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EDUCATIONAL POTENTIAL OF 3D MULTI-USER VIRTUAL ENVIRONMENTS

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Abstract

The text focuses on the issue of 3D multi-user virtual environments and their use in education. In the wake of the global Covid-19 pandemic, there was a worldwide need for a rapid transition in education at all levels of schooling and in lifelong learning to the online space. As this was a rapid organisational change, schools and lifelong learning institutions often found themselves in situations where tools not previously tested in the school were used, or online tools were used that did not lead to the desired effect. Therefore, it is necessary to investigate which types of online tools are most appropriate for education, depending on the age of the learners and the learning topic. This text analyses the educational potential of 3D multi-user virtual environments, which hold significant benefits for the application of basic didactic principles that bring significant advantages in terms of learning outcomes, in particular the principle of illustration, learning from simulated virtual experiences as well as direct contact with the learning community. The text concludes by discussing current perspectives on the effectiveness of these environments in the educational process.

Keywords: lifelong learning, online education, 3D virtual reality, multi-user virtual environment, the principle of illustration

VZDĚLÁVACÍ POTENCIÁL 3D MULTIUŽIVATELSKÝCH VIRTUÁLNÍCH PROSTŘEDÍ

Abstrakt

Text se zaměřuje na problematiku 3D multiuživatelských virtuálních prostředí a jejich využití ve vzdělávání. V souvislosti s globální pandemií covidu-19 vyvstala celosvětová potřeba rychlého přechodu vzdělávání na všech stupních škol a v celoživotním vzdělávání do online prostoru. Jelikož se jednalo o rychlou organizační změnu, školy a instituce celoživotního vzdělávání se často dostávaly do situací, kdy byly použity nástroje, které nebyly předtím vyzkoušeny, nebo byly použity online nástroje, které nevedly k žádoucímu efektu. Proto je nutné zkoumat, které typy online nástrojů jsou pro vzdělávání nejvhodnější v závislosti na věku učícího se a na tématu výuky. Tento text analyzuje vzdělávací potenciál 3D multiuživatelských virtuálních prostředí, která v sobě skrývají významné výhody pro aplikaci základních didaktických principů, přinášejících značné benefity z hlediska výsledků učení. Jde zejména o umocněný princip názornosti, učení se na základě simulovaných virtuálních zkušeností i přímého kontaktu s učící se komunitou. V závěru textu jsou diskutovány současné pohledy na efektivitu těchto prostředí ve vzdělávacím procesu.

Klíčová slova: celoživotní vzdělávání, online výuka, 3D virtuální realita, multiuživatelské virtuální prostředí, princip názornosti

INTRODUCTION

In the context of the global Covid-19 pandemic, the education sector is currently faced with the challenge of rapidly incorporating online learning tools into the classroom, often in the form of a complete transition to purely online learning due to mandated health restrictions. Educational institutions at all levels of schooling and lifelong learning institutions have not been sufficiently prepared for such a rapid organisational change. Many of them are facing the problems of teachers' lack of competence to work in an online-only environment or ignorance of specific online learning tools that can be used in teaching in a way that would be beneficial to education rather than a hindrance. In addition to a range of online communication tools (such as ZOOM, MS Teams, Skype, etc.), there are also various Learning Management Systems and 3D virtual reality environments. In this paper we will discuss the latter tools and their educational potential.

3D virtual environment, or 3D virtual reality (VR), represents anything that does not exist in reality but is simulated in some way by electronic media in three spatial dimensions. One of its pioneers, J. Lanier, defined VR as "*a computer-generated interactive three-dimensional environment in which one is totally immersed*" (Kmuníček, 2000). Therefore, some virtual environments are often referred to as immersive (from Latin *immersio* = immersion). Through the user interface, VR attempts to bring the computer environment as close to reality as possible as perceived by our senses, and current applications are able to incorporate the user into the environment with all the senses; i.e. utilise not only sight, hearing or touch, but also smell and taste (Vrtiška, 2009). A three-dimensional spatial (stereoscopic) image is used to simulate visual stimuli. Special glasses (similar to those used in 3D cinemas or for 3D television) or stereoscopic displays (one LCD panel or miniature screen for each eye) built into helmets are used to display it. Special optics ensure the widest possible field of view, reaching about 120° compared to 180° in reality (Brdička, 1995). The helmet also incorporates a sensor that transmits information about the position of the head and eyes to the computer; when the position of the eyes changes, the computer generates a new image in real-time and displays it on the screen. To simulate sound, stereo headphones are built into the helmets as an independent sound source for each ear. For tactile perception, a special data suit (most often a data glove) is used, which informs the computer about the user's motion in VR and provides feedback to the user in the form of tactile and force information about the properties of the space. For the olfactory sense, nose tubes are also built into the helmets to provide the user with olfactory information. According to Vrtiška (2009), the latest technologies can also induce the sensation "as if you have something in your mouth", but these experiments are still in the research stage. Further development of VR tools has occurred in recent years, especially with the development of 3D virtual games in the workshops of companies Oculus (https://www.oculus.com/), Google (https://arvr.google.com/vr/), Microsoft (https://www.microsoft.com/en-us/store/b/virtualreality), etc.

Currently, there are several levels of VR. B. Brdička (1995) characterises them as follows:

1) **passive applications** – work much like a classic film. This environment can be seen and heard but cannot be influenced in any way. An example would be the presentation of a stereoscopic (3D) film.
2) **active applications** – in this environment, it is possible to see, hear, be and move around. It can be explored freely from all sides but cannot be modified in any way. It is not possible to move or handle objects. Examples include simulations in flight simulators.
3) **interactive applications** – this environment has all the characteristics of active applications, and the environment can be modified. It is possible to pick up virtual objects, move them, work with virtual tools, etc. An example is a virtual training operation that a doctor can repeatedly perform on a model of a specific organ.

Today, VR is in practice most often used as a simulator of real situations, such as driving a car, driving an aeroplane, spacecraft, practising crisis situations, accidents, medical interventions, etc. In medicine, it is used to simulate medical procedures, organ modelling, etc. In architecture, it allows the creation of three-dimensional models and construction in three dimensions, such as CAD (computer-aided design). Another possibility is virtual travelling (e.g. GPS systems, global positioning systems). In current virtual spaces, it is also possible to meet a virtual person, talk to them, hold their hand or view them from all sides. One of the strong signals is the increased use of video and 3D virtual environments, which are also starting to appear as a basic user interface in some web browsers (i.e. http://3b.net/browser/demo.html) or for specific Internet applications, notably the large-scale Google Maps and Google Earth projects, complete interactive maps of the world that allow movement in a virtual environment, using environmental simulation to display 3D objects of buildings or terrain. It is also possible to navigate in an environment of panoramic photographs, etc., allowing the user to "walk" in an electronic environment mapping the actual real form of the physical environment.

Depending on how many users can interact in virtual reality, we distinguish between **single-user** and **multi-user** 3D virtual environments. While single-user virtual environments have been developed on the basis of computer games based on the player-computer interface principle, multi-user virtual environments have been developed by combining computer games and social networks (i.e. they are based on the principle of multi-user communication).

1. 3D MULTI-USER VIRTUAL ENVIRONMENTS

The 3D multi-user virtual environment (MUVE) has developed due to the convergence of **simulations, online computer games** and **social networking** (Gartner, 2007). At the same time, the first networked 3D multiplayer game *Maze War* (http://www.digibarn.com/history/04-VCF7-MazeWar/index.html) was the first to introduce the concept of online players represented as avatars. That gave rise to MUVEs, which are now viewed as environments with characteristics very close to the way a certain part of the planet's population will interact in the future.

MUVE is defined as a virtual 3D environment representing a simulation of real space in which multiple users can interact (adapted from Brdička, 1999). It represents an integration of previously used forms of online communication and becomes a medium through which it is possible to create social interactions very close to real space communication.

MUVEs can be categorised according to several aspects: from the user's point of view, there are two types of MUVEs (Holubcová *et al.*, 2010): **game-oriented** virtual worlds, which usually have predefined "virtual cultures", and **open culture** virtual worlds, which are the most attractive for educational purposes, as they allow users to apply to the virtual world the ways of acting and behaving that they use in the real world.

In terms of the use of this tool in education, we, therefore, further refine the definition and define MUVE as a social network in a non-immersive 3D virtual environment, simulating the real world, with an open culture in which the user navigates using an avatar. By narrowing the definition, we want to emphasise the aspect of **real social relationships** that the user in an open-culture MUVE can explore (whereas MUVEs in the form of 3D computer games are built on role-playing games, thus interactions in these environments are not natural but predefined).

The most distinctive feature of MUVE, which distinguishes it from its predecessors, i.e. especially computer games or simulations of real environments, is the aspect it has taken from the principle of social networks, namely the existence of "multi-users". The possibility of sharing the same virtual space has allowed electronic media to **simulate interpersonal relationships** in a certain way. Yee *et al*. (2007) studied the social norms and behaviours of avatars that users use to navigate in virtual reality and concluded that there were significant correlations in interpersonal relationships between the real and virtual worlds, e.g. the interpersonal distance between two men was longer than that of two women, the eye contact of two men was shorter than that of two women, the decrease in the interpersonal distance was compensated by averted eyes, etc.

MUVE has thus brought into the virtual world some previously missing **aspects of non-verbal communication**, such as proxemics, which were not possible with the existing tools enabling direct interpersonal communication (e.g. webcams). Anderson (2009) speaks of the so-called non-verbal immediacy that arises when emotional expressions are used in online communication (movement, eye contact, smiles, gestures, touch, etc.) that facilitate psychological bonding. At the same time, this bonding takes place in a relatively safe environment, so forming bonds between community members can be easier. Some companies also realised this and use virtual environments to build international virtual teams working on shared activities. A significant aspect of this non-verbal immediacy is the so-called social presence, i.e. the sense of "being there together".

Since its inception, MUVE has appeared in a variety of visual forms – from pure text to 2D projects or current multimedia 3D virtual reality. The earliest 2D projects include, for example, the text-based environment *TappedIn* (Teacher Professional Development Institute – http://www.ntts.com/interspace/). Larger projects include, for example, *Active Worlds* (http://www.activeworlds.com), where more than 2 million registered residents communicate. After paying an annual registration fee, it is possible to actively participate in the life of the community and create the user's own virtual world withetheir own rules. The environment also includes themed worlds, such as Star Wars, Lord of the Rings set in Middle-earth, etc. Users also create language-oriented communities. Communication between avatars takes place via text chat. Based on the Active Worlds platform, for example, the 3D interface project of the university library and the online campus of the University of Konstanz has been implemented as part of the Active Worlds Educational Universe initiative. This programme was established in 2000 as part of the Virtual Learning initiative (Vlearn). Currently, approximately 80 institutions from 25 countries are engaged in research activities on this platform (Říha, 1999).

There are also MUVEs aimed exclusively at the **younger generation of users**. Such projects include, for example, the separate environment for teenagers within the Second Life project (i.e. *Teen Second Life* (http://teen.secondlife.com). The most widely used MOPRG (Massive(ly)-Multiplayer Online Role-Playing Game) games in terms of the number of players include *World of Warcraft* (http://www.worldofwarcraft.com). The game is inspired by the fantasy genre and Japanese RPGs (especially Final Fantasy). Participants can choose from a selection of "races" for their role (e.g. humans, gnomes, elves, dwarves, etc.), and they perform tasks in the game, after completing which they advance to a higher level. Other large-scale projects include the *Furcadia* environment (http://www.furcadia.com), which is a Javascript-based environment in which users move in the form of animals walking on their hind legs. It allows object creation and user collaboration. Teachers and parents can block inappropriate content when installing. The *Whyville* project (http://www.whyville.net), which at one point had 3 million members, is aimed primarily at younger school-age children, and is partly focused on science. Children can play educational games, sell items through their avatar, contribute to newspapers, etc. The advantage is the robustness of the system and the possibility of parental access; the disadvantage is the impossibility to create educational content. The *Club Penguin* project (http://www.clubpenguin.com) is a space (owned by the Walt Disney Company) where characters, who take the form of penguins, can play games and earn money. Children can contribute to a magazine, learn about various topics such as healthy lifestyle, etc. Other projects include the *Atlantis Remix* (http://atlantisremixed.org/).

2. EDUCATION IN 3D MULTI-USER VIRTUAL ENVIRONMENTS

The transfer of the educational process to MUVE is still a relatively new development in education, but it offers a number of opportunities that have not yet been fully explored. In the past, it has been difficult to incorporate authentic learning activities into the classroom – whether because of the cost, the danger of the environment, or the impossibility of implementing the řsituation into the classroom. These boundaries are disappearing in virtual worlds. Here, learners can become astronomers, chemists or doctors without any impact on the real world.

Important arguments include the fact that, in the information age, students spend their free time in virtual environments, which can make traditional learning methods less motivating for them. The use of MUVE can, therefore, provide teachers with the opportunity to gain a greater level of student engagement, as the student is not merely placed in the role of a passive recipient of the information being conveyed – the virtual world offers a range of opportunities for **creative collaborative work** that would be limited by, for example, class boundaries or the number of participants who can collaborate at any given time in the real world. Virtual worlds can be adapted to implement authentic learning strategies that focus on the real world, problems and their solutions, the use of role-playing, problem-based activities, case studies and participation in virtual communities (Kluge & Riley, 2008). The learner is fully engaged in such situations as they cannot be passive in role-playing or participating in the simulation.

Virtual worlds provide educational institutions with a shift from teacher-mediated learning to a **student-centred** model. This model is consistent with constructivist pedagogical theories, where learners use their experience to actively construct an understanding of a problem that makes sense to them rather than having the problem presented to them in an already organised form (Kluge & Riley, 2008). In virtual worlds, learners are more actively engaged and remain in the process of constructing meanings based on their experiences. Virtual worlds provide opportunities for teachers to implement learner-centred pedagogical principles that promote active, constructivist learning based on problem-solving.

The first use of virtual worlds in education dates back to the 1990s (Bellotti, 2010). In these environments, students can browse content, manipulate objects, practice skills, and construct knowledge in a natural way. A positive element of 3D environments can be seen in particular in the fact that if the students truly get a “sense of place”, their navigation within the learning environment is more efficient – the difficulty of navigating within thelearning environment can lead to difficulty in conceptual learning. Virtual world environments have come to be used and created for purposes of education, particularly by universities – e.g. the *MediaMOO* environment at the MediaLab (Massachusetts Institute of Technology), the *Daedalus MOO* operated at the University of Texas in Austin, which served as a contact space for students to work together on assignments and other learning projects. In the Czech environment, virtual reality is used, for example, by students at the Mendel University of Agriculture and Forestry in Brno, who work in the *Virtual Reality Laboratory*. The students work in a 3D environment where they create projects in the field of graphics or other disciplines. The display system allows multiple observers to perceive objects displayed by special graphics software, such as spatial vision, through special 3D glasses. The system can perceive head tilt and position in space and manipulate the drawing accordingly. The workstation is interconnectible with similar facilities around the world, allowing teams from other universities to communicate and collaborate with each other. At the Faculty of Mechanical Engineering of the Czech Technical University in Prague, a real-time transmission between a virtual reality device – CAVE (located in the laboratory of the Institute of Intermedia at the Faculty of Electrical Engineering) and an open lecture hall was implemented (Houser, 2009). Transmission of this kind makes it possible to convey the experience of being in a virtual world to a remote user. TheCAVE looks like a cube with a side of about 2.5 meters; the user, who is in the cube wearing stereoscopic glasses, is surrounded on almost all sides by astereoscopic view of the virtual world, and thus feels as if he or she is present in this world. The multi-user mode, where more than one person can enter the cube, represents a significant difference from systems that would use, for example, only goggle projection or a so-called data helmet to view the virtual world.

In the beginning, the educational process included mainly various **simulations of real environments** (e.g. flight simulators, simulators for training job skills, etc.) or **computer games**, the most important aspect of which was the transfer of real situations into virtual space. However, in principle, this was only a technological enhancement of the existing learning environment (in the form of textual or multimedia materials); however from the sociological point of view, it was still a relationship of "isolated individual versus technological interface", which **lacked contact with the learning community**.

The format of e-learning as monotonous, solitary learning for oneself in front of a computer screen is nowadays, according to some authors, an outdated trend and, in light of the experience of many educators, it can only be effective in conjunction with other methods, most often in the form of blended learning, i.e. in conjunction with face-to-face courses. That is also evidenced by educational practice, e.g. at the Goethe-Institut in 2007, 1,200 German language learners ordered distance courses alone, while almost 200,000 people ordered face-to-face courses (Feldmer, 2009). Although today's modern LMSs tend to implement tools for asynchronous or synchronous communication, there is still a lack of modules that also support the social aspect, i.e. those that would incorporate non-verbal cues such as gestures, facial expressions, face-to-face interactions, etc. In particular, some studies have reported that a major factor influencing the take-up of e-learning is the perceived lack of social interaction, which seems to be a key factor in online learning and which students lack (Holubcová *et al*., 2010).

Therefore, 3D **multi-user virtual environments** seem to be the next logical step in the development of existing e-learning tools, which, according to some authors, have already reached the limits of further development. Compared to traditional e-learning systems, these environments bring a number of new aspects. According to Z. Součková (2012), the most important benefits of MUVEs include:

1) **Gamification** – (learning through play) allows playful tasks that may seem boring in traditional systems.
2) **Immersivity** – immersion, being involved in the situation. This experience is most valued in virtual environments, as it allows the person to put themselves in the situation and change from an observer to a participant in the action. The opportunity to experience, grasp and observe the situation from a different angle creates a unique, non-transferable learning experience.
3) **Creativity** – working with objects and creating them in a virtual environment allows students to approach education creatively – e.g. when learning architecture or geometry, etc.
4) **Time and space efficiency** – it is a very flexible environment that can be edited fast, learning objects are created here at a fraction of the cost

compared to creating a similar real situation. Learning takes place regardless of the specific time and space.

5) **Social networking** – MUVEs are social networks with communication options similar to traditional social networks such as Facebook. The fact that this communication takes place in a simulation of the real world further enhances the social contact aspect.
6) **Crowdsourcing** – users find answers to questions not from a higher authority, but from the community of other users. In the community of users with the same interests, they can get more ideas or find already created materials and objects.

The **advantages** of education in MUVE include, in particular, time and space flexibility, the ability to grow dynamically and adapt to the needs of users, the possibility of feedback, and the ability to work on tasks that are often not possible in the real world due to time or space constraints. Virtual worlds allow for collaboration that is not limited by the boundaries of physical space and the significant advantages include, in most cases, low financial costs and easy updatability of learning materials.

The **disadvantages** include mainly health reasons, as the current student generation spends too much time with ICTs, which has a negative impact on both the eyesight and the musculoskeletal system. Other negative aspects may include the lack of competence to work in virtual environments or to work with ICTs in general. However, the current generation of pupils and students, who belong to the group of so-called digital natives, does not face major problems when navigating in MUVEs. They interact with the computer interface on a daily basis, whether playing games, communicating with colleagues and friends or searching for multimedia entertainment. Other frequently repeated arguments include a certain sense of alienation, as human beings do not communicate directly (face-to-face) with each other but through a machine, which may have some impact on social skills and abilities. In virtual communication, "body language" and other personal aspects are also lost. Kluge and Riley (2008) see the negative impacts of virtual learning mainly in the technologies themselves:

a) participation in virtual worlds requires advanced hardware and a fast internet connection,
b) teaching in the virtual world is dependent on technologies that may not always work adequately,

c) the learner's success in the virtual world is dependent on their level of ICT competence,
d) the financial cost of education in the virtual world (cannot be considered a clear negative, it is a question of the choice of educational institution the same way as in the real world).

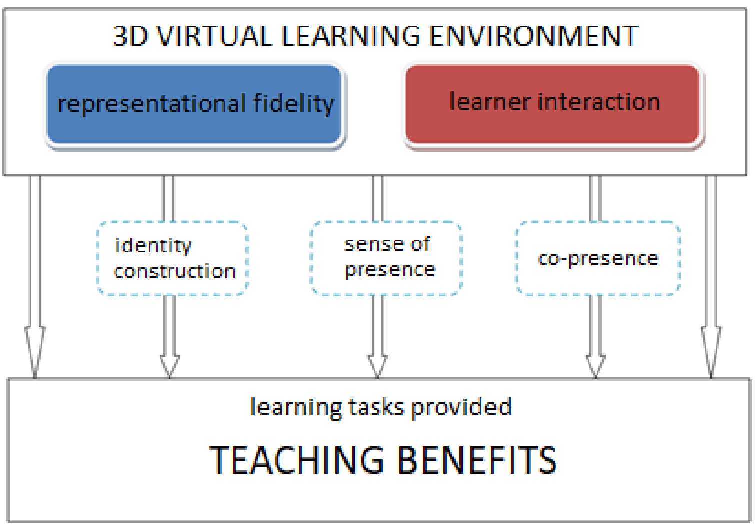
Last but not least, the limited use of MUVEs hosted on the Internet can be seen as a disadvantage – most of these environments are owned by specific companies that set the rules for use, which is advantageous in terms of maintenance and managemet but can lead to misunderstandings or different interpretations of rules and regulations in different countries. The solution may be an open-source alternative – *OpenSimulator* (OpenSim), which allows the user to creater their own virtual world for their own use (Součková, 2012). There are currently over 100 virtual worlds (grids) built on this technology open to the public.

3. EDUCATIONAL POTENTIAL OF 3D MULTI-USER VIRTUAL ENVIRONMENT

The interest in research on the educational use of MUVEs has been growing in recent years in proportion to the emergence of these environments in the educational process, especially in foreign universities. In recent years, a number of studies have appeared investigating the motivational and social aspects of MUVE (e.g. Dickey, 2005, de Jong *et al*., 2005), with the most cited arguments for its inclusion in the classroom being the promotion of an active learning process based on learning through playing (de Jong *et al*., 2005).

A fundamental change in the educational use of MUVE was brought about by the possibility of real-time communication of multiple people in one place (a technology that enabled the emergence of social networks, a principle that was quickly implemented in 3D multi-user virtual environments). MUVE thus brought a new dimension of **experiential learning** to the education process. Dalgarno and Lee (2009), in their research on 3D learning environments, point to the positive effects of learning in MUVEs, in particular the sense of identity, of "being together", experienced by people from different geographical areas, whereby the presence of other people in the learning environment, with whom the learner comes into contact during the learning process, increases intrinsic motivation and engagement of the individual, similar to the real learning environment. The ability to collaborate and create collaborative projects in realtime further enhances this aspect – MUVE allows users physically distant from each other to collaborate on joint projects or knowledge construction, which would be difficult and also costly to do in the real world. It also allows students to simulate real situations where they can, for example, learn to work with objects and demonstrate in virtual space the material they are currently studying, they can participate in activities and processes that would be inaccessible to them in real space (e.g. creating molecular structures, controlling an aircraft, etc.).

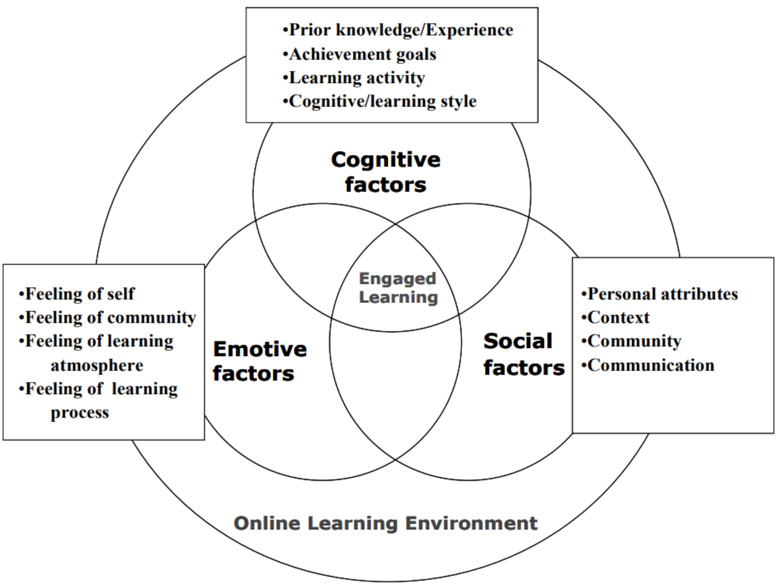
In contrast, traditional models of e-learning environments (LMS, websites or blogs), based on self-study of text or multimedia materials, where the individual is visually isolated in the learning environment, do not create this effect. Thus, MUVE can be considered a constructive learning environment, as it is not only a source of information but also depends on contact with other people, which is in line with current didactic theories emphasising the **social aspect of education**. As the following diagram shows, one of the most important aspects of learning in MUVE is, in particular, a sense of identity and collaboration in the construction of knowledge (Pic. 1.).



Picture 1: *Education model in 3D MUVE (Dalgarno & Lee, 2009)*

The importance of the presence of a sense of identity and a **sense of community** in the active learning process in online learning environments is also emphasized by Wang *et al.*, (2006). In their model of active learning, which they refer to as "cybergogy" – cyber pedagogy, they point to three areas that must be present if the learning strategy is to be successful. These are the cognitive, social and emotional aspects – the learner must engage their prior knowledge in online learning and relate it to constructing new knowledge, be motivated to learn and be positively engaged in the learning process.

The use of MUVE in education can be justified especially where it is not possible to satisfactorily carry out full-time teaching. In this case, situations can be simulated in the virtual world that would otherwise require face-to-face teaching. Working with real equipment can be replaced by its simulation in 3D, training in communication with customers can be realised in an immediate "real" situation when visiting a virtual shop, and exploring



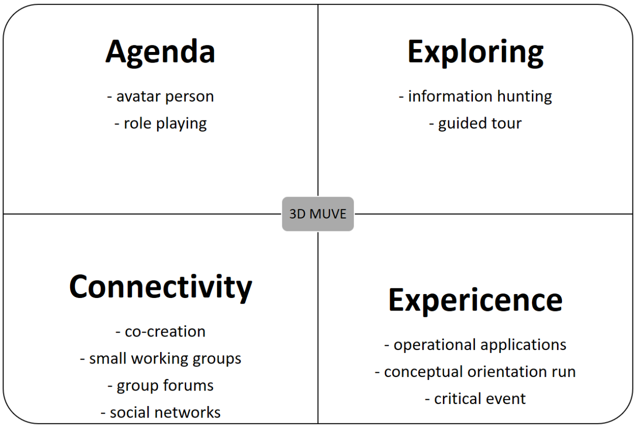
Picture 2: *Model of cyber pedagogy (Wang et al., 2006)*

the architectural elements of the Sistine Chapel can be done when visiting its three-dimensional replica, etc. Another reason for the use of MUVEs may be, according to the results of a study by Heaney and Arroll (2011), who investigated in a qualitative survey of teachers teaching in Second Life their attitudes towards MUVE, e.g. the practical solution to the situation of a student who cannot attend a class for various reasons, whether due to illness, transport problems or bad weather. On the other hand, the positives mentioned in this study were diminished by the shortcomings perceived by the educators, particularly the lack of real physical contact with students (and thus the inability to use non-verbal means in teaching) or the fear of unpredictable situations in the virtual environment and the associated potential embarrassment in front of students when they would not be able to resolve these situations.

MUVEs are currently being used mainly in building virtual universities of a global nature – there are currently several hundred virtual universities around the world, the oldest of which include, for example, the Clyde Virtual University Glasgow (http://www.virtualcampuses.eu/index.php/Clyde_Virtual_University).

The most widespread use is in language teaching, but MUVEs are also used outside the education sector, particularly in business settings for employee training. Equally important is the use of this environment for students with various types of disabilities or those with time or space limitations.

In MUVE, learning takes place through the active involvement of an **avatar** that moves in 3D space, which allows the user to see the shared space and the movement of other users, in addition to being able to express gestures, proxemics, touch, and some facial expressions and other natural aspects of social communication. The avatar can also touch and work with objects, reshape them, and create new objects. In a 3D environment, users can communicate synchronously via voice or text chat. Communication creates a sense of immediacy, as it is possible to hear the communication of other avatars the moment another user approaches them. The feedback and proximity of the avatars thus further consolidate the social presence. Thus, the user has to interact in 3D space very much like in the real world. The importance of the role of avatars in the educational process is highlighted by Kapp and O'Driscoll (2010), who list basic archetypes as prototypes of teaching activities that should be included in education using 3D virtual environments (Pic. 3.).



Picture 3: *Macrostructure of education in 3D MUVE*
(According to Kapp & O´Driscoll, 2010)

Personalisation and **avatar** customisation are the essential characteristics of navigation in MUVEs. Students create their own idea of a virtual being. According to Kapp and O'Driscoll (2009), the presence of an avatar is an important element in establishing communication, as they argue that students interact much more easily from a third-person perspective than from a first-person perspective. **Role-playing** using an avatar is also an integral part of the learning process, whereby the student can change roles throughout the learning process, and adapt the visual appearance of the avatar. Virtual role-play can also help students overcome fears of failure in real social groups (Broadribb & Carter, 2009). Kemp and Haycock (2008) demonstrated higher levels of student engagement and motivation when using MUVE. O'Connel (2009) demonstrated in her study investigating the effect of computer games on the improvement of innovative visual analytics tools that role-playing in a game had a positive effect on success, but communication between teammates was also essential.

Other archetypes of educational activities include **information retrieval or "hunting"**, which in MUVE provides students with basic knowledge, and based on the localisation of individual information in the virtual environment, they create complex knowledge. The information search can also be realised in the form of a **tour with a guide** (teacher) who prepares a list of locations for the student to visit in advance. The tour enhances the sense of space.

Operational applications in MUVEs simulate real conditions (e.g. virtual MRI, etc.), which is the closest to learning by doing. At the same time, students have to apply the knowledge they have already acquired in these activities. The **conceptual orientation run** situates students in situations in which they must be able to recognise the basic attributes of a given concept (e.g., specifying identical attributes using examples of different virtual car crashes). In a **critical event**, students must be able to quickly integrate skills and knowledge learned to date to solve a problem that would have fatal consequences in a real situation (e.g., cardiac arrest, etc.). The **co-creation** aspect allows direct student collaboration, e.g. in the construction of virtual objects, etc. **Working in small groups** and **group forums** that require intensive communication promotes a sense of belonging and the creation of community relationships based on sharing views and ideas, regardless of geographical, cultural or social barriers. In these groups, social networks that promote knowledge sharing and informal exchange of information are then formed.

The above archetypes in education in MUVE correlate with the basic ideas of **cognitive constructivism**, which characterise the process of education by constructing fragments of information from the external environment into meaningful structures, or **social constructivism**, which emphasises the irreplaceable role of social interaction in the process of constructing knowledge. In MUVE, each student is drawn into the action and solving tasks based on previous experiences and, at the same time, is forced to interact with other learners (therefore, tasks should be designed in such a way that the student cannot solve them alone). The student is therefore forced to be active. Each member of the learning group is thus drawn into the experience of constructing knowledge as much as possible (compared to traditional classroom teaching, where not all students need to be active in constructing knowledge at any given time).

Thus, if we compare the existing e-learning tools with MUVE, we can say that in many aspects that current pedagogical theories and approaches consider essential for effective education, MUVE offers greater educational potential. An overview of these is given in the following Table I.

Table I: *Comparison of educational potential of the current e-learning tools with 3D multiuser virtual environments*

Aspect of (self)learning	**Traditional e-learning environments**	**Multi-user virtual environments**	**Examples of pedagogical approaches and theories**
Learning management			
Execution of instructions	YES	MOSTLY NOT	B
Self-management (self-initiation, self-organisation, self-evaluation)	MOSTLY NOT	YES	SC, PLT
Aspects of the learning environment			
Multimediality	YES	YES	H
Interactivity	MOSTLY NOT	YES	C, ITPD, OP
Non-linear representation of curriculum	YES	YES	H
Social aspects of education			
Social communication	MOSTLY NOT	YES	SC
Learning community (teamwork, group work, group learning)	NO	YES	CC, CN
Collaboration, cooperation	NO	YES	SC, CC
Learning from one another	NO	YES	SC, CC
Learning strategies			
Project-based learning	MOSTLY NOT	YES	SC, CC
Non-directive learning	MOSTLY NOT	YES	PLT
Problem-based learning	YES	YES	C
Situational learning	NO	YES	CLT
Exploratory learning (through discovery)	MOSTLY NOT	YES	TLT
Complex networking	YES	YES	CN

Aspect of (self)learning	Traditional e-learning environments	Multi-user virtual environments	Examples of pedagogical approaches and theories
Learning based on diverse experiences	MOSTLY NOT	YES	CN
Didactic aspects			
Changing the role of the teacher (learning guide)	YES	YES	C
Individualisation of learning (learning styles)	YES	YES	C
Principle of illustration (simulation of real experience)	YES	YES	C
Non-linear representation of curriculum	YES	YES	H

Comparison of educational potential of the current e-learning tools with MUVE (Marešová, 2012). Explanation of values and abbreviations: YES = aspect is represented in the environment to a higher degree compared to the other environment, MOSTLY NOT = aspect is represented in the environment but to a lesser degree compared to the other environment, NO = aspect is not present in the environment. B = behaviourism, H = hypermedia tendencies, ITPD = interactive theory of personality development, C = constructivism, CC = community constructivism, CN = connectivism, OP = open pedagogy, PLT = personalised learning theory, SC = social constructivism, CLT = contextual learning theory, TLT = technological learning theory.

4. DISCUSSION

Despite the fact that much has been written about 3D virtual reality, no research studies have been carried out on the effect of education in a 3D multi-user virtual environment, which, in addition to the three-dimensional simulation of reality, also allows direct social contact with the teacher and classmates. The same conclusion is reached by Pellas *et al.* (2016), who analysed 50 peer-reviewed articles on 3D virtual reality in education from

2000 to 2016. Nevertheless, there are many institutions and schools that teach in 3D multi-user virtual environments (e.g. *Quest Atlantis*, a large-scale project aimed at children aged 9–15, involves more than 50,000 children; more than 22 countries are involved in Quest Atlantis projects; 35 schools with 38,000 pupils and students are involved in the MUVE built with *OpenSimulator* technology in American schools in Atlanta; Harvard University *The River City Project* for primary school pupils in grades 6–9, etc.).

Where studies are emerging, the results are not yet clear-cut. For example, a study by Topu *et al.* (2019) analysed the winter sports instruction of 104 high school students in Second Life, with half receiving guided and half receiving unsupervised instruction. It was found that there was a correlation between cognitive engagement and achievement with guidance, but no significant correlation between behavioural engagement and achievement.

Also, according to other authors (Mistakidis *et al.*, 2021) (https://www.mdpi.com/2076-3417/11/5/2412), the use of social virtual reality can provide authentic, simulated, cognitively challenging experiences in an engaging, motivating environment for open social and collaborative interactions and intentional, personalised learning.

The study of Bawa (2020) examined the effects of Covid-19 pandemia on learners' performance. The assumption was that teaching in the virtual environment will affect learners' performance negatively. However, the data analysis suggests otherwise – students performed equally or significantly higher when situated in the virtual environment.

Nowadays, one of the latest trends in 3D virtual reality is to build more complex virtual worlds in which people can do all things they are currently experiencing on the Internet network. One such world is the Metaverse, created by the Facebook company (Austin Visuals, 2021). This world allows users to share their virtual worlds with other people and interact with them in real life. People can buy and sell virtual goods and use the platform to travel, shop, and teleport. People can also play games and movies without leaving their homes. They can share information with others and communicate by simply clicking a button. It will soon be possible to market and build goods using this world. However, at this point in time, when this world is still in development, it is premature to assess whether the Metaverse will be a success or only a temporary communication tool.

5. CONCLUSION

Based on the above aspects, MUVE can be clearly recommended, especially for the area of **project-based learning**, where students work **together** to explore a given real-world problem and look for a solution within MUVE (without being exposed to the possibility of a real-world problem), for **research-oriented learning**, where students learn about phenomena by searching for information and performing activities within a virtual simulation, in the area of **role-playing**, where students are set in a simulation mode and perform tasks in the simulation.

Equally important aspects of MUVE compared to other e-learning tools include the possibility of synchronous **collective learning** and community learning, as well as the aspect of **experiential learning**, since the simulation of real situations and phenomena involves not only multiple sensory perceptions (sight, hearing, touch, smell and taste) but also the elicitation of emotional reactions to the visualised stimuli. According to didactic theories, the involvement of multiple senses and the association with emotional perception are among the most important parameters leading to deeper retention of information and, therefore, better learning outcomes.

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LITERATURE

Anderson, T. L. (2009). Online Instructor Immediacy and Instructor-Student Relationships in Second Life. In: Wankel, Ch., Kingsley, J. *Higher Education in Virtual Worlds. Teaching and Learning in Second Life*. Bingley, UK: Emerald Group Publishing Limited, ISBN 978-1-84950-609-0.

Austin Visuals (2021). Is the Metaverse a Future Trend? https://austinvisuals.com/is-the-metaverse-virtual-world-a-future-trend/.

Bellotti, F., Berta, R., De Gloria, A., & Primavera, L. (2010). Supporting Authors in the Development of Task-based Learning in Serious Virtual Worlds. *British Journal of Educational Technology*. Vol 41, No 1, pp. 86–107. https://doi:10.1111/j.1467-8535.2009.01039.x.

Bawa, D. P. (2020). Learning in the Age of SARS-COV-2: A Quantitative Study of Learners' Performance in the Age of Emergency Remote Teaching. *Comput.*

Educ. Open, No. 1, 100016. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7649631/.

Brdička, B. (1995). Učení s počítačem. Virtuální realita. *Bobrův pomocník.* http://it.pedf.cuni.cz/~bobr/ucspoc/ virtreal.htm.

Brdička, B. (1999). Víceuživatelské virtuální prostředí a možnosti jeho využití ve vzdělávání. *Bobrův pomocník.* http://it.pedf.cuni.cz/~bobr/MUVE/.

Broadribb, S., & Careter, Ch. (2009). Using Second Life in Human Resource Development. *British Journal of Educational Technology*. Vol. 40, No. 3, pp. 547–500. https://doi/10.1111/j.1467-8535.2009.00950.x

Dalgarno, B., Lee, M. J. W. (2009). What Are the Learning Affordances of 3-D Virtual Environments? *British Journal of Educational Technology.* Vol. 41, Issue 1, pp. 10–32. https://doi/10.1111/j.1467-8535.2009.01038.x.

De Jong, F. P. C. M., Van Der Meijden, H., & Von Berg, J. (2005). 3D Learning in the Workplace and at School: Playing, Learning, or both? *Educational Technology*, 45, 5, s. 30–34. ISSN 0013-1962.

Dickey, M. D. (2005). Three-dimensional Virtual Worlds and Distance Learning: Two Case Studies of Active Worlds as a Medium for Distance Education. *British Journal of Educational Technology*, 36, 3, pp. 439–451.

Feldmer, S. (2009). Výuka jazyků online je žádaná. Od e-learningu po blended learning. *DAF.* http://www.goethe.de/ges/spa/dos/daf/spr/cs4590436.htm.

Gartner research (2007). *GartnersSays 80 per cent of active Internet users will have a „Second Life“ in the virtual world by the end of 2011*. http://www.gartner.com/it/page.jsp?id= 503861.

Heaney, R., & Arroll, M. A. (2011). A Qualitative Evaluation of Academic Staff's Perceptions of Second Life as a Teaching Tool. *Proceedings of the 10th European Conference on E-learning*. Vol. 1, 2, pp. 311–318. ISSN 978-1-908272-22-5.

Holubcová, E., Ilková, M., Jílková D., Juhaňák, L., Kantorová, K., & Rychtová, V. (2010). Aplikace vzdělávacích a kolaborativních nástrojů ve virtuálním světě Second Life – projekt VIAKISK. *Inflow: information journal.* roč. 3, č. 1. ISSN 1802-9736. http://www.inflow.cz/aplikace-vzdelavacich-kolaborativnich-nastroju-ve-virtualnim-svete-second-life-projekt-viakisk/alt https://medium.com/inflow-kisk.

Houser P. (2009). CAVE: Virtuální realita v jeskyni. *Science World.* http://scienceworld.cz/technologie/cave-virtualni-realita-v-jeskyni-5276.

Kapp, K., M., & O'Driscoll, T. (2010). *Learning in 3D: adding a new dimension to enterprise learning and collaboration*. 385 pp. Dostupné z: http://books.google.

cz/books?id=d6lSyf3HNLIC&printsec=frontcover&hl=cs&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false. ISBN 978-0-470-50473-4.

Kluge, S., & Riley, L. (2008). Teaching in Virtual Worlds: Opportunities and Challenges. *Issues in Informing Science and Information Technology*. Vol. 5, 2008, pp. 127–135. http://proceedings.informingscience.org/InSITE2008/IISITv5p127-135Kluge459.pdf

Kmuníček, V. (2000). *K filosofickému rozměru vnímání virtuální reality*. http://vilemkmunicek.sweb.cz/teo1.htm.

Marešová, H. (2013). *Vzdělávání v multiuživatelském virtuálním prostředí.* Olomouc: Univerzita Palackého, 203 s. ISBN 978-80-244-3101-7.

Mystakidis, S, Berki, E, & Vltanen JP. (2021). Deep and Meaningful E-Learning with Social Virtual Reality Environments in Higher Education: A Systematic Literature Review. *Appl. Sci.*, 11(5), 2412; https://doi.org/10.3390/app11052412.

O´Connell, T. A. (2009). Leveraging Game-Playing Skills, Expectations and Behaviors of Digital Natives to Improve Visual Analytic Tools. *Journal of Virtual Worlds Research. Pedagogy, Education and Innovation in 3-D Virtual Worlds.* Vol 2, No 1, ISSN 1941–8477.

Pellas, N., Kazanidis, I, Konstantinou N, & Georiou, G. (2017). Exploring the educational potential of three-dimensional multi-user virtual worlds for STEM education: A mixed-method systematic literature review. *Education and Information Technologies*, Vol. 22, pp. 2235–2279. https://link.springer.com/article/10.1007/s10639-016-9537-2.

Říha, D. (2006). *Implementace prostředí neimerzivní virtuální reality v rámci "Kunst am Bau".* http://everest. natur.cuni.cz/ konference/2006/prispevek/riha.pdf.

Součková, Z. (2012). Multiuživatelské virtuální prostředí ve vzdělávání. *ICT ve vzdělávání.* Olomouc: Univerzita Palackého, 269 pp., pp. 178–185, ISBN 978-80-244-3362-2.

Topu, FB, & Goktas, Y. (2019). TheEeffects ofGguided-unguidedLlearning in DdVvirtualEenvironment onSstudents'Eengagement andAachievement. *Computer in Human Behavior*, Vol. 92, pp. 1–10. https://doi.org/10.1016/j.chb.2018.10.022.

Vrtiška, O. (2009). Virtuální realita poprvé stimuluje všech pět smyslů. *Týden. https://www.tyden.cz/rubriky/veda/technologie/virtualni-realita-poprve-stimuluje-vsech-pet-smyslu_108414.html*.

Wang, M., & Kang, M. (2006). Cybergogy for Engaged Learning: A Framework for Creating Learner Engagement through Information and Communication Technology. *Engaged Learning with Emerging Technologies*. pp. 225–253. https://link.springer.com/chapter/10.1007/1-4020-3669-8_11.

Yee, N., Bailenson, J.N., Urbanek, M., Chang, F., Merget, D. (2007). The Unbearable Likeness of Being Digital: The Persistence of Nonverbal Social Norms in Online Virtual Environments. *The Journal of CyberPsychology and Behavior*. No. 10, pp. 115–121. https://pubmed.ncbi.nlm.nih.gov/17305457/.

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