Exploring the efficacy of ClassVR in high school education

by

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Submitted to the

Department of English and German Studies

in partial fulfillment of the requirements for the degree of

Master's in Teaching and Learning English as a Foreign / Second Language

at

UNIVERSITAT ROVIRA I VIRGILI

June 13th, 2024

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2023-2024

Master's Final Project

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ABSTRACT

This project explores the effectiveness of ClassVR among a group of first-year high school students at an A2 level of proficiency in Tarragona. To better understand what students will encounter when using ClassVR, the project provides explanations and definitions of concepts such as the metaverse, virtual reality or augmented reality, along with their impact on education, and some theories and models relevant to the use of this technology. To assess the effectiveness of ClassVR, two groups of 15 students each were randomly assigned into an experimental group and a control group. The findings indicated that students who used ClassVR had a greater achievement of results than those who did not use it, along with motivation and general effectiveness. The paper concludes with some recommended points for future research and improvement.

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Chapter 1:Introduction

Technology is widely used and present in our day-to-day lives. Whether for checking messages, browsing social media or playing games, technology has become a crucial part of today's society.

It is important to research the evolving technology as it can be used for several purposes, and if used correctly it has the potential to change several aspects of the way we live.

More people every day are starting to learn what VR and AR are due to their increasing presence in several fields such as education, gaming or healthcare. In recent years, researchers have been investigating the impact of VR and AR in education as the more we know, the more accessible it becomes. Garzón (2017) highlights that educators, practitioners and researchers are creating diverse tools and approaches that integrate this technology to enhance students' and professors' learning and teaching experience.

Moreover, Marougkas et al. (2023), state that VR in education has the potential to transform students' learning process by engaging and immersive experiences that can help with their understanding of the contents. Furthermore, VR allows students and teachers to discover and examine detailed information about objects that cannot be seen without the necessary equipment (Alfadil, 2020?). For instance, in science classes, teachers could use VR and AR to show students microorganisms or insects in order to understand better the content presented. In addition, Liu et al. (2020c) state that research evaluating VR's use in different educational fields found positive results and evidence that supports its possible educational uses.

For this reason, the objective of this project is to investigate if the use of VR and AR is effective in an educational setting, comparing two groups of participants to see if there is a significant difference or not. To do this, ClassVR will be studied and implemented

among a group of participants. Therefore, this research intends to answer the following questions:

Q1. Does using ClassVR facilitate learning in an A2 level EFL class in Catalonia?

Q2. Does using ClassVR affect students' motivation to learn?

Q3. Is ClassVR effective for high school?

With the null hypothesis:

Q1. Using ClassVR does not facilitate learning in an A2 level EFL class in high school.

Q2. Using ClassVR does not affect students' motivation to learn.

Q3. ClassVR is not effective for high school students.

The alternative hypothesis:

Q1. Using ClassVR facilitates learning in an A2 level EFL class in Catalonia.

Q2. Using ClassVR affects students' motivation to learn.

Q3: ClassVR is effective for high school students.

Chapter 2: Literature Review

2.1 The Metaverse

The metaverse is a concept that has been defined in several ways since its creation. The word metaverse was first used by Neal Stephenson in 1992 with his novel Snow Crash (Chen et al., 2023). The term metaverse is divided into two other terms, the prefix 'meta' which means virtuality or transcendence, and 'verse' which means universe or word (Chen et al., 2023), leading to its definition as a virtual world. Another definition for this concept is the one proposed by Onu et al. (2023), which state that the metaverse is a virtual world that integrates augmented reality (AR) and virtual reality (VR) to offer its users an immersive and interactive experience. Moreover, Chen et al. (2024) define the metaverse as a 3D virtual environment where users can engage with others similarly to how they interact in real life.

Dwivedi et al. (2022) have the view that "metaverse implies that XR environments such as AR and VR can exist without a metaverse, but any metaverse cannot exist without AR and/or VR" (p.16). For this reason, sometimes the previous definitions might not be enough to distinguish the Metaverse from AR or VR.

Mystakidis (2022) explains that the term extended reality (XR) refers to a variety of immersive technologies: VR, AR, and MR (a mix of the previous two) which are electronic and digital settings that represent and project data (Mystakidis, 2022). Dwivedi et al. (2022) mention that XR can be considered the necessary tool for accessing the metaverse. With XR, metaverse users perceive and engage with a completely or partially virtual environment created by technology (Mystakidis, 2022).

The metaverse facilitates interactions between users who are not physically in the same space (Z. Chen et al., 2024), making it accessible to users from different parts of the world

who can connect using special googles (Mystakidis, 2022) to participate in different activities such as “discussing an issue, collaborating on a project, playing games, and learning from experiencing or solving some problems” (Bourlakis et al., 2009; Jovanocic & Milosavljevic, 2022; Park & Kim, 2022 as cited in Hwang & Chien, 2022). For instance, one user could be in Spain interacting with another user located in Australia, demonstrating the platform’s capacity to connect individuals across vast distances. Consequently, the metaverse can provide its users with activities that are the same as those presented in their real world without having to deal with obstacles such as geography or culture (Mystakidis, 2022, as cited in Onu et al., 2023).

Users can enter virtual worlds through portals and interact with the environment using tools such as controllers, head-mounted displays, or future mobile devices (Z. Chen et al., 2024). Dwivedi et al. (2022) state that in the metaverse, it is important to recognize the visual and auditory elements that constitute the world; therefore it is important to create an environment that presents them. For this reason, it is important to identify and illustrate different scenes and elements, and to identify and create sounds and voices (Dwivedi et al. 2022). Additionally, users can interact and discover this virtual world though avatars, who represents and acts as the user says (Dwivedi et al. 2022), even though users can choose the avatar’s style which could be completely different to what they look like in real life.

The metaverse would enable extensive experimentation to collect data on users' reactions to concepts or ideas of the virtual world (Dwivedi et al. 2022). To do so, tools such as AI, blockchain technologies and interactivity are used to maintain and update real-world data (Z. Chen et al., 2024). Due to human-computer interaction, eye-tracking, extended reality (XR), and other technologies, it is possible for users to fully immerse themselves psychologically and emotionally through avatars (Z. Chen et al., 2024). The use of AI

within the metaverse is important as it improves the users' experience, creating 3D objects, non-player characters, and customized avatars (Z. Chen et al., 2024).

The metaverse is developed for different purposes, such as education which will be seen during this project. However, the metaverse faces challenges: (a) physically, users get distracted by location-based AR causing accidents; (b) psychologically, users get too much information that needs to be avoided; (c) ethically, users have the ability to change and manipulate information; and (d) in terms of data privacy, users have the risk to share their data with other parties (Mystakidis, 2022).

2.2 Augmented reality (AR)

Arena et al. (2022) explain that the roots of augmented reality (AR) can be traced back to the 1950s with Morton Heilig's Sensorama Simulator in 1957, which provided a multi-sensory 3D experience to the user, and Ivan Sutherland's Sword of Damocles in 1966, which provided the first helmet with AR lenses designed to assist helicopter pilots. Lee (2012) further notes that it was in 1990 when it is believed that Tom Caudell attributed the term 'Augmented Reality' to this new technology. However, the definition of this term has been evolving over the years due to technology's improvement in these past years.

At first, Yuen et al. (2011) point out that AR was defined in terms of 'specific facilitating devices' such as head-mounted displays (HMDs). Nevertheless, they explain that Azuma (1997, as cited in Yuen et al., 2011) and other researchers argued that these definitions were simplistic, and redefined the implementation of AR by the following characteristics: the combination of real and virtual elements; real-time interactivity; and 3D registration, such as that the virtual content is connected to the real world. Now, AR typically involves overlaying digital content onto an actual scene, facilitated by wearable AR platforms such

as Microsoft HoloLens (Microsoft HoloLens, n.d. as cited in Scavarelli et al. 2020b) as well as mobile platforms with camera views (Scavarelli et al. 2020b). This integration makes AR more accessible for users in their daily lives, displaying texts, images, and videos generated by computers onto their perceptions of reality (Yuen et al., 2011). Dargan et al. (2022) provide us with a simpler definition: 'AR combines the real world with virtual digital objects or images to create a new interactive environment' (p.1058). This means that the main characteristic that AR presents is that users can still perceive the real world that surrounds them but with the integration of digital content.

2.3 Virtual reality (VR)

Pantelidis (2010) indicates that virtual reality (VR) has been present since the 1960s with the first digital flight simulators and has progressed with technology. With this progress, the term virtual reality became the phrase to represent devices that create an immersive, interactive environment with visual realism (Rosenblum, 1997).

Many different definitions are given to this concept. According to the Merriam-Webster dictionary (2024), virtual reality is defined as: "an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment". Another definition for this term is "a computer technology that gives the illusion, to those who use it, of being immersed in a virtual environment that does not exist. It is a computer simulation of a real situation where the human subject may interact with the virtual environment, sometimes by the means of non-conventional interface like glasses and helmets on which the scene is represented and the sounds reproduced" (Fassi et al., 2016. p. 140, as cited in Alfadil, M. 2020).

VR is a technology designed to provide a feeling of presence in a computer-generated 3D scene or environment (Steuer, 1992). VR has been shown to have a positive influence on motivation, experiential learning, spatial knowledge representation, and learning performance (Chang, Hsu, Kuo, & Jong, 2019; Dalgarno & Lee, 2010 as cited in Liu et al., 2020b).

VR experiences vary in their level of immersion. Merchant et al. 2015 explain that desktop VR is considered the least immersive and presents a 3D virtual world on a standard computer monitor, that offers a window into a virtual environment. An intermediate type of VR is Cave Automatic Virtual Environment (CAVE), which employs projectors to display a virtual environment on surrounding walls, sometimes enhanced with stereoscopic glasses for a 3D view (Boyles, 2017).

The most recent head-mounted displays (HMDs) for virtual reality provide users with a highly immersive experience (Radianti et al., 2020). When the user is immersed in a virtual environment, their perception of time and reality often become detached, which gives them the feeling of being in the place of the virtual environment (Radianti et al., 2020). This feeling within technology is called immersion.

Similarly, Radianti et al. (2020) suggest that there are affordable HMDs designed for mobile devices that allow anyone to immerse in virtual environments and allow interaction such as Samsung Gear VR and Google Cardboard. These low-cost HMDs, allow gaze control or provide a magnetic switch to interact with the virtual environment. While high-end equipment such as Oculus Touch, includes specialized controllers for games and to interact with the virtual environment (Radianti et al. 2020).

In some cases, there are symptoms that users might experience such as loss of balance or feelings of nausea, commonly known as cybersickness (Marougkas et al. 2023), making

them stop their experience to avoid the feeling (Coburn et al., 2017). Additionally, the prolonged use of headsets can cause head and neck fatigue due to their weight, which again, might make users stop using this technology for the sessions (Mystakidis, 2022).

2.4 VR and AR similarities and differences

VR and AR form part of the immersive technologies but have different functionalities. On the one hand, VR is designed to project a simulated environment onto the user, replacing the natural environment with a digital environment (Arena et al. 2022). On the other hand, AR projects digital objects into the natural environment (Arena et al. 2022), but the user can still see the natural environment that surrounds them.

To better understand this, Figure 1 is an example of VR. The image shows a 360 image that users can explore with ClassVR headsets. In this environment, the user is only able to see what the headset displays, the image in this case. Then, Figure 2 shows an AR image in the middle of the screen and a grey background. The grey background would show the natural environment in which the user is located.

Figure 1

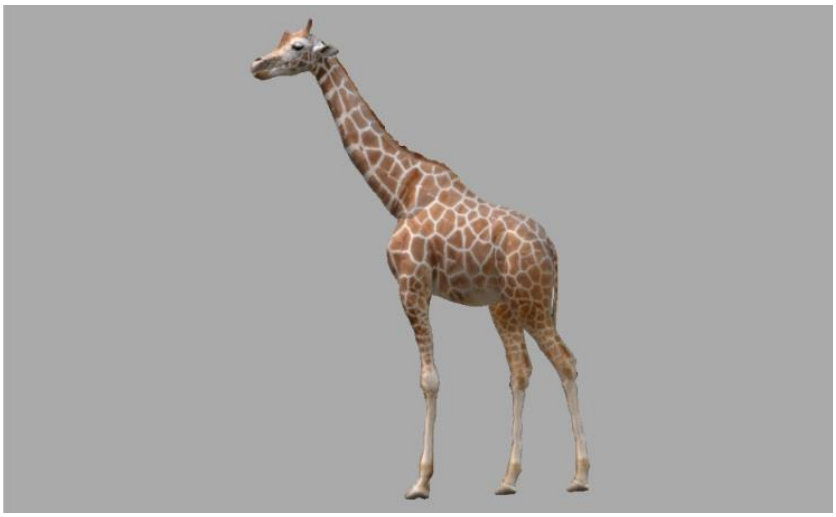

Figure 2

When we talk about VR and AR in the educational setting, Scavarelli et al. (2020) note that VR and AR technology are being used in grade school and post-secondary institutions to help learners, and they suggest that the classes are more engaging. Salman and Dede (1999, as cited in Scavarelli et al.2020) indicate that it is important to discuss that VR and AR are only tools that help enhance educational approaches and do not replace them. They view this technology as a support that can help professors to offer the best learning experience.

According to Scavarelli et al. (2020), there are some difficulties when integrating VR and AR into formal educational curriculums within classrooms. They indicate that some of the difficulties are related to the professor and student expectations training which requires previous setup and guidance on how they can navigate the system

Furthermore, Scavarelli et al. (2020), state that there is a need for more research to find stronger connections between the use of VR and AR, and conventional education. The last similarity that Scavarelli et al. (2020) present, is the high price of VR and AR technology equipment, stating that the inclusion of economical options, such as enabling access to content through mobile devices.

2.5 The metaverse in education

The use of the metaverse in education has rapidly advanced, going from casual games to games with educational purposes (Chen et al., 2023). The evolution of the metaverse in this field creates new opportunities and challenges for both professors and learners. The development of XR such as VR, AR, and MR has given attention to the educational advantages of the metaverse (Chen et al., 2023).

Recent investigations of the metaverse highlight the significance of immersive interactions between users and virtual environments, as well as users' interaction within the virtual environment (Z. Chen et al., 2024). These interactions of users within the virtual environment are the focus of discussions about the metaverse, which is being studied for its possible uses in different fields (Z. Chen et al., 2024). For instance, massive open online courses (MOOCs) are being transformed into massive open metaverse courses (MOMCs), changing from 2D to 3D spatial dimensions which offer students immersive learning environments (Z. Chen et al., 2024).

2.6 AR in education

Garzón (2021) indicates that the first AR application created specifically for educational settings was developed more than twenty-five years ago. He then explains that most AR applications were designed primarily for undergraduate students, and only a limited number of academic institutions could afford them due to their high cost (Van Krevelen and Poelman 2010, as cited in Garzón et al. 2021).

Arena et al. (2022) highlight that AR technology has the potential to improve student’s comprehension of some technical concepts.

Due to the increased power and compactness of technologies that make AR, it is possible to deliver AR experiences in academic settings through personal computers and mobile devices, which makes several educational approaches used with AR more feasible. (Lee, 2012).

Despite the benefits of AR in education, Lee (2012) highlights that incorporating AR into education remains a challenge due to issues such as its integration with traditional learning methods, high development and maintenance costs of the system, and resistance to new technologies. Additionally, Shelton (2002, as cited in Lee, 2012), determined that the absence of financial support from governments and recognition of the need for AR within academic institutions are reasons why AR has not been adapted into academic settings.

Nevertheless, Lee (2012) indicates that the potential to engage learners with new perspectives on materials suggests that integrating AR into education may become easier and widely accepted. This is a result of improvements in computers and the usability of AR, which have increased user adoption (Lee, 2012).

2.7 VR in education

Virtual reality is a relatively new concept in education and now its research is increasing due to different resources dedicated to this new area (Merchant et al., 2014). Radianti et al. (2020) emphasize that VR technologies are actively being incorporated into educational systems, teaching, and training in different domains.

According to Kavanagh (2017), many authors state that motivation among students increases just by introducing these types of technologies into educational settings. Additionally, students show higher motivation levels when engaging with 3D applications

compared to 2D ones (Limniou, Roberts & Papadopoulos, 2008, as cited in, Kavanagh, 2017).

VR enables students to engage with each other individually and in groups within a 3D environment and goes beyond this by allowing students to interact with objects in the VR space to gather information, explore, and construct their own knowledge (Alfadil, 2020b).

In the last few years, a few projects have been created to assess the effectiveness of VR in educational settings. However, as this is a relatively new topic, they explore different fields, use different materials, and are conducted differently. To illustrate this, this project presents three different pieces of research that aimed to see the effectiveness of VR in different contexts.

The first study, 'Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis' by Merchant et al. (2014b), aimed to examine the impact of selected instructional design principles in K-12 and higher education contexts using VR-based instruction, such as games or virtual worlds. This meta-analysis evaluated three different categories to address its research questions. The study concluded that VR-based instruction was generally effective, but some limitations were noted due to meta-analytical factors.

The second study, 'Effectiveness of virtual reality game in foreign language vocabulary acquisition' by Alfadil (2020b), aimed to explore the effectiveness of a VR game in an EFL classroom on the vocabulary acquisition of intermediate school students. This research provided a literature review on VR, language learning, and games leading to the design of an experimental intervention with a group of participants. Two groups of students participated in the research, divided into an experimental and a control group.

The results of this study indicated that the implementation of a VR game was more effective for vocabulary acquisition than those who did not use it.

The third study, 'The effectiveness of virtual and augmented reality in health sciences and medical anatomy' by Moro et al. (2017), aimed to assess the effectiveness of VR and AR compared to tablet-based (TB) applications in teaching medical and health science students. This study provided information regarding education and applications of interactive software to enhance education within the medical field. Participants were divided into three learning groups: VR, AR, and TB. After completing a lesson, they were tested to see their perceptions of each learning mode. The study did not find significant differences between the assessments, indicating that VR and AR offer benefits and increase learner immersion and engagement suggesting their use to supplement the lesson content in this field.

2.8 Theory and Models

As VR and AR are new topics with not so many years of research, theories and hypotheses are still evolving to address emerging questions and challenges.

There are different theories and models that along with VR and AR can improve students' outcomes. The theories proposed in this project include constructivism, connectivism, and Dalgarno and Lee's model. Each of these offers insights into how VR and AR can improve educational outcomes.

2.8.1 Constructivism

Constructivism is considered a significant theory of learning and is associated with the works of prominent authors such as Lev Vygotsky, John Dewey, and Jean Piaget (Mattar, 2018). The constructivism theory emphasizes that learners actively build meaningful

knowledge from their personal experiences (Huang et al., 2010; Scavarelli, 2020). This theory remarks that learners actively build their knowledge based on experiential methods (Scavarelli, 2020). Huang et al. (2010) state that this approach highlights learner autonomy in the learning process, aiming to close the gap between theoretical knowledge and real-life experience. That means that this approach is learner-centred (Huang et al., 2010). This perspective provides learners more autonomy to choose and coordinate/ their learning process with others (Huang et al., 2010). Additionally, Huang et al. (2010) state that the learning environment should offer realistic, case-based experiences for significant and real knowledge.

There are five instructional strategies proposed describing and analysing how a constructivist approach can be applied to developing Virtual Reality Learning Environments (VRLEs) (Huang et al., 2010):

- Situated learning: The environments created by the immersive VR provides a range of different situated learning experiences that are not found in a traditional classroom (Huang et al., 2010). These different environments create a sense of presence that motivates and encourages students to process the materials learnt. (Huang et al., 2010). In VR, learners can construct their knowledge through interactions with objects and events in a simulated world (Huang et al., 2010).
- Role-playing: Learners often prefer playing multiplayer games, as it offers competitive interaction between users (Shih & Yang, 2008 as cited in Huang et al., 2010). When integrating computer games with VR children and young learners could be motivated in their learning (Huang et al., 2010).
- Cooperative/Collaborative Learning: Collaborative VR environments allow learners to interact in the same virtual space with avatars and chat rooms to communicate and collaborate (Huang et al., 2010). In these shared virtual spaces,

learners can collaboratively solve problems and learn together (Huang et al., 2010).

- Problem-based learning (PBL): PBL is a learner-centered approach that teachers might adopt to improve the problem-solving skills of learners (Huang et al., 2010).VR learning environments can present authentic but sometimes with vague structure problems, that allow learners to immerse into realistic scenarios (Huang et al., 2010). This approach lets learners compare their ideas with others and facilitates active knowledge construction through problem-solving (Huang et al., 2010).
- Creative learning: Resolving problems sometimes requires creative thinking (Huang et al., 2010). VR promotes creativity and allows learners to develop their ability to solve open-ended problems (Huang et al., 2010). Creative visualization helps learners to develop their imagination in VR environments, making it an extensive instructional tool (Huang et al., 2010).

Huang et al. (2010) state that with these five instructional strategies, instructional designers can select or combine different strategies to create one effective virtual reality course.

2.8.2 Connectivism

According to Downes (2022), the term ‘connectivism’ is associated with George Siemens due to his significant contribution from one of his papers. In this paper, Siemens (2005) defines connectivism as ‘the integration of principles explored by chaos, network, and complexity and self-organization theories’ (p.5). Scavarelli et al. (2020) state that connectivism emphasizes that all learning takes place in a network, a connection of

entities, and not only within the learner's mind but also involving external nodes such as "non-human appliances". In this context, a node refers to the connection points that are found on a network and can represent organizations, websites, libraries, or other sources of information (Siemens, 2006 as cited in Goldie, 2016). Connectivism describes learning as an ongoing process that takes place in different settings, such as personal networks, communities of practice and in the performance of job-related tasks (Gutiérrez, 2012).

Siemens (2005) defines eight principles of connectivism:

- Diversity of opinions is an essential component of learning and knowledge.
- Learning involves connecting together specialized nodes or sources of information.
- Learning can happen through non-human devices.
- The ability to know is more important than what is currently known.
- Maintaining and supporting connections is crucial for continuous learning.
- The ability to identify connections between concepts, fields and ideas is an essential skill.
- The aim of all connectivist learning activities is accurate and up-to-date knowledge.
- Decision-making is a learning process in itself. The process of selecting what to learn and understanding the information is seen in the context of a changing reality. Even if the answer is correct now, it might not be tomorrow due to changes in the information environment affecting decision.

Connectivism is proposed as a more suitable theory for the digital era, where there's a need for action without relying on personal learning, using information beyond our existing knowledge (Mattar, 2018). Learning is no longer just an internal, individualistic process; learning now involves interaction with other people, organizations, or databases

(Mattar, 2018). These external connections enhance that what we can learn is more important than what we know at present (Mattar, 2018).

2.8.3 Dalgarno and Lee's model of learning in 3-D virtual worlds

Educators and educational institutions around the world see a big potential in using 3D simulations, games and virtual environments (VEs) for teaching and learning (Dalgarno & Lee, 2009). These tools give the possibility of a deep learner engagement, and the opportunity to explore, manipulate and construct virtual objects, structures, and metaphorical representations of concepts (Dalgarno & Lee, 2009).

According to multiple studies done since the mid-1990s cited by Jacobson (2006, as cited in Dalgarno and Lee 2009), well-designed and well-used immersive 3D virtual learning environments (VLEs) could enhance learning compared to 2D technologies used to deliver similar educational content. However, Dalgarno and Lee (2009) state that these applications are limited due to the high costs associated with the necessary equipment and computational power. As a consequence, "the findings of these studies have had little practical impact to date despite their theoretical significance" (p.11, Dalgarno &Lee, 2009).

The availability of personal computers and multimedia has generated interest in web-based VR (Dalgarno and Lee, 2009). The interactive and accessible aspect of 3D games has drawn millions of worldwide users, resulting to an extension in this field (Dalgarno and Lee, 2009). As a consequence, many educators are exploring the use of this virtual world for teaching to integrate the tools into the students' learning (Dalgarno and Lee, 2009).

From a pedagogical perspective, 3D VLEs present three aspects that differentiate them from interactive multimedia and that highlight and enhance the learning process: ‘immersion’, ‘fidelity’, and ‘active learner participation’ (Dalgarno & Lee, 2009).

Dalgarno and Lee (2009) state that the extension of Zeltzer’s (1992) work proposed by Hedberg and Alexander (1994), along with Withelock, Brna, and Holland (1996) put a theoretical framework that aimed to explore the connection between VEs and conceptual learning, introducing three main properties of 3D VLEs: representational fidelity, immediacy control, and presence.

Dalgarno and Lee (2009) explore these main properties presented before and conclude that the only two characteristics of 3D VLEs are: representational fidelity and learner interaction (Fowler, 2014). These properties together create a psychological experience known as presence, while in multi-user scenarios, there can also exist the co-presence or the “sense of being there together”.

Dalgarno and Lee (2009) mention that a potential learning benefit that simulations and microworlds can provide is that they can intrinsically motivate and engage users, which comes from the capacity of the learner to make a choice when pursuing their individual goal.

Chapter 3: Methodology

3.1 Research design

This study aims to examine the effect of VR on learning among a group of students. To achieve this, the project includes an intervention with two groups – an experimental and a control group. Both groups of participants learnt about the same topic, 'Exploring Africa', which focused on extending their knowledge about the continent, understanding geographical similarities and differences between countries, and learning about animals and their characteristics in a one-hour session. The experimental group used ClassVR headsets borrowed from 'La Factoria' at the University Rovira I Virgili, and the control group used a PowerPoint presentation to explain the topic.

3.2 Participants

The participants consist of 30 high school students from a public Catalonian high school located in Tarragona, Spain. Among the participants, 20 students (66.67%) are 12 years old, and the remaining 10 participants (33.33%) are 13 years old, and all of them are in their first year of high school education.

During English classes, this high school usually divide students into groups of 15. Therefore, for this study, two groups of 15 students each are randomly assigned to either an experimental or control group, with a total of 30 participants.

All participants speak Catalan and Spanish, with their native language depending on each individual. Additionally, there are 7 participants (23.33%) that also speak Arabic. Their English proficiency level is assessed at an A2 level on the CEFR, although some participants present a slightly higher level.

In terms of familiarity with VR, 80% of the participants claim to know what VR is, while there is 13.33% that do not know and an additional 6.67% are not sure or remain neutral.

Then, 66.67% of the participants have never used VR before, and 33.33% have used VR before. Some participants that used VR before stated that they have a VR headset at home or that they have used it in places like Port Aventura or at an exhibition in a shopping centre.

Regarding their willingness to use VR during classes, 83.33% of the participants would like to use VR during classes, while there is 13.33% that would not want to, and the remaining 3.33% are not sure or remain neutral.

In terms of VR being used to enhance participants' motivation during class 66.67% of the participants think that could motivate them, while there is 20% that are not sure or remain neutral, and the remaining 13.33% think that the use of VR could not enhance their motivation.

Finally, 50% of the participants think that the use of VR would be beneficial during class, while there is 30% that are not sure or remain neutral, and the remaining 20% think that the use of VR would not be beneficial during class.

3.3 Materials

The materials used for this project include virtual reality headsets for the experimental group, an existent lesson plan provided by ClassVR to use with the headsets, and an adaptation of the lesson plan provided by ClassVR for the control group.

Before proceeding with the explanation, as mentioned before, the ClassVR headsets and joysticks belong to 'La Factoria' at the University Rovira I Virgili, and I want to thank Jordi Barrero, who taught me how to use the headsets and helped me organise the technical part.

In this section, the VR technology tools that we have used with the experimental group are going to be presented. All the information can be found at the following link: https://www.classvr.com/.

ClassVR is an educational platform designed for schools, developed by Avantis Education and launched in 2017. This platform aims to enhance students' outcomes by increasing classroom engagement and improving retention through experiential learning. ClassVR is designed for students of all ages including kindergarten, primary school, secondary school, higher education, vocational courses and training, and students with special educational needs and disabilities (SEND).

ClassVR is paired with advanced virtual reality headsets and joysticks that offer immersive educational experiences through 360-degree images, videos, explorable scenes, and 3D models.

Figure 4

Figure 3

ClassVR is an open platform that supports virtual and augmented reality content. The platform allows teachers and students to create, upload, and share their content, which creates a collaborative community of educational resources with other users.

There is a portal for users of the ClassVR which provides access to plenty of curriculum-aligned VR resources and allows teachers to create playlists, deliver content and manage lessons. In the library section, there are four subsections named as follows: personal, shared, global, and subscriptions. The personal subsection is a space for the playlists that teachers create which is shown as ‘My playlists’, and ‘My cloud’. The shared subsection is a space for the playlists shared with the University Rovira I Virgili in this case, where people that have access though this University can share their playlists with other users. Then, the global subsection is a community space where different users share their playlists with other users around the world. And finally, the subscriptions subsection offers lesson plans, guides, and worksheets for students, CoSpaces, ThinkLink, Eduverse Showcase, and Eduverse36

Figure 5

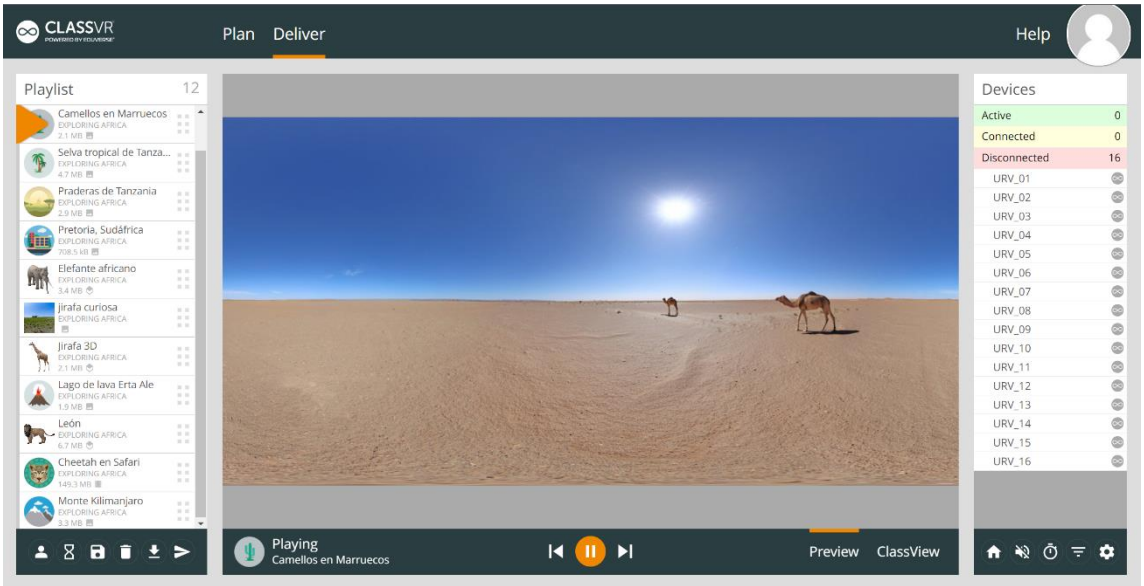

Figure 6

The portal gives the necessary tools for monitoring students during VR sessions, with preview and class view options. In the preview, teachers can select and see what students will see in their headsets before sending the track to their headsets, and then they can see what they are observing in the class view option.

The material needed for the experimental group includes a printed pretest and prequestionnaire for the day before the intervention, a headset and a joystick for each participant, a printed worksheet to be completed after the intervention, and a printed posttest and postquestionnaire distributed after the intervention.

The material needed for the experimental group includes a printed pretest and prequestionnaire for the day before the intervention, a computer and a projector in the control class, a PowerPoint presentation with the adapted lesson, a printed worksheet to

be completed after the intervention, and a printed posttest distributed after the intervention.

The pretests and posttests include multiple-choice questions to see the previous knowledge that students have about Africa. Along with the prequestionnaire, they will be printed and distributed on paper before the intervention of the lesson. The distributed material such as the pretests, posttests, prequestionnaires, postquestionnaires and worksheets were printed due to the policy of not using technology devices in the classroom in the first two years of high school. For this reason, the researcher provided the printed material to the participants.

3.4 Procedure

Both groups, consisting of 15 students each, were randomly assigned to either the experimental or the control group. A prequestionnaire and a pretest were administered and completed in a traditional paper-and-pencil format the day before each intervention. The prequestionnaire intended to see the background variables that the participants had and included open-ended and yes/no questions. The pretest evaluated the previous knowledge that participants had on the topic they would learn during the intervention and included multiple-choice, fill-in-the-gaps, true/false, and matching questions. In addition, a consent form was initially administered to the students' families via Microsoft Forms link; however, it was found that the paper-and-pencil format was more convenient for the families.

Then, each class completed a one-hour session on the topic 'Exploring Africa'. For the experimental group, participants worked with ClassVR materials provided by 'La Factoria' from the University Rovira I Virgili. The class was conducted by the researcher

with the support of the tutor of this research, and a member of 'La Factoria', Jordi Barrero, who brought the necessary materials to the academic centre and programmed the headsets for the participants. Due to an issue connecting the headsets to the center's Wi-Fi, it took about ten minutes to start the intervention with the material. In the meantime, the researcher reorganized the classroom layout, presented the agenda of the lesson, introduced the topic, and answered a few questions from participants. After resolving this issue, the material was distributed to each participant, ensuring that everyone had a headset and a joystick. The researcher guided the participants through the experiences instructing them on which experience to select for each occasion so that everyone was in the same space. Once all participants selected the experience, they had about two minutes to discuss what they saw with their partner. Afterwards, the researcher asked a few questions and explained the content presented. Initially, it was expected that participants would experience ten different experiences, however, some did not load, but it did not pose a significant issue. These experiences were supposed to be followed by an activity where participants worked on the topic but there was not enough time for completing it during the class, and they had the worksheet for homework.

For the control group, the class was also conducted by the researcher, and used a PowerPoint as material, adapting the ClassVR lesson plan that had already been made. Each PowerPoint slide contained information and videos or images that replaced the experience that the experimental group had. It followed the same dynamic as for the experimental group where participants were asked questions and then the researcher explained the content presented in each slide. Then, participants had a few minutes to work individually on a worksheet that reviewed the content explained.

A posttest with the same questions as the pretest was administered to both groups the day after the intervention in a traditional paper-and-pencil format. Additionally, the

experimental group was also administered with a post questionnaire to see the feedback about the materials they used.

3.5 Data Analysis

The pretest and posttest consisted of seven short activities and were created to see the participant's level of the topic before and after the intervention. The grade obtained from the pretest and posttest was coded and put into Excel to analyze the results via JASP in the Repeated Measures ANOVA to determine if participants showed better results when using VR or not.

The postquestionnaire consisted of statements measured on a Likert scale and was created to see the participants' feedback on the ClassVR application. The data obtained from the postquestionnaire was coded and put into Excel to analyze the results via JASP in the Chi-Square Goodness of Fit which is used for Likert scales.

4. Results

4.1 Results of the pretest and posttest

This chapter presents the results which were analysed using repeated measures ANOVA through the statistics program JASP. The first section reports the results of the pretest, posttest and postquestionnaire. The last section reports qualitative data collected throughout the implementation of the ClassVR.

Descriptive Statistics

	ExpPre	ControlPre
Valid	15	15
Missing	0	0
Mean	52.467	40.533
Std. Deviation	16.004	12.229
Shapiro-Wilk	0.880	0.965
P-value of Shapiro-Wilk	0.047	0.783
Minimum	36.000	15.000
Maximum	84.000	63.000

Table 1: Shapiro-Wilk Test

The sample is composed of more than ten but no more than thirty participants, therefore the Shapiro-Wilk test was taken on the pretest to determine whether the data is normally distributed or not. In Table (1), the p-value for the experimental group is 0.047, and the p-value for the control group is 0.783. These results show that the control group is normally distributed as $p > 0.05$, and the experimental group is close to 0.05. As the experimental group only misses 0.003 in the p-value in order to be normally distributed, it is reasonable to apply the repeated measures ANOVA to analyse the results. However, it is important to note that due to the small sample size, the results may not be as reliable, and the experimental group's data may be slightly skewed. Nonetheless, when analysing

both groups together on the pretest, the overall data distribution is normal, which justifies the use of the parametric test.

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η²
Group	4932.267	1	4932.267	12.316	0.003	0.304
Residuals	5606.733	14	400.481			
Testing	1706.667	1	1706.667	26.597	< .001	0.105
Residuals	898.333	14	64.167			
Group ✻ Testing	576.600	1	576.600	3.258	0.093	0.036
Residuals	2477.400	14	176.957			

Note. Type III Sum of Squares

Between Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p
Residuals	5616.333	14	401.167		

Note. Type III Sum of Squares

Table 2: Group and testing differences

Table 2 presents the pretest and post-test within subjects effects. The group effect analysis presents the following results: F (1, 14) = 12.316, p = 0.003, with an effect size of η^2 = 0.304. There is a significant difference between the pretest and the posttest results, as the p-value is less than 0.05, and therefore, we reject the null hypothesis and conclude that there is a significant effect. The effect size of η^2 = 0.304 suggests that 30.4% of the variance in the dependent variable can be explained by the independent variable or the effect being studied, indicating a large effect.

The testing effect analysis presents the following results: F (1, 28) = 26.597, p = <.001, with an effect size of η^2 = 0.105. There is a significant difference between the pretest and the post-test results, as the p-value is less than 0.05. Therefore, we reject the null hypothesis in favor of the alternative hypothesis that suggests that there is a significant

testing effect. The effect size of $\eta^2 = 0.105$ suggests that there is a large proportion of variance by the testing effect.

The group and testing effect analysis presents the following results: F (1, 14) = 576.600, p = 0.093, with an effect size of $\eta^2 = 0.036$. There is not a significant difference between the pretest and the posttest results as the p-value is greater than 0.05, and therefore we can't reject the null hypothesis. The effect size of $\eta^2 = 0.036$ suggests that only 3.6% of the variance in the dependent variable can be explained by the interaction between the group and testing effects, indicating a small effect size.

Post Hoc Comparisons - Group ✻ Testing

			95% CI for Mean Difference				
		Mean Difference	Lower	Upper	SE	t	p_{tukey}
Experimental, Pretest	Control, Pretest	11.933	−5.882	29.749	6.205	1.923	0.245
	Experimental, Posttest	−16.867	−28.440	−5.293	4.009	−4.207	0.002
	Control, Posttest	7.467	−8.982	23.916	5.566	1.342	0.550
Control, Pretest	Experimental, Posttest	−28.800	−45.249	−12.351	5.566	−5.175	< .001
	Control, Posttest	−4.467	−16.040	7.107	4.009	−1.114	0.685
Experimental, Posttest	Control, Posttest	24.333	6.518	42.149	6.205	3.922	0.003

Note. P-value and confidence intervals adjusted for comparing a family of 6 estimates (confidence intervals corrected using the bonferroni method).

Table 3: Post Hoc Comparisons

The Tukey Post Hoc comparisons show that the confidence intervals (CI) at 95% between the Experimental Pretest and the Experimental Posttest [-28.440, -5.293]; the Control Pretest and the Experimental Posttest [-45.249, -12.351]; and the Experimental Posttest and the Control Posttest [6.518, 42.149] are significant because the interval does not include zero.

On the other hand, the Tukey Post Hoc comparisons show that the confidence intervals (CI) at 95% between the Experimental Pretest and Control Pretest [-5.882, 29.749]; the Experimental Pretest and Control Posttest [-8.982, 23.916]; Control Pretest and Control Posttest [-16.040, 7.107] are not significant because the interval includes zero.

The significant results indicate that the experimental group had a more positive impact than the control group, whereas the not significant results indicate that there were no important differences between both groups in the pretests, and the control group results were not as significant as the experimental group.

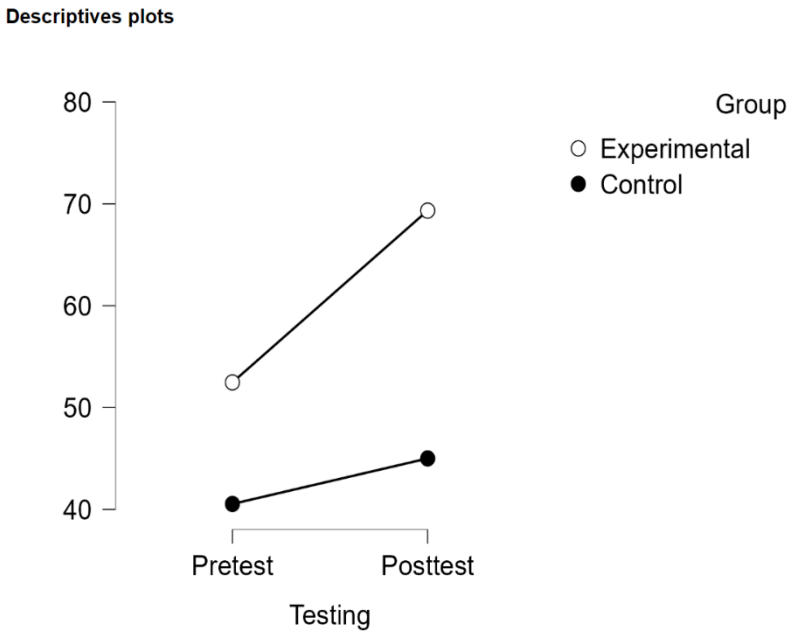

Table 4: Descriptive plots

In Table 4 there is a visual representation of students' progress that goes from the pretest results to the posttest results. It shows that the participants from the experimental group start with higher results than the control group and end with significantly higher results than the control group. Additionally, it is observed that both groups tend to improve their results, however, the grade of improvement is significantly better in the experimental group.

4.2 Postquestionnaire: Chi-Square Goodness of Fit Test results

The Chi-Square Goodness of Fit Test was implemented to determine whether participants' responses to the postquestionnaire would be expected in the general population of first-year of high school students under similar conditions in Catalonia.

4.2.1 Motivation- Chi-Square Goodness of Fit Tests

Three Likert Scale statements form part of the motivation section. The Chi-Square Goodness of Fit (Table 5) indicates that χ^2 (4, N = 45) = 31.778, p < .001. These results show that participants' responses from this section are significant as the p-value is less than .001, which means that similar responses can be expected if the study was repeated using a similar population.

Multinomial Test

	χ^2	df	p
Multinomial	31.778	4	< .001

Table 5: Multinominal Test

In Table 6 it is observed that there are 19 responses for Strongly Agree representing 42.22% of the total. The Agree section presents 17 observed responses which are 37.78% of the total. Then, the Neutral section presents 6 observed responses, representing 13.33% of the total responses. For the Disagree section, 1 observed response represents 2.22% of the total. Lastly, the Strongly Disagree section presents 2 observed responses which are 4.44% of the total.

Descriptives

Likert	Observed	Expected: Multinomial	95% Confidence Interval	
			Lower	Upper
A Strongly Agree	19	9.000	12.446	26.032
B Agree	17	9.000	10.696	24.057
C Neutral	6	9.000	2.274	12.057
D Disagree	1	9.000	0.025	5.297
E Strongly Disagree	2	9.000	0.244	6.817

Note. Confidence intervals are based on independent binomial distributions.

Table 6: Descriptives

In addition, Table 7 illustrates the observed data, where it is observed that most of the participants indicated Strongly Agree and Agree on ClassVR motivating them during the session. We observe that only 3 responses of the total do not support that, and a small remaining of responses stand in the neutral position. In conclusion, most of the participants strongly agreed that they feel motivated when using ClassVR in the classroom.

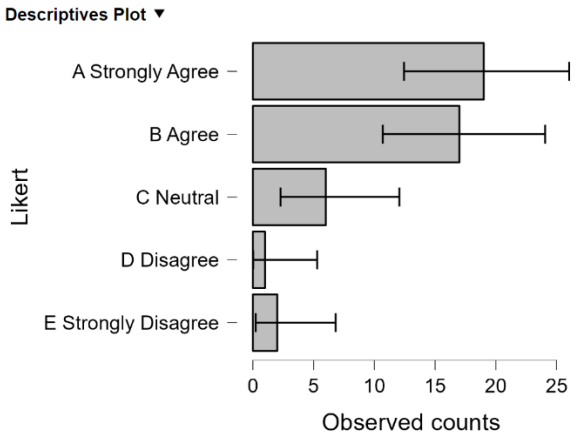

Table 7: Descriptive Plot

4.2.2 Comprehension Chi-Square Goodness of Fit Tests

The section on comprehension was composed of two Likert Scale statements. The multinominal test (Table 8) indicates that χ^2 (4, N = 30) = 11.000, p = 0.027. These results show that participants' responses from this section are significant as the p-value is less than .05, which means that similar responses can be expected if the study was repeated using a similar population.

Multinomial Test ▼

	χ^2	df	p
Multinomial	11.000	4	0.027

Table 8: Multinominal Test

In Table 9 it is observed that there are 4 responses for Strongly Agree that represent 13.33% of the total. The Agree section presents 13 observed responses which are 42.33% of the total. Then, the Neutral section presents 6 observed responses, representing 20% of the total responses. For the Disagree section, 4 observed responses represent 13.33% of the total. Lastly, the Strongly Disagree section presents 3 observed responses which are 10% of the total.

Descriptives

Likert	Observed	Expected: Multinomial	95% Confidence Interval	
			Lower	Upper
A Strongly Agree	4	6.000	1.127	9.217
B Agree	13	6.000	7.638	18.772
C Neutral	6	6.000	2.314	11.570
D Disagree	4	6.000	1.127	9.217
E Strongly Disagree	3	6.000	0.634	7.959

Note. Confidence intervals are based on independent binomial distributions.

Table 9: Descriptives

In addition, Table 10 illustrates the observed data, where it is observed that most participants indicated Agree and Neutral on comprehension, followed by Strongly Agree and Disagree, and the least Strongly Disagree. In conclusion, most of the participants agreed that they understood the content when using ClassVR in the classroom.

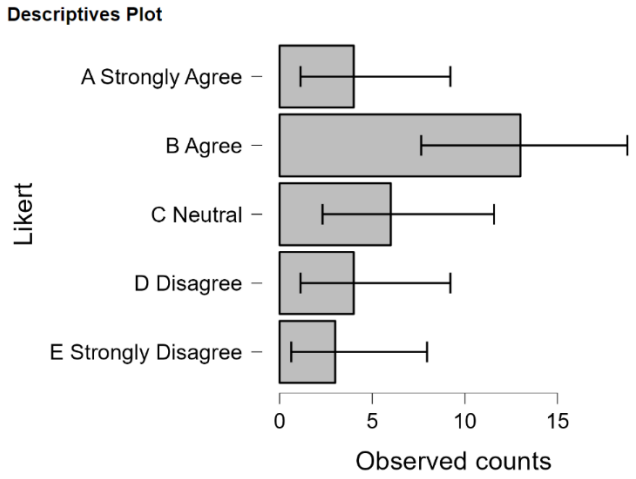

Table 10: Descriptive Plot

4.2.3 Beliefs Chi-Square Goodness of Fit Tests

The section on beliefs was composed of five Likert Scale statements. The multinominal test (Table 11) indicates that χ^2 (4, N = 75) = 6.000, p = 0.199. These results show that

participants' responses from this section are not significant as the p-value is greater than .05, which means that similar responses cannot be expected if the study was repeated using a similar population.

Multinomial Test

	χ^2	df	p
Multinomial	6.000	4	0.199

Table 11: Multinominal Test

In Table 11 it is observed that there are 15 responses for Strongly Agree that represent 20% of the total. The Agree section presents 21 observed responses which are 28% of the total. Then, the Neutral section presents 18 observed responses, representing 24% of the total responses. For the Disagree section, 9 observed responses represent 12% of the total. Lastly, the Strongly Disagree section presents 12 observed responses which are 16% of the total.

Descriptives

			95% Confidence Interval	
Likert	Observed	Expected: Multinomial	Lower	Upper
A Strongly Agree	15	15.000	8.736	23.124
B Agree	21	15.000	13.680	29.672
C Neutral	18	15.000	11.165	26.439
D Disagree	9	15.000	4.227	16.171
E Strongly Disagree	12	15.000	6.413	19.711

Note. Confidence intervals are based on independent binomial distributions.

Table 12: Descriptives

In addition, Table 13 illustrates the observed data, where it is observed that most participants Agree on positive beliefs about ClassVR, followed by Neutral and Strongly

Agree, and the remaining Disagree and Strongly Disagree with a higher proportion compared to the previous motivation and comprehension.

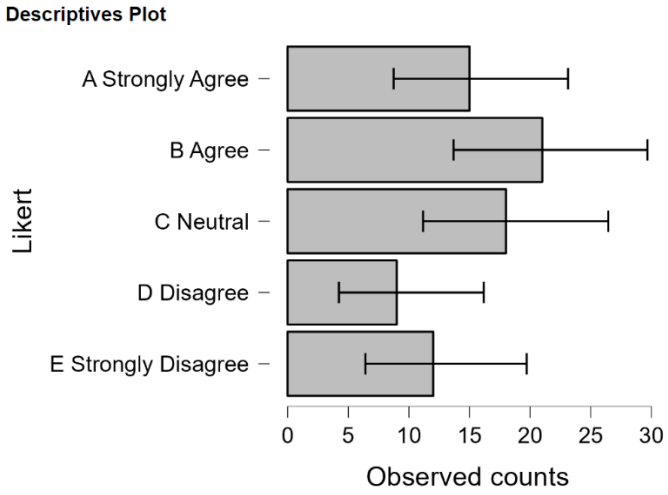

Table 13: Descriptive Plot

4.2.4 Experience Chi-Square Goodness of Fit Tests

The section on 'Experience' was composed of five Likert Scale statements.

Five Likert Scale statements form part of this section. The multinominal test (Table 14) indicates that χ^2 (4, N = 75) = 10.533, p = 0.032. These results show that participants' responses from this section are significant as the p-value is less than .05, which means that similar responses can be expected if the study was repeated using a similar population.

Multinomial Test

	χ^2	df	p
Multinomial	10.533	4	0.032

Table 14: Multinominal Test

In Table 14 it is observed that there are 25 responses for Strongly Agree representing 33.33% of the total. The Agree section presents 17 observed responses which are 22.67% of the total. Then, the Neutral section presents 12 observed responses, representing 16% of the total responses. For the Disagree section, 9 observed responses represent 12% of the total. Lastly, the Strongly Disagree section presents 12 observed responses which are 16% of the total.

Descriptives

			95% Confidence Interval	
Likert	Observed	Expected: Multinomial	Lower	Upper
A Strongly Agree	25	15.000	17.147	33.874
B Agree	17	15.000	10.345	25.344
C Neutral	12	15.000	6.413	19.711
D Disagree	9	15.000	4.227	16.171
E Strongly Disagree	12	15.000	6.413	19.711

Note. Confidence intervals are based on independent binomial distributions.

Table 15: Descriptives

In addition, Table 16 illustrates the observed data, where it is observed that most of the participants indicated Strongly Agree and Agree on having a positive experience with ClassVR. We observe that the Neutral and Strongly Disagree responses are the same, and the remaining indicated Disagree with having a positive experience using ClassVR.

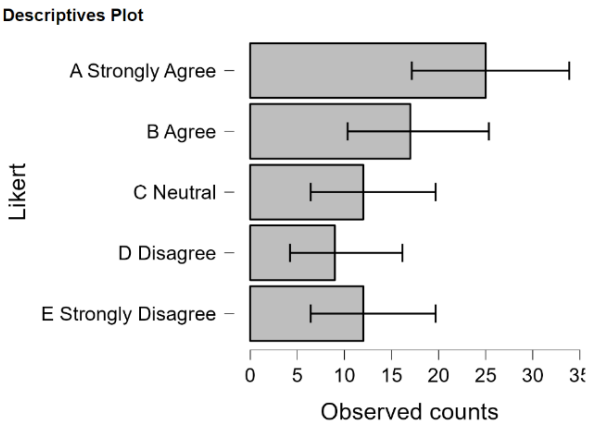

Table 16: Descriptive Plot

Chapter 5: Discussion

Due to the evolution of technology and its presence in society, there has been an increment in research about VR and AR in the last few years. This project focuses specifically on VR and AR in educational settings and is conducted to explore how these immersive technologies work among high school students. To do so, ClassVR was implemented in an experimental group and was later compared to a control group to answer the research questions initially proposed.

The first objective of this project was to determine the effectiveness of ClassVR in enhancing learning outcomes for A2-level EFL students in high school. Through the pretest and posttest results from the experimental and control groups, it is observed that $p = 0.003$. As the p-value shows there is a significant difference between the two, we accept the alternative hypothesis that states that using ClassVR facilitates learning in an A2 level EFL class in Catalonia. The results section shows that both groups improved their test results after their respective intervention, however, when comparing both groups, the experimental group significantly increased their results with respect to the control group.

This suggests that ClassVR facilitates learning among high school students from the first year by providing an immersive experience that engage students in the classroom, aligning with what Scavarelli et al. (2020) suggest. Additionally, VR has shown that it positively affects learning outcomes of students (Chang, Hsu, Kuo, & Jong, 2019; Dalgarno & Lee, 2010 as cited in Liu et al., 2020b).

Previous research supports these findings that highlight the efficacy of VR and AR in enhancing students' learning outcomes and comprehension. The postquestionnaire results show that participants' responses are significant as the $p = 0.027$ supporting once again

the alternative hypothesis, and with a total of 55.66 % of positive responses supporting that ClassVR has facilitated the comprehension of the topic.

The observations align with the quantitative results, providing insights into students' experiences with ClassVR during the session. Participants from the experimental group showed high levels of engagement and focus when using ClassVR, despite an initial difficulty with the navigation of the technology and some discomfort with the headset structure from part of a few participants. Additionally, they seemed to follow and comprehend perfectly the topic, as they were observing and commenting on the content with their partner.

These results suggest that ClassVR improves participants' learning outcomes, and facilitates exploration and participation, which makes a better learning experience for both the teacher and the students.

The second objective of this project was to determine if ClassVR affects students' motivation to learn. Postquestionnaire results showed that participants' responses were significant as $p < .001$, indicating that we accept the alternative hypothesis that using ClassVR affects students' motivation to learn.

The results of the post-questionnaire revealed a significant effect of ClassVR on students' motivation, with participants expressing higher levels of enthusiasm and interest towards language learning when using ClassVR. Additionally, a total of 80 % of the responses were positive regarding the effect on motivation using ClassVR.

These findings align with previous literature on motivation in these technologies. For instance, Kavanagh (2017) confirms that higher motivation is noted when students engage with 3D applications (Limniou, Roberts & Papadopoulos, 2008, as cited in, Kavanagh,

2017). In addition, VR has been shown to influence in a positive way motivation (Chang, Hsu, Kuo, & Jong, 2019; Dalgarno & Lee, 2010 as cited in Liu et al., 2020b).

The different environments presented during the session are said by Huang et al. (2010) to create motivation and encourage students in their learning process.

VR technology has been recognized for its potential to increase motivation by providing learners with agency, autonomy, and opportunities for exploration and discovery. By creating engaging and immersive environments, ClassVR has the ability to capture students' interest and sustain their motivation throughout the learning process.

The observations made during the intervention further support the positive effect of ClassVR on motivation, as students showed excitement and willingness to explore the virtual environments provided by ClassVR since the beginning of the lesson. By just introducing technologies such as VR and AR, states Kavanagh (2017), increases the motivation level among students which was experienced in the intervention. ClassVR has the potential to improve motivation and engagement among students, as proven by participants' constant engagement and excitement in the lesson, despite some obstacles noted by some of the students such as discomfort with the headset. However, it is important to note that the high level of excitement and motivation led to a difficult management of the class at the beginning of the session where participants were talking with their partners about the new things they were seeing and exploring. To address this, a rule was introduced to participants where they could only speak if the researcher told them to, or after raising their hand and being acknowledged with a touch on the shoulder. This adjustment made the class proceed and work better. After this, they were highly focused on exploring the content and following the researcher's instructions. They engaged with the content provided and participated in discussions about the material presented.

The last objective of this project was to determine the effectiveness of ClassVR specifically for high school students, particularly first-year students with an A2 level of English proficiency. The significant improvement in participants' learning outcomes and motivation suggests that ClassVR is effective for high school students in Catalonia.

Moreover, to see the effectiveness of ClassVR some questions were included in the postquestionnaire to capture participants' experience and beliefs using ClassVR. The results showed that 48 % of responses are positive in the section on beliefs and 20 % remain neutral, suggesting that most participants have positive thoughts about the use of ClassVR in the classroom. Additionally, participants' experience was overall good with positive responses on the postquestionnaire, however, eight participants felt dizziness at some point using ClassVR.

Additionally, during the observation, it was noted that participants struggled to navigate the virtual world with the materials even though they had previously received instructions on their use. It is important to note that they only had a session, and with time and practice, all students would likely become experts, as ClassVR is adapted for learners of all ages, meaning that it is simplified compared to non-educational headsets.

Overall, ClassVR is effective for high school, as the results were significant. Most participants had a good experience with this technology; however, it is important to note that some participants presented discomfort, dizziness or motion sickness with the headsets. Additionally, the headsets were not comfortable for some participants as the headsets were not adjustable for different face shapes, specially the nose.

5.2 Limitations

This section presents the description of several limitations encountered during this project, offering a solution for possible future research.

The first limitation was time. The intervention was conducted during a one-hour session, primarily due to logistical challenges such as class schedules and the transportation of the materials to the centre where the researcher was located. Additionally, the participants' teacher needed to cover the curriculum plan, which limited the time for the intervention.

The second limitation was the number of participants. The study was conducted with only 15 students per group, a total of 30, as most of the English classes of the educational centre are composed of 15 students and not more, which may limit the findings.

The third and last limitation is the level and age of participants. The project focused on 12 and 13-year-old students who presented an A2 level of proficiency, which may restrict the results.

The fourth and last limitation is the literature provided. As this is a new topic, there is not much relevant literature compared to other topics of study.

The fifth limitation is the content offered by ClassVR. As this is not a complex study, the lesson and material were taken from the ClassVR content. However, this platform provides the necessary tools for the creation of materials.

The sixth limitation is the feeling of dizziness that some students presented while using ClassVR, and the headset design, missing to adapt to different face shapes.

6. Conclusion

To conclude, this research aimed to see if ClassVR is effective in high school students, particularly first-year students with an A2 level of proficiency, measuring motivation and learning outcomes. The findings provided insight into the facility on learning, motivation and effectiveness that ClassVR provides to students.

The data collection shows significant improvement in learning outcomes, motivation and general effectiveness of ClassVR when used with high school students. Nevertheless, this same data shows that ClassVR headsets provide some discomfort in some cases.

Additionally, it is important to note that this project presents some limitations that should be taken into account for future research on the topic such as time restrictions or the number of students.

This project highlights the importance of research on new technologies such as VR and AR to improve learning outcomes and experiences in educational settings. Exploring these immersive technologies could help educators to understand their potential contribution to learners when used correctly.

6.2 Further Research

Having in mind the limitations that this project presented, additional research is recommended to continue the study of the efficacy of ClassVR or any similar tool with high school students.

Firstly, more hours of intervention could provide more valuable insights into the effectiveness of ClassVR over time, having a better understanding and assessment of the participant's results.

Secondly, increasing the number of participants in this type of research could contribute to more accurate responses to the effects of ClassVR.

To continue, include participants with different levels of proficiency or different aptitudes to explore the effects and adaptability of ClassVR.

Then, designing a lesson plan with the ClassVR platform and implementing it on a group of participants.

To conclude, in order to improve future experiences with ClassVR, it would be beneficial to have students share the headsets and joysticks in pairs, allowing them to take breaks and reduce their discomfort. This would likely make the experience more comfortable and enjoyable for participants.

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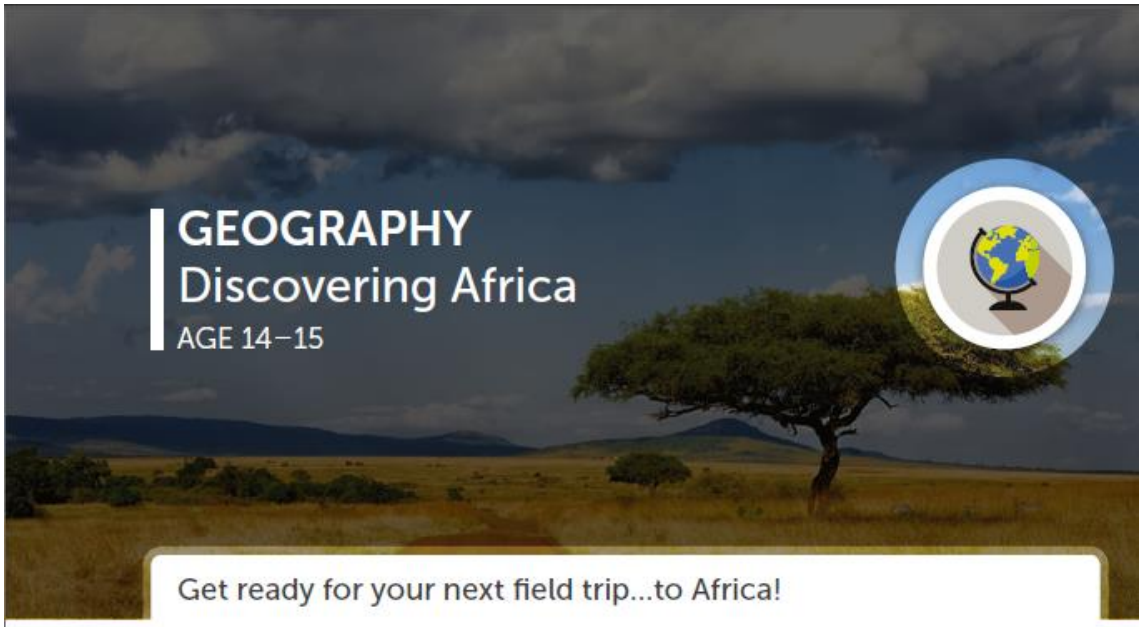
APPENDICES

Appendix A

CLASSVR LESSON PLAN



Get ready for your next field trip...to Africa!

Learning Areas

- Extending locational knowledge of world countries
- Understanding geographical similarities, difference and links between places

Before Your Trip to a Africa:

What different biomes/ecosystems can you think of? Share examples of these. Discuss which of these they would expect to find in Africa. Encourage them to justify their responses.

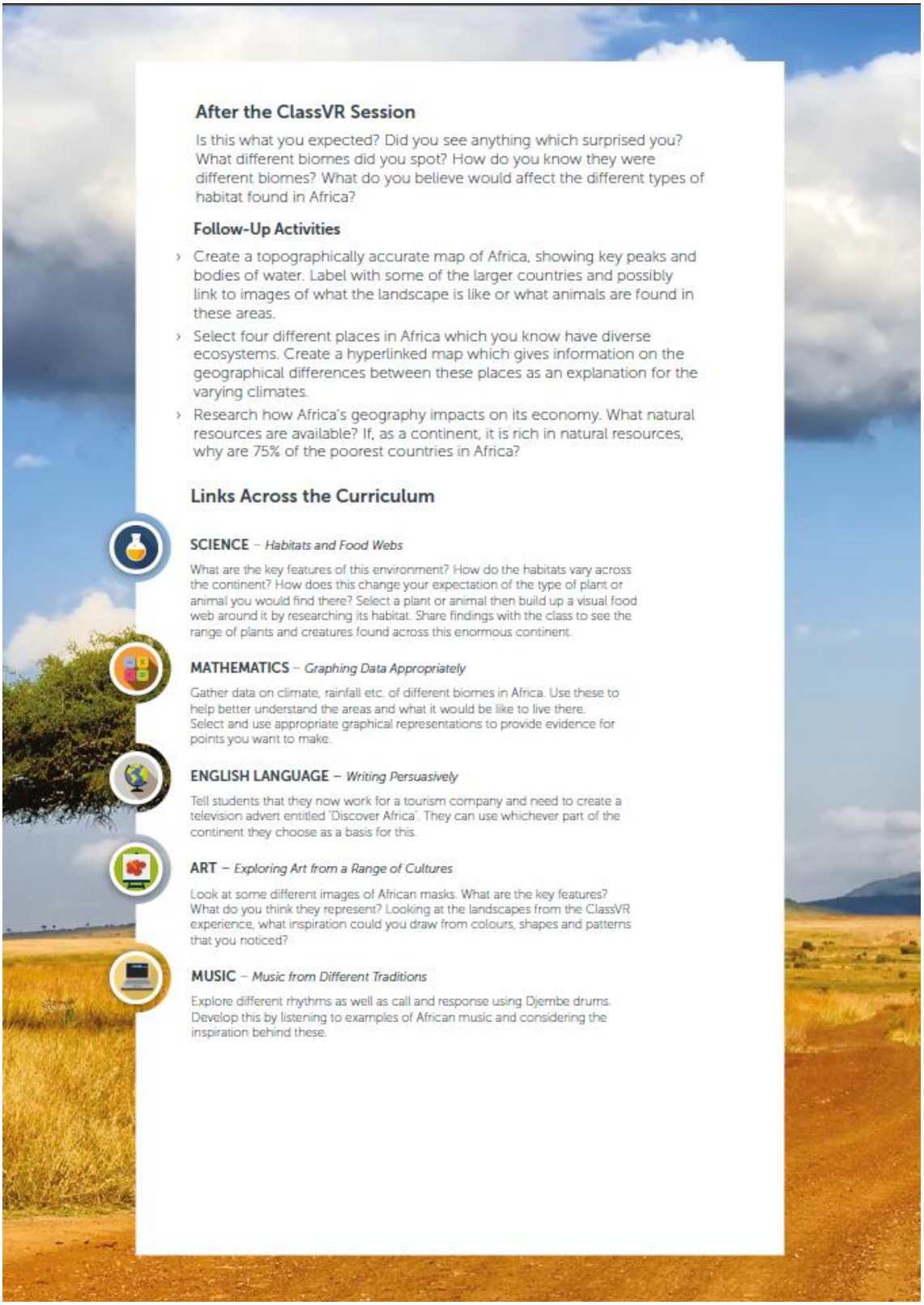
Immersive Experience

Allow students time to explore the scene on their own first. After a minute or so of independent exploration, turn the headset screens off using your teacher dashboard to bring students back into the room. Collect student ideas about points of note, then dive back in, making sure you draw attention to:

- What is the climate like?
- What plants and animals can you see or do you think you would find in this environment?

Africa Collection — Look for these icons

Subject	Area of Study
GEOGRAPHY	AFRICA
Science	Ecosystems
English Language	Non-fiction; narrative writing
Mathematics	Graphical representations of data
Art	Exploring different mediums
Computing	Great composers; musical elements



After the ClassVR Session

Is this what you expected? Did you see anything which surprised you? What different biomes did you spot? How do you know they were different biomes? What do you believe would affect the different types of habitat found in Africa?

Follow-Up Activities

- Create a topographically accurate map of Africa, showing key peaks and bodies of water. Label with some of the larger countries and possibly link to images of what the landscape is like or what animals are found in these areas.
- Select four different places in Africa which you know have diverse ecosystems. Create a hyperlinked map which gives information on the geographical differences between these places as an explanation for the varying climates.
- Research how Africa's geography impacts on its economy. What natural resources are available? If, as a continent, it is rich in natural resources, why are 75% of the poorest countries in Africa?

Links Across the Curriculum

SCIENCE – *Habitats and Food Webs*

What are the key features of this environment? How do the habitats vary across the continent? How does this change your expectation of the type of plant or animal you would find there? Select a plant or animal then build up a visual food web around it by researching its habitat. Share findings with the class to see the range of plants and creatures found across this enormous continent.

MATHEMATICS – *Graphing Data Appropriately*

Gather data on climate, rainfall etc. of different biomes in Africa. Use these to help better understand the areas and what it would be like to live there. Select and use appropriate graphical representations to provide evidence for points you want to make.

ENGLISH LANGUAGE – *Writing Persuasively*

Tell students that they now work for a tourism company and need to create a television advert entitled 'Discover Africa'. They can use whichever part of the continent they choose as a basis for this.

ART – *Exploring Art from a Range of Cultures*

Look at some different images of African masks. What are the key features? What do you think they represent? Looking at the landscapes from the ClassVR experience, what inspiration could you draw from colours, shapes and patterns that you noticed?

MUSIC – *Music from Different Traditions*

Explore different rhythms as well as call and response using Djembe drums. Develop this by listening to examples of African music and considering the inspiration behind these.

Appendix B

LESSON PLAN EXPERIMENTAL GROUP

Discovering Africa

1. Theme and topic: Exploring Africa
2. Students' level and age: 13/14 years old. A2 level of English (to be determined)
3. Number of students: 15
4. Time: 60 minutes
5. Objectives:

    -Learn new vocabulary

    -Extend locational knowledge of world countries

    -Understand geographical similarities, differences, and links between places
6. Materials:

    -ClassVR glasses

    -Laptop for the teacher

    -Worksheet

    -Whiteboard
7. Activities and detailed explanation:

Stage Objective/Time	**Teacher's actions**	**Students' actions**	**T/S ratio and interaction**	**Add. comments**
Welcome the students, direct their attention, and encourage them to	1. Ask them how they are, and related questions to catch their attention. 2. Explain to them that today they are going to use	1. Students provide an answer to the questions	60/40	

participate in the lesson. **2 minutes**	ClassVR glasses and that they have to pay attention and take care of the material.	asked by the teacher. 2. Students might ask some questions related to the materials (ClassVR).		
Introduction of the topic: Exploring Africa. Explain the objective and the agenda of the class. **1 minute**	The teacher presents the agenda of the lesson and the class objective.	Students pay attention to the agenda of the lesson and ask questions if needed	90/10	
Presentation: Present the lesson topic **7 minutes**	The teacher starts with a question: - Do you know what biomes/ecosystems are? - What different biomes/ecosystems can you think of? The teacher writes on the whiteboard the different vocabulary words that students provide. If they	Students participate in the interaction, answering the questions and providing the vocabulary words.		

	struggle to find the vocabulary words, the teacher will help them or provide the rest of the vocabulary. Following this, the teacher asks: - Discuss which of these biomes/ecosystems would you expect to find in Africa.			
Immersive experience 1: **15 minutes**	The teacher tells students to put on the VR glasses and explore the different scenes. First the teacher leaves time to students to explore on their own, and discuss it with their partner and then the teacher has to draw attention to the following: - What is the climate like? - What plants and animals can you see or do you think you would find in this environment?	Students put on the VR glasses and explore the different scenes. They can discuss with their partner the scenes that they are exploring. In addition, they have to participate and answer the	30/70	

		teacher's questions.		
Follow-Up activities: **25 minutes**	The teacher gives them a worksheet to work on the following minutes. The instruction will be explained in the worksheet, but the teacher will explain it to make clear to students what they have to do. The worksheet will have a map of Africa and the vocabulary words of the lesson will be provided. Students will have to link the words to the places they think they can find them. After that, they will have to write some simple sentences about the animals or the ecosystems. E.g.: we can find camels in the desert.	Students will have to work on the worksheet. They have to match the words with the place where they go and write some sentences.	20/80	If time allows it, students can use the ClassVR again to continue to explore the scenes.
Evaluation: Post-test **10 minutes**	The teacher will give them the post-test that will consist of short activities of:	Students will have 10 minutes to complete		

	- completing the sentences with the correct words - matching - true or false - multiple-choice activities	the short activities		

Appendix C

LESSON PLAN CONTROLLED GROUP:

Discovering Africa

1. Theme and topic: Exploring Africa
2. Students' level and age: 13/14 years old. A2 level of English (to be determined)
3. Number of students: 15
4. Time: 60 minutes
5. Objectives:

    -Learn new vocabulary

    -Extend locational knowledge of world countries

    -Understand geographical similarities, differences, and links between places
6. Materials:

    -Laptop for the teacher and projector

    -Worksheet

    -Whiteboard

-PowerPoint slides

7. Activities and detailed explanation:

Stage **Objective/Time**	**Teacher's actions**	**Students' actions**	**T/S ratio and interaction**	**Add. comments**
Welcome the students, direct their attention, and encourage them to participate in the lesson. **2 minutes**	1. Ask them how they are, and related questions to catch their attention.	1. Students provide an answer to the questions asked by the teacher.	60/40	
Introduction of the topic: Exploring Africa. Explain the objective and the agenda of the class.	The teacher presents the agenda of the lesson and the class objective.	Students pay attention to the agenda of the lesson and ask questions if needed.	90/10	

1 minute				
Presentation: Present the lesson topic **7 minutes**	The teacher starts with a question: - Do you know what biomes/ecosystems are? - What different biomes/ecosystems can you think of? The teacher writes on the whiteboard the different vocabulary words that students provide. If they struggle to find the vocabulary words, the teacher will help them or provide the rest of the vocabulary. Following this, the teacher asks: - Discuss which of these biomes/ecosystems	Students participate in the interaction, answering the questions and providing the vocabulary words.		

	would you expect to find in Africa.			
Presentation: **15 minutes**	The teacher presents a PowerPoint with images of different landscapes and animals from Africa (the same as the ClassVR shows) and asks students the following questions: - What is the climate like? - What plants and animals can you see, or do you think you would find in this environment?	Students look at the images and think (they can discuss it in pairs) and answer the teacher's questions.	30/70	
Follow-Up activities:	The teacher gives them a worksheet to work on the following minutes. The	Students will have to work on	20/80	

25 minutes	instruction will be explained in the worksheet, but the teacher will explain it to make clear to students what they have to do. The worksheet will have a map of Africa and the vocabulary words of the lesson will be provided. Students will have to link the words to the places they think they can find them. After that, they will have to write some simple sentences about the animals or the ecosystems. E.g.: we can find camels in the desert.	the worksheet. They have to match the words with the place where they go and write some sentences.		
Evaluation: Post-test	The teacher will give them the post-test that will	Students will have 10 minutes		

10 minutes	consist of short activities of: - completing the sentences with the correct words - matching - true or false - multiple-choice activities	to complete the short activities		

Appendix D

PREQUESTIONNAIRE (ENGLISH)

Name:

Age:

Languages that you speak:

	Yes	No	Other
Do you know what VR is?			
Have you ever used VR before? *			
Would you like to use VR during the class?			
Do you think using VR could motivate you to learn?			
Do you think using VR during class would be beneficial?			

*Where?

PREQUESTIONNAIRE (CATALAN)

Nom:

Edat:

Llengues que parles:

	Si	No	Altres
Saps què es la realitat virtual?			
Has utilitzat mai la realitat virtual?*			
T'agradaria utilitzar la realitat virtual durant les classes?			
Penses que utilitzar la realitat virtual podría motivart-te a apendre?			
Penses que l'ús de la realitat virtual durant la clase seria beneficiós?			

*On?

Appendix E

POSTQUESTIONNAIRE (ENGLISH)

Likert scale (Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree)

	SD	D	N	A	SA
ClassVR should be used for learning					

ClassVR improved my retention of information					
Learning is less interesting with ClassVR					
The use of ClassVR increases the motivation for learning activities					
The use of ClassVR enhances the understanding of the topic					
ClassVR makes learning more interesting and fun					
ClassVR should not be used for learning					
ClassVR does not contribute to the retention of information					
ClassVR facilitates the understanding of the topic					
I felt nauseous using ClassVR glasses					
I am not satisfied with my experience using ClassVR for learning					
I struggled to comprehend the topic despite using ClassVR					
I found difficulties using ClassVR					

I would like to carry out academic activities with ClassVR					
I am satisfied with my experience using ClassVR for learning					

POSTQUESTIONNAIRE (CATALAN)

Likert scale (Molt en Desacrod, en Desacord, Neutre, d'Aacord, Molt d'Acord

	MD	D	N	A	MA
ClassVR s'haruria de fer servir per apendre					
ClassVR millora la retenció d'informació					
Apendre es menys interesant amb ClassVR					
L'ús de ClassVR augmenta la motivació per a les activitats de classe					
Lús de ClassVR millora la comprensió d'un tema					
ClassVR fa que l'aprenentatge sigui més interesant i divertit					
ClassVR no s'haruia de fer servir per apendre					

ClassVR no contribueix a la renenciño d'informació					
ClassVR facilita la comprensió d'un tema					
M'he marejat utilitzant les ulleres de ClassVR					
No estic satisfet amb la meva experiencia dent servir ClassVR per apendre					
He tingut dificultats per entendre el tema tot i fent servir ClassVR					
Trobo dificil fer servir ClassVR					
M'agradaria fer activitats acadèmiques amb ClassVR					
Estic satisfet amb la experència fent servir ClassVR per apendre					

Appendix F

PRE-TEST AND POST-TEST:

1. Choose one definition for ‘ecosystem’:

    a) An ecosystem consists of all of the living and non-living things in an area. This includes plants, animals, and other living things that live together in an area. An ecosystem also includes non-living materials—for example, water, rocks, soil, and sand.

    b) An ecosystem consists only of all the living things in the area —for example plants, animals, and other living things that live together in an area.

    c) An ecosystem consists only of all the non-living things in the area—for example water, rocks, soil, and sand.

2. Choose the ecosystems that we can find in Africa:

    a) Savannas
    b) Deserts
    c) Tropical rainforests
    d) Forests

3. Where can we find camels?

    a) In the desert, and countries like Morocco and Egypt

b) In tropical rainforests, and countries like Morocco and Egypt

c) In the desert, and countries like Kenya and South Africa

d) In tropical rainforests, and countries like Kenya and South Africa

4. Where is the Mount Kilimanjaro?

- Ghana
- Ethiopia
- Tanzania
- Egypt

5. Complete the following sentences with **four** of the following words:

Predators, Endangered, Savanna, Ethiopia, Tanzania, Desert

The lava lake of Erta Ale is located in _____.

Cheetahs can be found in the _____.

Elephants are _____ in Africa.

Leons are _____ and hunt zebras and antelopes.

6. True or False:

- The savanna is a type of African desert ecosystem (F)
- Rainforests in Africa have low biodiversity (F)
- Deserts in Africa are characterized by high rainfall (F)
- Mountains in Africa are always covered in snow (5)

7. Match the pictures to the vocabulary:

Mount Kilimanjaro

Savanna

Erta Ale

Tropical Rainforest

Appendix G

PowerPoint control group

Savanna

- Area covered in grass with some trees.
- Animal diversity.
- Warm weather.
- Located in central and southern Africa.

Elephant

- Largest animal on earth
- High level of intelligence
- Found in different habitats

Lion

- Live in groups called prides
- Predators
- Can live in diverse environments

Giraffe

- Tallest animals
- Long legs, long neck
- Eat leaves

Cheetah

- Fastest land animal
- Long legs, small head
- Hunt and live alone or in small groups

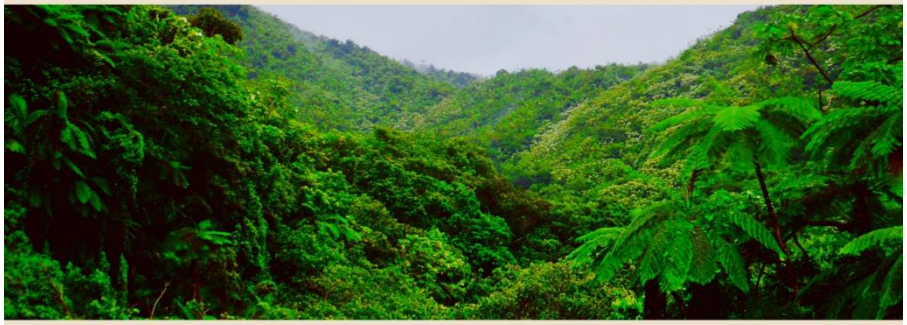
Desert

Sahara desert:

- Largest desert in the world
- High temperatures
- North Africa

Camels

- Well-adapted to arid and desert environments
- Humps: resources for energy
- Efficient water conservation mechanisms



Tropical rainforest

- Big biodiversity
- Abundant rainfall during the year
- Warm temperatures
- Central Africa

Erta Ale

- Active volcano
- One or more active lava lakes
- Located in Ethiopia

Mount Kilimanjaro

- Volcanic mountain
- Located in Tanzania near the border with Kenya
- Tallest mountain in Africa

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Appendix H

IMAGES OF THE EXPERIMENTAL GROUP DURING THE INTERVENTION

Appendix I

PRETEST AND POSTTEST RESULTS

	Experimental Pretest	**Experimental Posttest**	**Control Pretest**	**Control Posttest**
1	36	26	31	78
2	36	63	42	42
3	57	73	31	42
4	84	89	63	57
5	68	84	36	42
6	36	78	47	47
7	63	82	52	73
8	63	89	47	34
9	42	50	31	47
10	63	92	15	31
11	36	36	47	47
12	36	50	36	26
13	52	76	57	31
14	73	84	31	47
15	42	68	42	31

Appendix J

POSTQUESTIONNAIRE RESULTS

MOTIVATION	SD	D	N	A	SA
Q.4	0	0	4	5	6
Q.6	0	1	1	4	9
Q.14	2	0	1	8	4

COMPREHENSION	SD	D	N	A	SA
Q.5	1	2	4	5	3
Q.9	2	2	2	8	1

BELIEFS	SD	D	N	A	SA
Q.1	1	1	3	6	4
Q.2	1	3	5	5	3
Q.3	6	4	1	2	2
Q.7	6	3	4	0	2
Q.8	2	5	5	1	2

EXPERIENCE	SD	D	N	A	SA
Q.10	2	1	4	2	6
Q.11	6	3	2	2	2
Q.12	6	2	2	3	2
Q.13	5	4	2	3	1
Q.15	1	1	2	5	6