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SECTION: VIRTUAL REALITY AND EDUCATION

VIRTUAL REALITY AND EDUCATION - WORLD OF TEACHCRAFT?

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ABSTRACT: 2016 was announced the year of virtual reality - without any true breakthrough in its adoption yet. The usage of the technology has not been as widespread as professional predictions forecast, especially in education. The present paper aims to introduce the definitive theoretical frames and research topics of educational VR, casting light upon the methodological connection between educational VR and forms of learning, the aspects of designing educational VR and its present challenges. Recent studies and surveys concerning the adoption and use of educational VR by teachers, instructors and professors will also be discussed in order to offer a more realistic description of the state of educational VR in global and Central European (Hungarian) contexts.

KEYWORDS: Virtual reality, educational VR, simulated space(s), immersion, multisensory experience, constructivist and situated learning

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Introduction

“It is inevitable that some of these devices will overpromise and under deliver”, “We don’t even think we are in the first inning yet”, “Only after 2016 will the VR/AR game begin”, to quote just a few remarks from the article *Is 2016 the Year of Virtual Reality?* in the December 2015 issue of *Fortune* (Morris, 2015). Apparently, the magazine focused on the return on investments in virtual reality (VR) and on the key players and processes of the market, especially after Facebook purchased Oculus Rift, considered as the shop window designer of VR, by one of the biggest acquisitions in the previous year. Yet, the author as well as the analysts and developers cited in the article had conveyed the same message for as long as two years: VR will not catch on among ordinary consumers as fast as predictions of technological improvements might suggest. After a thought-provoking presentation that listed VR innovations among other things at a 2017 conference on new technologies and their social effects, a colleague of mine, an excellent social scholar remarked, “It’s great to have all those gadgets but all I can see is that buses are as late as they used to be.” This seemingly lay opinion is not uninformed, especially if we think of educational VR. But let’s not rush things. While many proclaimed 2016 as “the year of VR”, renowned manufacturers (graphics chip company Ndivia) and analysts (Gartner) (BBC, 2015) warned of the lack of graphics capabilities required by VR as early as the beginning of that year. In 2016 approximately 13 million PCs, only 1% of 1.4 billion in total, were found fit for this purpose. Even though this number will to rise to an estimated 100 million (7%) by 2020, the breakout hit of VR has given rise to other concerns. In his article in the January 2017 issue of *Forbes*, Leetaru (2017) analysed why 2016 was *not* the year of VR. In addition to cost and lack of available content for VR systems, he mentioned the complex physical and psychological exposure already experienced by VR users but underexplored by researchers. Evidently, there is a VR optimist and a VR pessimist approach. The latter cannot see the social, individual and cultural conditions of the spread of and need for VR but the economic advantages some have out of it, while the former identifies the new experiences, functions, activities and possibilities available through VR as the joyful cultural and economic turn. Between the two extremes there are the realists but they are few and far between and can hardly gain a profound insight into the matter due to the lack of a sufficient number of independent surveys of VR development and use, to business interests in VR[1] and to the very applications that are still hardly necessary in everyday life and require specific devices. Therefore, this paper does not venture to report on a comprehensive scholarly analysis of the situation of VR. Instead, it only offers some insight into the theoretical approaches and research findings of educational VR as a special field of use. Research into the links between VR and education took an upswing after 2010 and made progress in line with the global need for the digital development of learning and teaching, and classrooms, and with the radically insecure future (Nyíri, 2012, p. 192). While the international literature suggests that educational VR has mostly positive effects on learning efficiency and while the number of scholarly papers on the subject has increased exponentially, it is hard to find the relevant surveys, texts and professional-scientific discourses in Hungary and in the Central European region. This paper aims to raise awareness of this deficiency, raising the question if VR has promoted education and showing the effects that educational VR has on learning, the potential causes of its design and use, and the knowledge and skills, explored so far, of the technology's teachers as a target group concerning the use of VR (Aczél, 2017a).

Virtual Reality

VR is one of the professional and scholarly terms that have gained wide currency without any consensus over its meaning. VR mostly refers to all non-physical simulated complex media that are generated and maintained by a computer. Previously called *computer generated illusion* then *virtual reality* by Jaron Lanier (1989), the term is typically used to mean a 3D computer simulation that creates the effect of reality without its actual (physical) quality.

> "Using visual, aural, or haptic devices, the human operator can experience the environment as if it were a part of the world. This computer-generated world may be a model of either a real-world object, such as a house; or an abstract world that does not exist in a real sense but is understood by humans, such as a chemical molecule or a representation of a set of data; or it might be in a

[1] According to a recent trend analysis (July 2017), the value of the VR market will exceed 30 billion dollars with a double digit combined annual growth rate in the forecast period. The key market players include Oculus Rift (Facebook), Sony, Samsung, Vuzix, Sensics, Microsoft, and EON Reality Research and Markets. *Global Virtual Reality Market Size, Market Share, Application Analysis, Regional Outlook, Growth Trends, Key Players, Competitive Strategies and Forecasts, 2017–2025*, https://www.researchandmarkets.com/ research/rj3q6z/global_virtual

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completely imaginary science fiction world. Usually VR is described as a particular collection of technological hardware" (Riva et al., 2015, p. 536).

The definitions of VR emphasise two distinct perspectives (Coelho et al. 2006). One is the technological perspective, from which VR is a complex set of various technologies organised for an interactive purpose. The other is the psychological perspective, showing VR as a technology that offers various degrees of social media and behaviours and of sensory-psychological immersion.

VR, then, is a computer environment that exists not in its reality but in its effect and is available for direct sensory experience (Aczél, 2017b), "a medium composed of interactive computer simulations (...) giving the feeling of being mentally immersed or present" (Sherman & Craig, 2003, p. 13), a virtual space which "is a hybrid of technical, social and economic practices" (Kuksa & Childs, 2014). The key features of VR include its spatial and visual character, the immediacy and immersion offered to its recipients, its realistic nature, the possibility to break the man-machine interface, and its interactivity: the 3 I's as summarised by Burdea & Coiffet (2003), i.e. *interaction*, *immersion* and *imagination*.

The VR user is no longer a viewer but an actor present in real time. This is one of the reasons why Bricken (1990) identified VR as a paradigm shift nearly thirty years ago as follows:

Desktop paradigm (old)	Virtual paradigm (new)
the user's activity is *symbol processing*	the user's activity is *reality generation*
the user *views a monitor*	the user *wears a computer*
the experience is *symbolic* (conventional, abstract)	the experience is *experiential* (concrete)
the surface of the presence is *interface*	the presence is *inclusive, immersive*
the representation is *visual*	the representation is *multimodal*

Source: Based on Bricken (1990, p. 4).

From the mid-20th century, disregarding now the more remote historical background, technology contributed to making the experiences of still and motion pictures more enjoyable and to improving certain job-specific skills and competences (e.g. pilot training). Morton Heilig is usually credited as one of the first pioneers of modern VR with the Telesphere Mask, his stereoscopic glasses patented in 1960, and the Sensorama, a multisensory device invented in 1957. In 1968 Ivan Sutherland, known as "the father of computer graphics", created the Sword of Damocles, a head-mounted motion sensor application, fixed to the ceiling due to its weight and hence looking like a hanging sword, which can clearly be seen as the precursor of today's VR technologies. Also, Miron W. Krueger's long-lived Videoplace Project in 1975, which created a responsive virtual environment and the possibilities of interactive art, can be considered as a key precedent of today's room-sized CAVES and Powerwalls that surround the user. In the 1960s General Electrics developed a simulator to model lunar expeditions and in the 1970s the MIT created a system for spatial data management applying a laser based video disk technology, which eventually led to the creation of the project Aspen Movie Map in 1981. This already offered some features of today's Google Maps and Google Earth. VR first aroused high expectations between 1980 and 1990. In that period many hoped that technology would rapidly spread, and its use would become common. These expectations were not met as the expensive and complex systems together with the exponentially growing attention to the internet slightly dampened the enthusiasm about VR. Yet, research continued and indeed gained strength from that time. In addition, the 1990s brought about achievements that were also new for users, including the stereoscopic glasses, designed to create 3D images, the responsive work station, and the CAVE. Afterwards, the head-mounted displays became one of the main elements of development as they initiated people in their own positions in the world of three dimensional images, greatly enhancing comfort and experience in the use of VR. The biggest challenge for VR hardware and software is still this function of comfort, easy use, availability and price, with the technology requiring the combined efficiency of various areas of development (McLellan, 2004). The late 2010s witnessed a renewed interest in and heightened expectations about VR. While there is still little evidence to support the dramatic effect of VR in the coming years, this paper also wishes to claim that it makes sense to maintain scientific interest in the topic.

Educational VR

VR is an umbrella term as the simulated immersive spaces that it denotes do not form a homogeneous group. Several types are normally posited in terms of the link with reality (reality, augmented reality, developed virtuality, virtual), the user's perspective (unmarked, using technology in his or her own name or in the avatar's name), the depth of immersion (remote view desktop, reach-in, and immersive, presence based spaces), senses stimulated by the medium (visual, aural, haptic and vestibular channels), portability and the possibility of the body's movement, and the number of participants (Brill, 1993; McLellan, 2004). None of these can be detailed here but it is indispensable to point out the criteria of genre and content. VR systems are categorised in two big types according to their genres: game oriented (World of Warcraft) and social oriented (Second Life) (Papagiannidis, Bourlakis, & Li, 2008; Dawley & Dede, 2014). The former is greatly regulated, the program determining the narrative and visual framework of participant identities and activities, whereas the latter offers freedom to the different modes of identity and behaviour. VR can also be categorised in terms of a) purpose, b) the type of information conveyed and represented, c) the platforms where and how VR interactions can take place and with which VR is connected, d) the target groups of VR development, and e) the business model underlying VR and the social and economic criteria of access.

Educational VR is a subgroup where the purposes include the need for learning, the extension of knowledge, credible (specific, disciplinary) information, the potential connection with other methods of education, and the target groups of teachers and learners. In line with the 20-year-old pedagogical and methodological reform, the orientation to education strategies based on a constructivist theory, the challenges of traditional classroom education, and the proliferation of new media technologies, recent years have witnessed a growing interest in the use of educational VR worldwide.

The methods of education developing complex knowledge and skills are different from frontal teaching aimed at disseminating knowledge. The former requires from the learner a high degree of personal involvement, interpretation, interaction, acquisition of experiences, sharing of knowledge, and concrete personal experiences that are made even more important by insight, autonomy and the assumption of responsibility. In VR there is a simulated complex visual-spatial-aural environment, a wealth of stimuli, and the possibility of immersion in narratives and embodiment that support a complex learning experience, whether formal (with explicit learning goals, methods, and environment) or informal (without a goal or intention of learning). Such interfaces requiring immersion are categorised in three types that are also suitable for education:

- Virtual Reality, which provides a medium of sensory immersion, the illusion of bodily presence, and the experience of intensive participation.

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- MUVE (Multi-user Virtual Environment), where users appear through their avatars, are involved in the situation from a psychological and not a sensory perspective, while meeting other avatars and a changing environment in the given narrative.
- Mixed or Augmented Reality, where computer generated information enriches, shapes, speeds up or slows down real situations (Dede, Jacobson, & Richards, 2017). In sum, educational VR exhibits the following characteristics:
- It creates a simulated environment with a spatial-visual logic, where the learner can take on the roles of observer, participant and creator.
- It creates complex circumstances and media for the possibility of immersion and insight, multisensory experience, social interactions and collaborations.
- Its link to physical reality can be subtractive (socio-cultural situations and experiences that are hard or impossible to access in physical or psychical terms), additive, supplementary (illustrative or developed, merging with physical reality), specifying (the representation of a part of physical reality which can only be accessed in an abstract way and creative participation in this, e.g. controlling the operation of neurons or getting to know political processes) or independent (creating an alternative to reality, imaginary, fictitious).
- It reduces or eliminates the potential physical and moral burdens of the consequences of acts in a simulated medium, thereby creating the possibility of protected and safe experience. At the same time, it can increase and make uncontrollable the physical and psychical burden of its use and can add to the cognitive burden (by creating an environment which is saturated by stimuli).

To find out what makes VR fit for education (Dawley & Dede, 2014), there is a need to consider the design criteria (if there was an explicit or implicit pedagogical goal), the forms of behaviour required by the content (cooperation or competition), the reliability, verifiability and accuracy of the information, and if the learning results can be formally explicated or are rather informal and implied. In view of media convergence and the fact that the function of education cannot always be separated from the functions of entertainment, fun and dramatisation (Bell, 2008; Richter & Dawley, 2010), educational VR can be categorised in three groups.

The first includes developments explicitly designed for education, specifically for teaching and learning (e.g. Quest Atlantis, Rome). Their advantage is that the program follows well the learning goals. Their disadvantage is that the education function cannot be identified, which reduces the willingness to learn. The second group comprises the kind of VR whose primary goal is to create simulated and communicative social spaces and entertainment but also includes educational functions (e.g. virtual museum tours, JumpStart). The classroom integration of these types is more problematic, especially for learner safety as it is inevitable to encounter unknown online players or participants. The third group comprises the immersive simulated virtual spaces which offer, in addition to many other functions and presentations, an opportunity to design contents and functions for educational purposes (e.g. Minecraft or Second Life).

In such cases the challenges include exact goal setting, the lack of designer competence or innovative intention, cognitive overburdening or, on the contrary, little motivation. educational VR mostly targets the generation between 10 and 15 years. By contrast, older youths and adults prefer virtual spaces fit for creating their own contents. (Dawley & Dede, 2014; Liu et al., 2017).

Educational VR and its learning models

The learning capacities offered by VR and virtual worlds, the simulated complex environment requiring involvement, and the total physical response functions allow for the adoption of basically three, not clearly distinct, learning approaches.

One is the *constructivist* approach supported by the theory of Piaget (1936; 1957) on the evolution of mental models and children's cognitive development. This model, confirmed by several contributors including Bruner (1961; 1990) Vygotsky/Vigotszkij (1971; 1978), Lave & Wenger (1991), views man as the creator of knowledge who receives and processes stimuli creatively, and develops his own knowledge frames. Constructivist education enables learners to discover, identify and discuss links, build their own knowledge actively and creatively, enabling teachers to change, learn and generate knowledge creatively. In the teaching process, learners are given a context and a problem for which they must develop an individual or collective solution. Here the solution is non-normative and non-universal in terms of eliminating the problem: learning efficiency can be interpreted in terms of the dynamics of the process and not necessarily its result. VR and virtual worlds clearly promote such learning processes by providing motivation and context with the narrative, ensure involvement through sensory stimulation, require individual or group activity for participation, and reveal the consequences.

The second model is called *experiential learning*. This posits man as a being that creates sense, and breaks away from the standard of one-way knowledge dissemination from experts to lay people. In this framework, knowledge is based on individual or collective experience, trial and insight, promoting the enforcement of critical views in the interpretation of experience. Learners and groups interpret experiences according to their own socio-cultural characteristics and this, in turn, gives rise to reflective and active behaviours. Based on Dewey (1916), this approach is related to a number of educational methods, mostly containing a circular process of multiple steps and elements. This cycle is built of *feelings* from experiencing new things, of *observations* and *reflections*, of *thinking* and *action* (Kolb, 1984; Miller & Boud, 1996). Experience in everyday life does not always generate knowledge and the methods of experiential education are designed precisely so that trial will actually generate knowledge. Experience can take place in the real world (primary experience), by mediation (secondary experience) or in the classroom through tasks. VR and virtual worlds also create an efficient hybrid of mediated experience for education. Incidentally, mediated experience is remote, with an obvious distance between the experiencer and the experienced thing in spatial, temporal, cultural and contextual terms as when some news item (text or multimedia) is received (Thompson, 1995). While in VR the presence of media technology is physically perceivable (the screen or VR glasses, wires or the treadmill and their physical consequences, such as sweating), mediation may cease to be marked for perception, thus immediacy can be created, when the user gets involved in the narrative. VR as a means of experiential learning is especially efficient as the realistic nature of representations and narratives makes the entire cycle (sense, thinking, action, and reflection) suitable for planning, as opposed to a text based problem in school or a teacher's verbal instructions.

Related to the previous two models, the third one is *situated learning*. This emphasises the importance of human presence, contextual involvement, and the type of learning which can be made more intensive if it is integrated in a situation. Situativity requires the observation and interpretation of new contexts, participation, interaction, activity, situative "embodiment", and hence immersion. Also, it allows for metacognitive learning, i.e. learning about learning (the acquisition of knowledge) (Driscoll, 2000; Dunleavy, Dede, & Mitchell, 2009). In reality, situated learning takes a

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great deal of human and financial resources and a significant amount of time, e.g. travels, company visits, internships, etc. VR and virtual worlds can cause such difficulties but also allow for using media that are commensurable with the real in terms of intensity and subtly applying situative contexts. In the design of VR and virtual worlds, the constructivist approach can emphasise the creation of knowledge, the experiential approach can emphasise experience, and the situative approach can emphasise the importance of context.

In a meta-analysis of nearly 500 scientific studies, Hew & Cheung (2010), Dawley & Dede (2014) identified three functions in the use of VR and virtual worlds by primary, secondary and tertiary education:

1. VR as a space of communication
2. VR as a simulation of physical spaces and
3. VR as a space of experience.

For the first type, Dawley (2009) devised the pedagogical model of social learning in VR (Social Network Knowledge Construction, SNKC). SNKC describes the five steps that newcomers to VR take to get involved in a social network. The learner starts the process as a neophyte finding his or her way to VR then finishing it as a mentor by *observing, identifying, contributing, creating* then *controlling*.

Educational VR and the forms of learning

The use of virtual reality can serve to support six mutually non-exclusive forms of learning (cf. Liu et al., 2017). One is observational learning, which offers new perspectives, experiences, and a sense of familiarity with new media by stretching the physical boundaries. Examples include virtual campuses and the virtual representations of museums, archaic historic locations, works of art, and natural formations, which can be found out about, observed and brought closer without real presence. Here the basic idea is cognition and its multiple perspectives offered by VR and the elimination of the physical and psychical or even financial burdens imposed by cognition (cf. *situated learning*).

The other type is activity based learning, which offers an opportunity of action and the experience of the consequences in virtual media. In doing so it offers not only an understanding of complex concepts but also the experience of testing and trying knowledge (e.g. physical laws, mathematical laws, rules of language, social norms, experiencing and managing weightlessness in the NASA Newton World or trying foreign languages with Mondly’s device). Here learning is mostly characterised by experience, trial and feedback without the consequences of becoming a part of physical, social reality (cf. *experiential learning*).

The third type is social learning, which helps to experience presence, co-presence and cooperation across the physical boundaries (e.g. Harvard’s HBX Live Project and its virtual CS50’s Introduction to Technology on edX.org in 2016). Described with the possibility of reciprocity created by the new technologies and platforms, Howard Rheingold (2014; 2016) talks of a new learning method called “peeragogy”. Taking place with research, authorisation and collaboration, this learner based process emphasises the other learner’s presence and active critical feedback, and the importance of responsibility. Here the key elements of learning include the sharing of knowledge, presence, interaction and cooperation (cf. *situated learning*).

The fourth type is exploratory learning. Some research areas and course materials can only be built in perceivable reality through simulation either because they are inaccessible for human senses or because they are too complex in terms of time, space, and components. Examples include nano-particles and democracy. The use of VR can make phenomena that have so far been grasped at an abstract level concrete and suitable for modelling and shaping from a visual and experiential point of view (e.g. VR anatomical atlas) (cf. *constructivist learning*).

The fifth type is future-oriented learning, which essentially promotes the development of the resilient, future-proof person's skills. In their future-oriented approach, Seligman et al. (2016) call the social human being *homo prospectus*. Their novel book of psychology, evolution, and philosophy suggests that human perception, memory and emotion do not relate to the present or the past but much more to the future. In other words, through cognition, evaluation and emotions, people essentially do not comprehend, preserve or experience but primarily imagine, expect and predict (Seligman et al., 2016). The book is a fine example of the "turn of the future" now taking place in science, which may be related to resilience or the shaping of grit non-cognitive skills in education. Activities that include non-cognitive skills, such as a sense of purpose, optimism, perseverance, failure management, flexibility, empathy and cooperation, can be motivated less in a "brick-and-mortar" physical classroom with frontal education, but more with VR. In a simulated environment, by motivating experience and the use of energy, through target centeredness, foresight, and guided procedurality, it is possible develop planning as well as flexibility due to testability, and in certain contexts failure and stress management. (In the latter, VR is a means used efficiently and with increasing frequency, e.g. Bravemind PTSD VR). Imagining and designing the future is offered by building and home design programs (e.g. Google SketchUp, iStaging, Sim City VR). Usually these are not explicitly designed for educational or pedagogical purposes but for an activity or function, sometimes fun activity developments (cf. *constructivist learning*).

Finally, the sixth type is, in short, learning from and through the media, i.e. the enhancement of mindful media behaviour, the development of media literacy and media understanding from the perspective of learning, the promotion of *metacognitive learning*.

The design of educational VR

Fogg (2003) coined the term *captology* as a general concept of the man-computer interaction, defined as the study of computers as persuasive technologies. Captology focuses on the design procedure which can make technology persuasive for users. While this branch of inquiry mostly seeks to explore why people want to interact with computers and not why they use computers to get in touch with others, the author's idea can also serve as a framework of interpretation of the persuasive power of VR. All the more so because Fogg (2003, p. 16) also considers technology itself as a "participant" in the communication processes that motivates, influences and involves and that may shape perception, emotions, and social behaviour. The basic idea comes from the three functions of computer technologies. The first is the instrumental function. In this sense technology is persuasive if it facilitates, speeds up and makes the target activity more efficient, smoothly guiding or potentially conditioning its user along different processes. The second is the function of medium. In this sense technology is persuasive because it creates a symbolic medium, e.g. a simulated one in the case of VR, where sensory experiences and creative and interactive behaviours can take place. Technology as a medium enables people to identify causal relationships, to acquire motivating experiences that replace real experiences, and to try behavioural models in a protected and safe environment. Fogg also calls this function simulation (2003, p. 69) as a reference to the complex, multi-sensory and stimulus rich character of persuasive technology.

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The third is the social actor's function as when technology enters into a social relationship with humans and they, in turn, relate to technology in terms of reactions or emotions as if it was human. Here the persuasive power can come from the modelling of feedback, reinforcement, behaviours, social support and the experience of embodiment. Fogg's categories of educational VR also offers a stratification model of the design and use of virtual worlds with 1) functional, 2) interactive and 3) constructive levels. The functional level means how hard or easy it is to use a simulated medium or interface, if it is accessible in technological terms, or if it requires special competences and hence energy, if the steps of the planned process are recognisable, if the goal is identifiable and ethical, how much educational VR protects or makes its user (learner) exposed in terms of data protection or identity. On the interactive level we can consider the quantitative aspects of possible participation (number of participants, intensity) and its qualitative aspects (the reliability and soundness of information, trustworthiness of actors, the ethical nature of goals, causes and consequences, safety, control). On the constructive level, we can examine the creative potential of educational VR, the graphic and aural quality of representations, their sensory and narrative complexity, the possibility of experience, and the extent to which human intention, creativity and responsibility can become manifest.

Educational VR definitely poses a new challenge for using pedagogical methods and models, achieving educational goals, and for teaching and learning. In traditional education, the dissemination of knowledge was typically based on the relationship with texts and the dialogue between teacher and learner. The use of VR and connected virtual worlds in education involves, in addition to the text, powerful visual, aural, and complex sensory experiences based on "presence". The option to have more diverse interactions and broader experiences logically requires a novel approach to the design of teaching and learning strategies in the virtual world. With respect to tasks, it is vital to create exact pedagogical goals, and safe and protected circumstances for learners. This must be stressed especially because designing educational VR does not necessarily require, depending on the business model, pedagogical expertise or criteria, and educational goals may only be "derived subsequently" for a virtual environment. One of the many reasons is the need for business profit from the success and popularity of the product and the bottleneck of financial, IT and pedagogical expertise and interests. As the developers of Oculearning, designing educational VR services for key elements in the UK's National Curriculum, say, the heavyweight players of the VR market usually focus on the low-hanging fruits of games and entertainment (Swift & Allatt, 2016).

De Freitas et al. (2010) conducted a survey among learners and produced a model called *Four Dimensional Framework* to identify the methodological criteria of designing VR and virtual worlds in education. Specifically, planning must consider the following:

- the learner(s): the needs, potential roles and competences of the learner or group of learners, and the components of the learning experience
- the pedagogical model: the underlying ideas of the pedagogical model; the principles and elements of cognitive, associative, social, situated or experiential education (experiential pedagogy)
- access, usability: the existence or lack of conditions required by the operation and availability of technology, the capacity of Internet access, the user centeredness of design, and speed of operation
- the challenges of real and virtual contexts: the difficulties of adaptation to the virtual medium (learners cannot establish a meaningful contact with the "non-real"), adaptation, the parallel nature of real and virtual contexts.

The latter point can be complemented with the special challenge posed by digital developments in the past two decades. VR requires the reversal of multitasking behaviours brought about by the proliferation and convergence of media technologies, the undivided nature of attention with immersion, and its renewed focusing.

The results and challenges of educational VR: the 3H framework

Liu et al. (2017) conducted a bibliometric analysis of 975 studies and research reports on educational VR from 1995 to 2016 (from 59 countries, written in English[1]). Their meta-analysis led to the conclusion that the vast majority of scholars think VR is a suitable and beneficial means in learning processes and many are also convinced that VR can bring about a significant positive change in learning and can be successfully used in maintaining attention, comprehension, and memory enhancement (cf. Bamford, 2011[2]). At the same time, the meta-analysis revealed that most research in the papers under review had been conducted with simpler methods, observation and self-report questionnaires, with complex survey procedures being atypical. Also, it should be emphasised that the efficiency of educational VR is not only linked to technology but also to many other factors, such as the micro-contexts of learning (learner, teacher, subject, group, class), its mezo-contexts (school environment, regulations, framework curriculum) and macro-contexts (national curricula, education system, digital divide), as well as to the individual's social, cultural and financial situation.

The authors (Liu et al., 2017) set up four categories to summarise the challenges of educational VR. The first is technology, where the goals can be to reduce costs, enhance portability, perfect simulation, and improve interactive experiences between man, technology and simulated environment. The second category is use in education, where there is a need for an accredited content and teaching method, the prevention of cognitive overburdening, and for checking and assessing learning effects. The third category includes the challenges of the learning experience in eliminating the difficulties of the use of technology (by training and support), in promoting the virtual transformation of identities, and in ensuring data protection. The fourth category is integration, which allows for the connection of VR with other teaching methods and for creating a smart learning environment.

In a SWOT analysis of educational VR by Minocha (2015), strengths include lifelikeness, error free learning, gaming to enhance motivation, environments that can be of low cost, distributed and duplicated, whereas weaknesses include limited body movement due to wires and displays, health consequences (dizziness, balance issues, etc.), and problems of platform compatibility. Opportunities include education through telepresence and the potential role of VR in the teaching of various subjects

[1] The 59 countries do not include any of the 20 in the Central European region that have published most in the subject.

[2] Bamford's research findings have been adopted by a number of opinion articles and internet sources on educational VR, most of the time inaccurately. According to the available document (white paper), the research report refers to the use of 3D and not VR (obviously, the differences are not necessarily essential). In his survey involving 740 students, 47 teachers and 15 schools from seven countries, Bamford examined the differences of efficiency between the transfer of knowledge in 2D and 3D. Based on the comparison of pre- and final test results, his findings show that 86% of the students in the 3D groups made progress as opposed to 52% of the students in the 2D groups. The test results improved by 7% in the 3D groups and by 8% in the 2D groups. Regarding attention, it was found that 92% of the students paid attention during 3D presentations while the 2D presentations were only followed by 46%.

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(engineering, medicine, arts, military, etc.). Threats include the costs of VR hardware and software, unrealistic expectations of the technology, the often false sense of security offered by use and the technical and cultural challenges that are precisely caused by VR.

Somewhat surprisingly, neither this nor any other approach identifies the problem of retaining knowledge as a challenge or weakness. Teaching is a dynamic process mainly aimed at human development but the traditional text-based education with its medium, the book, is in a way a repository of certain forms of knowledge and skills (cf. Nyíri, 2012). How is knowledge retained in a space of educational VR? Will it be possible to abstract knowledge from current learning processes and participants? Can educational VR function as a repository of knowledge that may be referred to in its complexity? While this may not be the primary goal, at the time of ephemeral media, when future-proofing by data, facts, news, knowledge, and knowledge-based society is becoming a topical issue again, it is worth considering these matters or at least mentioning them as a challenge.

These summary analyses suggest that the challenges of educational VR should be managed in the following 3A framework:

1. *Access*. As pointed out in the introduction, the graphic requirements of VR pose a daunting challenge for the IT equipment available to schools, institutions and individuals. The use of educational VR clearly has its technological obstacles. This is closely related to financial difficulties and problems of content (the availability of specifically developed contents with information that is reliable and suitable for the user's age group in intellectual, moral and health terms, the shareability of subject-specific content developments), data protection, security, the enforcement of institutional frameworks (own developments, rights, sharing), and the digital divide (in terms of finance, generation and information, cf. Csótó, 2017).

2. *Ability*. The use and design of educational VR require competences and qualifications that are not necessarily possessed by users. Also, users do not have access to training or support (e.g. lesson plans) for obtaining such competences and qualifications at every time and place. Some can be studied formally (e.g. pedagogical and technological skills), others can be learnt more during socialisation (getting used to VR technology, connecting certain activities to this, the evidence of accessibility, etc.), yet others require physical and health skills which depend on the individual characteristics of the body and the psyche and can be grasped in physiological terms. Another potential challenge is the extent to which educational VR developers and providers have pedagogical knowledge and practice and the ways and business model in which we can combine the diverse types of disciplinary knowledge required for creating educational VR.

3. *Aftermath*. The overall perception of educational VR is positive according to research but most inquiries still lack long-term perspectives. VR supports well certain forms of learning (e.g. playfulness) but it is still unknown how much continuity it can provide with other cultural forms (e.g. books) in education, or how much, how long and in what ages it supports learning modes best, and which. Likewise, research reports about the health effects of VR are not numerous enough or long-term for their findings to guide the use of VR. Another approach to the aftermath of educational VR and its challenges is the sustainable business model with questions like to what extent can VR technology be an open graphic surface and how educational VR can serve the open access needs of knowledge based societies.

Lack of cultural appetite? - Surveys about the use of educational VR

This section overviews the findings of four international surveys and one Hungarian survey conducted in the past three years, of the patterns of VR use by teachers, for an insight into the state of educational VR regarding one of the key target groups.

Samsung and the GfK[1] Knowledge Network conducted their first joint survey in 2015 (Samsung-GfK, 2015) across the USA to explore the use of classroom digital technologies by kindergarten, elementary and high school teachers (K-12 instructors, a total of 1,008 respondents). The results revealed that while most teachers (90%) think it is important to use tech in the classroom, more than half of them (60%) do not feel well-prepared for this. More than a third (37%) were willing to use technologies but simply did not know how to do that. 81% of the respondents agreed that technology helped learners acquire practical experiences and a similar number (80%) reported a need for lesson plans providing help with the use of technology.

Another joint survey by Samsung and GfK (Samsung-GfK, 2016), which involved 1,011 pedagogues, also explored the use of VR. Of the respondents, primarily millennial teachers (Generation Y, born between 1985 and 2000) claimed to be technological innovators in the classroom, too, and had experienced VR for personal or professional purposes, while this was much less true for the older people (Generation X, Baby Boomers). It turned out that only 2% of the teachers had used VR in the classroom and 85% thought that technology could have a positive effect on their students. The most typical reason (68% or above) why they found educational VR useful was that it supports experience and visits to otherwise inaccessible locations, a better understanding of complex concepts, and trips to distant world landmarks. The respondents found the use of VR the most efficient in the teaching of science (82%), social studies (81%), and history (81%). Nearly half (42%) of the high school teachers would like to use virtual reality to tour college campuses to encourage students to pursue higher education. Most respondents (83%) claimed that VR supports teaching efficiency but only one third (36%) thought their schools would adopt the technology in 5 years and 28% did not believe this would ever happen.

In April 2016 UNIMERSIV (2016), one of the biggest US developers of educational VR platforms, released *The State of Virtual Reality for Education*. Their survey, of unrevealed details and circumstances, sought to explore the extent to which VR users apply the virtual environment for learning goals and why. Obviously, the questions also aimed to find the brand and products that the respondents identified educational VR with, and how much they would spend to use educational apps. The results showed that more than half of the respondents had never tried educational VR while nearly 100% thought this medium was the right means to learn something new. Most respondents (53.4%) found VR the most suitable for teaching science (followed by history) and they typically (43.9) found educational VR a good experience if it helped to learn something. The survey revealed that more than one third of the respondents did not identify the development of educational VR with any company or brand (none of the companies named was mentioned in more than 16% of the cases), and 85% of them would be ready to pay $5 or $10.

Based on the data released in the spring of 2017 by KALLIDUS, one of the biggest UK based learning and talent management platform providers (KALLIDUS, 2017), 81% of the 200 education professionals (organisation trainers, teachers, developers) thought

[1] *Gesellschaft für Konsumforschung*, a German market research company with global operations, the fourth biggest of its kind worldwide.

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VR had a major potential in development (although only 11% found it "the next big thing"), and more than half of them would be willing to build VR in their teaching practices before any other new method. At the same time, only 4% had previously used educational VR and only one in three had used any type of VR, not only for educational purposes. The vast majority of the respondents (over 80%) thought the biggest benefit of educational VR is that it creates an education environment encouraging involvement, replaces practical training that would entail dangers and risks in reality, and enhances innovation in the organisation. As regards the areas of development, they found it most useful in practical, health and adaptation skills. The biggest obstacles to educational VR were costs (75%), lack of knowledge on how to use VR (61%), and lack of "cultural appetite", i.e. willingness (38%).

Based on the themes and findings of the preceding inquiries, in May 2017 the Institute of Behavioural Sciences and Communication Theory of Budapest Corvinus University (Aczél, 2017a) launched a short digital questionnaire (typically taking 5 to 10 minutes to complete) for a specific purpose, sent out for a short period (15 days). This was the first questionnaire to offer an insight into VR practices at universities. The digital questionnaire was filled in by 120 higher education teachers so the results are not representative but confirm the data released by Samsung-GfK, UNIMERSIV and KALLIDUS in some respects. Nearly half of the Hungarian respondents (45%) were 41 to 50 years old, the age range typically termed "generation X" among the media use clusters, but at least 10 people represented the beginners (aged 21 to 30), seniors (61-70) and the intermediate category each. Almost the same number of respondents were female (48%) and male (52%). 87% of them hold a PhD or a higher degree in science or art and most of them teach social studies (49%), humanities (39%) and economics (22%). (At the same time, 17% came from science and 6% from sports in addition to pedagogy, psychology and medicine). As opposed to the diverse disciplinary affiliations of the respondents, their answers to a key survey question were clear: 91.7% had never used VR in their teaching practices and only three of them reported the use of VR in teaching on more than two occasions. By contrast, the vast majority of the 8.3% that had previously used VR for educational purposes found it was worth the effort. Another clear result is that over 94% of the respondents had never assigned any homework that required the use of VR. None of them thought educational VR would be "the next big thing" but, consistently with the survey of KALLIDUS, 88.3% of the respondents agreed that the use of educational VR had certain potential but the renewal of education would take more than that. In this respect, those who did not choose any of the options but gave a different answer remarked, among other things, that educational VR will "only be exciting in 5 years as it's still undeveloped", "palpable phenomena are more important than the virtual", "there is more hype around it than what you can expect of its use", and "excessive visuality could be a problem for conceptual thinking and the verbal exchange of information". Nearly half of the respondents (45.8%) were not planning to use VR in their teaching practices, 25.8% said they would start using it within 3 years, 16.7% said they would do so within 5 years, and only 11.6% mentioned the next academic year, i.e. the foreseeable future. The number and proportion of those willing to use VR are also similar to the findings of KALLIDUS. 97.5% of the respondents claimed their students had never asked them to use VR in their classes. At the same time, the question if their students would be open to such medium received an affirmative answer from 90%. 76.7% would use a VR application developed for their courses and available for free. The subjects where educational VR was found to be useful included five key areas (over 35%), specifically media (50%), medicine (48.3%), history (44.2%), communication (44.2%), and IT (36.7%). In sum, the Hungarian answers were unique and peculiar in viewing VR as a means of media education and this may reveal the logic by which VR is, in a way, a subject of media skills. To the question which existing form of education could be complemented or replaced by educational VR the most efficiently, most respondents chose the practical trial of knowledge (57.5%), the solutions of cases (48.3%) and the classroom application of knowledge in a group task (40.8%). The key benefits of educational VR for learners included the application and testing of knowledge, practical training (25.8%), the comprehension of new material (24.2%), and complex problem solving. In this context, the least chosen options included responsibility, involvement (7.5%), the identification of problems (4.2%), the sharing of knowledge (0.8%), and the improvement of critical sense (0.8%). The biggest obstacles to using educational VR included the lack of technical conditions (80.8%), course-specific content developments (72.5%), teachers' interest (70%), and teachers' IT literacy (50.8%), while the lack of students' interest was only chosen by 5%.

Discussion and summary

As is shown by the survey findings, the state of educational VR is much more vague and controversial for teachers as one of the key target groups of users than suggested by research into the use of this technology. On the one hand, there is enthusiasm, probably as a result of the media discourses that keep business and technological information about VR on the agenda. On the other hand, knowledge about educational VR is clearly rather superficial and commonplace in the previous sense (carrying elements and emphases of mainstream media and technological discourses), and it barely reflects knowledge from the practical use and pedagogical research or the coherence of critical and practical views. The preceding international and Hungarian surveys aimed at different target groups of teachers with only partial overlaps, and contained different, only partly identical, questions so the comparison of their findings requires due caution. At the same time, these surveys are clearly consistent in that educational VR is not yet common, its trial and use in teaching are not remotely an everyday practice, teachers do not expect the "invasion" of classrooms by VR as soon as do tech gurus, and there are still no key players in the market of VR development for education. In addition to the coincidence of subjects that can be taught well with VR (e.g. science, social studies, communication, history), it is a special phenomenon only reflected by the Hungarian surveys that VR is found the most useful in media education, and this suggests an even bigger distance from the experience of the real and useful functions of educational VR. The survey findings have clearly revealed a yawning gap between current practices and the willingness to use educational VR, and this gap is only bridged in part by the stated obstacles to its use. According to the answers in both KALLIDUS and the Hungarian survey, a major cause is the lack of cultural appetite and teachers' interest. Also, familiarity with the use of VR and its costs together with the lack of an institutional environment are clearly problematic. At the same time, the Hungarian survey has shown that teachers do not think their students resist to technology (even though, for lack of practical experience, this view may also be based on the stereotypes about media generations). None of the surveys has reflected the specific teaching benefits (e.g. in learning models and forms) that are increasingly discussed by scholars. The Hungarian questionnaire contained such a question and both the answers to it and the infrequent mentions of certain forms of learning that are efficiently supported by VR also suggest the lack of practical experiences. At the same time, in view of the representativeness and clients of the surveys, we should be extremely cautious to not reach hasty conclusions. Instead, we should assess the findings as a snapshot of the use of VR in Hungarian and international education, ask some relevant questions, and clarify the theoretical framework and goals to conduct further research into teaching practices, and into the awareness, attitudes and needs concerning the link between learning and VR. Probably, the future of educational VR will be greatly determined by the extent to which pedagogy, psychology and other disciplines can rearrange the (financial) interests and goals of development projects, and the way in which they will

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shape the future of VR according to their respective logics. Thus, the question if VR has promoted education is best replaced with another question, one that also warns us of our own responsibility: Has education promoted virtual reality? Proposing the framework of 3A's, this paper is meant to be a humble contribution to such considerations.

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