BOOKLET: VR FOR EDUCATION

Math Reality

The only source of knowledge is experience

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INTRODUCTION

At the age of 87, Michelangelo, an accomplished master, said: 'I am still learning'. What a wonderful thing to admit! As humanity, we never cease to improve, especially now, in an era of great technological advances which are part of our everyday lives.

Virtual Reality (VR) does no longer belong to the future, as it has entered many fields of people's lives. When you think about Virtual Reality, the first thing that comes to your mind is entertainment. But VR is not just about games, it is also present in education, medicine, human resources, travelling or military training.

Virtual reality is a form of computer simulation, in which the participant Is immersed in an artificial environment. It provides new forms and methods of visualization, drawing on the strengths of visual representations. VR can more accurately illustrate some features, processes, and so forth than other means, as it can provide greater experience of „touching" concepts that were so far only theoretical. After all, following words of another great personality of our times - Albert Einstein, it is true that 'The only source of knowledge is experience'.

The use of VR in education can be considered as one of the natural evolution's of computer-assisted instruction (CAI) or computer-based training (CBT). Using this technology in the classroom can create new learning and thinking opportunities together with an opportunity to boost student engagement. As a hands-on, interactive, immersive experience, it provides a new way of learning for students by delivering new experiences. [1]

Using VR in education will modernize the pedagogical process and bring the teaching content to young people in an interesting way and encourage them to independently explore and otherwise acquire knowledge.

The possibilities of using VR in education can be inexhaustible. Traditional teaching methods tie teachers to providing facts, which has little to do with education and a lot to do with being informed. Students being fed too much information on a multitude of subjects in a short period of time find themselves overwhelmed, leading them to boredom and disengagement. The use of Virtual Reality in education has a possibility to revolutionize the classroom interaction. In this way, they can learn by doing and they are offered a better sense of place, the opportunity to experience scale-learning, to develop their creativity and improve the acquisition of information by reacting emotionally to it.[2]

[1] Hu-Au, Lee (2017)
[2] https://theblog.adobe.com/virtual-reality-will-change-learn-teach/

INTRODUCTION

Math Reality is a project that consists of co-developing and implementing an innovative pedagogy methodology and usage of VR to enhance current didactics of mathematics.

Math Reality is a project co-funded by the Erasmus+ Programme of the European Union and is the result of a collaborative work between 6 organizations: Fermat Science (France), Citizens in Power (Cyprus), High School Ivanec (Croatia), Colegiul National "Doamna Stanca" (Romanie), Liceo Montale (Italy), and Logopsycom (Belgium).

As this material will cover the technical terminology and the general explanation of virtual reality therefore before entering the topic, it is important to establish it properly.

Here are the definitions that will allow you establish the difference between Augmented reality, mixed reality and virtual reality:

AUGMENTED REALITY

Refers to a virtual interface, in 2D or 3D, that enriches reality by superimposing additional information on it. It is an extension of reality.

MIXED REALITY

Allows synthetic objects to be added to the real environment in the form of a hologram with which the user can interact.

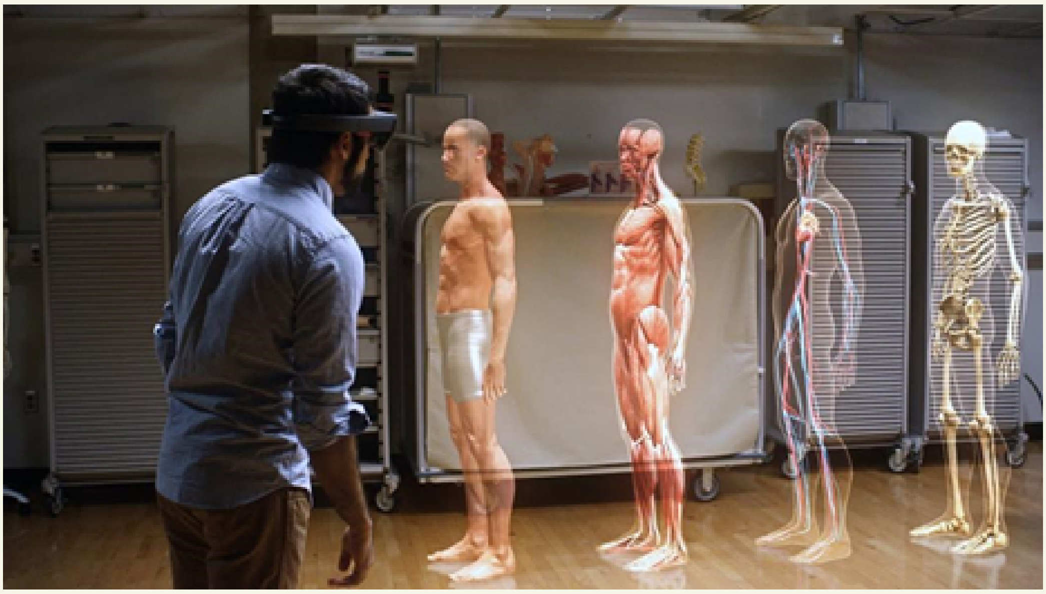
VIRTUAL REALITY

Is a simulation of a digital totally imaginary world based on computer-generated images. It can be a reproduction of the real world or a totally imaginary universe. The experience is visual, auditory and, in some cases, haptic with the production of a feedback of effects. When the person is equipped with the appropriate hardware, such as gloves or clothing, he or she may experience certain sensations related to touch or certain actions.

THE PEDAGOGICAL ASPECTS OF VR

The process of reading an interesting book frequently drives us into the realm of fantasy, allowing to experience non-realizable events and situations: to navigate imaginary spacecrafts into space, to explore non-realistic scenes and fairy tale landscapes and even to travel inside our own bodies. And while the question of the previous century was 'how would we feel if all the images that do exist in the sphere of the imaginary could be transformed into a real experience?', scientists are nowadays able to give an affirmative answer to this question.

And indeed, what seemed impractical can now be accomplished through an innovative technology that borrows knowledge from various widely developed fields such as Computer Sciences, Physics, Biochemistry and Graphic Design, all being put into one multidisciplinary virtual entity which makes usage of the most revolutionary technologies in the development of relevant apps, whilst simultaneously remaining capable of functioning as a 'mirror', or as a reflection of even the most extreme realistic scenarios, without though being deprived of either veritable details or sensory emotions.



Microsoft's HoloLens partners with Western Reserve University.
Image Credit: Microsoft
(Retrieved from: https://www.iotforall.com/augmented-virtual-reality-higher-education/

THE PEDAGOGICAL ASPECTS OF VR

From a technological point of view and as Costa et al (2001) had first argued, Virtual Reality (VR) could be considered as the most natural among all the Man-Computer Interfaces (MCI). Such achievement should be attributed to an array of potentials that this system provides -even to its very unexperienced users-; to navigate into three-dimensional scenes in real time conditions by maintaining a 'multi-sensorial interaction', thus implying both the activation and involvement of at least the four out of five senses; sight, touch, hearing and -in some cases- smell.

This opportunity for multisensorial interaction and activation of most of the human senses has also been the prime argument accompanying the assumption that during the upcoming decade, virtual reality will have attributed a new dimension to the learning experience -as this is being founded on formal education systems-, without though necessarily implying that this 'immersion' within the apps context would be responsible for providing concrete solutions to chronic educational problems but primarily for reinforcing the process of implementing modern pedagogical approaches.

Hence, the theoretical pedagogical component must be the one that ultimately determines the ways in which VR technology will be introduced within the educational framework. During the last decade, scientists have associated VR's educational ramifications with constructivist learning (Barilli, 2012: 144). As Barilli (2012) puts it down: '[...] theories of interaction-based constructivism* and with dialectics brings as fundamental truths:

1) that all knowledge comes from social practice and returns to it;
2) that knowledge is a collective undertaking and cannot be produced in the loneliness of the subject (Vygotsky, 1984 apud Neves and Daminani, 2006).

* 'Constructivism is a new approach in education that claims learners are better able to understand information they have constructed by themselves than becoming passive recipient of knowledge. According to the theory, learning is a social advancement that involves language, real world situations, and interactions and collaborations among learners. Based on the theory, learning involves mastery, self-paced and self-study, which is not restricted to the traditional classroom with minimal interaction. The theory implies that learning can also be in a virtual environment.'
(The International Journal of Modern Social Sciences, 2015, 4(2): 71-81)

According to Beker (1993), authors considered as social constructivists such as Piaget, Freud, Vygotsky, Wallon, Luria, Baktin, and Freinet have the action of the student as a praxis in the medium of the learning process, as their common place, understanding 'praxis' as any intervention of human beings in society and on nature' (Barilli et al, 2012: 144).

And what is being implied here is that the usage of VR could allow students to 'construct' knowledge on their own, as a result of their meaningful experiences. In many cases, the results of scientific research indicate that with the applicability of relevant apps which simulate realistic scenarios within virtual settings, low-performing students have presented an improved academic performance than others who receive knowledge through traditional pedagogical methods (Winn et al., 1997).

This is largely attributable to the potential of VR for students to end up with their own representations of knowledge through the construction of visual and tractable objects, whilst simultaneously invoking already acquired knowledge and previous experiential conclusions. In addition, the potential of VR to transform almost any immersive learning context into customizable, self-paced and actively engaging environment, reinforces the educational landscapes in their totality, as it takes into consideration the existing diversity in terms of individual learning needs, cognitive styles and ability of sensory perception of the outside world's stimuli (Smith et al., 2014).

Construct3D: A Virtual Reality Application for Mathematics and Geometry Education (Retrieved from: www.cg.tuwien.ac.at)

The three-dimensional creatures illustrated within VR apps shatter any obstacles caused by the PC screen and, by allowing physical interactions, achieve to bring as close as possible to the user the feeling of a pragmatic realization (Kirner and Siscouto, 2007: 4).

Besides, it creates conditions which enable essential learning processes to flourish, and which require an array of competences, such as analytical skills, problem identification, analysis and solving, as well as decision-making abilities.

VIRTUAL REALITY. A NEW WAY OF TEACHING

If we ask our pupils what emotion they associate school with, “boredom” would probably be the answer (Larson & Richards 1991, Mora 2011). Bored students can face consequences such as low attentiveness (Farmer & Sundberg 1986), less effort (Pekrun, Goetz, Daniels, Stupnisky & Perry 2010), negative affect (Harris 2000) and shallow information processing, that often lead to low grades and drop out (Dube & Orpinas, 2009, Wasson, 1981). Boredom also has a negative effect on cognitive and metacognitive skills, preventing students to reach their potential.

But why do children and adolescents feel bored at school? Traditional methods of lecture-based education lead to disengaged students, who, dissatisfied by the negative experience of a passive learning, often tend to drop out of school. By contrast, the more students are engaged in the learning process, the bigger their chance is to improve and develop their skills.

We need to find complementary forms of teaching to lecture-based learning, in order to engage students and show them that school can be an exciting place. As discussed before there is a belief that Virtual Reality (VR) could be a way to interest students in the subjects and to stimulate their curiosity.

Besides, the strategic introduction and further incorporation of such kind of technological applications within the official learning curricula of school subjects which have typical reputation of being boring, irrelevant or low appeal like STEM oriented fields, can provenly pique the interest and stimulate curiosity of even the most disinterested or low-performed students, thus growing the academic potentiality of this innovative pedagogy (Costa and Melotti, 2012).

VR INCREASES STUDENT ENGAGEMENT

Virtual Reality is an interactive and immersive experience. Students can do something they have never done before in a safe environment: it is possible to simulate trips to places of interest such as monuments, oceans, the Moon, the space, the human body, etc. (Lau & Lee 2015). Students are free to explore the setting and to learn at their own pace, then they can discuss about their experience with their mates, improving overall engagement (Ferriter 2016).

It is also possible to increase interest in subjects students could find boring or irrelevant by providing them with an "immersion" in the lesson. The ability to simulate an environment and increase a student's sense of presence is one of the most important opportunities of VR to create more engaging educational experiences.

VR ALLOWS AUTHENTIC EXPERIENCES

During a classroom-based learning, students Often get distracted by the real world, i.e. their daily experience, and they can't understand why they have to memorize facts that do not seem related to real life. They would prefer a situated learning approach, in which learning is strictly connected to the context and takes place within an authentic activity.

VR gives students the chance to learn from meaningful experiences, dealing with authentic tasks, trying to find a solution to real problems and cooperating with others. Winn et al. (1997) found that academically low-performing students improved more than those learning through lecture-based methods, even more than their high-achieving counterparts.

As regards pupils who attend technical courses relevant to different sectors of Engineering or courses related to various ramifications of Medicine, Bio-Chemistry and Biology, VR provides the possibility for virtual training which allows the students to conduct as many trials (testing) as needed, thus enabling them to re-apply with accuracy, confidence and discipline an identical process in real conditions, by, though, avoiding criticism and without being afraid of making errors that would eventually have been financially affordable, risky or even dangerous for the student's health.

Google's Daydream conducted an experiment which led to the conclusion that people who got VR training learned faster and better than those who were simply shown video tutorials*. There are quite a few apps that will help learners acquire new skills. For example, Unimersiv offers Forklift VR Training, which will teach users how to drive a forklift, how to control it, the gravity and the security rules.

In addition, VR enables the students to attend virtual training within real time conditions, whilst in parallel allowing them to time or assess their performance, by subsequently tracking their total progress.

* https://www.opencolleges.edu.au/learning-online

By provenly having increased the level of student's engagement due to its ability to simulate a vivid sense of presence and immersion in comparison with traditional learning contexts, VR generates a unique multi-sensory, hands-on experiential process that facilitates interactions between actors and objects, bringing into life any phenomenon that had been remaining unexplorable by the learning communities during previous decades.

Crane Training through VR by Bechtel Brothers and ITI (Retrieved from: https://www.roadtovr.com/bechtel-partners-iti-expand-vr-crane-training-capabilities/)

Some VR applications (such as VR Language Learning and Public Speaking VR) also give students a way to practice public speaking without feeling anxious (Virtual Speech, 2016). One of the examples is Mondly, available for Android and Oculus Rift. It focuses on realistic scenarios, like checking into a hotel, riding in a taxi, ordering at a restaurant or chatting on a train. The user has an interlocutor who will respond verbally based on a list of possible answers. There is also voice-recognition software that allows immediate feedback on the user's pronunciation, which is helpful in perfecting speaking skills. Montly VR offers 30 languages, including Chinese, French, English, German, Russian or Spanish.*

In addition, VR allows for practice in a highly immersive environment and closely parallel real-world situations: students can visit any location, historical period and/or person. It is possible, for instance, to give students a glance on their future workplace: Google Expeditions contains career expeditions' experiences, where students can follow a scientist or professional in their laboratories or offices (O'Brien 2016). This kind of technology can be very useful, expecially for schools with low resources: even if students are exploring a virtual space, they can make worthy authentic experiences, that could encourage them to learn more about their interests and/or about their future career, including fields that are usually not so represented in classroom (Butler 2003).

* https://www.fluentu.com/blog/virtual-reality-language-learning/

UNDERSTANDING ANOTHER POINT OF VIEW

One of the most interesting uses of VR is visualising difficult models, such as simulating to be an elderly person, a toddler, or a dyslexic student: studies demonstrated that the use of VR for these purposes signficantly increased empathy towards older and younger generations (Passig, Klein & Neuman 2001; Bailenson et al. 2008); it also improved teachers' awareness of the dyslectic pupil's cognitive experience (Shavit 2005). VR has the great power of creating empathy in students and teachers, immersing them in a realistic experience, changing their point of view and giving them the opportunity to understand a different point of view.

VR ENHANCES CREATIVITY

VR allows users to create something from their imagination and to manipulate objects in order to facilitate the acquisition of difficult concepts. Students can easily shape their abstract ideas and then demostrate their mental models (Winn et al. 1997); it is also possibile to enhance artistic abilities, for example by painting, sculpting, and creating 3D objects using impossible materials, such as fire, snow, stars, thanks to Tiltbrush, a Google application. According to the theory of embodied cognition (Da Rold 2018), this kind of experience increases cognitive learning.

VR: EXAMPLES OF APPLICATION IN EDUCATION

When it comes to the field of Natural Sciences, research indicates that the student, being in the centre of the learning process and by applying the constructivist premises of learning, can fully exploit an array of possibilities provided by VR apps, which allow both the visualization and manipulation of three-dimensional tractable objects.

Hence, students obtain skills which enable them to acquire an accurate perception and a thorough comprehension of even the most abstract scientific mathematical concepts, whilst in parallel gaining the possibility to construct three-dimensional representations of spatial concepts (e.g. for geometric structures and systems), the capture of which could not easily be explained orally or even outlined with the help of two-dimensional illustrations on a piece of paper (Lima et al., 2007: 3).

In Statistics for instance, where data are multi-varied, the interpretation and analysis of data could be interactively conducted in specialized immersion systems which can respond in a variety of cognitive styles, enabling pupils of different levels of performance to comprehend complex data sets.

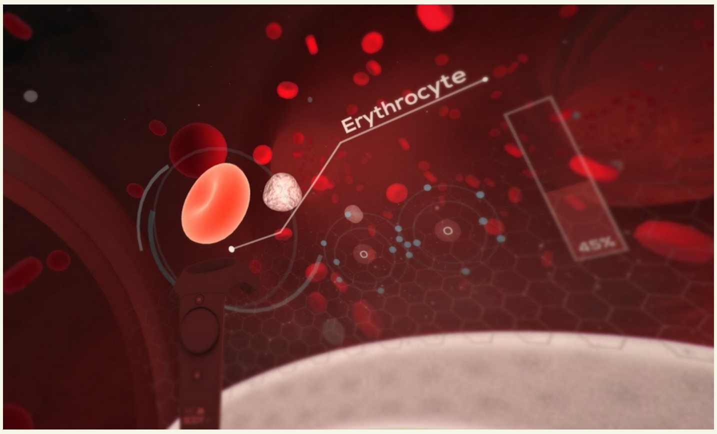
As regards individuals with different cognitive styles, VR technology can offer the student a multiple selection of different methodologies to absorb knowledge; learning by using graphics and images instead of theories/formulas and principles, exploration instead of deduction, active interaction instead of reflection, visual communication instead of verbal communication (Kaufman, 2009).

HERE THERE ARE SOME EXAMPLES OF VR INTEGRATED IN STEM LEARNING:

Plainview-Old Bethpage Central School District in New York:
This school used zSpace workstations to teach different arguments, such as Newton's laws of motion or anatomy (Zaino 2016). Students can interact with the subject taught in a creative and engaging way, by stacking blocks, setting up ramps, dropping out balls; or they can literally turn around a 3D heart, to understand how it is made and how it works, and feeling its beat going faster or slower. Students can explore subjects at their own pace, without feeling ashamed of their mistakes, that become, according to constructionist learning, an opportunity to enhance their skills and knowledge;

Arizona State University:
The virtual-reality biology lab is one of the most interesting ways this University adopted to teach this subject. Through Daydream VR, a Google operating system, students can access to content by logging in with their own google accounts. After logging in, students must "wear" a lab coat and gloves in order to proceed. In this lab, students must take two blood samples from basketball players to determine their blood glucose level. After this experience, they can view what it is inside a glucose molecule, and they are asked to put the molecule in the right place to demonstrate the Kreb cycle (Faller 2018);

The Body VR:
Journey inside a Cell: thanks to this free VR experience, students can travel through bloodstream, discovering how blood cells work to spread oxygen throughout the body: students can also decide to "jump in" one living cell, in order to learn how it works (The Body VR, n/a);

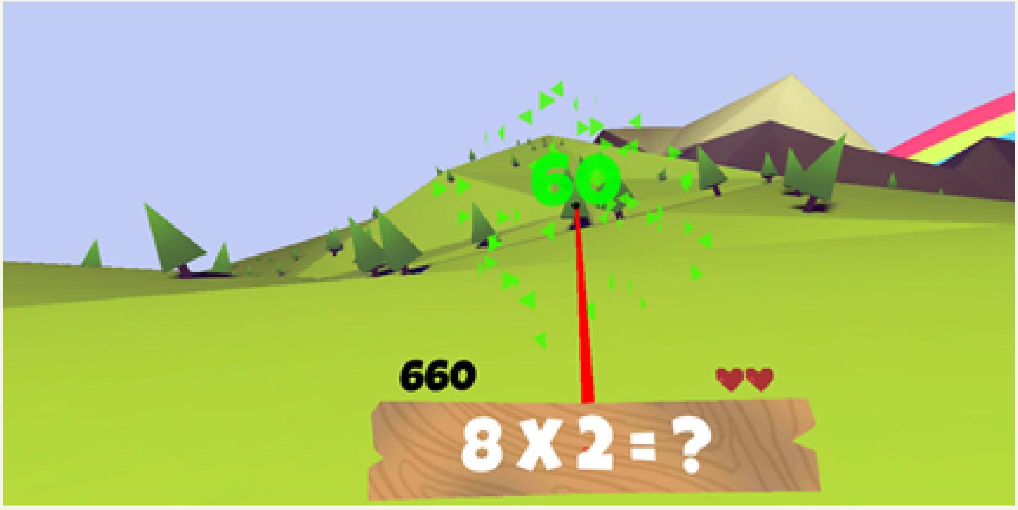


The Body VR: Journey Inside a Cell - HTC Vive Trailer
(Retrieved: screenshot from The Body VR Youtube channel

CalcFlow:
This application, aimed to high school students, gives the opportunity to explore mathematical theorems and scenarios in VR. Features included are: manipulating vectors with hands, explore vector addition and cross product, creating a parametrized function and vector field (Bambury 2018);

VR Math:
The application presents a series of tasks (mostly geometric): students are asked to identify properties like edges and vertices; it is possible to deliver content as a teacher or access content as a student, via VR Headset. This kind of tasks are very useful in order to enhance students' spatial awareness. (Bambury 2018);

4D Toys:
It's an extremely interactive immersion into a 4D world: users must move objects through the fourth dimension by picking them up, then sliding a finger on a touch surface to move back and forth in 4D space. Instructional text appears and reacts to your every grab of objects and swipe through four-dimensional space (Machkovech 2017).



Times Tables VR is a fun way for students to practice their multiplication skills in virtual reality using only their eyes in an immersive 360 degree environment (Retrieved from: https://play.google.com/store/apps/details?id=com.KhoraVR.MathGame&hl=en)

Medieval Math VR:
Another application that uses a lucid approach: students must defend their own towers by firing arrows on a wave of enemies. They must solve math problems in order to earn more arrows. It is possible to play the game with four different types of exercises, i.e. addition/subtraction, multiplication/division, fractions, pre-algebra. (Bambury 2018);

Fantastic Contraption:
This is another example that uses constructionist theory to reinforce principles of physics, where the player builds a machine and if it does not work properly, he or she uses problem-solving skills until it functions correctly (Porter, 2015). In this way it is possible to improve visual and manipulative skills, while learning STEM contents;

EXPERTS OPINIONS

To gain practical perspective on the topic of Virtual Reality in education Math Reality project partners have asked some of international experts and practitioners few questions about their views regarding the use of Virtual Reality in education.

Do you think that if your schools had integrated Virtual Reality in the process of teaching, you would have experienced a better personal and professional development?

"Well, if I had benefited from this kind of teaching, I would have definitely started my business sooner. As for my personal development, a modern way of teaching, using VR, would have made student life a lot easier, as I would have learned from experience; I would have enjoyed lessons more thanks to the possibility to visualize the information provided. Take physics, chemistry and math, especially geometry, for example. VR can revolutionize the whole concept of teaching these subjects, as it could turn them into a hands-on experience."

Ovidiu Pop, CEO of Ovilex,
Romanian company that takes pride in creating some of the best games involving driving and piloting simulations

What do you think about using VR technology in the classroom? What are the benefits and challenges?

I think Virtual Reality definitely has a place in the classroom. In my opinion, it is more engaging and more immersive than any other consumable content in the classroom. It far outweighs textbooks, videos, images, and websites. But it's not something that I think replaces those other mediums of learning. It should be a part of that classroom package that elevates and enhances the learning process alongside those are other mediums.

I've seen first hand how engaging VR can be for students. It has the ability to transport your students anywhere in the world, at any time in history, and even beyond to unimaginable places. But VR, just like with any other learning tool, has its challenges too. Mainly cost of devices, cost of content, and equitable access in schools.

Michael Fricano II
Technology Integration Specialist & Technology Teacher for K-6 at 'Iolani School in Hawaii

What subjects do you think are most appropriate for the use of VR?

It is complex to attribute to a subject the exclusive use of virtual reality since its application turns them into transversal subjects. It is applicable in geography, sciences, history, art, etc.

This technology allows motivating narrative comprehension (new media - storytelling), recreating experiential immersive scripts (User - empathy), imagining and constructing narrative worlds (Mathematics and design - 3D Creation), developing scenes based on facts or data (Mathematics and logic - Programming).

Jordi Martos
an expert in AR, VR and User Experience from PublicVisual in Barcelona

What is the role of a teacher in facilitating lesson which uses VR?

Some might think that VR has the potential to replace teachers in the classroom. But I personally feel like the teacher can never be replaced because of the empathy and personal connections we bring to our classrooms for our students. VR is just another tool in a teachers tool belt. The teachers role while using VR in a lesson is to facilitate the discussions and to ask the important thought-provoking questions that help students to apply what they see in the VR experience to what they already know and what they are learning in class.

Michael Fricano II
Technology Integration Specialist & Technology Teacher for K-6 at 'Iolani School in Hawaii

Humans are important for the relationship to context and learning - without that connection the learning gets lost. Teachers need to facilitate question asking, support for learning and steps prior to using VR and then post VR.

Craig Kemp
An educator with over 14 years experience both in the classroom, in leadership and in consulting, passionate about VR in education

VR: HEALTH RISKS AND SAFETY ASPECTS

VR technology will, in the future, completely change the way we teach, practice or even think of certain things in education. Although the benefits of the application of VR technology in education are enormous, it is also important to be aware that this is a very powerful technology and, hence, it should be used properly and with reason.

There are different contexts to use VR such as education and leisure. But have we ever wondered how long is too long to use virtual reality all at once? Manufacturers like Oculus suggest a "10 to 15 minute break every 30 minutes, even if you don't think you need it". This rest between tasks using virtual reality helps us mitigate and soften symptoms such as eye fatigue, headaches and, in some cases, nausea. Experts say that's because of the way VR affects the eye-brain connection, called the "shame-accommodation conflict".

"In a virtual environment, the way we see and interact changes because we may be projecting into our eyes something that seems very far away, but is actually only a few centimeters from the eye"

Walter Greenleaf, a behavioral neuroscientist who has studied VR in medical settings for more than 30 years, who works with Stanford University's Virtual Human Interaction Laboratory.

This way in real life, our eyes naturally converge and concentrate at a point in space, and our brain is so accustomed to this that it joins the two responses together. However, virtual reality separates them, confusing the brain.

Some manufacturers have set a cut-off age, usually age of 13, while PlayStation VR even set the age limit at 12. However, all manufacturers state that VR should not be used without adult supervision. With that in mind it is very important that teachers are always present when VR is used in the classroom and that they pay close attention to users for involuntary muscle twitched and loss of balance as a signal of potential problem.*
To avoid such side effects, it is recommended to use frequent breaks, adjust headsets, tighten or loosen straps, and fix the focal distance or eye distance.**

* https://amp.cnn.com/cnn/2017/12/13/health/virtual-reality-vr-dangers-safety/index.html
** https://www.vesttech.com/4-health-risks-from-using-virtual-reality-headsets/

Safety information page for HTC's Vive says „While wearing the headset you are blind to the world around you. Do not rely on the product's chaperone system for protection". Thus it is very important that the classroom is secure for activities with VR technology. There should not be any obstacles on the floor or in the manoeuvring area.[1] The Virtual reality health & safety usage guide[2] emphasize that it is important to remain seated using the headset, unless your content experience requires standing.

To avoid skin or eye irritation, hygiene of headset is of most importance. It is necessary to clean the headset between every use with non-alcoholic antibacterial wipes and with a dry microfiber cloth for the lenses. VR headsets should be stored somewhere where they won't collect dust. From time to time it is good to air blow the headsets. Also, people who have a contagious condition should not be sharing a headset with others.[3]

Virtual reality is not appropriate for every instructional objective. There are some teaching scenarios when VR can be used and some when it should not be used. Some authors state that VR can be stored in the brain memory center in similar ways to real – world physical experiences.[4]

Although this is very useful for education and training, it can have serious emotional and psychological consequences if the content isn't appropriate. If the content is fighting, violent or anxiety provoking, it can cause the body to react physically, including increasing heart rate and blood pressure, or induce psychological reactions such as anxiety, fear or even Post traumatic stress disorder. Author Bailens wisely instructs: „If you were to do this in the real world, how would it affect you? That's the way to think about virtual reality. When VR is done well, the brain believes it is real".[5] Thus, it is important that the content is educational, inspirational and appropriate for a certain age.

In conclusion, the application of virtual reality technology in educational purposes has many benefits. It provides teachers with new forms and methods of visualization and presentation which have the potential to really make a difference in education and lead students to new ways of learning that are more exciting and valuable. Still, there are certain risks and disadvantages of using VR in classroom[6] that need to be considered. But as with all technology, some of these risks can be eliminated with appropriate use and by following the safety guidelines.

[1] https://amp.cnn.com/cnn/2017/12/13/health/virtual-reality-vr-dangers-safety/index.html
[2] http://www.classvr.com/health-and-safety/
[3] Ibid.
[4] Pantelidis (2009)
[5] https://amp.cnn.com/cnn/2017/12/13/health/virtual-reality-vr-dangers-safety/index.html
[6] Pantelidis (2009)

VR: SOME TECHNICAL TERMINOLOGY EXPLANATION

On the first pages of the booklet we established definitions of VR, AR and Mixed Reality. In this section of booklet we present to you more in depth explanation of what is Virtual Reality.

1. DIFFERENT KIND OF VIRTUAL REALITY SYSTEMS

VR can be immersive or not. That which sets it apart is the use of physical technologies (supported by logical ordering technologies).

- Non-immersive systems: are based on the use of a monitor, mouse, or touch screen. These are simpler and have low cost and are ideal for distance education courses via the Web.
- Immersive systems: Do not allow contact with real-world resources. The most perfected Virtual Reality systems allow the user to feel "immersed" inside the virtual world.

The immersion phenomenon can be experienced through 4 different modalities, depending on the strategy adopted to generate this illusion.

We can find:

- The personal cabin
- The collective cabin (pods, group cab)
- The cavern or cave:
  based on the use of multiple large projection screens arranged orthogonality with each other to create a three-dimensional environment or cavern (cave) in which a group of users is located. Of these users, there is one who takes on the task of navigation, while the others can devote themselves to visualizing the dynamic Virtual Reality environments in real time.
- The isolated operator HMD (head-mounted display):
  is a display device, worn on the head or as part of a helmet. They occupy the user's field of vision in such a way that he has no perception of the surrounding environment, thus allowing the user to fully immerse himself in a virtual reality, as he will only perceive the images created by the computer and reproduced on the screen.

*https://amp.cnn.com/cnn/2017/12/13/health/virtual-reality-vr-dangers-safety/index.html
**https://www.vesttech.com/4-health-risks-from-using-virtual-reality-headsets/

THERE ARE 3 MAIN CATEGORIES OF VIRTUAL REALITY HEADSETS:

1. Mobile virtual reality headset: they are really housings, which do not have their own screen or processor but are prepared to house a mobile phone, in which the images will be reproduced.

Examples of Samsung Gear VR and Google cardboard
(Retrieved from: www.amazon.com

Important technical points to check:

- compatibility with smartphone(s) (screen size and operating system)
- holding system
- battery life of the phone in game situation
- good air circulation in the helmet to avoid overheating

2. Virtual reality headset without processor: they include their own screen and sensors but are connected to an external device (typically a personal computer) to receive the images.

Example headset without processor: HTC Vive and Oculus Rift
(Retrieved from: www.amazon.com

Important technical points to check:

- computer power and system requirements
- number and length of cables
- easy installation of the device
- space necessary for full use of the device
- storage capacity

3. Standalone virtual reality headset: these are those that include all the necessary components, such as the case, screen, sensors and processor.

Picture 8: Oculus Go headset
(Retrieved from: www.amazon.com

Important technical points to check:

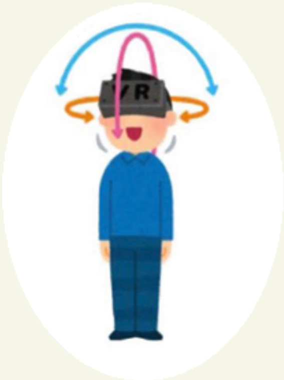
- battery life and charging time
- storage capacity

CHARACTERISTICS OF VIRTUAL REALITY HEADSET

All VR headsets have some form of positional tracking and, although there is a significant disparity between how different models work. VR headsets can be separated into two types:

- stationary VR (3DoF)
- walkable VR (6DoF)

Degrees of Freedom VR (DoF)



3 Degrees of Freedom

6 Degrees of Freedom

Source: aniwaa.fr (adapted from @YuukiOgino)

THE 6 DEGREES ARE:

Rolling: Roll is where the head pivots side to side
(i.e. when peeking around a corner)
Pitching: Pitch is where the head tilts along a vertical axis
(i.e. when looking up or down).
Yawing: Yaw is where the head swivels along a horizontal axis
(i.e. when looking left or right)
Elevating: Elevation is where a person moves up or down
(i.e. when bending down or standing up)
Strafing: Strafe is where a person moves left or right
(i.e. when sidestepping)
Surging: Surge is where a person moves forwards or backwards
(i.e. when walking)

THREE DEGREES OF FREEDOM (DOF) – ROTATIONAL MOVEMENT

The 3 rotational movements are pitch, yaw, and roll. These movements are tracked by most HMDs' on-board sensors. As you tilt and turn your head, the HMD senses the movements and alters its display accordingly.

Rotational Movements are tracked by IMUs or inertial measurement units consist of accelerometer, gyroscope and magnetometer. These IMUs measure the HMD's velocity, orientation, and gravitational forces to infer rotational orientation and movement.

The 3 IMUs are often marketed as having "9 DOF". The 9 DOF are calculated by adding up the 3 DOF detected by each IMU. In reality,accelerometer, gyroscope and magnetometer all measure the same 3 DOF: pitch, yaw, and roll.

In essence, these tools allow a device to measure how it is moving in three types of directional rotation (aka 3DoF). Certain user movements are registered by these sensors and translated so that the VR program running on the phone can respond in real-time.

SIX DEGREES OF FREEDOM (DOF)
ROTATIONAL AND TRANSLATION MOVEMENT

TRANSLATIONAL MOVEMENTS

The 3 translational movements are left/right, forward/backward and up/down. These movements are usually tracked by an external camera or other sensors. Few HMDs use on-board sensors to track translational movements.

The ability to tracking translational movements is required for positional tracking, the ability to determine the absolute position of an object in a 3D environment.

Incorporates the three rotational measurements (rolling, pitching and yawing) and adds three further directional movements that allow a person to physically move around in a virtual space, rather than simply standing in one spot.

With Six Degrees of Freedom (6DoF) both the headset and the controllers worn by the user are tracked. This can be achieved either by using external sensors to capture movement (known as outside-in tracking) or using sensors attached to the headset itself (called inside-out tracking) which continuously relays the positions of the headset and controllers back to the computer.

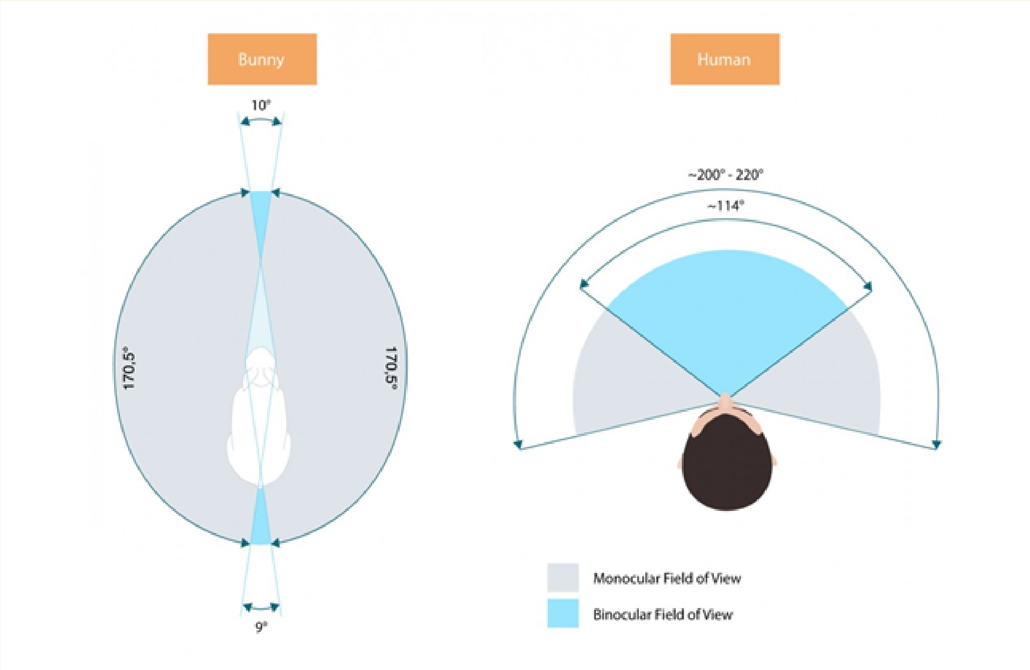
A. RESOLUTION

Since the screen is viewed extremely close to the eyes, it is essential that the resolution it proposes is as high as possible. The higher it is, the more immersion will be important. Otherwise, we obtain a grid and pixelation effect.

Another criterion is the depth of black. With classic LCD screens, LED screens or FULL-LED LCD screens the black is not "deep", i.e. it appears dark grey. With OLED and AMOLED technology displays, a black pixel is really black. The contrast (the passage between a dark and a light area) is thus much better.

B. FIELD OF VIEW (FOV)

Humans have a binocular stereoscopic field of vision that allows them to perceive 3D objects of approximately 114°.



Source: VR Lens Lab

The pair of lenses in the helmets allows the standard vision of the screen to be replaced by a resemblance to reality. These special lenses define FOV. If a large FOV allows good immersion, the essential factor for a good VR experience is the perfect match between the FOV and the screen size.

C. DEGREE OF INTERACTION

The idea of interaction is connected to the capability of the application to detect the inputs from the user and immediately change the virtual world and the actions in it (reactive capability)

360° VIDEOS: the only possible interaction is to move the video to the angle we want to see.

Source: airpano.com

Kinect is a sensor-based device that allows users to control and interact with the device without traditional physical limitations, through a natural interface based on gestures, motion, voice, shape recognition, objects and images

Tracking: The tracking devices themselves can be used as tools to interact with the virtual world. To do this, a receiver or target of the tracking devices is coupled to a wireless controller.

Example of different wireless controllers
Source: www.amazon.com

- Head tracking
- Eye tracking
- Hand tracking
- Room scale tracking

Mobile phones: Today's mobile devices have sensors that allow them to measure their position, orientation or speed of movement. This makes it possible to use them as interaction systems (with a functionality similar to a Wii Remote). We are using android devices as an interaction mechanism in virtual worlds.

D. INDIVIDUAL OR COLLABORATIVE ENVIRONMENTS

Individual: Only one person can interact in a virtual world (non-multiplayer video games, 3d Cinemas, etc.)

Collaborative (Multiplayer) It is possible that more than one person shares the same virtual world and interaction at the same time with the same and / or between them.

SUMMARY

Teaching and learning with the aid of Virtual Reality have, as mentioned above, a multitude of advantages, such as: offering visualizations that otherwise would not be possible in the classroom, creating interest and increasing engagement.

It also favors studying with less effort, as it is based on the creation of experiences. The emotional connection offered by an immersive first-person experience increases motivation and has a greater impact on learning processes. As a disruptive tool, it provides students with the skills associated with tasks such as exploring, interpreting, analyzing, solving problems and communicating.

Given the great range of apps to choose from, VR aims to improve the quality of education in many different fields. It transforms the figure of the teacher: going from an instructor to a facilitating and orienting agent in the conscious, pedagogical and critical use of these contents or technologies. Plus, it promotes the student body as the creator of experiences, as well as the practice of skills and competences inherent to the creative process.

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