Virtual Reality in Education

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This paper provides an overview of virtual reality technologies and described the different ways that it is possible for a learner to engage with the virtual environment within. Five affordances of VR are described alongside some suggestions for how VR technology might be orchestrated in the classroom. The article concludes with potential risks and considerations for using VR with young children.

WHAT IS VIRTUAL REALITY?

Virtual Reality (VR) 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" (Merriam-Webster, n.d.).

In simple terms, virtual reality is a simulated experience that may be similar to the real-world or different from it. Such virtual environments are created using computers and one can interact with them using specialized electronic devices such as a helmet fitted with a screen or handheld sensors.

TYPES OF VR TECHNOLOGIES

Current virtual reality technologies can be classified into two broad categories based on how immersed a user feels in the virtual world. They are:

Non-immersive virtual reality: This type of VR technology often provides users with a virtual environment generated by computer without the users feeling immersed in the virtual world. Common examples include games played on the Playstation, Xbox or Nintendo. Even though the user interacts with the virtual environment that is the game, they do not feel fully immersed in it. In simple words, the screen is a window to the virtual world.

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Immersive virtual reality: This type of VR technology offers the user a sense of "being there" in the virtual world. Immersive VR technology allows the user to wear or hold a head-mounted display and explore and interact with 3-dimensional virtual environments using controllers, which can be wireless. Based on the type of head mounted device used, there are two sub-types:

- Mobile-based immersive VR where the user interacts with a 3D world on their mobile phones such as Google Cardboard, which are held in front of the eyes.

- Dedicated device immersive VR where the user interacts with an exclusive device that offers virtual reality experiences such as an Oculus Rift or HTC Vive.

DIFFERENT WAYS TO ENGAGE AND INTERACT WITHIN VR ENVIRONMENTS

There are different ways in which one can interact with, and explore inside, virtual environments and, alongside, the ways that users select and act on objects in the virtual world can also vary. Some of these ways are device dependent, and others are programmed as part of the design of the virtual world.

- **Head movements** - The user can tilt or move head sideways to explore what the virtual environment looks like to their left or right and above or below.
- **Eye movements**- By focusing on a specific object in the virtual environment, a narration about that object may be triggered.
- **Hand gesture (no technology)** - Users may use a 'pinch and hold' gesture to pick an item in the virtual environment and drop it into a shopping basket.
- **Hand operated buttons** - A click of a button on a hand held controller can select an object or click on an object in the virtual environment to trigger a change for example, clicking on a plant may produce flowers.
- **Touchpad** - Using a wireless touchpad, the user can select objects in a menu or move from one item to another by swiping forward or backward.
- **Controllers** - These controllers may have buttons and triggers for grabbing an object or shooting as in an Oculus Rift.

WHAT ARE THE AFFORDANCES OF VR?

Virtual reality removes the barriers of the traditional classroom walls and enables access to learning environments from anywhere. Affordances in the context of learning environments refer to "relationships between the properties of an educational intervention and the characteristics of the learner that enable certain kinds of learning to occur". (Dalgarno and Lee, 2010). The affordances of VR have been discussed extensively since the 1990s and there has been significant emphasis on the dimension of immersion.

Immersion has been defined as the technical capability of a system to deliver "an inclusive, extensive, surrounding, and vivid illusion of reality to the senses of a human participant" (Slater and Wilbur, 1997). They proposed six dimensions of immersion all of which have an effect on presence - the sense of "being there" in the virtual environment. The higher the immersiveness, the greater the presence and the greater the presence, the more likely it is that users behave in the virtual environment as they would in a real world. The dimensions of immersion are interlinked, and they contribute to the overall immersiveness that has been shown to promote learning by increasing engagement on part of the learner - as seen through its links to motivation and supporting evidence from self-reports from students.

The five dimensions of immersion are:

A) **Inclusiveness:**

This refers to the extent to which the physical reality is shut out - making the user feel like s/he is part of the virtual world. This has the potential to allow for situated, contextual learning which helps the learner better apply concepts learnt to new situations (Dede, 2009; Dalgarno and Lee, 2010). As a result, this allows for experiential learning to take place in out-of-everyday situations and in places that would otherwise be impossible to access due to different reasons such as cost, time or danger (Mikropoulos and Natsis, 2011).

B) **Extensiveness:**

This refers to the range of sensory modalities accommodated by the VR technology. VR has the potential to allow users to see and hear information that is otherwise inaccessible to human senses such as seeing ultraviolet light the way bees can or hear the infrasound like elephants (also referred to as size, by Winn, 1993). Similarly, it is possible to have spatialized sound that would make the virtual environment much more immersive, thereby making the student feel a part of it and experience it closely.

C) **Surrounding:**

This refers to the visual presentation of the VR technology to which the external physical world is shut out. This could be through a head-mounted device or handheld controllers that would allow a user to explore a 360-degree view of an environment such as an ocean or space. Such explorations also feel more real-world as one can turn around and explore different dimensions. This would potentially allow for conversion of abstract concepts such as geometry or algebra into concrete, visible and tangible forms - as students get inside them and explore how such shapes are constructed.

D) **Vividness:**

This corresponds to the fidelity and resolution with which the VR technology simulates the desired environment (e.g. visual information). Virtual worlds offer users the potential to shrink down to explore micro-worlds, or view an enormous space such as the solar system or an ocean, with a great deal of fidelity (referred to as transduction by Winn 1993).

E) Matching:

This refers to the delay in feedback between when the user makes a body movement / shifts in positive and the manifestation on the VR display.

For example, as the user walks two steps ahead, the character in the virtual environment would walk two steps ahead almost immediately so as to make the user feel more "present". Quick feedback allows for increased presence and potentially promotes learning through engagement of the learner.

The immersiveness of VR plays a key role in providing the potential for "presence". Presence or the 'sense of being there' is one of the game-changing aspects that immersive VR affords (Steuer, 1992). It refers to the subjective experience of the user of feeling as though they are in the virtual environment. This allows for situated, contextual learning which supports the learner to better apply concepts learnt to new situations (Dede, 2009; Dalgarno and Lee, 2010). This allows for experiential learning to take place in out-of-everyday situations and in places that would otherwise be impossible to access due to different reasons such as cost, time or danger (Mikropoulos and Natsis, 2011).

ORCHESTRATION OF VIRTUAL REALITY IN THE CLASSROOM

Orchestration of VR refers to the implementation of VR in classrooms as part of ongoing lessons. This is influenced by several factors such as the teacher and student ratio, pedagogical approaches and methods, teacher's beliefs, comfort and familiarity with VR, students' attitudes to learning with technology and availability of resources.

As VR is still an emerging technology within education, and few classroom based studies have been conducted, some emerging design principles to inform the implementation of VR in classrooms are:

A) Don't overuse VR in classrooms. VR has tremendous potential to complement lessons by providing relatable, relevant content that may be inaccessible in real life and fuel imagination. But it cannot replace traditional lessons and when used for long periods may not only defeat the purpose but also pose other risks (outlined in the next section).

B) A flipped learning approach, where students are encouraged to engage with a topic at home before coming to a class may enable lesson time to be used to explore the topic using VR. This might be particularly appropriate where lesson duration is limited or class sizes are large.

C) If access to immersive VR is limited, it may not be possible to provide each student with a headset. In such instances, the classroom could be divided into two, with half the class engaging with VR while the other half work on their own or in teams to get familiar with the topic by reading or through worksheets and videos. This would require careful planning and classroom management of the resources.

D) Another challenge to using immersive VR headsets is space. This is particularly relevant when the idea behind using VR is to make the child feel like he is in the virtual environment and explore and interact with the technology as freely as possible though walking or gestures. This is affected by presence of classmates who sometimes may walk into each other! It helps to have the children at a good distance or possibly even outdoors when they are interacting with highly immersive environments. This would also help overcome the chances of bumping into objects and people.

E) Some teachers and schools may already be using some form of technology in their classrooms. Therefore, it always helps to understand the technical specifications and compatibility of these tools to identify how best to introduce and integrate a new form of technology, such as VR.

F) Enabling a flexible and teacher-controlled management of learning content and technology where the orchestration load is shared with students would be helpful particularly in classrooms with high teacher-student ratios or curriculum load.

POTENTIAL RISKS AND CONSIDERATIONS FOR USING VR WITH YOUNG CHILDREN

It should be noted that age restrictions exist for most of the commercially available VR headsets and they are not designed nor recommended for children under 12 years of age (Won et al., 2017). Headsets available for use for children in the 3 - 10 age range include Google Cardboard and Mattel View-Master though they advise adult supervision when children use them. There have been different concerns on the effect of immersive VR on children some of which include:

A) **Effect of VR on vision:**

Safety concerns on the effect of using immersive VR viewers are mostly speculative. However, there have been studies where some children showed worsening of balance after 20 minutes of immersive VR play. While these are only a small set of children, they are still causes for concern and it is recommended that along with monitoring the use of immersive VR, the period of use be restricted to not more than 15 minutes. Further, development of most of vision takes up to 7 years while some aspects may take up to 13 years which makes it advisable to use immersive VR after 13 years of age. Finally, in some of the immersive VR viewers the distance between the two lenses are higher than the inter-pupillary distance in children especially those between 3 - 10 years. This mismatch can potentially cause binocular stress. Therefore, when using an immersive VR, it is imperative that the inter-lens distance is adjusted/ adjustable to accurately match that of the child's inter-pupillary distance. This is especially important while using viewers that come with fixed inter-lens distance such as Google cardboard. In such instances it is recommended to use them only when it matches the inter-pupillary distance at higher ages.

B) Concerns of VR on cognitive development:

Young children find VR to be more "real" than older children and adults which means they are influenced more easily both in positive and negative ways. Some of the studies that look at the effect of immersive VR on young children have found that elementary school children were more likely to develop false memories when a false event was presented to them (for example, exposure to a virtual sea world made children think they had actually been to a sea world) compared to having a narrative of the event read to them or seeing edited digital photographs of the event.

C) Practical concerns when using VR in classrooms:

As mentioned earlier, when using highly immersive headsets, there is the possibility of children bumping into each other as they walk and explore virtual environments. It helps to spread out the children in bigger spaces including outdoors when possible. Further, the number of children using the headsets at one instance can be restricted while the rest work on other material so as to avoid too many VR explorations at the same time.

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