CLASSVR®

Virtual Reality for Schools

RESEARCH IN THE USE OF VIRTUAL REALITY LEARNING

Introduction

This document has been written to explore current research into the use of virtual and augmented reality within the sphere of learning. We have collated research from a range of sources, studies and organisations to substantiate how and why virtual reality learning can be used to enhance and improve outcomes for learners in various contexts.

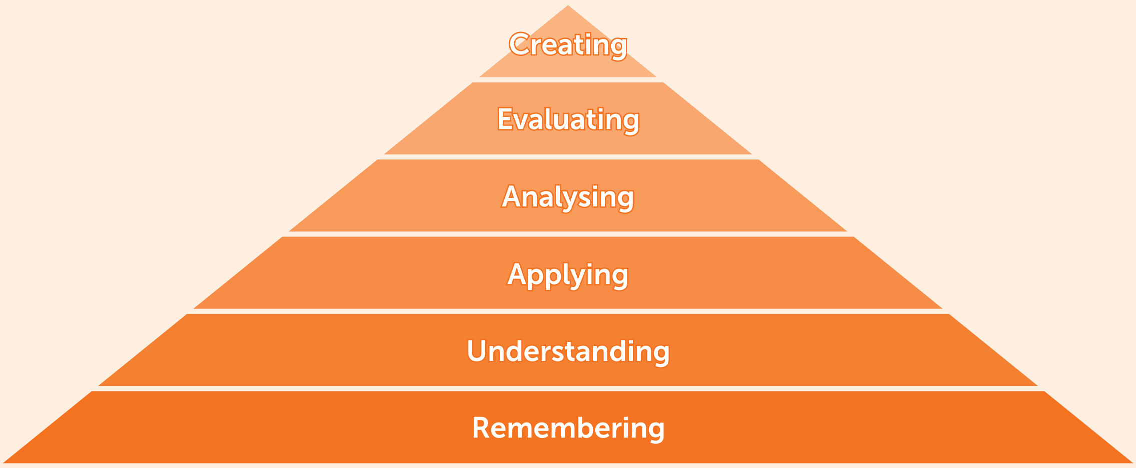
Research In The Use Of Virtual Reality Learning

Wanting to learn is a basic human desire (Papert, 1994). Indeed, Papert goes on to suggest that by contextualising and providing a situation to learning in the real world, individuals' construction takes place more felicitously. Virtual Reality (VR) and Augmented Reality (AR) learning provides a style of remote learning which is as close to visiting the reality as possible – with high-quality visual stimuli giving unparalleled access to concepts, places and experiences. VR and AR have been implemented in educational settings for years and increasingly empirical evidence is demonstrating that these tools support student's learning outcomes and vastly enhance their enjoyment in different contexts and across various subjects (Bower *et al*., 2014). Markowitz *et al*. (2018) suggest that a virtual experience is underpinned by two concepts: immersion and presence. Immersion refers to how well the technology approximates actions and movements in the virtual space. Whereas presence is the psychological sense of "being there" (Heeter, 1992; Slater and Wilbur, 1997).

Indeed, as VR technology progresses rapidly and its applications broaden, Allcoat and von Mühlenen (2018) outline exactly why VR- and AR-enhanced learning can be an irreplaceable tool within the classroom setting. For example, they outline that by presenting environments in 3D format or by embedding audio, visual and even haptic feedback in 360-degree worlds, students are able to benefit from learning in a multi-modal way. For example, students using VR-enhanced learning can be placed within any given context, visually, audibly and in turn, emotionally and socially. This is particularly apparent for learners when using VR with concepts which are largely inaccessible. As Dragani (2019) explains, VR technology can be a game changer for students who need training in an area that is dangerous, impractical or impossible to simulate in real life. Furthermore, presenting learning materials in 3D can be especially beneficial for teaching subjects where it is important to visualise the learning materials, in subjects such as chemistry and biology.

Further to this, from Edgar Dale's cone of learning theory, we know when students experience something – whether a simulation or the real thing – their ability to retain, reproduce and apply this learning is greatly improved. Indeed, if learners are immersed within a context, a situation or given an augmented experience to hold and manipulate, Dale's theory would suggest that their recall, application and indeed even information creation can be scaffolded and supported, leading to schematic connections being developed easier and with more long-lasting results.

Bloom's Taxonomy (1956)



Woolfolk *et al*. (2008) states that learning occurs when experience causes a relatively permanent change in an individual's knowledge or behaviour and countless researchers support the concept that technology-enhanced learning can help pupils to "learn and construct new knowledge" (Sutherland *et al*., 2009). Further, Huang *et al*. (2019) explains that VR technology-based instruction may improve students' learning outcomes in various subjects and contexts, as evidenced by the meta-analysis undertaken by Merchant *et al*. (2014). VR technology facilitate spatial presence, which is the subjective experience of physically being in a virtual environment. When users allocate their attention to spatial information from the mediated environment, they form a mental representation of the environment (Schubert, 2009) and thus create a more intense and perhaps even long-lasting memory. In addition, once a learner begins to treat the virtual environment as a physical world, they begin to experience the sense of presence that has been positively associated with enjoyment of the VR tool (Kim, K. *et al*., 2015).

Having a variety of learning tools available in a classroom is absolutely crucial to maintaining students' interest and dynamically appealing to the variety of preferential learning styles amongst any group of students. As Allcoat and von Mühlenen (2018) suggest, VR and AR learning provides a platform of varied, interactive and tactile learning, which appeals to various learning habits and preferences. ClassVR's platform of being able to add, manage and control the varied content provides teachers with a flexible system of being able to change what appears and what the students interact with by one click of a button. This content may be in the form of 360-degree images, 360-degree videos or interacting with 3D models through the use of the ARCube.

Studies

Virtual reality tools have proven to be more than just novel visual aids for education – they are powerful learning tools. Research shows that retention rates rise when students or trainees use virtual reality to immerse themselves in a lesson or scenario. In Dragani's (2019) investigations into why virtual learning works, she found that a University of Maryland study showed median recall accuracy rates with VR headsets hit 90 percent compared to 78 percent for learning with desktop computers. She also explains how, in Beijing, students whose lessons were supplemented with VR averaged scores of 93 on a final exam, a 20-percentage point increase from those who relied on traditional classroom learning.

Having a range of studies available to analyse and evaluate is becoming more commonplace; however, Markowitz *et al*. (2018) state that the connection between VR and education has likely been underdeveloped because of the challenges associated with using virtual technology to facilitate learning: cost, usability and fear (or lack of a skill-base) from staff. This is a really important point to note, as ClassVR allays these three issues with affordability, pre-made and pre-loaded content, a simple and ready-to-use interface, as well as comprehensive staff training and online professional development.

Markowitz *et al*. (2018) go on to explore two comprehensive studies they undertook; in both, there was a positive relationship between VR learning and improved outcomes. Their first study suggests that using the devices overtime can help support stable knowledge gain – in that students were able to recall information many weeks after the VR experience.

In addition to this, Allcoat and Mühlenen (2018) undertook tests to compare the impact of VR-enhanced learning, when compared to traditional, textbook learning and video learning. Below, figure one demonstrates the improved impact on outcomes which VR learning and how it shows the most progress within this sample of students. The VR learning shows that students both made more progress and scored higher when using virtual learning; their self-reported confidence levels also showed the greatest improvement and the highest overall score. In part, this may be because of the more complete experience users get from such learning methods (Dragani, 2019).

Table 1. Number of participants (N), knowledge scores (percentage correct) and confidence ratings (1–5) in the pretest and post-test separately for the three conditions.

Condition	*N*	Pretest	Post-test	Difference
Knowledge scores				
Virtual	34	28.1%	56.5%	28.5%
Video	34	27.9%	43.9%	16.1%
Textbook	31	25.3%	50.2%	24.9%
Confidence ratings				
Virtual	34	2.24	3.35	1.12
Video	34	2.33	3.04	0.71
Textbook	31	2.14	3.32	1.18

Further, multiple sources (Scott, 2018; Allcoat and Mühlenen, 2018) suggest that VR learning was found to significantly and positively impact the mood of students and learners, whilst many other mediums of learning are shown to disengage or fail to retain learner engagement - as figure two below shows (Allcoat and Mühlenen, 2018).

Table 2. Number of participants who responded with qualitative feedback in grouped types: positive, negative and mixed feedback.

Condition	Positive	Negative	Mixed
Virtual	5	3	5
Video	2	13	2
Textbook	1	15	6

Outcomes

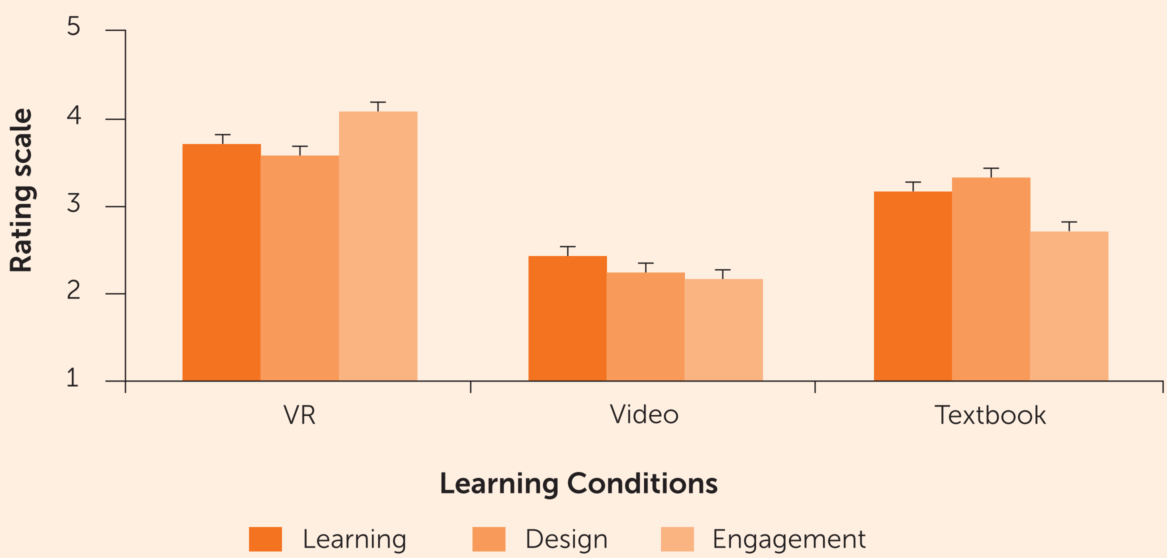
The outcomes we have seen with ClassVR usage have been excellent. Teachers from around the world have shared their testimonials with us and have explained that in various subjects they have seen improved understanding, greater concentration, a renewed enthusiasm for learning and a better quality of responses and engagement. The SAMR model below shows, when students use 360-degree imagery, videos and immersive learning, they are able to transform their learning and, similar to Bloom's taxonomy, they can create new ideas and concepts through experiential learning.

The SAMR Model

TRANSFORMATION	REDEFINITION	Students use 360 photos and videos to create, explore and share their physical experiences
	MODIFICATION	An online blog is created, where feedback about photos and videos can be received
ENHANCEMENT	AUGMENTATION	A messaging service is used to add photos and videos to the message
	SUBSTITUTION	An SMS is used to send a message instead of a postcard

Another reason for improved outcomes and accelerated progress may be because of the positive emotional response many users have with VR learning. Scott (2018) states that researchers found that positive emotions were rated higher for the group who experienced the VR learning method in comparison to textbook or video-based learning. VR students also performed better than students learning with video, showing that the active interaction with the VR environment helped improve learning, as indicated by figure three below (Allcoat and Mühlenen, 2018).

WBLT evaluation scale



Many of our ClassVR user schools are seeing outcomes improve, such as an increased resilience and ability to answer open-ended questions (ClassVR, 2018, P.20) and extend their current understanding by drawing from what the students perceive whilst immersed (ClassVR, 2018, P.25). Further to that, the ability to create, edit and then present their learning in a totally different and dynamic way (ClassVR, 2018, P. and P.26) has provided a more memorable and captivating platform for their learning to take place. Through our 30 Creative Ways to Use ClassVR document, we have seen teachers reporting students having a better understanding of historical concepts, as well as being able to see the context and lifestyle that many historical events are set in. Through the use of 3D models and augmented reality, teachers have also explained how their students' understanding of different historical artefacts has greatly improved (ClassVR, 2018, P.10 & P.16).

Other Contexts

Another learning context in which virtual reality has become an important fixture is within the emergency service sector. By providing fully immersive, crisis situations for emergency personnel to train with, as well as using these resources as a tool for guiding staff through hard-to-reach places, Cakiroglu and Gokoglu (2019) suggest using virtual reality-based behavioural training has significantly improved skills towards fire safety. Indeed, their study found that when undertaking fire safety training with students, that most could transfer their behavioural skills to real environments. This study underpins the impact that VR-enhanced learning can have and reinforces the cone of learning theory about how influential the simulation of real-life environments can be for adjusting outcomes in ways that other mediums may not be able to access.

Augmented Reality and 3D concepts

Yip *et al*. (2018) undertook a study, in which students' learning experiences were compared between a controlled non-AR group and another AR-enhanced learning group. Their findings suggest that AR can offer a better delivery of basic knowledge, even for issues of higher complexity. In part, this is because 3D concepts are made easier to process and grasp when displayed through a 3D medium and when they are able to be manipulated and investigated. For example, when using many of the 3D models with ClassVR, students are able to explore these in great detail through the use of the ARCube in enhancing their spatial connection between the model and their line of sight. Indeed, students can also view a plethora of different models which link together by subject, topic or theme, or they can view isolated, specific and bespoke models – sometimes of objects which not ordinarily be accessible within a classroom.

Allcoat and Mühlenen (2018) suggested provided a user has become familiar with the AR equipment and understands how the interface and hardware work, then the use of AR-enhanced learning should be beneficial to the student. Indeed, it moves learners from the lower end of Bloom's taxonomy (1956) to being able to 'create' new ideas and make schematic connections more easily. Andrew (2019) explains that because AR drives high levels of visual attention on the brain (almost double that of non-AR tasks), the security of "remembering" and "understanding" is greatly improved. Thus, the scaffolding around learners then being able to engage in higher-order thinking skills is made less cognitively challenging, as they are able to use this secure foundation of knowledge to think more critically.

In addition, Andrew (2019) discusses how, in neurological terms, if any type of learning is to be effective, it needs to be encoded into the long-term memory; otherwise, it will have minimal impact on any of our future behaviour. She goes on to say that the research certainly suggests AR experiences are considerably more engaging and memorable than non-AR experiences, which presents a huge opportunity for brands to lead the way in leveraging the technology. This is where we at ClassVR lead the way with integrating curriculum-aligned and increasingly interactive content through our ARC (augmented reality classroom) app. This app is installed into the firmware of the device and enables students to move and manipulate these animated and lively AR experiences.

Social constructivism

To extend and develop children's interactivity with technology from a surface level, to a deeper level, effective and purposeful talk must be embedded and planned throughout (Beauchamp, 2012). This highlights the importance of social constructivism (Vygotsky, 1978) in computing, which promotes deeper interactivity, as children can assess and extend their knowledge (Hargreaves *et al*., 2003), through purposeful and subject-specific talk. With VR learning, students will be captivated and excited by the medium of learning and will, in turn, be much more likely to talk about their experience and the different things they heard, saw and perceived. Hence, VR learning may be a significant tool in the enabling of effective and wide-spread social constructivism.

Summary / Conclusion

Allcoat and Mühlenen (2018) and Markowitz *et al*. (2018) agree that overall virtual reality and augmented reality learning seems to enhance, support and enrich traditional, textbook-style learning and improve mood and engagement from students. These benefits may have a longer-term impact on learning, such as improvements resulting from the learning experience and increased knowledge retention, as well as being able to analyse and apply new understanding through high-quality, immersive experiences. In addition to that, Scott (2018) claims that VR headsets are the most stimulating form of learning method, based on research at the University of Warwick. ClassVR hopes to hone this through providing a range of VR and AR learning which can be adapted to be unique, specific and targeted areas of learning. In addition, being able to control, manage and direct students' attention, whilst immersed in an experience, means that the ClassVR online portal can help teachers to focus specifically on areas which meet the needs of their students.

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