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Virtual Reality in Education: Attempting an Epistemic Justification

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ABSTRACT

In discussing the limits of human knowledge, physical objects are, in principle, not identical to the apparent ones. This is because the latter depend also on the observer. Virtual reality (VR) models are environments that address the senses and therefore belong to the apparent space. Therefore, they seem to prevent an epistemic justification. Based on that, this paper discusses VR technology's potential to provide knowledge of external reality to students. This is particularly important in light of the conditions imposed by the COVID-19 pandemic, which have led to an increasingly significant role of VR related technologies in education. The research question of this study is whether VR models being used as educational tools, bring us closer – or not – to knowing the properties of physical objects. The main focus of this epistemic investigation is Russell's theory of perception with an emphasis to the concept of space. Analysis indicates that VR is educationally useful especially when it comes to objects that are absent from our perceptual range. VR technology brings us closer to the theoretical properties of non-perceptual objects, those that cannot be perceived by the senses, like exoplanets. Furthermore, it brings us closer to the non-perceptual properties of directly perceived objects, properties referring, for example to subatomic structures. In a theoretical level, this macro and micro "terra incognita" may be linked to the *sensibilia* entities proposed by Russell (1914).

1. Introduction

The ability of knowing the actual properties of any physical object has always been a source of fruitful discussion. A physical object is one that can be dealt with using physics. The way this object is perceived – determining thus our knowledge of its properties - depends on three parameters: the observer, the object and the surrounding conditions. Accordingly, the three places associated with any given percept are: (1) the place in physical space where the object is, (2) the place in physical space where I am, and (3) the place in my perspective which my percept occupies in relation to other percepts (Russell, 1959). For example, the color of a rose, e.g. its redness, depends on how my eyes perceive the rose, as well as on the conditions under

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which I perceive it (e.g. perspective, light, etc.). Thus, knowing something is a complex perceptual process.

Today, Virtual Reality (VR) technology demonstrates a further step in exploring how knowledge on external/non mental or physical objects can be acquired. Technological developments in this field have led to the use of techniques in 3D graphics (e.g. constructive solid geometry) which allow the creation and display of a complex surface or object. Geometric data, such as length, width, height and depth, are the basis for the three-dimensional modeling and display of objects through specialized software. All 3D objects are demonstrated as collections of points in 3D space. These points are connected to each other through various geometric entities such as triangles, straight line segments, curves, etc. So, physical objects, like those found in external reality are virtually simulated. The discussion about the epistemic value of VR is reinforced, especially nowadays, by the conditions incurred due to the COVID-19 pandemic. Digital learning has largely replaced in person learning, and estimates suggest it will play a leading role in the future (Sousa & Rocha, 2019; Tvenge & Martinsen, 2018; Grand-Clement, 2017).

Furthermore, educational research needs to highlight essential and robust pedagogical technological designs. In order to ensure the sustainability of education’s shift to a virtual format, learning and teaching must be founded on guiding principles with an epistemological justification. Based on the above, the research question of this paper is whether VR models being used as educational tools bring us closer - or not - to knowing the properties of physical objects. Or in other words, whether the educational use of VR provides real knowledge about the world around us.

The main focus of this paper will be key points of Russell's theory of perception and the concept of “space”. The originality of this paper is that, unlike most modern researches, it is a purely theoretical investigation aiming at the epistemological foundations of VR.

2. VR and education

What is Virtual Reality? VR may be defined as an immersive, multi-sensory experience (Gigante, 1993, p. 3). It is also associated with the term “telepresence”. According to Steuer (1995, pp. 35-36) when a technological medium mediates the process of perceiving things – e.g. to our eyes, a device mediates (either in whole or in part) vision -, the user ends up perceiving two separate environments at the same time: 1) the physical environment in which he/she is really present and 2) the environment presented to him/her through the medium. The term "telepresence" is used here to describe the superiority of the second environment, as an experience, over the first. It represents the degree to which one feels that one exists within the constructed rather than within the apparent natural environment. It is the subjective sense of being there, in a setting that is portrayed by a medium (Barfield et al., 1995). “Telepresence” refers thus to the "mediated" perception of the environment. In addition to the technological requirements that are essential in order to achieve that perception (e.g. high quality virtual graphics, immediate response and accurate motion detection), human factors (such as sense data qualities, specific mental processes and past experiences) also play a key role in this process. Thus, subjective perception, although filtered through technology, is what ultimately determines the achievement of a successful telepresence (Thornson, 2009).

The incorporation of VR in education and e-learning is considered as a natural evolution of computer-assisted teaching. Children and young students interact and learn in a virtual environment and VR models have the prospect of simulating knowledge, inspiring imagination and enhancing understanding (Almusawi et al., 2021; Rustempašić & Habul, 2020). Furthermore, the educational use of a virtual environment may, in some cases, prove itself more useful compared to direct experience. As reported by Bowman (1999, p. 318), experience is only a part of practical training. In fact, it is dangerous to rely solely on experience. Empirical data could lead to wrong cognitive models (for example, one might observe that the free fall of a brick is faster than the fall of a feather, and thus erroneously conclude that gravity acceleration is based on the mass of an object. Of course, some concepts cannot be observed empirically and directly in the world, such as the interactions between subatomic particles. In these cases, a virtual environment can provide an important first step of understanding, along with pre-existing personal knowledge (background) and information available from teaching. For Pantelidis (2009, pp. 63-64) an important advantage of using VR in teaching is that it encourages student participation and captures, to a great extent, their attention. It can also depict features and processes more accurately, as it offers the ability to focus on an object and examine it more accurately. For example, once a molecule has been modeled in a VR environment, students can study it in detail by entering the virtual model of the molecule, roaming in it etc. This way, students become acquainted with the molecule's components.

Medical education and training makes extensive use of VR technology. Researchers are deploying VR to teach mindfulness strategies to patients. For example, they are reconfiguring the scans of COVID-19 patients in order to examine them alongside lab work. This way VR can potentially accelerate learning as far as patients are concerned and supplement the traditional in-hospital medical training (De Ponti et al., 2020). In engineering education, VR applications could prepare graduates for practical experience of real industrial environments. They offer engineers the opportunity to apply theoretical knowledge to real industrial problems and develop their creativity, team-working and problem-solving skills. So, interactive and immersive 3D visualization is promising for the engineering education and research by offering an innovative technology that can be employed to produce creative learning and training in engineering material and environments (Bohné et al., 2021; Abulrub et al., 2011).

There are, of course, also arguments against the use of VR in education. According to Chen (2006, p. 39), although VR seems to offer promising instructional benefits, there are still a lot of issues that need further investigation. These include the need to: identify appropriate theories and/or models to guide its design and development for educational purposes, explore how its features support learning and whether its use may improve performance and comprehension, as well as investigate its effects on students of different abilities.

3. Real and apparent space

When referring to virtual reality we mainly refer to virtual space. Virtual space, made possible by sophisticated technologies of virtual reality and artificial intelligence, enables "existing" in a simulated universe that looks and feels like our physical world. So, if an answer is sought, to the question of how and to which extent VR technology brings us closer to the inherent properties of physical objects, a first reference must be made to the concept of "space".

As already mentioned, physical objects are those dealt with using physics. They represent the constituents of the actual world. Physical objects occupy real space and are not necessarily identical with the apparent ones. In the epistemology of perception there is a distinction between real and apparent space. Russell (1912/2001, p. 14) cites as an example a round coin, which we consistently consider to be round, although it would look oval if we did not look at it from a vertical angle. Similarly, the railway tracks do not seem parallel to us while we look at them extending to the horizon, despite the fact that they are indeed parallel to each other. Sensory knowledge applying to apparent space seems imperfect to grasp the actual constants, the inherent properties of each physical object. This type of knowledge applies to the apparent qualities of an object, which of course depend on the observer and the surrounding conditions and are certainly personal.

Apparent qualities are perceived by the senses and the mind. But there are certain elements that cannot be perceived. Russell introduced the term "*sensibilia*" to describe those objects that are found in places where there happen to be no sensory organs/minds. These objects are supposedly real although they are no one's data (Russell, 1914). They are unsensed particulars that become sense data when a perceiver becomes acquainted with one of them. *Sensibilia* belong to real space. In addition, the actual invariable properties that we potentially perceive through our senses, and which are of certain scientific interest, occupy some space - a real or physical space outside the apparent space of each individual. This real, scientifically centered space is common to all, while the apparent is strictly personal. Our senses are personal and the apparent properties (e.g. shape, color, etc.) are perceived by our senses, therefore the apparent properties (e.g. shape, color, etc.) are personal.

The following diagram represents the two spatial concepts as sets.

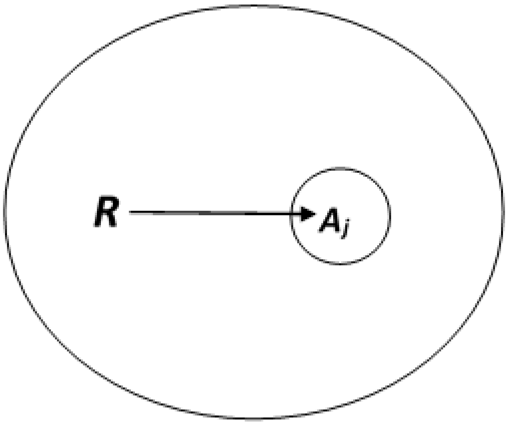

Figure 1. A representation of the apparent (Aj) and the real (R) space for any individual j

As shown in Figure 1, the two spaces are not completely identical. Personal space is a subset of the real space. Even though physical objects are not identified with the phenomena we perceive as sense data, they can, nevertheless, trigger our senses. In other words, there is a causal relationship between the two objects. Real/physical space functions as a field of causes and apparent space as a field of effects ($R \rightarrow A$). It is only through the causal action of the outer world upon us that we are able reflect the world. These causal lines enable us also to be aware of the diversity of objects (Russell, 1959, p. 24). In order for the connection ($\rightarrow$) between the physical property and the sensory one to take place, there must also be appropriate conditions that allow this causal relation; a common space containing both the object and our sensory organs. For example, we need to be able to smell something to get the sense of smell for it. I need to be close to that something. Thus, the observer and the real/physical object, which is an object of perception, are in the same physical space.

4. VR space

Within this physical space, VR space may be considered as a subset of the apparent one. Personal VR space does exist, especially in collaborative virtual environments. There, users tend to maintain, in a similar way to the physical world, a distance when they are interacting with each other [Nassiri et al., 2010; Wilcox et al., 2006). Furthermore, it is a virtual environment of a completely synthetic character that allows the introduction of visual, auditory and other data. In that sense it is a synthetic space where technology interacts with human senses, which in turn determines the extent of personal space. It is a sub-field of effects or a field of sub-effects properties (see Figure 2).

The senses identify virtual space with the personal space, while technology seems to separate them. The artificial-synthetic nature of VR also allows the capture of unsensed reality. Here the cause is epistemological, not ontological. Knowledge of things that are not directly perceived through the senses leads to their simulation, not to the things themselves. Therefore, a distinction can be made between the objects/properties in real space which we can perceive through the senses and the objects/properties belonging to the space that is necessary for the actual world but cannot be perceived by our senses. The objects and properties in the latter space refer to a micro (Figure 2, R_1: e.g. subatomic particles) and macro level (Figure 2, R_2: e.g. exoplanets).

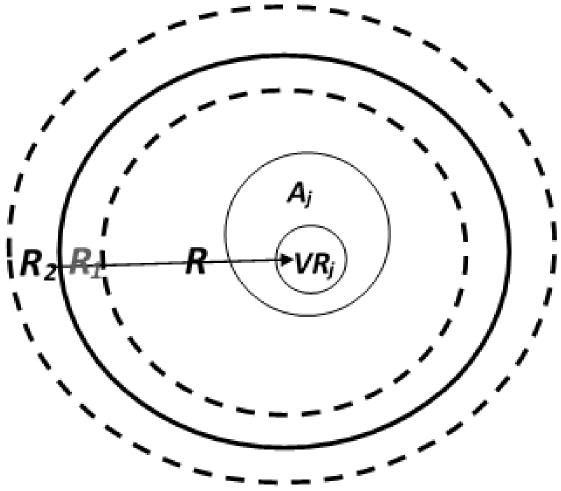

Figure 2. A representation of the apparent (Aj), real (R) and virtual VRj space for any individual j (R_1 represents non-directly perceptual properties of physical objects and R_2 non-directly perceived physical objects)

Furthermore, the VR space can be defined as part or subset of the apparent space, more limited due also to the non-use of all senses' capabilities. Within VR, the senses of sight and hearing have a primary role. Touch or, more precisely, the idea of touch plays a secondary role. A possible next step in VR technology may be the further integration of touch as well as the introduction of taste and smell. Particularly in multisensory devices there are already technologies that structure and shift thresholds of taste and smell in order to develop new perceptual experiences. Virtual stimulation of smell and taste is considered as an important step in expanding the technology related to multisensory communication and virtual reality (Kerruish, 2019; Cheok & Karunanayaka, 2018).

Based on these findings, the following argument can be formulated:

1. Apparent space is necessary for the understanding of the real properties of things.
2. VR as a synthetic space is a subset of apparent space.
3. VR simulates non-directly perceived objects/properties.
4. Non-directly perceived objects/properties belong to real space.

∴ VR is needed to understand the real properties of things by simulating non-directly perceived objects/properties.

This conclusion represents the educational utility of VR models and is in agreement with the findings of (Bowman et al., 1999; Pantelidis, 2009). VR is useful when it refers to non-directly perceptual properties (e.g. outer space and the core of Earth, the behavior of elementary particles, behavior/strength of materials under extreme temperatures, nanotechnology, etc.);

properties that are, in fact, only in real space. Of course, VR can be also useful as a tool for understanding the properties of personal and immediate perceptual space. But its usefulness does not entail new knowledge but rather an enhanced outlook on external reality.

An insightful reader might ask at this point: How is the epistemological use of VR justified, since it is merely a sub-field of the limited apparent space of any human being? One answer is that, although VR space is a sub-field of apparent space, the former has a strong advantage over the senses. This lies in its ability to process a huge amount of both apparent effects and theoretical knowledge; knowledge that differs from empirical knowledge. It thus combines data from these two epistemic sources, having, additionally, the ability to digitally represent them. This use of background theoretical knowledge, as a parameter, upgrades VR from a simple personal experience to a platform of reliable projections of the world.

With regards to the interaction between real and apparent space within a virtual environment - which is given as far as our senses are concerned - it continues to be valid, although the fact that there are predetermined digital geometric structures seems to weaken its validity. This weakening is due to the fact of knowing in advance that there is a pre-designed and specific micro-environment representing real entities. There is an artificial creation instead of the most "unpredictable" and "mysterious" natural one. Based on this, the distinction between apparent and real metric spatial elements takes on a different character. The interaction between them is determined by the quality of technological means.

5. Conclusion

In VR modelling, the actual object, as a necessary condition of perception, is absent. What exists is a representation of the object. Upon it, each observer/user enacts his/her perceptual ability. This ascertainment limits, in principle, the possibility of knowing the external world. However, when the object is not within our perceptual/personal range and space, VR can be labelled educationally useful. Therefore, this kind of technology, which is advancing at a high rate lately and especially during the pandemic, is actually useful when it comes to objects/functions not perceived by the human senses. That is, when it corrects/strengthens our, by nature, imperfect sensory organs.

Furthermore, we cannot argument on a clear bypass of the apparent in perceiving the real. Despite the fact that reality is replaced by a virtual one and thus a virtual space replaces the real, an interaction between spatial relations remains, as it should. In real life and real space – contrary to our personal space - there are cases (e.g. distances between planets) where we cannot have the same direct perception of distances. VR simulation ‘loaded’ with theoretical knowledge can adequately cover this gap. This interaction is achieved through technology. VR technology brings us closer to the theoretical properties of non-perceptual objects, those that cannot be perceived by the senses, like exoplanets. In addition, it brings us closer to the non-perceptual properties of directly perceived objects; properties referring, for example to subatomic structures. In a theoretical level, this macro and micro “terra incognita” may be linked to the *sensibilia* entities proposed by (Russell, 1914).

Finally, regarding the direct perceptual properties of objects that exist within our perceptual field, VR models serve only as an enhancement tool of representation, a subfield of our sensory field. Components such as graphics and equipment enhance the superiority of virtual experience (see telepresence) over the physical one with its limitations. By achieving a satisfactory level of telepresence, VR effectively incorporates more knowledge on any entity, which is crucial in the context of education. Educators have the privilege of being both receivers and transmitters of these developments. On the one hand, educators will benefit greatly from the virtual representation of objects and processes that previously existed only in textbooks and manuals, while on the other hand, they will be the ones giving feedback for better VR models, models which need robust epistemic foundations for depicting elements of real space inaccessible to the human senses.

Conclusively, these initial findings could be taken into account by instructors who incorporate VR into their courses. In doing so, they would be able to distinguish more easily the possibilities but also limitations of VR as an educational tool.

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