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TEACHING PROJECT DEMONSTRATION ANTERIOR TO THE PANDEMIC COVID-19 EXPERIMENTING EDUCATIONAL USE OF VIRTUAL REALITY TECHNOLOGIES

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Abstract

As part of the studies of the *University Bachelor of Technology* in the University of Orléans, France, second-year students in *Logistics and Transport* must provide a group project. During the 2018-2019 academic year, a group of four students carried out such a project whose goal was to implement a web documentary aiming at a *Virtual Reality* (VR) presentation of the Chartres's Institute of Technology (*IUT de Chartres*, FR). This project, with the acronym *PixEL3D*, has been successfully introduced to the public using smartphone VR headsets during the University's *Open Days* event in spring 2019 and has since been linked to the official web pages of the Institute.

This paper presents VR technology and material used for this project which was selected by the *Call for Innovative Digital Educational Projects* of the University of Orléans for the 2018-2019 academic year. Feedback from the project's final users is also being discussed. Next, an experimental course programmed with *A-Frame* and tested in a real course situation is presented, *A-Frame* being a free open-source and under MIT license web framework for building 3D, VR, and AR (*Augmented Reality*) experiences.

A discussion on the potential of using virtual reality technology for educational purposes, its advantages as well as drawbacks and constraints of virtual worlds, and on the interaction between VR and learning processes will conclude this work which may figure as a *pilot study* on educational applications of VR in the ongoing pandemic COVID-19 situation.

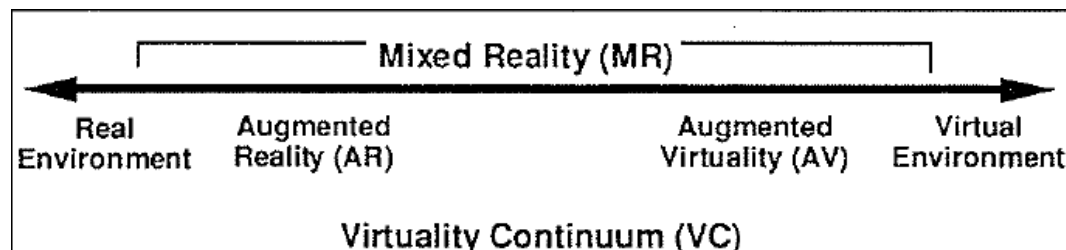
Keywords: virtual reality, innovative technologies, learning process, pilot study, gamification.

1 INTRODUCTION

Since the *Sword of Damocles*, considered to be the first virtual reality (VR) and augmented reality (AR) head-mounted display (HMD) system created by Ivan Sutherland in 1968 (Sutherland, 1968) huge progress has been made in terms of sensor miniaturisation, signal processing, etc., leading to a wider offer of cheaper and more accessible VR devices than ever before. Nowadays, their fields of application range from virtual tours of museums for the general public (Bozec, 2017), to sport, education, entertainment, staff training in companies, rehabilitation assessment, treatment and research (Schultheis, 2001), clinical medicine (Li, 2017) or military field (Liu, 2018).

Figure 1

Simplified representation of a "virtuality continuum"



Note. Reprinted from IEICE Trans. Inf. & Syst., A Taxonomy of Mixed Reality Visual Displays (1321:1329), by P. Milgram, F. Kishino, 1994.

There exist numerous definitions of virtual reality in the literature. The work presented here is inspired by the definition given by Milgram and Kishino (Milgram, 1994) as illustrated in Figure 1. The authors introduced the concept of a *virtuality continuum*: at the left end of the continuum, one can find the real world only and, at its right end, one can find a purely virtual world containing exclusively virtual objects. The space between those two ends define the Mixed Reality (MR) environment while Augmented Reality and Augmented Virtuality (AV) are two MR subspaces defined by the blending degree of real and virtual environments. Our work belongs to the right end of this *virtuality continuum* to which we added *complete immersion* (Hamilton, 2020) and *interactivity* for better knowledge acquisition and understanding (Grivokostopoulou, 2020).

VR technology is still not widely used for educational purposes. Thus, long before the current pandemic COVID-19 situation, we took up the challenge of testing virtual reality-based technologies' contribution to higher education and in real teaching conditions. At our knowledge, no other similar experiments had been conducted before at the University of Orléans, France, so we were starting from scratch. After writing of the project proposal, we applied to the *Call for Innovative Digital Educational Projects* of the University of Orléans, France, for the 2018-2019 academic year, and we were pleased to have our application accepted; we were then able to start this project called *PixEL3D*.

The project is structured around three parts described in detail in the following section. It uses *innovative technologies* applied to education, such as VR, 3D 360° cameras and programming through a web framework for designing VR experiences. The integration of the final deliverable from the project into traditional teaching courses is a step forward in evaluating the contribution of *immersion learning* to teaching and its place in the whole learning process will be discussed in the last section of this work. Furthermore, the possibility of *gamifying* this process is a very interesting possibility that has been experimented within the project and will be presented in section 4. Finally, in the current context of pandemic COVID-19 situation that has accelerated the use of digital technologies for educational purposes, this work may be considered as a pilot study of the educational applications of virtual reality.

The rest of the paper is organised as follows. Next session elaborates the *PixEL3D* project's framework. The resources we needed and the methodology we applied are developed in Section three, while Section four presents the obtained results in details. Conclusion in the last Section highlights the fact that virtual reality-based technologies can contribute to achieving educational objectives while remarks and some perspectives for future development are also introduced.

2 PROJECT FRAMEWORK

Logistics and Transport Department's second-year students in the Chartres's Institute of Technology, France (*IUT de Chartres*) must work in groups on a project of their choice or on a theme proposed by a member of the teaching staff. As pedagogical and digital referent at the University of Orléans, France, for the IUT de Chartres component, the author of this work applied on behalf of the component to the *Call for Innovative Digital Educational Projects* of the University of Orléans for the 2018-2019 academic year with a project entitled "*Projet immersif et expérimentation de cours virtuel 3D*" (Immersive project and 3D virtual course experimentation") and whose acronym was *PixEL3D*.

The main objective of the project was to design and implement a framework for the development of web-documentaries by combining the skills of the project team members and making them available to a group of second-year students chosen among the three BTEC higher national equivalent diplomas proposed by the IUT de Chartres. The different techniques used for its realization could be integrated in one or more courses on the University's electronic platform for online courses named CELENE. In parallel, an experiment should be carried out to create a virtual reality course on "databases theory" course for smartphones that will complement the traditional CELENE course. Finally, the deliverable should serve as an introduction to interactive web-based technologies, such as 360° images/videos, virtual reality and programming VR applications for portable electronic devices.

Finally, a group of four second-year Logistics and Transport department students expressed their interest in *PixEL3D* and were given the project as part of their studies (the project's validation being mandatory for graduation) while the author of this work was their tutor. The project was then framed according to the department's pedagogical specifications and was divided into three distinct parts:

1. *Creation of a VR-based web-documentary* targeting future students on the Logistics and Transport department enhanced with 360° multimedia content (images and videos) and able to run on phone headsets for virtual reality. The students group was responsible for obtaining

quotes for the purchase of the necessary equipment, drawing up a script for the web-documentary and carrying out the filming. Their supervisor took charge of the technical part of the project (programming of the site)

2. *Experimentation of a virtual reality-based version of an existing course.* This part was carried out by the project leader, i.e., the author of this work.
3. *Implementation of a new virtual reality-based course:* the underlying idea being to help students prepare for an internship interview by viewing a VR-based simulation in which the management teacher took on the role of the recruiter and one of the project students the role of the candidate. This part was based on the *gamification* principle.

The first part of the PixEL3D project should be delivered for the University's *Open Days* event in spring 2019 but also tested by visitors to the IUT de Chartres during the event.

The next section describes the methodology used to carry out the PixEL3D project.

3 RESOURCES AND METHODOLOGY

3.1 Resources

The student's group provided purchase estimate of software and hardware needed for the project as well as a script for the web-documentary's guided tour of the Logistics and Transport department of the IUT de Chartres. After having studied the quotations the following equipment has been chosen:

3.1.1 Hardware

The camera we chose for 2D/3D multimedia footage (images/videos) was the *Vuze VR 4k 360° 3D* model with a *Manfrotto* Virtual Reality kit with a mini tripod and extension. For adding audio content (comments, etc.) on existing videos we chose the *Rode NTG2* condenser shotgun microphone. We also opted for a laptop configuration designed for virtual reality (*Intel Core i7 8750H* processor, *NVIDIA Quadro P3200* graphics card, SSD M.2 hard disc, etc.), a portable external hard drive and a Google Chromecast to stream content to TV screen. Finally, we have completed the hardware with a certain number of *Zeiss VR One Plus* Virtual Reality smartphone headsets for live demonstration of the derivable during University's *Open Days* event.

3.1.2 Software

For editing and rendering stereoscopic 3D 360° footage from *Vuze's* camera we used the native software *Humaneyes VR Studio*. To program the pages of the PixEL3D's first (web-documentary) and third (immersive learning) parts we used the *Wonda VR Studio* authoring solution. Note, however, that this solution has now been replaced by the *Wonda VR Spaces* software and it is no more supported by the publisher.

3.2 Methodology

3.2.1 Conceptual work

The specifications of the project included an initial stage of *mind mapping*, i.e. a set of concepts represented graphically and linked together around the central concept by means of branches. Mind mapping is an effective tool for prioritising ideas and therefore needs for the realisation of a project. Thus, the first part, as imagined by the students in charge of the project, consisted, on the one hand, of a guided walking tour from the Chartres train station to the IUT de Chartres, divided into three parts in the form of 360° videos and, on the other hand, of a visit to the premises of the IUT de Chartres. Then, the visit of the IUT of Chartres consisted of a virtual presentation of the different classrooms with video demonstrations, an interview with the head of the Logistics and Transport department, a presentation of some study projects carried out by their fellow students, a 360° video presentation of themselves following a precise scenario etc.

These mind maps were used as a basis for programming the website in VR. Their translation into the authoring software resulted in a graphical representation similar to that of the mind maps. Figure 2 shows a small part of the latter: the blocs correspond to the concepts and the curves to the branches used to move from one concept to another.

4 RESULTS

We will now present the deliverables for each of the three parts of the PixEL3D project.

4.1 Virtual reality-based web-documentary

4.1.1 A Brief Overview

The web-documentary is articulated around two main axes: a *commented walk*, camera in hand from the train station to the IUT de Chartres and a *guided tour* inside the IUT de Chartres, including video clips illustrating the use of the different classrooms, a talk by the head of department, testimonials from former students, cultural and sport activities opportunities for the students, but also extracts from major events organised by Logistics and Transports department's students. All audio-visual material provided by the project's student group was recorded with a spherical resolution of 4K per eye and in 2D in order to have a high frame rate of 60fps (frames per second). The web-documentary pages are hosted on the Wonda VR publisher's servers and are permanently accessible through the official web pages of the University of Orléans, France, at <https://www.univ-orleans.fr/fr/iut-chartres/projets-etudiants/pixel3d>.

Every page of the web-documentary contains a return link at the nadir of the spherical image, a music background and a special short sound is played when the reticle of the VR headset hovers over an element that allows interaction with, while several pages have added audio comments mixed with the video takes. The web-documentary can be viewed both in web-VR mode, i.e., in a traditional manner from a PC, laptop, tablet or smartphone, and in a complete VR immersion through VR headsets.

4.1.2 Project Launch Day

Figure 3

a) Students of the project group, b) user completely immersed into the VR world of the experience c) event teaser, and, d) event advertising



During the University's *Open Days* event - day of the official launch of PixEL3D, the students of the project group took care to arrange the exhibition room in such a way as to optimally manage the flow of visitors in and out. Indeed, in a first step, each visitor wishing to experiment the web-documentary, had to download and install on his smartphone a Wonda VR application thanks to a QR code allowing to launch the experience, then to put the smartphone in the virtual reality headset and plug in a set of headphones to live the experience in full safety from a rotating stool allowing a great freedom of head movement, and finally, to fill in an anonymous satisfaction survey before leaving the room. Others could also choose the web-VR experience casted to a TV screen using Sony's PlayStation controllers to make the experience more playful for the youngest among the users. Images illustrating the event are provided in Figure 3.

4.1.3 Results of the Survey

In order to evaluate the impact of innovative technologies use for educational purposes but also to evaluate the quality of PixEL3D, project's students generated statistics from the responses to the anonymous survey form from forty eight visitors. Here are some of the obtained results:

- 79% of the web-documentary users were under 20 years of age,
- 55% of the web-documentary users were familiar with VR headsets and among them 70% had VR experience through gaming,
- most of the web-documentary users considered the use of VR technologies for educational purposes pertinent, innovative and entertaining, and,
- 42% of the web-documentary users considered that university courses in virtual reality could be interesting.

More generally, the youngest among the users already familiar with the use of high-end technologies such as QR code scanning or virtual reality headsets were delighted to see that such digital technologies can be a complete fit with the higher education syllabus. The gamification of the experience offered by the use of wireless game controllers and on-screen casting has clearly contributed to this perception. Moreover, all users who participated in the survey gave the project a score higher than 11 out of 20 and 37.5% of them gave it a score higher than 16 out of 20.

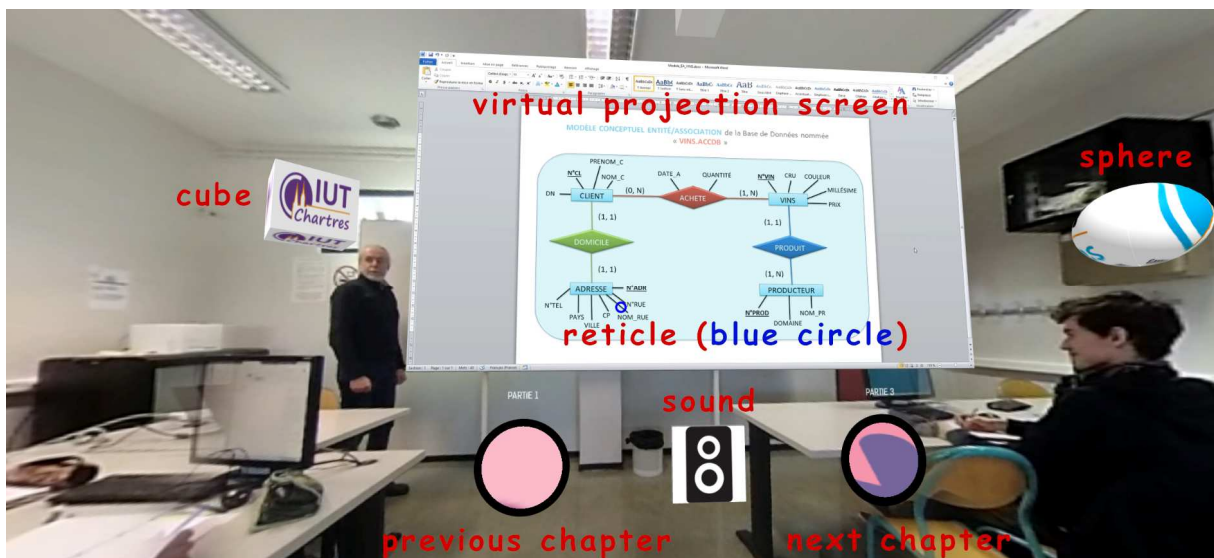
At the end of this fruitful experience, there was a general embrace of the use of innovative digital technologies, such as virtual reality, in higher education. The message conveyed through the public's response is one of encouragement, suggesting a more frequent use of these technologies for educational purposes in higher education in the short and medium term.

4.2 Experimentation of a virtual reality-based version of an existing course

For this second part of the PixEL3D project, the project leader chose to use *A-FRAME* - a web framework for VR experiences, as programming tool of an existing course named "Database theory". A-Fame is an independent open source project launched back in 2015 and conceived within *Mozilla*; based on top of html, A-Frame is a powerful three.js entity-component framework and it is cross-platform VR supporting most VR and augmented reality (AR) headsets. The A-Frame project is licensed under the MIT license and nowadays, it is maintained by *Supermedium* (A-FRAME, 2021).

Figure 4

The A-FRAME experimental course



As illustrated in Figure 4, this virtual course uses a 360° short looping video background filmed in the real classroom, and the virtual projection screen containing the course is placed upon the physical blackboard. The course consists of a video of the usual course with commentaries; its size can be maximised using the 3D cube on the left-hand side or it can be minimized using the 3D sphere on the right-hand side. The video only plays when the blue reticle of the VR headset is inside the virtual projection screen, otherwise the video is paused. In that case, if the user wants to make a break It is possible to play a background music by hovering over the 3D speaker with the reticle. The user can also move around the x-axis as well as the y-axis of the virtual environment using the arrow keys.

4.3 Implementation of a new virtual reality-based course

Second year's student of the Logistics and Transport department of the IUT de Chartres must complete an internship in order to validate their degree. And it is up to them to make the necessary steps to find their internship. One of these steps is the interview between the recruiter and the future employee. During the "Human resources" course, the teacher shows the students the different techniques for preparing and giving an interview so that it goes as smoothly as possible. The aim of this third PixEL3D project's part was to allow students to put themselves in the shoes of the interviewee, to experience their reactions, hear their thoughts and learn from their mistakes...

Figure 5

The 360° camera is placed on the applicant's head



We therefore thought of a way to fix the camera on the interviewee's head, i.e. a member of the students group, as illustrated in Figure 5. The interview questions and answers were prepared in advance and traps were deliberately set here and there. The interview was filmed in a subjective and an objective way.

Figure 6

Internship interview filmed: a) in an objective manner, and, b) in a subjective manner



Figure 6 illustrates the ways the internship interview was filmed: on the left-hand-side (a) the camera was placed on its tripod in front of the two interlocutors (objective way) while on the right-hand side (b) the interviewee was wearing the camera on his head (subjective way). The students experiencing the interview with a VR headset can either observe both characters at the same time (i.e. in an objective way), or take the place of the interviewee and feel his/her emotions and reactions (subjective way). In the second case, a thought cloud appears at the top right to alert the user that a voice is about to comment on the candidate's state of mind: this is intended to help the user better understand the interviewee's responses.

Both objective and subjective ways to film can be useful in order to *gamify* the immersion experience in a virtual world. After a tricky question of the interviewer and before the interviewee responds, the student apprentice user may be asked to choose the correct answer from, for example, 3 possibilities and depending on the choice he/she has made, a comment can be displayed with the relevance of the choice, go back if the chosen answer is wrong or go forward in the video if it is not. This can be a good way of putting into practice the theoretical notions acquired in the course, but it is also very complementary to that traditionally taught course. The arrival of the current health situation made it impossible to implement and test this virtual course supplement under real learning conditions for the duration of the PixEL3D project.

5 CONCLUSIONS AND PERSPECTIVES

The first part of the PixEL3D project has been successful. It has been also introduced by some members of the students group in charge of this project in a presentation workshop during the "Pedagogical Innovation Day" organised by the University of Orléans, France, on July the 1st, 2019. At that time, no other work on virtual reality had been undertaken at our university to our knowledge. This work being anterior to the actual pandemic, it has actually proven to be very useful for virtual tours of the university. The response from the work group of students to this challenge was tremendous and the responses to the survey full of promise for a future where a clever blend of innovative educational approaches and new digital tools could bring better learning outcomes.

The second part of the PixEL3D project has been introduced only to one Logistics and Transport department's second year class of students. More experimentation with A-Frame is necessary in order to make the course more interactive and therefore attractive to students.

Finally, the third part of the PixEL3D project is already implemented into the University's electronic platform for online courses; unfortunately, the arrival of the pandemic has so far prevented its experimentation in a classroom context. Nevertheless, this module was experienced by the students carrying the project and a demonstration was also made to their teacher and they were all enthusiastic about the prospect of creating and adding to it a gamification module based on a question-answer game and the attribution of bonus and penalty points.

Furthermore, the study presented in this work revealed that a particular focus should be done on the VR environment design in order to avoid VR sickness whose symptoms are headache, vertigo, nausea, etc. (Tanaka, 2004). Also, the use of gamepads which is the most commonly used walking interaction method together with keyboards should be done in a way that does not cause VR sickness (Lee, 2017). Lastly, this work proved that the VR environment is suitable for learning activities based on the principle of gamification (Grivokostopoulou, 2016) and it has been shown that such scenarios are particularly popular with younger students. Investigations on how to develop the PixEL3D project so as to fit an Intelligent Virtual Learning Environment (IVLE) (Kamath, 2021) are also ongoing.

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