Virtual Reality, a Telepresence Technique Applied to Distance Education: A Systematic Mapping Review

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Abstract: The growing demand for innovation in education coupled with the advancement of visualization technologies has led to a large number of people and researchers becoming interested in immersive technologies, the use of virtual reality, which offers opportunities and challenges in the education sector, in so doing, the advancement of hardware and software has made it possible to incorporate this technology into teaching strategies. The present work details a systematic mapping review, which gathers existing scientific documentation on virtual reality in the field of education, as well as describing the methodology used to carry out this review, it also sets out the results and conclusions obtained at the end of the review.

1 INTRODUCTION

Virtual Reality (VR) has been and is an important branch in Computer Science, which has been studied since the beginning of the 20th century (Zhou & Deng, 2009). VR technology focuses on generating virtual environments by allowing the simulation of physical presence in a specific location in the real world, users can access this technology through the use of several special devices that allow recreating sensory, visual, hearing and even olfactory experiences. This technology has three main characteristics: immersion, interaction and imagination (Heng, Cheng, & Wong, 2004), on these VR has been applied in various fields such as the military or medical, but above all it has been applied in education (Pantelidis, 2010).

In the field of education, VR has created opportunities in terms of distance, diversity and disability, so it has been explored how education can go hand in hand with VR in order to improve the cognitive skills of people who use this type of technology (Brown, Turkay, & Sitbon, 2018). In higher education, VR applications need to be updated frequently to be always driving better practices in teaching (Liu, et al., 2019). This technology brought about several changes in the traditional higher education industry. By using this technology, students can be offered a visual experience that transcends the barriers of so-called distance education (Liu, et al., 2019). Most of the articles present projects developed with VR or try to explain how VR can improve the skills of people who use this technology, however, there are articles that also explain how this technology can serve to include people who have some type of disability, as mentioned by (Paudyal, Banerjee, Hu, & Gupta, 2019), in addition, he mentions that in online classes students lack the shared context losing the benefits of collaborative learning. The purpose of this paper is to collect as much information as possible from experiments or projects that deal with VR in education.

The continuation of this document is structured as follows: i.) Section two explains the methodology for conducting the systematic mapping review, defines the research questions, study search and data extraction. ii.) Section three provides answers to the research questions. iii.) Section four gives way to discussion of the topic and results for future contributions, and iv.) Section five details the conclusions obtained once the investigation has been completed, ending with the

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reference section, where all the documents used for the development of the present are evidenced.

2 METHODOLOGY

The first reason to carry out a systematic mapping review is to know what has been researched on the subject, carrying out an extensive analysis of the literature, in this case related to VR and its use within the educational field, in order to provide a synthesis of information corresponding to the projects and experiments carried out according to a filter generated with the inclusion criteria. The second reason is to be able to identify the tools most used in the development of VR applications. The third reason is to identify the areas of study and propose future systematic mapping reviews within these.

The present study was carried out following certain steps described in the template for a mapping study protocol, as mentioned by Fernández in her article (Fernández-Sotos, et al., 2018) and the guidelines recommended by (Velásquez, 2015).

2.1 Research Directives

In this section, following the phases outlined above, the research questions are defined. Within this systematic mapping review the protocol to be followed is defined, which starts with preliminary research questions, search strategies, document selection criteria and data extraction. In addition, the synthesis of the selected papers will serve to answer the research questions posed. Finally, the protocol includes tables showing research interest in the identified areas of study.

The research questions (RQ) for this systematic mapping review are as follows:

RQ1. How many documents related to VR in education have been published? What is the time trend?

As mentioned in the introduction to this document, there are a large number of publications related to VR experiments and projects, however, we would like to know the amount of literature that exists involving this technology in education.

RQ2. What areas of knowledge are involved with VR?

In addition to being a technology applied to video games, VR is also applied to the development of this and other areas, hence the importance of knowing the areas of knowledge that involve the technology.

RQ3. What are the tools and what VR devices are used most regularly for the development of VR applications?

It is important to know which development tools are most commonly used, as well as which devices users use to have a VR experience.

2.2 Data Collection

The method for searching for studies leads to including studies that are relevant to answer the research questions, while excluding irrelevant documents. The search involves querying different databases by referring to search strings customized for this purpose, followed by filtering results using inclusion and exclusion criteria. In this case, two investigators are responsible for the execution of the search plan.

2.2.1 Source Selection and Search String

Due to the fact that the topic to be dealt with is a technical one and that it includes engineering areas, it was considered to carry out the search in 3 digital databases, being these the following ones: Scopus (Elsevier), IEEE Explore (Institute of Electrical and Electronic Engineering Digital Library) and ACM (Association for Computing Machinery).

From the defined research questions, keywords were identified, which will form the search string, it should be noted, that search strings can be formed using synonyms of the defined keywords. For this purpose, search strings were used in each of the databases, this is detailed in Table 1.

Table 1: Search strings used in each digital database.

Database	Search String
IEEE	(((("All Metadata": virtual reality) OR "All Metadata": telepresence) OR "All Metadata": teleconference) AND "All Metadata": education)
ACM	((virtual reality) OR (telepresence) OR (teleconference)) AND (education)
SCOPUS	TITLE-ABS-KEY (("virtual reality" OR "telepresence" OR "teleconference") AND "education") AND PUBYEAR < 2016

2.2.2 Source Selection and Search String

After having defined the search strings to be used in the databases chosen for this review, inclusion criteria were defined in order to filter those documents that are not in the context of the topic presented.

Based on the aforementioned inclusion criteria are the following: I1 Documents that contain at least two key words in their title; I2 Documents that have been published in the last 10 years and I3 Documents in English.

On the other hand, the exclusion criteria are as follows: E1 Documents not indexed in at least two databases; E2 Documents containing opinions and E3 Documents that do not contemplate the use of VRs.

2.2.3 Search Process

As shown in Figure 1. The search string was used in each of the digital databases, where different amounts of documents were obtained in each database. After going through a filtering process with the inclusion and exclusion criteria, 331 documents were obtained. Then, a parallel and independent reading was carried out by the researchers to filter the final documents, selecting only the articles that had information regarding the application of VR in education, later in the meetings of the researchers the debate was discussed. Finally, the content of the 17 documents is read by the two researchers independently in order to have an in-depth knowledge of each document.
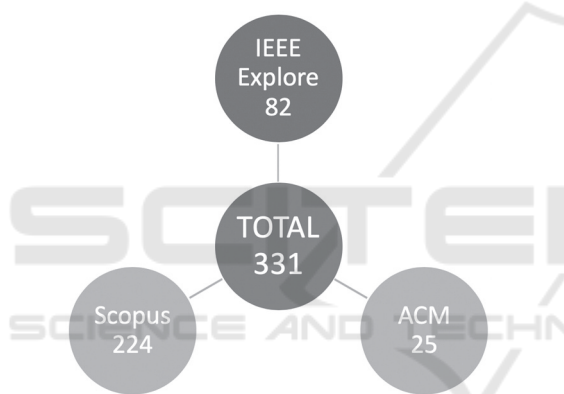

Figure 1: Documents obtained from each database consulted.

In general, a final set of 17 documents is produced at this stage of the systematic mapping review (Table 2).

Table 2: Search and filtering of documents.

	Before applying criteria	After filter I	After filter II
IEEE	1342	82	3
ACM	4212	25	10
SCOPUS	4509	224	4
Total	10063	331	17

3 RESULTS

Finally, the 17 documents were selected in accordance with the described process, and it is emphasized that these documents were selected in such a way that the two researchers agreed.

The synthesis of information from each of the selected documents is then used to answer the research questions.

3.1 Research Directives Overview of Selected Papers

The summary of the papers is presented according to the evaluation approach, in this case, the evaluation approach biases to know the number of published documents that relate VR to education and also to know the growth or decrease of the interest of researchers on this subject.

3.2 Number of Documents Published and Time Trend

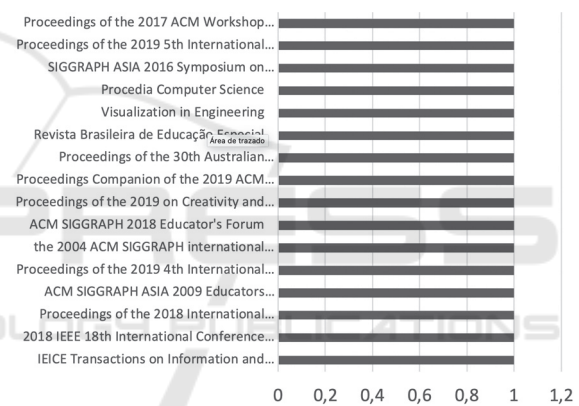RQ1: How many documents related to VR in education have been published? What is the time trend?

Figure 2: Journal and congresses of published articles.

Figure 2 shows the number of articles relating to VR in education, as well as the main places where they were exhibited.

The period within the inclusion criteria is between 2009 and 2019, in these years have been obtained a total of 331 works related to RV in education were published. It was observed that there is a temporal trend which can be seen in Figure 3.

RQ2: What areas of knowledge are involved in VR and application development with this technology?

The areas covered by the publications, especially those related to VR in education (331) are various, and areas such as education, computer science, information technology and engineering in general have been identified, however, there are areas such as psychology that are also involved on a smaller scale, and an article was found that talks about the importance of VR as an assistive technology to help people with special abilities, since it can compensate

for the effects of a disability (Buzio, Chiesa, & Toppan, 2017). In this sense, (Paudyal, Banerjee, Hu, & Gupta, 2019) proposes a VR application which aims to facilitate the performance of a live class focused on hearing impaired people. Figure 4 shows the knowledge areas involved within the VR, comparing them with the articles selected at the end of the search phase. The evaluation criteria in this figure correspond to: author's articles (Ib), articles that cite an author (IIa) and reviews (IIb). These evaluation criteria were created by the researchers in charge, with the purpose of making known the areas that are most involved in virtual reality projects in the field of education. As shown in Figure 4, the results obtained show that the areas that are most associated with virtual reality are Computer Science, HCI and Education, which is a clear indicator that the line of research is within the area of study of the researchers.
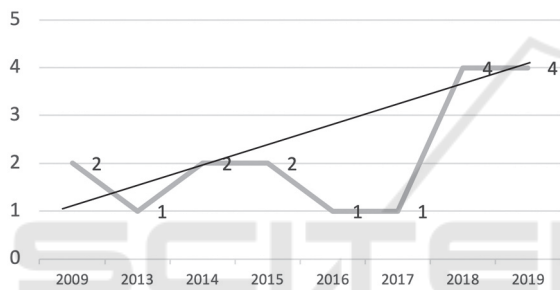

Figure 3: Temporal trend.

RQ3: What are the tools and what VR devices are used most regularly for the development of VR applications?

Regarding the design of virtual reality environments, (Stavroulia, 2019) defines a project in which an application is developed using the Unity 3D platform in real time, accessories such as HTC VIVE (HTC, 2019) and OculusRift (Facebook Technologies, 2019) appear as VR devices, with the aim of improving the empathy skills of the participants and stating that the participants indicated that the sense of presence was achieved. The study conducted by (Miyata, Umemoto, & Higuchi, 2009) defines some tools used in a prototype, however, the author considers that the method to perform a VR application can also be a tool and defines it as a comprehensive method that requires several skills, which is why teamwork is necessary. This kind of tools and models recommended by certain authors may or may not be considered when developing a VR application, however, this information remains as a background in case there are readers interested in VR application development.
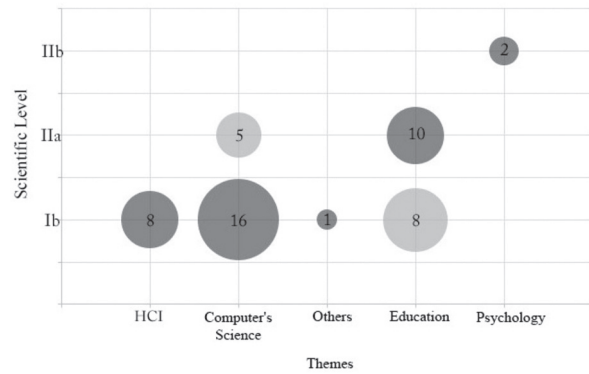

Figure 4: Knowledge areas within VR.

4 DISCUSSION

The present systematic mapping review is a work that shows the literary background to start in the development of a VR application. The documents published in recent years (2009-2019) have produced certain results, which have been set out in the answers to the research questions. The dominance of the high impact publications that have been selected is evidence that the results point to an important degree of maturity within this review process. Table 3 shows the documents with the most citations.

Table 3: Documents with a greater number of citations.

Article name	Citations
A Novel Earthquake Education System Based on Virtual Reality	5
Realidade Virtual como Intervenção na Síndrome de Down: uma Perspectiva de Ação na Interface Saúde e Educação	9
Adopting virtual reality as a medium for software development process education	1
An Education Method for VR Content Creation Using Groupwork	4
ConstruiRV: constructing knowledge using the virtual reality	4
Creating Compelling Virtual Reality and Interactive Content for Higher Education: A Case Study with Carnegie Mellon University	2
Educational Virtuality: Cognitive Benefits, Design Processes and New Frontiers	1
Successful education for AEC professionals: case study of applying immersive game-like virtual reality interfaces	19
Teaching Methodology for Virtual Reality Practical Course in Engineering Education	89
Virtual Reality and Augmented Reality for Education: Panel	2
Virtual Reality for Special Educational Needs	5

As for the empirical evaluation approach, it has a level of quality evidence due to the research model that was carried out, the quality of the evidence is purely scientific. With respect to the temporal evolution of the number of publications in the last 10 years, this has been an increase that is not as progressive as could be seen in Figure 4, there are seasons in which VR research tends to stagnate, and however, there is a growth in research in small jumps of about two years.

Regarding the management of tools, there are documents that specify the tools and materials used in the project, however, most studies focus more on explaining the changes obtained by implementing virtual reality in a given environment, this is because, in theory, is what must be exposed for the project to be taken as relevant or not.

5 CONCLUSIONS

This systematic review shows a growing interest in VR research, the different approaches that it may have are those that necessarily have to be defined at the time of conducting a review on this topic. Proof of this is the progressive increase in the number of published investigations as well as the number of citations of certain articles, which can be said, now are the basis when it comes to talking about Virtual Reality.

In the field of education, VR has been gradually incorporated. This does not mean that there is a lack of interest on the part of researchers or developers in relating VR to education, but rather that, in order to implement this technology in the education process, other areas of research such as teaching, psychology and others need to be considered. However, it was observed that RV has been implemented in certain case studies and has been considered to include people with disabilities in learning processes. On the other hand, the research process has focused on the study of the educational domains where VR is involved.

Finally, an important article should be pointed out within the articles analysed in this research paper, since it mentions the use of virtual reality as an inclusion tool, allowing people with some type of disability to enter the educational system, which It is one more reason why we should continue analysing the use of virtual reality not only in the educational field but also as a tool to include people with some type of disability in society.

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