teachers and students from other schools, they organized the working groups and the strategies to solve the proposed activity. The internet was more stable which allowed a consistent work since the students were not disconnected. The students programmed a 3D rocket, more complex compared to the table they programmed in the first class.

In the third class on the Immersive Web Environment: the students showed great ease of navigation, they configured new avatars, avatars with webcam, which allowed

the students to see each other’s faces. They kept the same behavior and interaction of session two and demonstrated acquisition and application of the acquired knowledge, they cooperated amongst themselves and between groups to complete the activity which consisted in programming 3D objects allusive to Easter, the artifacts produced by the students showed great quality.

**Analysis of Students’ Answers of the Before and After the Experiment Questionnaires**

It was of interest to the authors to find the students perceptions about this experience in these immersive environments. To the statement “I like/liked learning programming” (Table 1).

**Table 1.** I like/liked learning programming

Questions	Q1	Q2
I totally agree	21	20
Agree	7	9
No opinion	1	0
Disagree	0	0
I totally disagree	0	0

In this matter, the differences of opinion before and after the experience are not significant. Only one student, who had no previous opinion, gave a favourable opinion after the experience, stating that he liked learning to program. On the question “I will like/liked learning 3D Modelling” (Table 2).

**Table 2.** I will like/liked learning 3D modeling

Questions	Q1	Q2
I totally agree	14	17
Agree	8	9
No opinion	5	3
Disagree	2	0
I totally disagree	0	0

It can be inferred that the students enjoyed modelling 3D objects using visual programming, noteworthy that none of these students had programmed 3D objects before. As it can be seen from the table, before the experiment, 5 students had no opinion and 2 students thought that they wouldn’t like 3D modeling. After the intervention the students’ perception was more favourable. On the question “I will liked/like learning in an immersive web environment.” (Table 3).

**Table 3.** I will liked/like learning in a virtual reality environment

Questions	Q1	Q2
I totally agree	20	18
Agree	5	8
No opinion	3	3
disagree	1	0
I totally disagree	0	0

As can be seen the students had higher expectations regarding the virtual immersion experience, perhaps it is due to the fact that they are used to the immersion of video games and these present components of greater playfulness, when compared to educational immersive environments.

In the questionnaire presented before the experiment the students were asked to answer the following question "Tell in your own words what you expect to find in the classroom in an immersive environment" The following answers were given (Table 4).

**Table 4.** What you expect to find in the classroom in virtual reality environment (Q1)

3D modeling
I would like to learn more about virtual reality since never had experience with it
Entertained
Don't know
More "fun" ways to learn
A new challenge that is very interesting and fun
To have a real life like experience
Many 3D objects
Many interesting and diverging objects I hope it will be good
I honestly have no idea
Real things but in virtual reality
No idea
Learning to use virtual reality
A big space with many possibilities to learn new things in a more creative
New things in more creative ways
I hope to find new ways of learning about
Game programming and programming in general and how to
Create games in virtual reality

*(continued)*

**Table 4.** (continued)

3D modeling
An open space with a menu where you can select objects and make objects, using them to make something creative
A new world where I can be creating whatever I want
I hope to find new ways to learn to program, both in general and in games
A dynamic or different learning
I don't really know
Some virtual reality goggles, and I green background so we can have a better view of the result
To have a healthy environment
The VR glasses
I hope I find something surprising
I hope to find something surprising
To be able to create objects
I hope to find a realistic classroom

Analyzing Table 4, we can see that of the 20 top written words by students (Fig. 5) the words “learn”, “hope”, “objects” and “Virtual reality” stood out. It should be noted that students had never experienced an educational activity in virtual reality and/or 3D immersive environment. Students were only informed that they would program 3D objects in an immersive environment. Regarding expectations, some students associated this type of environment with video games, others with a creative and fun way of learning, while others had no idea what they were going to find.



**Fig. 5.** Top 20 words mentioned by students (before the experiment)

After the experience the students were asked to answer the following question “Tell in your own words what you found in the classroom immersive environment”. The following responses were given (Table 5).

**Table 5.** “What you found in the classroom in the virtual reality environment” (Q2)

Good
In the virtual reality classroom, you can solve problems with the other people there and “see” each other
3D objects

(continued)

**Table 5.** (continued)

Good
Diversity
In the virtual reality classroom, there is not much distraction and I find it better
Very fun and an interesting experience
A classroom
Nothing special, it was just a virtual classroom
I don't know
I found some classrooms, meetings, moved objects, boards etc.
A classroom
I was surprised, because I was not expecting all that
I found the possibility to find objects and different people in which we could create objects
It is very nice because we can feel ourselves in a new environment
My classmates, and others from other schools
A different emersion
Funny objects
Students
I found a good environment where all users could interact freely with each other
I found many things between animals and objects but I made a rocket
I created I blue rocket, many objects that we could interact with
Work, a camera going into the walls, my share flying and going through walls, making a rocket and a table with the scheme that was on the board was interesting, the outside with a house and the rest empty; and people who don't talk coming in and out of the room

The students' answers to the open question "what you found in the classroom in the virtual reality environment" highlighted the words "classroom" and "objects" (Fig. 6) as the most frequently mentioned. The students focused on the activity to be performed (programming 3D objects), collaborating with colleagues from other schools, in a space identical to the traditional classroom, but they refer to this space as less distracting.

**Fig. 6.** Top 20 words mentioned by students (after the experiment)

In the questionnaire applied after the intervention, it was also asked if they agreed with the following statement “I was inspired to learn more about programming after this class in immersive environment” they picked the answer from a Likert scale that started on “I totally agree” and ended in “I totally disagree as shown in Table 6.

**Table 6.** I was inspired to learn more about programming after this lesson in virtual reality environment

Questions	Q2
I totally agree	10
Agree	8
No opinion	3
Disagree	1
I totally disagree	0

Not all students answered this question, only 21 out of 29 and it was found that most enjoyed and felt inspired to learn to program in an immersive web environment.

### 3 Final Remarks

The results show that the students interacted, collaborated, and learned with their peers, however they had high expectations about using the Immersive Web Environment to learn curricular concepts, on the other hand, the students enjoyed modelling 3D objects using programming. The experience was classified as very positive, and they referred that they would like to have more classes in this sort of environment. Despite the reduced number of classes, only three of 50 min, the results were optimistic, and it is possible to conclude that: i) students like programming, ii) students like modelling 3D objects through programming, iii) students liked the immersion experience. The results allow us to infer those students were motivated to learn programming, in this sense, this research will start the next stage of development of an immersive experience under a theme to be decided by the students, in which they will create the 3D objects to include in the environment and customize it to their liking.

In conclusion, as indicated in the literature review, these environments have the potential to provide a good learning experience, with several benefits for students, and can be used as strategic resources to motivate and engage, as they offer the possibility to collaborate and interact, allowing exploration and discovery. The more involved with the activity, the greater the motivation to develop it, therefore, the greater the effectiveness of learning. It also enables collaboration between students from various institutions and allows interaction between peers, or even, extend to collaborations between teaching institutions [15].

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