A Virtual Reality Check: Covid-19 & the Challenges Facing Virtual Reality as an off-the-shelf Mainstream EdTech Solution

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Abstract. Virtual Reality has been much researched as an education technology, particularly under the constructivist perspective of learning environments. Whilst some education institutes have already applied VR within their curriculum, or for marketing purposes, interest has calmed much around the technology. However, since the start of the global Covid-19 pandemic, many educators were faced with the need to distance educate, which sparked a new wave of interest in VR as a potential education technology solution; even to extent of classroom substitution. Whilst the advantages of VR to education have been researched, this paper seeks to address a specific research gap to assist education in the selection of VR as a suitable education technology. Based on qualitative interviews, literature research and the practitioner experience of the authors in the field of education and VR, a technology fit assessment model has been proposed to support education institutes in their VR evaluation process.

Keywords. Virtual Reality, EdTech, Constructivist Learning Theory, Covid-19

1. Introduction

Virtual Reality (VR) gained the attention of educators and academics long before VR became known to the public and portrayed in the media. Although some of the earliest studies of seeing aids in education date back to the 1950s, it was with the birth of modern computing that Virtual Reality sparked a new interest in redesigning learning environments.

Helsel [1] proposed in 1992 how educators portray a natural understanding of VR's learning potential to create virtual learning experience offers for students. McLellan [2] traced early learning concepts back to Airforce studies of 1960s, while Youngblut [3] conducted research into the use of VR in learning environments. His research revealed a wide-spanning field of application cases in almost all areas of education and age groups. However, Youngblut's [3] research suggested the particular usefulness of VR in constructivist learning environments. Constructivist learning theory is based on the experience of learning, the learning environment and the responsibility of learning [4]. The impact of computing technology and particularly virtual technologies has always been closely associated with the development of the

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constructivist learning model [5]. Pantelidis [6] proposed a model to evaluate the use of VR in educational setups by assessing previous literature and research on the topic. It was concluded that VR has specific advantages in experiential based and thus constructivist learning environments. On the detrimental side, cost and learning efforts are mentioned. The model itself is summarized in 10 process steps to guide an educator through the VR selection and design process. Despite of VR's tremendous potential to reshape education and training, it has not found its way into mainstream application, neither in education, professional trainings or even household applications [7]. VR has thus lost some of its glitter and hype, even vanished from the Gartner Hype Cycle Emerging Technology in 2018, whereas in 2017 VR was categorized as a maturing technology [8,9].

Through the emergence of the global Covid-19 pandemic early 2020, VR has found its way back to the media and received a lot of attention as a potential substitute for face to face teaching, learning and even working environments [10]. Exhibitions moved to the virtual spaces [11] and even some universities have adopted virtual learning as part of the solution to substitute physical classroom learning [12]. Through these circumstances and heightened interest in technological solutions to overcome digital barriers, the question of whether VR is the future of learning technologies gained new traction [13, 14].

This paper seeks to evaluate the mainstream readiness of VR for modern education to propose an evaluation model for VR technology selection purposes within constructivist learning environments. Doing so, this paper builds upon the model of Pantelidis [6] by establishing a threshold requirement analysis that expands from subject application to socio-economic and infrastructural aspects.

Since spending on Education Technologies (EdTech) has substantially increased in Australia, through Prime Minister Turnbull's innovation agenda for schools [15], the authors have selected to research exclusively on VR application of Australian educators.

2. Virtual Reality Use Cases

There is plenty of scholarly work on the advantages and disadvantages of VR in educational settings [16, 17, 18], however, a current notion arising out the COVID-19 pandemic is to substitute classrooms through VR. This idea had already received scholarly attention during the boom of online education [19].

As of now, there are various practical examples of educational institutes applying VR as a substitute or add-on technology to deal with the Covid-19 impacts on learning environments. Amongst these institutes is the University of South Wales, which applies VR to teach students crime scene investigation and other specialized subjects [20]. This example is particularly interesting as it focuses on the need to create immersive learning experiences and thus seeks to capitalize upon VR's technology benefit. It also shows how expert knowledge is being built and disseminated across the university to increase the digital or technology literacy of staff in order to create other useful application cases.

The Kellyville Ridge Public School in the North of Sydney applied VR as a teaching technology to have students design a virtual reality neighborhood tour of historic sites [21]. This example is interesting as one of the school's educators details how the technology-facilitated reaching students in a different way. It is noteworthy to mention that over 2 million students worldwide completed a google VR tour [22].

Many schools and universities have followed a similar example and created virtual campus tours, particularly to substitute physical campus visits since the emergence of Covid-19 [23].

Other schools implemented VR to enhance teaching subjects and courses, even in remote appearing domains, such as college football. The University of Michigan's football team applies VR to football training and even player recruiting [24]. The University of British Columbia even integrated VR to give virtual law lectures [25]. VR application cases have emerged in almost all school systems, ranging from primary education [26] to higher education [27].

3. Research Approach

The study is guided by the following research question: What is the readiness of education institutions and homes for deploying Virtual Reality as an EdTech solution?

This research question includes both the readiness to select the appropriate technology for each institutions' respective use case, as well as the readiness to deploy the very technology to maximize the technology's utility. In doing so, the authors investigated aspects ignored by prior research: infrastructural and socio-economic readiness. The underlying notion to this research question is grounded in the practitioners' understanding of the authors, that VR's potential can only be realised if infrastructural and application thresholds are met. The research approach to this paper is outlined in Figure 1.
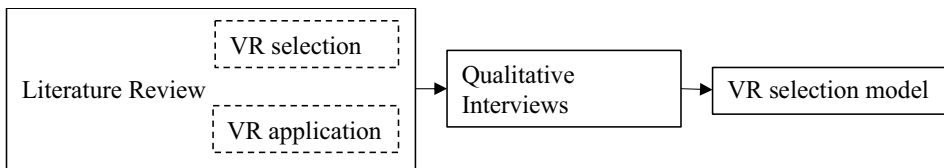

Figure 1. Research Approach

3.1. Literature Review

A literature review was conducted in EBSCO Host, assessing 566 journal publications, ranging from 2010 to 2020 on the abstract based search "Virtual Reality" + "Education".

Much of the academic research discovered suggests Virtual Reality offers a substantial potential for education and training [28, 29, 30]. Particularly VR's potential to support the constructivist learning approach while motivating student engagement with various subjects has been highlighted as a major technological benefit [31, 32]. There are clear reasons to pursue and deploy VR as an education solution, but aside from the paper of Pantelidis [6], no further scholarly work examining selection bias or selection prerequisites was found. The current relevance of Pantelidis [6] could be seen as questionable, as commercial-grade VR headsets were not available during the study and the technology has moved on significantly since its publication.

3.2. Qualitative Interviews on VR readiness in Australia

There are a number of basic assumptions made when considering VR adoption in schools; a simple example of this is requiring a building with power, or a facility to power up a VR headset, or internet to connect the devices. The literature review found no academic work examining the extent of the assumptions, or the truth of the assumptions being made about the current school ecosystem in the context of VR education. The qualitative interviews, in part, sought to discover the adequacy of the assumptions being made and to further understand the relevancy of these factors to the utilization potential of VR in education.

3.3. Settings and Participants

Interviews were conducted with three digital technologies teachers, covering years 7-12, at three schools in Perth, Western Australia. The respective schools spanned the following three socio-economic categories:

- low socio-economic government school,
- a high socio-economic government school, and
- a high fee private school.

All three schools, regardless of their socio-economic status, are regarded as excellent examples of science, technology, engineering and mathematics (STEM) education, as well as digital technologies teaching. Each school has a VR program, run with the schools' students and each program differs significantly in its implementation.

3.4. Interview Method

Participants were asked seven questions, via teleconferencing methods, with the stated understanding that they may not know or could best guess the answers.

1. What is the ratio of computers to students at the school?
2. What is the ratio of computers to students at home?
3. What percentages of students have computers powerful enough for VR?
4. What percentages of students have VR headsets at home?
5. What percentages of students have mobile devices capable of creating AR or VR?
6. What steps are you taking to achieve digital literacy at home during the Covid19 lock down?
7. What issues do you face implementing at home tech learning?

4. Results

Table 1 provides a brief transcript of each interview. Despite the school's varying socio-economic status, their general advancement in applying VR to their curriculum is likely to reflect outcomes in table 1 as the best-case result scenarios per socio-economic group.

Table 1. Interview Summary

	School 1	School 2	School 3
Q 1	1:6	1:4	1:2 or better
Q 2	1:0.6 (40% have no computer)	1:1	1:1 or better

Q 3	5% at best	5-10% of school	50%
Q 4	0%	0.2% at best	1-5%, maybe?
Q 5	10%	50%?	90+%
Q 6	Sourcing of 90 5+yr old pcs for students to take and use at home. Australian business network provided data packs as many students either had no internet at home or insufficient data. Started crowd funding for further pcs.	We have implemented courses online, but tech courses are not online courses. Often the students have limited video conferencing.	It was difficult transferring lessons to online.
Q 7	Students don't have computers at home, or the whole family relies on a single parent's mobile for connectivity. Adults in the family often have never used or had technology in the home and are therefore unaware how to use it or aid their child in its use. We have had to implement adult tech training. We have had to keep the school open regardless to account for at risk students.	Some teachers have poor home connectivity which makes online delivery even harder. There is a duality of learning intent behind technology lessons. Tech is useful to teach collaboration and communication and teamwork, these are all lost online. Consumption based tech experiences hook the students but don't actually provide useful learning tasks. The vast range of home computer quality means no one approach fits each student	Nil aside from typical online issues.

5. Discussion & VR selection model

It is clear from the interviews conducted that the readiness of the schools to implement VR as a solution is heavily impacted by the social and economic conditions. Particularly infrastructural prerequisites, such as the availability of computing equipment and more specifically, powerful enough computing equipment has shown to be a major bottleneck for the schools interviewed for this paper. This could lead to either increasing the social inequality gap, on both institutional and private levels. Adding to this is the requirement for additional, application ready VR headsets as further hardware requirement. In either school or home setting, this hardware needs to mirror the quantity of parallel users, which poses additional investment needs to be met.

If the hardware conditions are met, there are still narrative-based considerations to be met for VR to be effective [33]. It is unclear how much impact narrative considerations have in VR, however poorly met narrative factors may render the VR learning experience void. Narrative in a VR sense refers to more than a storyline, it refers to the entire environmental setup associated with the VR user experience, the user's familiarity and an array of factors unique to VR. Arguments of efficacy notwithstanding, how does a teacher set digital homework to a class whose cohort is unlikely to have computing available at home? Understanding the consequences of socio-economic disparity encompasses whole fields of research, but in the context of education, it is important to understand that VR adds a unique layer of considerations.

It is, therefore, that the authors propose an alternative selection model, specifically for VR, refer to Figure 2, to the earlier quoted model by Pantelidis [6], which addresses identified gaps in academic literature, but also qualitative findings from conducted interviews. The proposed model strives to achieve the highest VR utility, which is a product of infrastructural and application readiness, as mentioned prior in this paper.
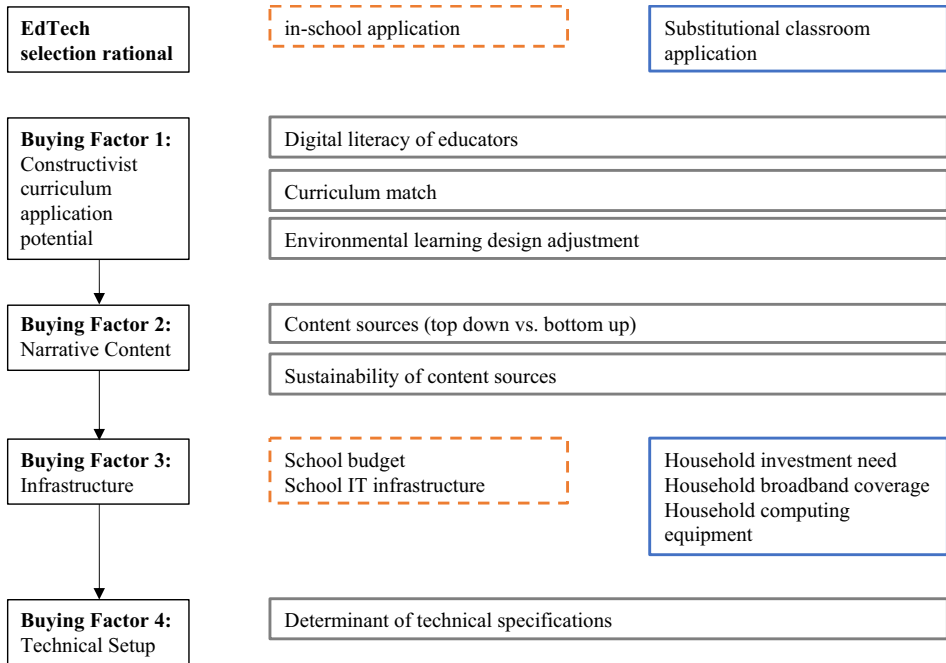

Figure 2. VR Selection Model

The model considers both in-school as well as classroom substitution application fields. In the first instance, the reason to acquire VR as an EdTech solution is a key determinant for the further selection criteria application. This follows the notion of Pantelidis [6], as shown in buying factor 1. Buying factor 2 considers the very narrative requirements of VR to allow for a sustainable hardware application. Only if conditions for buying factor are met, will it make sense to move to buying factor 3 and assess infrastructural prerequisites for VR's mainstream application. As a final step, the model is to create the specification determinants. Therefore, the focus on the maximum investment and thus technology utility is assured. This model therefore fundamentally shifts the experience the authors have with educational institutions to consider hardware before application, while considering relevant application, infrastructural and social-inequality prerequisites.

6. Conclusion.

VR provides the remarkable potential to elevate learning experiences under the constructivist learning theorem. This paper however notes, that VR is not yet an off-the-shelf solution for education institutes.

VR, unlike other technology, requires the consideration of a special environmental and content narrative to realize the full potential of the technology to achieve user immersion. Thus, even if education institutes rightfully select VR on the basis of an application assessment, the potential to have mismatching content and application experience is high. This impact is assumed to be influenced by the degree of digital literacy of VR applying educators.

This paper proposes a model, expanding on previous academic work, to support education institutes in their VR selection process by addressing socio-economic, infrastructural and narrative considerations.

The authors argue, that the proposed model can find a wider application to the assessment of novel EdTech solutions in general.

7. Limitations.

Although the authors have undertaken all reasonable effort to avoid limitations, the following limitations are noted. Due to the authors' technology predisposition, a perspective bias cannot be excluded. Further, since this paper builds on qualitative, non-representative interviews, it requires further quantitative studies to support generalizations.

8. Areas for further research.

Four avenues for further research are identified. First, it is proposed to replicate this study quantitatively to verify findings representatively.

Second, it is proposed to do further fit studies of the proposed model for other technologies, such as Augmented Reality (AR).

Third, the authors propose to research how and when an application mass adoption tipping point emerges for novel EdTech. This is particularly relevant to understand how and when new learning environmental designs emerge to maximize the utility of a given technology.

Fourth, the authors encourage academics to research how the impact of VR as an EdTech solution can be linked to students' learning performance, as the ultimate measure of success, following the constructivist learning theory.

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