Web and Virtual Reality as platforms to improve online education experiences

Diogo Cortiz
Web Technologies Study Center (Ceweb.br)
Brazilian Network Information Center (NIC.br)
São Paulo, Brazil
diogo@nic.br

Jefferson O. Silva
Computer Science Department
Pontifical Catholic University of São Paulo
São Paulo, Brazil
silvajo@pucsp.br

Abstract— **Some universities and schools have offered virtual courses to their students as part of their official curriculum. Online learning is a coherent approach for contemporary education; however, some studies show it has some weaknesses that could be addressed to enhance its potential. In this paper, we argue how virtual reality improve online learning in some aspects, such as giving students the sense of presence in an immersive world, and bringing a new way to interact with colleagues and teachers when they are not in the same place. We also discuss the role of WebVR as an open platform to bring new possibilities to explore virtual reality worlds in education.**

Keywords—WebVR; virtual reality; online learning; web;

I. INTRODUCTION

Distance learning is an educational model used for decades, such as books and lessons sent by mail post early in 70's. However, the progress of information technology and the spread of Internet access have created a new milestone for distance learning. Nowadays, many official curriculums from universities and schools use virtual classes to mitigate the distance problem, making them available to a wider audience, even reducing costs. In Brazil, the Ministry of Education has allowed universities to explore virtual classes, at a maximum of 20% of their curriculum, in traditional undergraduate courses. It is worth mentioning that some nontraditional undergraduate courses have their curriculum 100% online. Blended learning is a potential approach to align teaching perspective with new generation of students as well as creating a more inclusive educational model. Despite information technology has brought a new world of possibilities for online learning, it is important to identify its shortcomings. Each online learning model has its own characteristics and use a set of technologies, such as Moodle, blogs and so on, to achieve its goal. This common set of educational technology has a key role to share information and help teachers to organize their classrooms, but there is a lack of interactivity and sense of community on it. A study performed by Song [12] points some drawbacks about online learning, such as difficulty in understanding the objectives of online courses and a perceived lack of sense of community. It may occur because the current technology used for online learning based on web has focus on content sharing rather than in the interaction among students and between teachers and students. Generally, online education has a passive approach in which the teacher provides content and the students must meet certain criteria. Even forum sections and quizzes available in an online educational platform, such as Moodle, are not much used by the students, even when teachers try to encourage their use. Interaction is important in an educational online environment, but, in general, students work alone, focusing on their own activities, and only a few of them participate in forums, rarely talking to each other. Sometimes, the teacher assumes the role of content mediator, focusing too much on make the content available, but not on how students process it. Importantly, this is not the teacher's fault, nor the students', but the format of the current technologies used just in online learning provide this kind of behavior. We argue that emergent Virtual Reality Technologies could be explored to boost online and blended learning, allowing professors and teachers to create a virtual world where they can explore content transmission and focus on interactivity, collaboration and give students the sense of presence. We show in this paper how virtual reality can address the online learning shortcomings, and we also discuss how WebVR – an open API to explore Virtual Reality using the Web - can become a major player in the future of online education. We present its main characteristics and their development trends. The methodology of this paper is based on the literature review and we explore the development of a virtual reality prototype that could give us initial evidences about interaction in virtual reality being used in educational context.

II. WEB, ONLINE LEARNING AND THE SENSE OF COMMUNITY

Building effective online learning environments is a formidable task, requiring their designers to use good principles to answer questions such as: how to start the community; how to encourage commitment; how to encourage contribution; and how to regulate behavior of the community participants [9]. Despite their rapid growth and worldwide use as part of online educational practices, online learning environments still need to address many important issues in satisfying students' needs more effectively, as evidenced by the high dropout rates [13]. Ho et al [7] research finds that students' commitment to finish an online course is weak, showing that 35% of students only

signs in the platform, not even accessing the course; 56% of students accesses less than half of the available chapters; 4% of students accesses more than a half of available chapters, but does not earn the certificate; and only 5% of students finishes the course and earns the certificate. There are many causes for this scenario, but one that calls our attention is the students' low sense of community. As we have discussed, few students work collaboratively in online learning as few of them actively participate in forums and chats. This behavior is a weak scenario for the learning process, because lack of close interaction among students could have conflicting consequences, leaving students experiencing a feeling of isolation. Rovai [11] discusses the importance of online interaction between students in order to achieve what is called sense of community, a sense of trust and interaction among others community students, which gives a sense of common goals and values. Hara e Kling [6] highlights the importance of the sense of community, and they argue that the lack of sense of community – the sense of isolation – has caused students to feel stressed during online courses: "Students reported confusion, anxiety, and frustration due to the perceived lack of prompt or clear feedback from the instructor, and from ambiguous instructions on the course website and in email messages from the instructor". This quote clarifies how low interaction in online learning could reduce the effectiveness of this learning model. It also highlights that the use of websites and educational platforms, such as Moodle, which has been the web solution used until now, has some challenges to stimulate the interaction between students and the teacher. Virtual Reality, which has been developed for decade and just now is achieving the minimal requirements to become a useful technology, has the potential to be a change maker in education, especially the projects of Virtual Reality on the Web.

III. VIRTUAL REALITY IN EDUCATION

Virtual Reality is a term that has been discussed since the 60's, when many research projects had taken place to attempt to create an effective immersion technology such as Sensorama and The Ultimate Display. One of the first projects to deal with Virtual Reality was created by Furness [4] for Air Force, which consisted of a head-mounted display (HMD) to be used by flight pilots in simulation. Since then, the virtual reality technology had many improvements and we have reached a development level in which it is possible to have affordable commercial products for virtual reality. Furness [4] specified some requirements to achieve a minimal standard for virtual reality: 1- HMD with a wide field of view; 2- Tracking the position and attitude of the user's body; 3- transducer and others mechanism that could interpret the player's movement and natural behaviors; 4- high update rate, so the virtual world is always updated in response to player's movement. All those requirements are now being addressed by current HMD's Virtual Reality technologies such as Oculus Rift, Google Cardboard and HTC Vive. It is important to highlight that the main objective of Virtual Reality is to achieve the concept of "immersion". Jennett [8] defines immersion as the involvement with the virtual environment which causes the lack of awareness of the real time and real world, causing an experience of "being" in this virtual universe. Jennet worked on this definition considering game context, but the essence of such definition could be explored when analyzing any virtual reality environment. "Immersion" in Virtual Reality is commonly used in respect of "spatial immersion", the perception of presence in a nonphysical world, which is caused by the stimulation of images, animations, sounds and others interactivity aspects. The user can explore the virtual environment in 360 degrees and can interact with things inside this virtual world; the user sees and hears this virtual environment as an authentic place, and it is what we call the "sense of presence". One may argue that a full and complete "immersion" may involve all human senses, while the current virtual technology focus mainly in sight and hearing. This is true; the current commercial virtual reality technology does not involve others human senses, such as taste, smell, and touch. However, we argue that only exploring sight and hearing is possible to achieve an interesting level in sense of presence, which could be useful for games, entertainment, health, and education purposes. There are some examples of virtual reality in educational context, such as a study carried out by Du [2], during his PhD, shows that replacing a traditional projector by HMDs for Virtual Reality increases the motivation of students in the learning process. In this example, the experiment was not for online learning, but for a traditional class in the university, which reinforces the potential of Virtual Reality to enhance educational practices and engage students in the learning process. Griol, Molina and Callejas [5] show how a virtual environment could improve the learning in Computer Science. In this case, the researchers have not even used HMDs, but only virtual 3D worlds, such as OpenSimulator. The results of this research reinforce that this kind of environment encourages engagement and collaboration and support students to understand complex concepts. Mathur [10] offers a low cost virtual reality demo that may be used for medical training and instruction purposes. Using a HMD, in this case Oculus Rift and Razer Hydra, he could prepare an immersive experience where trainees could perform both simple and complex tasks, such as identifying certain organs and perform an incision; trainees could learn by doing, even in the virtual world. The consulting firm Accenture had performed an experiment in the field of neuroscience that shows us that humans learn better when presented to 3D instructions rather than 2D instructions [14]. Those experiments and researches show significant evidences that Virtual Reality has characteristics of an immersive technology that could provide a more active and engaging learning environment to motivate students and keep their attention. The sense of presence affords an immersive world where student should focus in the learning process. This environment can help to address the problem of sense of community we have pointed out in the beginning of this paper, since a student can feel present at the same place as your classmates and teacher, and they can chat to each other and performing some tasks in collaboration. In the following section, we describe a prototype of a virtual reality environment that has been developed to be used in education, allowing

teachers to create an immersive virtual world where students could join using a low-cost HMD and the teacher can manipulate the scenario from a Web application.

IV. IMMERSIVE EDUCATION

Due to the intrinsic characteristics of digital technologies, young students are living in an active world where instant communication and real-time responses are the regular behavior. A study published by The Council of Economics Advisers of White House has showed some evidences to believe that millennials are part of a new generation and for this reason they are constantly looking for new approaches to deal with information, acquire knowledge and solve problems. However, most universities ignore the fact that students had changed their skills, behaviors and preference and higher education courses are still adopting the same methodologies as they used in the past. We have discussed in this paper that online and blended learning are coherent educational approaches, but sometimes they fail because the teacher or the instructional designer do not choose the right practices to use the technology – we also need to consider that some technology has its own limitation. This scenario was our motivation to research about how emerging technologies, especially Virtual Reality, could be used to improve learning process for a generation that could not pay attention to a lecture for long period and has serious problems to attend online learning tasks as we have discussed before. We have been working in a prototype of Virtual Reality environment to investigate how the technology could be explored in online and blended education in the future. We chose to develop a low-cost prototype that could give us the possibility to identify initial approaches of interaction in virtual reality and its effectiveness in educational context. We decided to explore Google Cardboard to verify if it would be an affordable HMD for educational purposes. Google Cardboard is a low cost Virtual Reality HMD made of cardboard, which uses the screen of a mobile phone as the projector. The HMD support is cheap and even students can build it by themselves. The students do not need anything more than a smartphone. We have compared Google Cardboard with others HMDs such as HTC Vive. We detected some technological limitations on Google Cardboard, but we understand that its low cost overcomes those restrictions. As we have discussed about the state of the art of Virtual Reality for Education, there are many tools available to be used in different aspects, such as the simulator of human body for health training or the use of OpenSimulator as a virtual environment of teaching. A study performed by Freina and Ott [3], regarding the literature review of immersive virtual reality for education, has shown many different projects of virtual worlds for education, some already mentioned in this paper. Based on this article, we could identify that most of the projects focus on simulation or experiments to deal with specific subjects. However, we identified that the new technologies of Virtual Reality have potential to surpass the idea of metaverses, such as simulating a classroom in the virtual reality. We stand in the position that these new generation of students may not be motivated to join in a virtual world that is a copy from their real classroom. Our purpose is to build new possibilities where students and teachers could interact and visualize content in a new way, exploring the sense of presence to strengthen the sense of community. The prototype has been conceived to enhance both classroom and online learning, focusing in content transference and acquisition and in the collaboration among students. This prototype is supported by a multiplayer environment in cloud computing in which the teacher could create and control a virtual world, a place where the students could explore using a virtual reality HMD via Web. This tool was projected to support both classroom and online learning. In other words, a teacher even physically present in the same classroom with students may use this tool to enhance her or his class. For example, instead of use a blackboard to write information about any topic, such as art history, why not use this prototype to create an immersive virtual world where teacher can drag and drop information, images, and videos while the students could explore these contents using their own HMD's. The same configuration is applicable for online learning. The structure of this prototype allows teachers to have a better control of the learning environment. It was not developed to teach a specific subject, this prototype is a common platform in which teachers could customize it based on a teaching topic. In real classroom, teachers need to deal with physical limitations, but in a virtual reality environment, they can create their own rules and even add a playful touch. This is an ongoing research and this prototype has few featured implemented, but it gives us the possibility to identify a bunch of functionalities that could be developed in the future. Basically, a teacher could use a Webpage to connect to the prototype. Once connected, he or she can create a virtual world and use a dashboard to organize the environment such as add images, graphs, videos and so on available on the web. The teacher could organize the environment before students join to the virtual world or even on real time, i.e., the teacher can explain about an artistic movement, while showing images, videos and playing sounds in an immersive way. The platform also allow teacher to speak with all students in realtime.
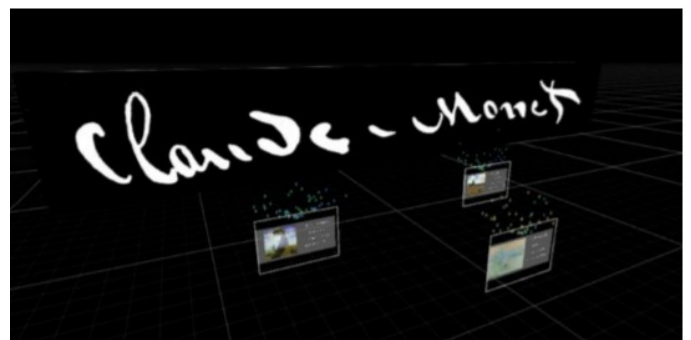

Fig. 1. Screenshot of environment prepared by a teacher

In this example, we explored the prototype in a class of art history, specifically about impressionism movement. The teacher can create a virtual environment to expose the main artists and their artwork instead of just speak about the movement and give some information about art production, as

expected in a traditional classroom. In Fig. 1, it is possible to see a space with Claude Monet's artwork, where the teacher could guide students by each artwork using virtual reality HMDs or let them explore the scenario by themselves. In this case, teacher added images and information – such as tittle, date, local and type - of three artworks and let students navigate through them while speaking and adding more information or images. In order to provide a more immersive environment, the teacher decided to add Monet's signature as a great skybox. A survey performed by Pew Research Center [1] reinforces the assumption that millennials' brain is being rewired to adapt to an unprecedented way to process information, therefore this requires a reform in education that should recognize that distractions of all kind are the norm now. The report suggests that educators should take in account the management of multiple information streams, emphasizing the skills of filtering, analyzing, and synthesizing information in learning process. The study also mention the importance for the students to appreciate the silence and ignore distraction. The prototype was designed to give a new way for teachers to present content and create new learning narratives to students, create challenges for them while the learners may have a better engagement in tasks and a more effectiveness content acquisition in an immersive world. The sense of presence, as students' sight and hearing senses are responding to a virtual environment, has a great potential to deal with distractions from real world once they feel immersed in a learning world. The fact that teachers and students are immersed in this same virtual environment sharing information and collaborating in tasks also helps to fill the sense of community, one of the main shortcomings of online learning.
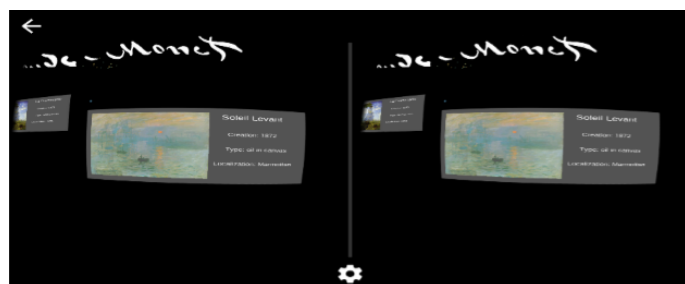

Fig. 2. Screenshot of students' Google Cardboard screen

In Fig. 2. we can see the same environment configured by teacher but through the students' virtual reality HMD based on Google Cardboard. In this case, it is possible to notice that the teacher could guide students through a series of information in an immersive and interactive way. In other words, the teacher is responsible to transfer the same information as if he was in a traditional classroom, but using a great technological support. For example, while the teacher explains a concept about impressionism artwork, the student could hear in background sounds effects or even music from the same period and explore details of a painting of Claude Monet. The teacher can also create challenges for students, such as a task to motivate them to identify characteristics of an art movement, which can help to address the lack of sense of community.

V. DISCUSSION AND CONCLUSION

We have argued in this paper that both online and blended learning are coherent educational practices for the new generation of students. However, those practices still show some weaknesses to satisfy students' needs and they bring a profound change in education. Some studies have shown that few students finish an online course and that the dropout rates are very high. Many reasons can be responsible for causing this scenario, however, in this paper we focus mainly in the discussion of the technology that has been currently used, which does not fulfill the sense of community and presence for students. In fact, the current technologies used in online and blended learning are, at most, cases educational websites where teacher add content, such as videos, texts, audio, and students join to consume such information. The interaction between teacher and students are based on forums and quizzes, but just few of them explore those functionalities, which causes a sense of loneliness for the most part of the students. We have showed how virtual reality as an emergent technology could improve those educational practices. The literature review and a research about the state of the art about virtual reality in education showed that this kind of technology is useful for educational context due to its intrinsic feature to bring immersion and a new way of interactivity. We also described a prototype of a virtual reality platform for exploring immersion and interactivity to be used in education. This platform allows the teacher to build a virtual world and to add content such as text, video, structured data, and images, which are meant to be explored together with the students. The idea of this prototype is to understand the potential of integrating Web Technologies (such as Web pages, WebGL and Semantic Web) and Virtual reality to build a platform for online education. In this case, we applied Web technologies to build an interface for teacher, where he or she can create a virtual world and customized it; while students can use Google Cardboard Virtual Reality to explore this same world. It is important to highlight that there is a project called WebVR, an API to explore Virtual Reality directly in the Browser, situation that reinforces the importance of Web for Virtual Reality's success. Regarding pedagogical aspects, the fact that the teacher and students are in the same environment, sharing information and performing collaborative tasks in real-time show that the use of this prototype helps to address the main problem in online learning: the lack of sense of community. The example shown in this article demonstrates the potential of virtual reality to bring new interactivity approaches to be explored by both teachers and students. The sense of presence is also a feature that is very interesting since the students feel that they are in the same place. The teacher also could explore this platform to present content to students in a new way and the immersion created with videos, images and sound effect seems to create a more effective educational environment; the students feel as if they are immersed in a world of knowledge. This paper is about a work in progress and

explored literature review to identify the main threat in online education –lack of sense of community - and the prototype give us initial evidences about how virtual reality can be used to address it. This prototype also allowed us to generate new hypothesis that will be verified in future studies.

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