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EDUCATION IN THE METAVERSE: AMIDST THE VIRTUAL AND REALITY

L'EDUCAZIONE NEL METAVERSO: TRA VIRTUALE E REALE

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Abstract

In the past year the word "metaverse" seems to have become ever more present in an array of publications and projects in different fields spanning from economics, psychology, education, and philosophy to engineering and computer sciences. The founder of Meta has claimed that the metaverse is the future of internet and has described it as "a set of virtual spaces which you can create and explore with other people who aren't in the same physical space as you […] it will be an embodied internet operated by many different players in a decentralized way". During the Meta Connect conference in October 2022, Microsoft announced their collaboration with Meta for the development of Microsoft Teams Mesh to bring Teams into the metaverse. In addition, Meta has launched Horizon Workspace, Zoom has created Zoom VR, there are different releases of Moodle VR, Google AR/VR division is working on features of Workspace for Virtual Reality whereas the majority of Learning Management Apps have already developed features and versions for VR or for metaverse. This massive use of Extended Reality (with the metaverse or with other similar technologies) will have a high impact on the way we teach today and in the future. To date, it seems that we do not have sufficient lexis to

analyze the implications of the use of this kind of technology in relation to teaching learning processes, and in this perspective simplex didactics seems to offer a possible path to initiate this debate.

Nell'ultimo anno il termine "metaverso" sembra essere diventato sempre più presente nella letteratura scientifica in ambiti fra loro anche molto diversi quali quello economico, psicologico, educativo, filosofico ,ingegneristico, informatico ecc. Il fondatore di Meta ha affermato che il metaverso è il futuro di Internet e lo ha descritto come "un insieme di spazi virtuali che puoi creare ed esplorare con altre persone che non si trovano nel tuo stesso spazio fisico […] sarà un internet incarnato gestito da molti attori diversi in modo decentralizzato". Molti dei software più usati per l'erogazione della didattica a distanza stanno già sviluppando features specifiche per il metaverso. Durante la conferenza Meta Connect nell'ottobre 2022, infatti, Microsoft ha annunciato la collaborazione con Meta per lo sviluppo di Microsoft Teams Mesh per portare Teams nel metaverso. Inoltre, Meta ha lanciato Horizon Workspace, Zoom ha creato Zoom VR, ci sono diverse versioni di Moodle VR attualmente disponibili, la divisione AR/VR di Google sta lavorando sulle funzionalità di Workspace per la realtà virtuale. Questo uso massiccio della Realtà Estesa (con il metaverso o con altre tecnologie simili) avrà probabilmente un forte impatto sul modo in cui facciamo e faremo didattica. Ad oggi, sembra che non si disponga di un lessico sufficientemente sviluppato per analizzare le implicazioni che l'uso di questa tecnologia potrebbe avere in relazione ai processi di apprendimento/insegnamento, e in questa prospettiva, la didattica semplessa offre una possibile via per avviare la riflessione scientifica in relazione a questa tematica.

Keywords: metaverse, simplex didactics, extended reality, embodied internet.

Parole-chiave: metaverso, didattica semplessa, realtà estesa, internet incarnato.

Introduction

In the past year the word "metaverse" seems to have become ever more present in an array of publications and projects in different fields spanning from economics, psychology, education, and philosophy to engineering and computer sciences. Since Facebook inc. has changed its name in Meta inc. in 2021, hence showing an interest in effectively creating the "metaverse", a lot of Big Tech companies have started to make investments in this system. Currently, what the metaverse is, is not totally clear. Indeed, a number of aspects still need to be defined, such as the currency that will be used, the protocols and platforms that will be identified from a software point of view or which laws will protect user privacy.

On the other hand, however, there is a clear vision of what it could become in the future. The founder of Meta has claimed that the metaverse is the future of internet and has described it as "a set of virtual spaces which you can create and explore with other people who aren't in the same physical space as you […] it will be an *embodied internet* operated by many different players in a decentralized way[1]". The Washington Post describes the System as "a kind of online playground where users could join friends to play a multiplayer game like Epic's 'Fortnite' one moment, watch a movie via Netflix the next". The latter definition seems to consider the metaverse only as a form of entertainment, but it will involve also other aspects of human life, like work, bureaucracy, education and so on. The definition of Matthew Ball seems to be, from this point of view, more exhaustive. Indeed, the venture capitalist describes the metaverse as "an expansive network of persistent, real-time rendered 3D worlds and simulations that support continuity of identity, objects, history, payments, and entitlements, and can be experienced synchronously by an effectively unlimited number of users,

[1] Retrieved on 21/10/2022 from://www.theverge.com/22588022/mark-zuckerberg-facebook-ceo-metaverse-interview

each with an individual sense of presence" (Ball, 2022, p. 25). What these definitions share in common is the fact that the metaverse will soon be another way to inhabit the internet and the principal medium to foster the users' sense of presence will be the use of Extended Reality (Virtual and Augmented Reality). "Video has become the main way that we experience content […] but this isn't the end of the line. The next platform in media will be even more immersive. An embodied internet where you're in the experience, not just looking at it. We call this the metaverse" [2]. Furthermore, it is interesting to point out that the name *metaverse* derives from the Neal Stephenson's 1992 cyberpunk novel *Snow Crash*, where it referred to a 3D virtual world inhabited by avatars of real people, and it means, literally, *beyond* (from Greek prefix *meta*) the universe (verse), or another universe. On the basis of this information, the metaverse will be a complex social and technological phenomenon. This article will, naturally, focus only on some aspects of it.

Taking into account that, as stated earlier, there are a lot of aspects regarding this new 'world' which still need to be defined, it is absolutely legitimate to ask ourselves whether it is worth worrying about a technology that does not yet exist today. Fully aware that, as history has taught us, it is almost impossible to predetermine the future development of technology, we may argue that the metaverse is only a name that synthetizes an evolutionary trend in technology which, in reality, started various years ago. What we contend is that even if the metaverse is not developed, in the next future, there will probably be similar technology that will alter our perception regarding the level and moments of interaction of when we use the Internet. Eric Smidth's (Google CEO) reply to the question posed regarding the future of the Internet, while on the stage of the Word Economic Forum in Switzerland in 2015 at a panel called "The Future of the Digital Economy", sustains this claim: "Internet will disappear. There will be so many IP address…so many devices, sensors, things that you are wearing, things that you are interacting with that you won't even sense it". As Steenson (2022) point out, what awaits us is a highly interactive and interesting world that will emerge as a result of this disappearance of the Internet (Steenson, 2022). If we had to focus on the "disappearance" alleged by Smidth in 2015, it would seem contradictory but, what it actually meant was that the Internet would have become more and more *invisible*; seven years on, we know that this is what has actually happened.

The development and diffusion of technologies like the Internet of Things (IoT), Non-Fungible Tokens (NFT), Artificial Intelligence (AI), blockchains and, more generally, the evolution of ubiquitous and cloud computing has made this trend possible. All these technologies have changed the web as we had known it before the last decade. The Internet, according to Smidth's words, is nowadays more invisible and we spend much more time browsing it. As a result, if we are always connected, if we are online 24/ 7, how should we interpret the term "reality"? (Accoto, 2022). The philosopher Luciano Floridi synthetizes this technological drive to the hybridization of real and virtual life in his neologism "onlife" (Floridi, 2015). The latter is a term deriving from the fusion between "online" and "life" highlighting the impossibility to keep the "virtual" and the "real" worlds apart. From this perspective the dichotomies virtual/real, online/offline become obsolete and inadequate. Borrowing the slogan from the TV advertisement of metaverse, we can say that internet "can also be considered virtual, but its consequences are real". In this scenario, Zuckerberg's significant investments in this hybridization process, on the one hand, has forced the other Big Tech companies to follow suit, yet, on the other hand, this fusion between the digital and the real life seems to be a spontaneous evolution of the web, irrespective of Meta's agenda. In the end, to a certain extent, Zuckerberg's objective is that of creating an ecosystem with new rules and norms by putting together the existing technology. In other words, if Meta's efforts were to be in vain, most probably, this trend will continue its evolution.

[2] Zuckerberg (2021) "Founder's Letter", retrieved on 21/10/2022 from: https://about.fb.com/news/2021/10/founders-letter/

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Metaverse and education

During the lockdown period and the successive uncertain periods of the Pandemic, the Italian education system, has ensured academic progression through different types of online platforms and Learning Management Systems. The most used applications, as was suggested by the Ministry of Education, were Microsoft Teams, G-suite (now Google Workspace), Moodle, and other applications ranging from Zoom to Whatsapp to guarantee communication. However, what happened during this emergency was that, often, teachers were not able to capitalize the potential this technology had to offer and approached teaching using traditional methods, as they were used to doing in presence (Pace, 2021). With this technological revolution that is gaining ground, there seems to be the risk that our education system will not be ready to take advantage of this progress. In fact, the software cited is being upgraded with specific features for the metaverse. For example, during the Meta Connect conference in October 2022, Microsoft announced their collaboration with Meta for the development of Microsoft Teams Mesh to bring Teams into the metaverse (see figure 1; for more details, the video-presentation can be found at the QR code available in figure 2 or at the link https://www.youtube.com/watch?v=Zm1ucd629A0). In addition, Meta has launched Horizon Workspace (Figure 3), Zoom has created Zoom VR (Figure 4), there are different releases of Moodle VR, Google AR/VR division is working on features of Workspace for Virtual Reality whereas the majority of Learning Management Apps have already developed features and versions for VR or for metaverse. Furthermore, Meta has made a television advert (Figure 5) for the metaverse that is totally focused on teaching and learning inside the metaverse. This is being transmitted internationally via TV channels; in Italy it is being broadcast by mainstream television networks like RAI and Mediaset (the advert can be accessed through the QR code shown in figure 6 or at the following link: https://www.youtube.com/watch?v=Ok2QPG1f2us). It is interesting to point out that the communication strategy chosen is totally focused on how the metaverse will change the way in which we teach today.

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Figure 1

Figure 2

Figure 3

Figure 4

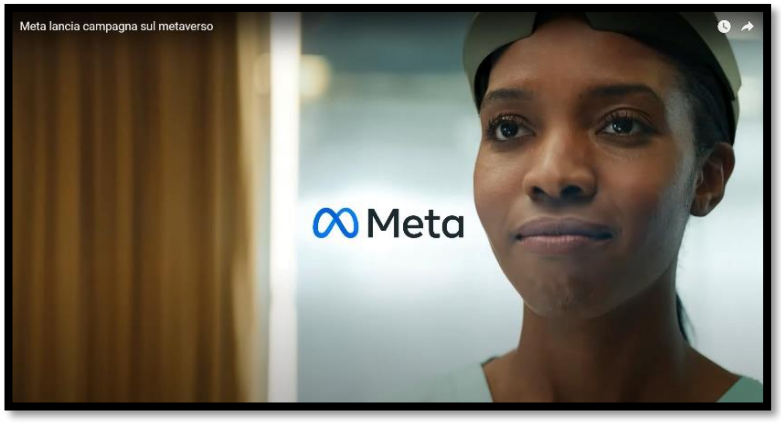

Figure 5

Figure 6

According to Zuckerberg, the metaverse will be the next evolution of the web. It will probably modify the way in which we consider the web today, as with other media revolutions which have widened the use and levels of interaction with different forms of media from the mobile phone to the television to printed media and so on. This web 3.0 is described as an embodied internet, so one of the aspects that seems to characterize the metaverse will be a high degree of body involvement in human machine interactions. In this perspective, it appears that one of the media that will be central in the metaverse will be Virtual Reality.

Based on these premises, it can be claimed that the metaverse (or other similar technology) will have a strong impact on the way we teach today not only in schools but also universities. Thus, it is timely to initiate a debate on the different aspects that characterize it but also reflect how the massive use of a medium like Virtual Realty will impact the teaching-learning processes. This work concentrates on the latter aspect. More specifically, the research hypothesis from which the article starts is that the massive use of VR can significantly redefine the concept of inclusion, creating new opportunities for accessibility and new forms of exclusion.

Bit legs and rubber hands: a perspective on the metawelt

Describing what VR is, is definitely not a trivial task. Starting from description available in Wikipedia, VR is "*a simulated experience that employs pose tracking and 3D near-eye displays to give the user an immersive feel of a virtual world*"[3]. The Encyclopedia Treccani describes is as a "computer simulation of a real situation with which the human subject can interact, sometimes by means of unconventional, extremely sophisticated interfaces, such as headsets and data gloves aimed at translating movements into instructions for the software"[4]. Both the definitions indicate that the VR is a medium based on a higher degree of body involvement in the Human Machine Interaction and that the VR is a simulation of real experiences or situations, but if we analyze the etymology of the term 'virtual', we understand how the true potential of this media is not in the simulation but in the creation of new forms of reality. The term virtual derives from the Latin word '*virtus*' which means 'strength' or 'power', from which late medieval translators, having to render the Aristotelian term '*dyna-mis*' into Latin, coined the neologism '*virtualis*' understood as 'potential'. In this sense, the original dimension of virtual reality is not simulation, as is usually assumed, but potential. It is what can come to be, the latent power of a thing (or a body). It is not the illusory nature of the simulated copy, but the dimension of possibility inherent in all of reality (Accoto, 2022). Also, if one of the main characteristics of the VR is a high degree of bodily involvement in forms of human-machine interaction, the involvement of the body does not imply that a virtual avatar, personified by the user, must necessarily replicate the same properties of the human body (avatars can take on non-humanoid forms). Basically, in this perspective, space, time and body become aleatory and unpredictable variables.

Literature on VR technology suggests that the involvement of the body stimulates a 'sense of presence' (Coelho, 2006; Riva, 2014), of 'being there' in the virtual world. But what happens when a user 'is there' with a body that is completely different from his human body? According to Maturana and Varela (1987), if we consider the body as a *knowledge machine* that builds meaning on the basis of interactions with the surrounding environment, we can argue that different body structures, *different machines*, result in different meaning processes and, in turn generate different kinds of learning processes. According to Uexkull (Kull, 2021), the living organism lives in the same physical world, but not in the same environment (Umwelt). The latter is developed through the interaction allowed by the structures of their body with the world. In other words, different body structures interact with the same physical environment in different ways, generating different perceptions, or different *umwelten*. To explain this concept, figures 7 and 8 show a draft made by Uexkull that illustrates how the same environment is perceived differently by a human and a bee.

[3]Retrieved on 21/10/2022 from: https://en.wikipedia.org/wiki/Virtual_reality
[4]Retrieved on 21/10/2022 from: https://www.treccani.it/enciclopedia/realta-virtuale

Figure 7

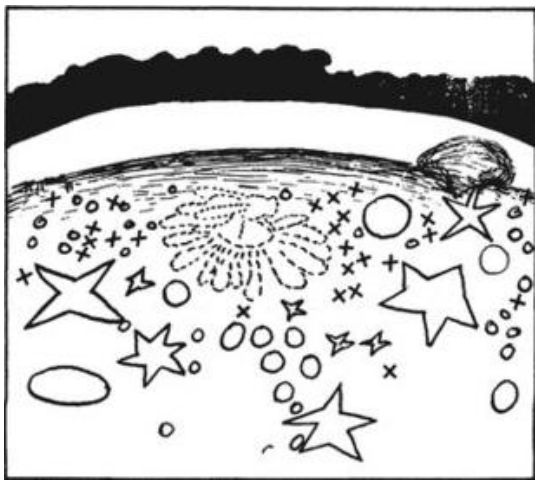

Figure 8

In line with this view, according to Kull (2021):

> A basic idea of the Umwelt is […] that organisms are communicative structures. What organisms can distinguish is dependent on the design of their structure and on the work of their functional cycles. The latter, which consist of perception and operation, are responsible for creating the Umwelt. Umwelt is an entailment of the perceptual and operational world (Merkwelt and Wirkwelt). And each Umwelt forms a closed unit in itself, which is governed, in all its parts, by the meaning it has for the subject, (Uexkull 1982: 30). From this it appears that signs and meanings are of prime importance in all aspects of life processes. Correspondingly, Emmeche (1998: 11) has defined life as a functional interpretation of signs in self-organized material code-systems making their own Umwelten.

In this sense, the human being is a kind of '*animal symbolicum*', a creature "whose distinctive character is the creation and manipulation of signs - things that stand for or take the place of something else" (McLaughlin, 1990). As proposed by the German neo-Kantian Ernst Cassirer, this creature uses its body like a semiotic machine. VR seems to be able to push the definition of the body, according to the *extended mind theory* (Clark,1998: Menary, 2010; Rossi, 2011), beyond the simple continuum of meats and bone, redefining it also beyond (or in a stronger way) what the other media have done so far (McLuhan, 1997), to a new sort of *meta-body*.

Quoting Rizzolatti (2006), using our logical reasoning, if we look at a dog wagging its tail, we can hypothesize that the dog is happy, but we cannot really understand what wagging a tail means because we do not have one. We cannot perceive what interacting with the world by wagging a tail means and what type of social or logical consequences this type of interaction has because our body structure does not allow this kind of interaction. But what happens when a human being acquires a tail through an avatar? Obviously, the question is posed in a provocative way. We do not want to argue here that an avatar can change the brain structure of an individual permanently, nor create forms of *neuro-mythologies* (Rivoltella, 2012). What we want to analyze is what kind of impact the control of a non-humanoid avatar can have on the user. Krekhov claims that "the illusion of virtual body ownership is applicable to animal avatars" (Krekhov, 2018), and, according to Steptoe's paper "Human tails" (2013), if a user has an avatar with a tail, he/she perceives the feeling of having one as part of his/her body. Furthermore, results of this research suggested "the importance of visuomotor synchrony in forming convincing perceptions of body ownership and agency, and that this factor was significant in determining response to perceived threats to the virtual body" (Steptoe, 2013). Therefore, the results of these studies suggest that the sense of presence and the sense of ownership of parts of the body that do not belong to the physical human body can be experienced as *real* by the users. These

are the same parameters which had already been identified in the studies on the illusion of the *Rubber Hand* carried out by Botvinick in 1998. According to Yee and Bailenson (2007) and Carter (2013), the use of an avatar with certain characteristics can change the behavior and self-perceptions of the individual (phenomenon named "Proteus effect") and modify their agency (that is a fundamental variable in the field of Didactics) (Aiello, 2019). In synthesis, as Peter Sloterdijk claims, "*Dasein ist Design*" - existence is design - (Latour, 2008).

Thus, all these aspects seem to justify the economic investment, announced at the Meta Connect Conference of 10/10/2022, that Meta is allocating to the development of devices aimed at:

- extending the control of the Avatar also to the legs in addition to the upper body;
- being able to recognize and replicate expressions;
- using the same Avatar in different apps.

Naturally, these contribute to fostering in users the sense of presence and the sense of identity and to attributing a more natural sense of social interactions inside the metaverse which, as a result, increase the depth and breadth of involvement within this world. In addition, at this point, it is essential to clarify that such improvements in the recognition of leg movement and visemes will not only have the potential to be replicated in the virtual world but can also be used to generate other kinds of interaction. For instance, the movement of a leg can be represented in VR as the movement of a tail or a wing whereas a facial expression, such as a smile, can even produce a specific movement, depending on the code assigned to it. Last but not least, the ability to create one's own avatar and to use it in different contexts and applications, from work to social life, from educational apps to game applications, will strongly contribute to fostering the development of a sense of identity in the user, making the link between users and avatars stronger. The framework depicted seems to present opportunities and risks for an education that, potentially, happen in a 'no-place' with 'variable' bodies.

New 'meat' for the creation of new languages

If we assume that meaning and learning processes are deeply linked to the structure of the body, and that the meaning of things is linked to the structure of the language, it appears clear that one of the major issues regards the fact that we do not yet have sufficient lexis to talk about what interacting in a *no-place* virtual world with a *variable body* will mean. As indicated in the title of this paragraph, borrowed from David Cronenberg's slogan of the 1983 movie *Videodrome*, new bodies (new virtual or real meats) implies new languages. Taking into account Wittgenstein's statement that "the limits of my language mean the limits of my world"[5], it seems that we cannot go deeper in our reflection, and we need to wait until the metaverse concretizes itself before it becomes the focus of further debate. In fact, the major risk is that users, teachers and students in this case, will use these metaverse features in an acritical manner, exposing themselves to the risk of taking on a passive, submissive role when interacting with technology. Furthermore, whereas on the one hand the potential seems to be endless, when considering, for instance, the significant opportunities in terms of accessibility and inclusion, at the same time, this technology also brings with it the big risk of exclusion and digital divide. What we have to avoid, quoting Clarke's third law, is that "any sufficiently advanced technology is indistinguishable from magic". Thus, it is essential to try to think about the language before the metaverse becomes the new norm so as to prevent an inadequate use of it in the future. At least in this case, we need to flip Giustiniano and Dante's affirmation from '*nomina sunt consequentia rerum*' (words are the consequence of things), to '*res sunt consequentia nominum*' (things are the consequence of words). In this regard, the theory of simplexity (Berthoz, 2011), which studies the

[5] Wittgenstein, L. (2022). Tractatus logico-philosophicus. Italia: Feltrinelli Editore.

way in which all living organisms, regardless of the structure of their body, adapt and learn through common principles and properties, and simplex didactics (Sibilio, 2014; Aiello et al., 2021), which aims to capitalize these principles and properties in the teaching-learning processes, appear to be a completely natural starting point to lay the foundations for a reflection aimed at investigating the ways in which teaching and learning can happen in a *no-place* with a *variable body*.

Design and experimentation of an inclusive virtual environment

As a result of these reflections, we tried to design an experiment aimed at testing how to design inclusive virtual environments based on the principles and properties of simplex didactics. Still in its initial phases, the results presented in this article have been yielded from the second phase of the alpha test of the designed environment, which was adjusted on the basis of the data collected in the first alpha test phase (Di Tore, 2022) in terms of the graphical configurations set. The alpha test was aimed at analyzing what happens when a student, irrespective of ability, is exposed to a virtual environment in which an operator is able to remotely manipulate some body characteristics (like height), graphical aspects (vignette effects, light, shadows and color intensity), communicative elements (font types, voices of prerecorded messages) and even the Avatar's movement. For each of these characteristics, the operator has 3 preset parameters. The test is focused to identify bugs inside the developed virtual environment and to try to design, according to the simplex principle of deviation, a different set of parameters that can be useful from a didactic point of view in a virtual environment. In other words, the aim was to create a sort of CSS (style sheet), or a whitepaper for didactics in virtual reality.

Matherial & Methods

The software prototype used in the research was developed by University of Studies of Salerno through the 3d engine "Unity 3d". The prototype was developed to run on the headset "Meta quest Pro 2". All the historical 3d models reproductions presented inside the environment was created through 3d scanning technique. The 3d scanner used is the Shining 3d HD. The video presentations of the historical objects inside the prototype are based on accurate historical descriptions retrieved from the museums that have collaborated on the project. The presentations material and the utilized questionnaire was co-designed and co-developed in collaboration with university students with mental disabilities.

The meta-museum

The prototype presents a virtual 3D environment (a room in a museum) that can be accessed via a Head Mounted Display Oculus Quest 2 or, simply, a mouse, keyboard or joypad in gamepad mode (see figures 9,10 and 11).

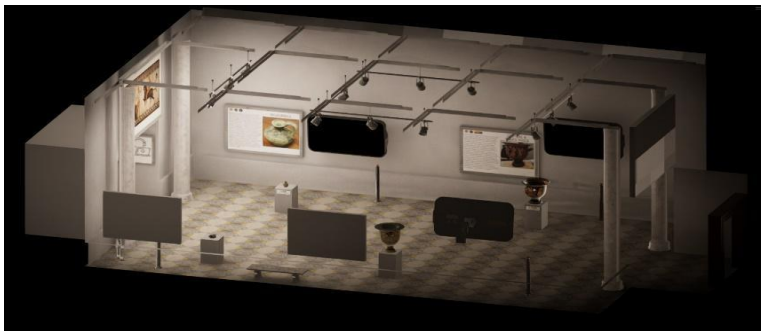

Figure 9

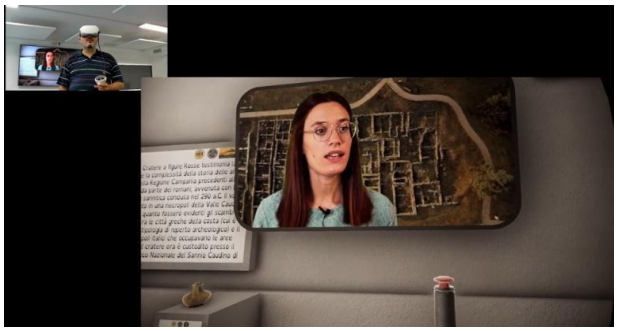

Figure 10

Figure 11

In the VR mode, users can utilize their hands, besides the headset and can physically walk or use a joypad to move around. The prototype, which is currently only accessible on Windows operating systems (in PCVR with Meta Quest 2 or with a mouse and keyboard), can be downloaded for free at the following link or QR Code: https://drive.google.com/file/d/1FTcY-FVuPo932O8VffmCiNrREHv1bJAf/view?usp=sharing

In the room there are historical remains provided by the archaeological museum of Carife (province of Avellino, Italy) which have been scanned and reproduced in 3D. In VR mode, the users can interact with these remains freely using their hands (grabbing, turning, moving, throwing). In addition, the following objects are present in the environment:

• 4 monitors which, when activated through buttons in the room, project a video that explains some of the properties of the archeological remains;

• 4 display cases with written information about the different archeological remains;

• 1 android which, when activated by the proximity of the user, provides an explanation of the historical artifacts.

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In addition, in the VR mode, the software has been designed in such a way that it can be managed by a second user (an operator) who can manipulate different environmental elements and forms of interaction. Specifically, the operator can remotely change:

• the intensity of the vignette effect (Figures 12 and 13);

• the contrast (Figures 14 and 15);

• the intensity of lights and shadows;

• the height of the user's avatar (Figures 16 and 17);

• the font with which the texts are shown in the display cases (Figures 18 and 19);

• the color intensity.

Moreover, the operator can move the avatar remotely using a joypad or keyboard.

Figure 12 medium Vignette effect

Figure 13 High Vignette effect

The vignette effect reduces the user's visual field, attenuating the peripheral visual field, and is used in VR apps to decrease the sense of nausea. In the application created, the intensity of the effect is managed by the operator directly during the game phases. Contrast, lighting and colors are also adjustable to maximize the level of accessibility for the visually impaired.

Figure 14 Low Contrast

Figure 15 High contrast

By default, the app calculates the user's height by itself starting from the distance of the helmet from the floor. However, a minimum height has been set to allow its use by both children and adults. In addition, the height of the avatar can be adjusted in case the user is sitting rather than standing.

Figure 16 user high

Figure 17 modified high

Furthermore, the operator can remotely change the font of the written text shown in the display cases. The three different fonts are Times New Roman, Arial and OpenDyslexic. The latter is a highly legible font that facilitates access to written content by users with reading difficulties. It should be noted that each text is also accompanied by reading via speech synthesis. Therefore, the user can choose the preferred medium freely.

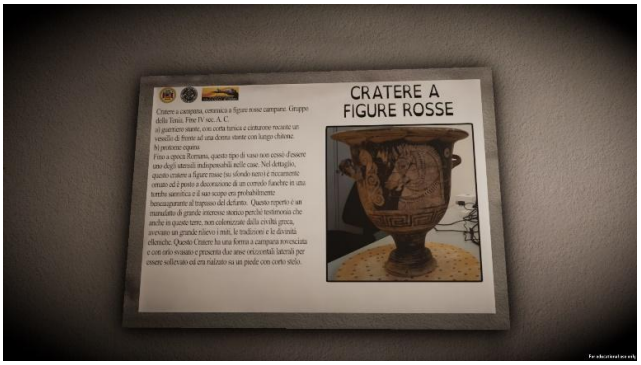

Figure 18 Font Arial

Figure 19 Font OpenDislexic

The tests conducted so far have been carried out in the presence of the developers and with the participation of 7 to 12-year-old pupils, some of whom had special educational needs. During the use of the virtual environment, the operators, in this case the developers, activated the various options described above to evaluate whether or not they influenced the use of the VR environment. Before using the app, all participants were shown how to use the headset and the joypads. While using the app, the operator explained the activities that can be done in the environment and how to activate them. The following questions were posed to the users before and during the experience:

Questions before using the app:

- Do you often play videogames?
- If yes, for how long and which games do you play?
- Have you ever used an app in VR?
- Have you ever seen or used a headset like this before?

Questions during the use of the app:

- Do you prefer to move using the joypad or using your own body? (Asked after the first minute using the app)
- Do you prefer to sit or stand? (Asked after about two minutes using the app)
- Now I will increase the Avatar's height. Do you feel better or worse?
- Now I will activate a vignette effect. Tell me if you think it is better or worse with the effect.
- Now I will modify the contrast. Let me know if you think it is better or worse when I increase the contrast.
- Now I will increase the intensity of the lights and color. Tell me if it is better or worse.

The data obtained from the alpha test phase do not currently allow significant inferences regarding the effectiveness of the accessibility measures adopted in the software. This is mainly due to the small number of pupils with heterogenous special needs who participated in the test (such as autism spectrum disorders, down syndrome, visual and hearing impairment). However, the testing phase produced data that is certainly relevant to correct design elements of the environment. This will be redesigned together with the pupils with special needs involved in the alpha test phase. The aim is to create accessibility configurations differentiated by type of disabilities. Meanwhile, interesting insights into the use of the VR app by the other pupils will be discussed in the following paragraph.

Collected Data

In the alpha test phase 20 pupils aged between 7 and 12 with typical development participated. None of the pupils wore glasses. Following a training phase of about ten minutes, the participants were allowed to explore the environment freely for another ten minutes. The first four questions were posed before the training and were aimed at estimating the users' level of technological confidence. Seventy percent of the participants replied that they had used similar technology for about 4 hours per week. The videogames these participants had used were related to the categories of third-person and first-person games, played on different devices (consoles, PCs, smartphones, etc.). Only 1 of the participants declared that they mainly played puzzle games and strategic games. The study with this type of video game was conducted in the awareness that video games differ profoundly from each other based on their gameplay. First-person and third-person videogames bear some similarities to the forms of interaction that can be experienced within our VR app. On the other hand, puzzles and strategic games present very distant forms of interaction.

Thirty-five percent (n=7) of the participants, of which six were among the 70% of participants who had already had gaming experiences, declared to have already used VR apps. All knew how to use the headset MetaQuest 2 and, thus had, a good level of knowledge with regards to the tool and the medium being used. It should be noted that the alpha test phase was conducted with the primary purpose of evaluating the correct functioning of the software created and identifying any bugs or design elements that could be improved. Therefore, no specific hypotheses were formulated to be evaluated prior to the test. Nevertheless, it was expected that these users who participated in the test, and, even more specifically, from that part of them who already possessed confidence with the instrument and with the media, a certain level of consistency in the choices of interaction and graphic preferences, especially in relation to the changes already made in relation to the data obtained from the first phase of alpha testing (Di Tore, 2022). The data, however, seems to suggest that this did not happen.

With regards to the other questions, twelve of the participants preferred to use the app while sitting down rather than standing. Out of the remining eight participants, only two declared to prefer to move using their body rather than the joypad. Seven preferred to increase the Avatar's height when compared to that calculated by the software. Twelve participants appreciated the use of the vignette effect, four of whom chose the strongest effect. None of the participants liked the intense contrast and lighting. These results show a high level of heterogeneity. Dividing the participants in two groups, one with prior knowledge to VR (group 1) and the other without and previous experience (group 2), statistically significant differences still emerge in both groups with the χ^2 test, in relation to the choices made regarding the characteristics of the virtual environment, described above ($p<0,001$). When comparing the two groups, significant levels of agreement are not obtained in relation to the choices made by the two groups ($k = 0.45$ in relation to sitting down/standing up; $k = 0.18$ in relation to the use of the body/joypad; $k = 0.35$ in relation to normal/intense vignette effect). In full awareness that the analyzed sample does not authorize any form of statistical inference, it is however interesting to note that the tests conducted represent, at least in the analyzed sample, a situation of almost total heterogeneity. 20% of users (4 participants) declared that, in the absence of the changes made, they could not use the VR environment for the time required (20 minutes) due to undesirable effects (nausea, dizziness, headache etc.). The concept of accessibility in this sense could, in the future, embrace a much wider user category, regardless of the presence of disabilities, disorders, sensory deficits or social conditions.

Conclusions

In conclusion, we can say that a massive use of Extended Reality (with the metaverse or with other similar technologies) will have a high impact on the way we teach today and in the future. The experiment described above seems to suggest that each participant experienced the virtual environment and found different ways to feel comfortable in it. One of the risks that emerged from this test is that also users without special needs can, in certain conditions, experience sickness or uneasiness using these technologies. Thus, on the basis of this data, the use of such technologies may broaden issues regarding accessibility, generating new forms of digital divide. Indeed, these *reality technologies* (Accoto, 2022) seem able to change the way in which phenomena present themselves to the conscience, and, so, they are, in some way, able to create a new phenomenology. To date, it seems that we do not have sufficient lexis to analyze the implications of the use of this kind of technology in relation to teaching learning processes, and in this perspective simplex didactics seems to offer a possible path to initiate this debate.

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