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Simplexity to Improve Human-Machine Interaction in 3D Virtual Reality

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ABSTRACT

The purpose of this paper is to present the use of the notion of simplexity to facilitate the design of virtual and immersive environments. Through ahistorical and argumentative excursus, the authors specify the motivations that have led to the introduction of the notion of simplexity as a natural support to the teaching-learning process, regardless of the environments virtual and immersive, and then explore the links with the latter. If immersiveness makes it possible to generate interactions in a physical space, projecting a world surrounding the user and proposing interactions (apt to foster the teaching-learning process), then one could adopt in the of design simplexity that takes into account cognitive, metacognitive, and motor processes, realizing a virtual reality perceived as credible explorable, interactive, and indeed, immersive.

KEYWORDS

Cultural Heritage, Edugame, Empathy, Simplexity, Special Education

1. RESEARCH BACKGROUND: THE COMPLEXITY OF HUMAN-MACHINE INTERACTION IN EDUCATION

This paper attempts to present important and current reflections within the philosophy of technology; these ideas start from a series of constatations of the world in which we live: during the nineties, a historical period that took on a role of connection between the twentieth century and the new millennium, the complex face of didactic and pedagogical research emerged, marked by numerous historical events: the increase in the level of education, the exploits of technology, the spread of the media, the use of educational institutions for political, social and cultural purposes (both in democratic and totalitarian terms) and discoveries in the field of physics and biology (Cambi, 2005, pp. 3-13). Taken together, these events have profoundly marked scientific research, in every field of knowledge, including, in its own right, didactic and pedagogical research (Ibidem), influencing the researchers who have described, analyzed, modeled and faced these elements; bringing out a complex vision of the teaching-learning process. Therefore, pedagogical research inherits this multifaceted

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vision of the educational phenomenon from the last century (Todino, Di Tore, 2018). Thanks to this superimposition of points of view, the complex vision of the teaching-learning process has overcome numerous dualisms: body-mind, self-other, individual-society and teacher-learner. Furthermore, it is possible to highlight that the complex vision harmonizes (thanks to the synergy of the parts): theory and practice, the knowing subject and the object of knowledge and, finally, teaching and learning (Sibilio, 2014, p.2). This complex vision allows for a significant paradigm shift: bringing out the biological matrix of the teaching-learning process, according to the principle of educability (Sibilio, 2014, p.3). This principle takes into account the biological and cultural possibilities of the learner, being able to affirm that: The training process has taken on the characteristics of an evolutionary and developmental process that takes into accounts the biological and cultural constraints and possibilities of the subject. However, the complexity that involves the study of the teaching-learning process can trigger an interpretative loop that exponentially multiplies the analysis plans (Ibidem), generating accessory complexity and privileging the axis of description (identification and understanding of didactic phenomena and pedagogical) to the detriment of the intervention axis, to support existence and development (Todino, Di Tore, 2018). A recursive process transforms the praxis-theory-praxis circularity into a theoretical-descriptive spiral (Sibilio, 2014, p.3). To recompose this descriptive drift it is necessary to adopt a functional point of view: one that aims, through action, to decipher complexity, in awareness. The complexity depends on the size of the grain and] on the level of precision with which the system is described (Sibilio, 2014, p. 6). At the same time, the idea that living organisms have found simplifying principles for complex processes (Berthoz, 2014, p. XIV) can be used as a support for didactic theories and practices (Berthoz, 2014, p. XIII)). Therefore it would be desirable to grasp the simple and generalizable rules applicable daily in the teaching-learning process. More in detail Alan Berthoz, through his works has brought out the properties that regulate the functioning of living beings and the human brain (Berthoz, 2011), highlighting a certain regularity of behaviors and ways to act that are summarized in elegant solutions optimized to process complex situations (Sibilio, 2014). Simplifying Principles for a Complex World is not easy at all, although the physiologist Alain Berthoz proposes a primary list of straightforward features (properties) of living organism that establish the tools for them for the foundation of different "patterns of interaction among the constitutive parts of a system. In other words, these provide the theoretical underpinnings for the interpretation of the behaviour of complex adaptive systems" (Pace, Aiello, Sibilio & Piscopo, 2015, pp. 71–87) These behaviors show a certain degree of simplexity in interactions, as an adaptation mechanism that allows survival, finding identical or similar patterns (Berthoz, 2011, p. 13) that all living beings use, during their existence to relate to what surrounds them, to minimize energy or increase the speed of information transmission (Ibidem). These characteristics can also be found in the teaching-learning process which, among other things, occurs: 1) by adaptation to the environment; 2) through the projection that the learner makes in the world through his interactions (Todino, Di Tore, 2018). In summary, simple teaching (which is based on the concept of simplexity) highlights in detail a series of properties and principles that can favor the teaching-learning process by giving indications that regulate teaching and guide its] flow with originality and wisely in order to ensure a wider range of resources available to each person (Sibilio, 2017, p.12).

2. VIRTUAL AND IMMERSIVE ENVIRONMENTS

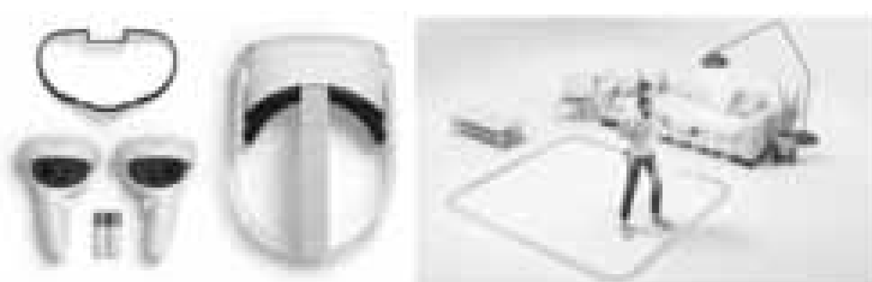
One of the main technologies that can support the human teaching-learning process is presumably virtual reality, which can be used in formal (e.g. at school), non-formal (e.g. museums) and informal (in everyday life) contexts (Pellerey, 2002). In fact, in recent years, the relationship between virtual and immersive environments and the teaching-learning process has emerged in the scientific community (Freina, Ott, 2015; Kavanagh, Luxton-Reilly, Wuensche, Plimmer, 2017; Radianti, Majchrzak, Fromm, Wohlgenannt, 2020). In addition, it is reasonable to identify in virtual reality and immersive spaces two possible candidates to be the next technologies that will reach global and widespread diffusion.

It is therefore necessary to describe its main characteristics. Chris Woodford in an article published on March 3, 2017, entitled *What is virtual reality?* manages to summarize the definition of virtual reality through a simple but effective explanation: virtual reality means experiencing things through our computers that don't really exist (Woodford, 2017). In fact, it is possible to agree with this author that virtual reality, even if it influences the person who uses it, only exists inside the computer that produces it. It is only thanks to human-machine interfaces that the experiences made with this technology can be perceived as true or plausible (Todino, Di Tore, 2018). We might ask ourselves if virtual reality is really something new under the sun. Surely, before reaching this technology, humanity has always felt the desire to reproduce the reality that surrounds it, for example through painting and photography (Todino, Di Tore, 2018). However, a wonderful pictorial work differs from virtual reality, because it has no interactive elements. To give further examples, listen to symphonic music, read an engaging book, go to the cinema, these are situations that project us into realities that do not exist, but the immersion is unfortunately limited, in fact, by just turning the gaze for a moment, the fiction of the virtual world vanishes (Todino, Di Tore, 2018). This long prologue is necessary to reduce the ambiguity at the philosophical level of the term virtual reality in the meaning used in this work, rigorously defining a series of characteristics that determine this technology. The virtual reality must be: 1) perceived as credible; 2) explorable; 3) interactive; 4) immersive; 5) created on the computer using machines equipped with adequate interfaces, to make the previous characteristics feasible, that is, allowing the simulation of an imaginary world (Todino, Di Tore, 2018).

Furthermore, each installation, relating to virtual and immersive environments, should take into account the well-being of the user. In summary, it is possible identify reality _ virtual as a believable, interactive 3D computer-created world that you can explore so you feel you really are there, both mentally and physically (Woodford, 2017). Sometimes, environments for virtual reality are divided into sub-categories: 1) with total immersion, which use all the human-machine interfaces currently available, namely: virtual helmet (Head-Mounted Display), gloves (touch controllers), stereo headphones and immersive room; 2) partial immersion, in which one or more of the elements described in the previous point may be missing.

Current immersive technologies are being studied because they can offer interesting educational opportunities by creating spatial contexts, in which the body is free to move and experience, to allow the user-learner to experience sensations, to be present in an environment and to control it (Aiello, 2012, p.147). Furthermore, through an immersion experience, in a virtual environment, it is possible to implement forms of deep learning that are based on some key factors: identification, challenge and control (Di Tore, 2013), thus, the user learns by adapting to the virtual world that surrounds him and through the interactions proposed by the computer (Todino, Di Tore, 2018).

Figure 1. On the left the MetaQuest system components that in the whole allow for a multisensory experience; on the right the virtual environment should be set at the beginning of the experience, the figure shows the scheme proposed in the official video



3. A BRIEF OVERVIEW OF SIMPLEXITY

The rapid social, cultural, economic change partly reflects the various changes that have been imposed by new technologies, and in turn this new technologies are changing the world. Consider especially the change due to the introduction of the Internet into society: this change has put pressure on the education sector. Now, one can be almost certain that Virtual Reality, and particularly its distributed applications such as the Metaverse (as proposed, for example, by Mark Zuckerberg's Meta Connect company), will do the same. Educational institutions need to ensure that students have the digital literacy skills (Reddy, Sharma, Chaudhary, 2020) and digital skills (Van Laar, Van Deursen, Van Dijk, De Haan, J. (2017), they need to cope with and effectively manage the complexity they face. One possible way to cope with that degree of complexity is the concept of simplexity addressed by Alain Berthoz and translated into education. The brief excursus on the paradigm of complexity, the introduction of the concept of simplexity and the description of virtual reality can provide important elements of reflection for the design (technological, content and methodological) of virtual and immersive environments (Todino, Di Tore, 2018). Simplexity is a cooperative set of "answers" that performed in the progression of human evolution to let people to live notwithstanding the difficulty of life. These natural and biological adaptive systems, embodied in each of us, allow us to survive in complex circumstances in a rapid, elegant and efficient way (Berthoz, 2011). Alain Berthoz places "acting" at the center of any analysis of the functioning of living organisms, thus he postulates the existence of simplifying principles governing perception. It should be specified that the idea of the perception-action pair that Berthoz addresses is the idea matured in phenomenological reflection, consolidated in neuroscientific research, whereby the two moments of perception and action are not seen as consecutive and discrete, but with a paradigm reversal, perception is a function of action (Sibilio, 2014). Similarly, an analysis that refers to education as a complex system might consider as its object the concrete instances of the teaching-learning process and assume that this process is guided by simplifying principles that leave out of consideration from interpretive models (Ibidem). Entertainment promotes learning, and this is true between both in formal, non-formal and informal settings. For this reason, alternative approaches to those traditionally used for learning, based on virtual and immersive reality, are being considered around the world to stimulate greater synaptic plasticity at the brain level and benefit all those with special educational needs. If it is true that a simplex system is adaptive, and to be so it must have as requirements its properties in order to apply its principles, a virtual reality system if well designed (according to simplex properties) will be able to be in turn fast, adaptive and personalized, meeting every Special Educational Need. So, how can we manage to do all this? For the design of technologies in simplex key we refer to a dedicated text (Todino, 2019), what can be said briefly that the design, to take advantage of simplex principles, must take into account the following paradigms (properties): *Specialisation and Modularity* typical of well-designed systems by software engineering, that tries to simulate "the human brain [where] different areas process specific aspects of perception, action, memory, and emotion, while in society, this modularity can be observed in the division of work" (Pace, Aiello, Sibilio & Piscopo, 2015, pp. 71–87); *Speed* (typical of high-performance PCs) "referring to the ability of decision making by anticipating and predicting consequences of actions, through the capitalization of the results of past experiences and guessing and betting on the behaviour of others" (Pace, Aiello, Sibilio & Piscopo, 2015, pp. 71– 87), this is typical of big data analysis systems; *Reliability* (typical of stable and backed-up systems) "which is needed to reduce the margin of error to a minimum" this is request in simulators and serious games; *Flexibility, Vicariance and Adaptation to Change* (essential to deal with even a new problem, characteristic of neural network systems that profile a user who has specific needs); reliability to compensate for functions that have failed; memory to treasure past experience and predict the future (typical of artificial intelligence and data mining), more in detail "which are essential to be able to select the right strategy from a repertoire of choices to resolve a problem, and perceive, capture, decide, or act depending on the context the system finds itself in. Hence all these are fundamental in decision making, problem solving, creative thinking, coping with stress and emotions, initiative taking and the spirit of entrepreneurship" (Pace, Aiello, Sibilio & Piscopo, 2015, pp. 71–87); *Memory* "as the characteristic on which present action relies to predict the future consequences of an action. There are multiple mechanisms of memory (explicit, implicit, episodic, verbal, iconic and effective)" (Pace, Aiello, Sibilio & Piscopo, 2015, pp. 71–87); finally, *Generalization* an ability to perform abstraction, this is the last "property of complex adaptive systems, which refers to the competency of capitalizing patterns of interactions, and transferring these from one context to another, even if they are not two completely analogous situations" (Pace, Aiello, Sibilio & Piscopo, 2015, pp. 71–87). If all properties are satisfied, in this case by the virtual reality, it will have a number of principles: 1) *Principle of Inhibition and the Principle of Refusal;* in other words typical of *stop and go* issue, some tasks are developed to improve this feature that is strongly related with the executive functions: inhibition, working memory (verbal and visuospatial) and cognitive flexibility (Blair, Razza, 2007; Quiroga et al., 2009); 2) the principle of selection and specialization, to put a focus on a particular point that requires concentration and precision; 3) probabilistic anticipation; 4) deviation (detour) to deal with a challenge or problem in a different way; 5) cooperation and redundancy that allow acting in line with other individuals or other parts of oneself (e.g., two eyes allow stereo stereoscopy); 6) the principle of meaning, in fact the system in theuna function and an intention that is manifested in the act of choice.

4. HOW SEMPLEXITY CAN IMPROVE EMPATHY IN HUMAN-MACHINE INTERACTION IN 3D VIRTUAL REALITY EDUGAMES?

Virtual reality sets in motion, at the same time, biological, physical and cultural aspects in the one who uses it. Therefore, the installations could be designed to bring out in the user the principles that are described in depth in the didactic declination of simplexity such as deviation, probabilistic anticipation, inhibition and the principle of rejection, the principle of specialization and selection, cooperation and meaning (Sibilio, 2014). It is highlighted that simplexity is accomplished through actions and interactions and the immersive space favors, through its imaginary worlds and its man-machine interfaces, their fulfillment. It is therefore possible to theorize that simplexity can favor the design of immersive environments (Todino, Di Tore, 2018). If the concept of simplexity is used in the design of virtual and immersive environments, this can favor the teaching-learning process, especially in its sense of adaptation to the surrounding environment, creating a virtual reality compatible with didactic needs. This design is based on the simulation and emulation of the possible behaviors (Berthoz, 2005, 2015) that the learner could perform while using virtual technology and immersive spaces (Todino, Di Tore, 2018). It is also possible to make a further reflection: contents have always had a profound relationship with the media that supports them (Ciotti, Roncaglia, 2000), through the correlation between the messages conveyed and the media itself, as Marshall McLuhan already knows (1968). In this specific case, virtual reality (being a media that includes interfaces related to movement) will favor perceptual-motor learning. Therefore, virtual reality can be used to promote plural teaching anchored to the multiple levels of training that incorporate the intellectual embodied dimensions of people (Sibilio, 2012, p.329). 3D videogame engine, such as Unity3D, aimed at fostering interactions between user and machine through the improvement of egocentric, allocentric and heterocentric perception of space (Berthoz, 2011). Thus, 3D Edugame promotes the development of the ability to change perspective - PT Perspective taking a basic skill to improve empathy (Berthoz et al., 2016; Di Tore, 2016). Finally, a MetaQuest offer through its multisensory offerings already was, and not in the future, gives simplex education an opportunity. In fact, the bodily and kinesthetic element makes it possible to seize new opportunities, avoid unnecessary risks, and save the energy of each teacher and learner for a teaching-learning process that takes advantage of virtual spaces as a place to enact this process.

CONFLICT-OF-INTEREST STATEMENT

In this work, researchers of University of Salerno, museums or schools who collaborate have the same interest: realize open-source digital assets, and virtual learning environments. All these files are and will be available for download at http://www.labh.it/disuff/

FUNDING INFORMATION

All the activity has been carried out not through special public or private funding or financing. Researchers (who are already paid for their research activities by the University) have gone to carry out the activities. Similarly, and consistent with what was stated in the paragraph titled "Conflict-of-Interest Statement" All these files are and will be available for download at http://www.labh.it/disuff/

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