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Original Article

Possible Application of Virtual Reality in Geography Teaching

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Abstract

Virtual reality represents simulated three-dimensional environment created by hardware and software, which providing realistic experience and possibility of interaction to the end-user. Benefits provided by immersive virtual reality in educational setting were recognised in the past decades, however mass application was left out due to the lack of development and high price. Intensive development of new platforms and virtual reality devices in the last few years started up with Oculus Rift, and subsequently accelerated in the year 2014 by occurrence of Google Cardboard. Nowadays, for the first time in history, immersive virtual reality is available to millions of people. In the mid 2015 Google commenced developing Expeditions Pioneer Program aiming to massively utilise the Google Cardboard platform in education. Expeditions and other VR apps can enhance geography teaching and learning. Realistic experience acquired by utilisation of virtual reality in teaching process significantly overcome possibilities provided by images and illustrations in the textbook. Besides literature review on usage of virtual reality in education this paper presents suggestion of VR mobile apps that can be used together with the Google Cardboard head mounted displays (HMDs) in geography classes, thereby emphasising advantages and disadvantages as well as possible obstacles which may occur in introducing the immersive virtual reality in the educational process.

Keywords: *geography education; Google Cardboard; immersive virtual reality, innovations in teaching; virtual education.*

Introduction

Modern education which has to prepare the individual for fast-changing society is not possible to conduct without adjustment to the global development and influence of the new technologies to all segments of human life (Milutinović, 2008). Nowadays, children grow up in the media environment where usage of computers, the Internet and mobile devices is part of everyday life, representing both challenge and development possibility for educational institutions (Andevski, Vidaković, & Arsenijević, 2014; Arnold, 2015; Hussein & Nätterdal, 2015; Kőrösi & Esztelecki, 2015).

Digital competence is one of the 11 general and cross-subjects competencies in the educational system of the Republic of Serbia dedicated to the completion of high school education in which the aim is providing students with skills to utilise resources in the field of information and communication technologies (ICT) in everyday life, education and future job (Zavod za vrednovanje kvaliteta obrazovanja i vaspitanja, 2013). A lot of programs for permanent professional development of the teaching staff provide capacity for acquiring digital competencies, thus it is necessary to emphasise that for the school years 2014/2015 and 2015/2016 there was accredited program "*Electronic communications in enhancing the teaching – m-learning*" whose main topics were: Android apps, mobile Internet in education and use of mobile devices in education (Kőrösi & Esztelecki, 2015; Zavod za unapređenje obrazovanja i vaspitanja, 2014, 2016). Andevski et al. (2014) conducted the research during the school year 2013/2014 on use of the Internet in teaching and learning on the sample of 175 high school students and 32 teachers. The results of this research showed that 69.9% of students had their own computer and that 88% used the Internet at home, while 81.5% of teachers used the Internet often (Andevski et al., 2014). Popadić (2011) pointed out that contemporary students are interested in modern technologies and they are computer literate, however it is necessary to direct their interests and use of modern technologies to utilisation in learning process. Numerous papers were written on possibilities and methods of application of computers and the Internet in geography classes (see Ivkov-Džigurski, Ivanović, & Pašić, 2009; Popadić, 2011; Živković & Jovanović, 2006). When it comes to formal use of mobile devices in teaching, Serbia is left behind since schools mostly forbid use of mobile phones during classes (Kőrösi & Esztelecki, 2015).

Sung, Chang, and Liu (2016) conducted a meta-analysis of the effects of mobile devices in teaching and learning in which 108 experimental and quasi-experimental journal articles published during the period from 1993 until 2013 were analyzed. The results of this meta-analysis showed that learning with mobile devices is significantly more effective than traditional lecture-style teaching or desktop-computer-based instruction (mean effect size of 0.523, according to Hattie's criterion represents a medium effect size). Additionally 22 experimental studies (in which affective variables were involved) were analyzed and positive impact of the application of mobile devices on motivation, satisfaction and attitudes toward education were determined (mean effect size of 0.433, according to Hattie's criterion represents a medium effect size). Also, the authors noticed that the use of mobile phones in education increased significantly since 2009 with positive trend (Sung et al., 2016).

Golijanin et al. (2014) pointed out that nowadays high school students cannot imagine their lives without mobile phones, and in their research 75% of students reported that they used their mobile devices for communication on social networks during the classes, but they also used their smartphones to browse information teacher was talking about (half of the students).

Kőrösi & Esztelecki (2015) explored the use of mobile phones in schools in Vojvodina (Republic of Serbia). In this research 455 elementary and high school students (age 11-18) together with 49 teachers took part. The results showed that 71.8% of students (age 11-14 = 68.22%, and age 15-18 = 73.46%) and 45.8% of teachers had mobile phone and that 69.37% of students already used their mobile devices for learning (e.g. for browsing and gathering information and making notes). The use of mobile devices in teaching was supported by majority of students and teachers in possession of smartphones, while teachers who did not possess them quite often were poorly informed about didactical possibilities of mobile devices (Kőrösi & Esztelecki, 2015).

Yap (2016) pointed out the importance of smart mobile phones which students possess and possibility of their application for educational purpose. Data on possession and use of mobile phones are important when considering implementation of BYOD (bring your own device) or BYOT (bring your own technology) programs which already have been implemented in many schools worldwide (Arnold, 2015; Kőrösi & Esztelecki, 2015; McLean, 2016; Yap, 2016). Implementation and use of virtual reality (VR) in education is naturally linked to the teaching and learning using computers and the Internet (Pantelidis, 2009) and educational apps and mobile devices (Hussein & Nätterdal, 2015).

Virtual Reality and Education

Gatalo et al. (2006) emphasized that development of virtual reality started with the machine (which provided the user with the sense of flying) constructed by Edwin Link in 1929, and Sensorama device constructed by Morton Heilig in the beginning of 1960s.

Freina & Ott (2015) stressed that term virtual reality originates from the early 60s of the last century and that there are two different types of virtual reality, immersive and non-immersive. Non-immersive VR is based on computer generated environment and simulates real or imaginary places which can be accessed by computer, while immersive (or complete) virtual reality creates perception of presence in simulated environment and demands use of additional devices, mostly HMD (head mounted display) (Freina & Ott, 2015).

Merchant, Goetz, Cifuentes, Keeney-Kennicutt, and Davis (2014) emphasized that immersive VR was beyond schools' budget, that quality of instructional design of virtual environment was poor and that there were many inconveniences in using old HMDs. While immersive VR was in stagnation, non-immersive (computer-based) VR developed rapidly following the development of computers. This technology (non-immersive VR) found its place in K-12 and higher education in the form of using games, simulations and virtual worlds (such as Second Life). Merchant et al. (2014) conducted a meta-analysis of non-immersive virtual reality use in education and examined 13 studies in the category of games, 29 studies in the category of simulations and 27 studies in the category of virtual worlds. The results of this meta-analysis showed that all of them (games, simulations and virtual worlds) had positive influence on learning outcome and that games gave better results comparing to simulations and virtual worlds (Merchant et al., 2014).

In the last few years, especially in 2016, significant progress was achieved in the development of immersive VR devices causing new way of thinking on possibilities to utilise this technology in education. This paper discusses possible application of immersive virtual reality in geography teaching process.

Immersive virtual reality can be defined as computer generated three-dimensional environment available in real-time and in compliance to end-user behaviour (Nadrljanski, 2003) by applying special hardware-software aids (Gatalo et al., 2006). Hussein & Nätterdal (2015) pointed out that immersive VR is a collection of hardware (PC or mobile, HMD and tracking sensors) and software to deliver an immersive experience. Recent definition of VR was proposed by LaValle (2016, p. 1): "Inducing targeted behaviour in an organism by using artificial sensory stimulation, while the organism has little or no awareness of the interference.". Virtual reality is based on the senses of sight, hearing and touch (Gatalo et al., 2006), while Freina & Ott (2015) emphasized that for the complete immersion in a virtual environment all five senses should be involved, however the focus is on sight and hearing.

Jorgić (2014) stressed out that virtual education can be defined as a process of knowledge, skills and habits acquisition in simulated (computer generated), three-dimensional auditory and tactile environment in real time and in compliance to the end-user behavior. According to Vilotijević & Vilotijević (2008) virtual reality is three dimensional computer generated simulation which student experiences in real-time and the interaction is complete and real. Spatial immersion into virtual reality creates perception of being physically present in a non-physical world (Freina & Ott, 2015), student feels its presence in virtual surrounding and that he/she is part of it (Pantelidis, 2009). Virtual reality allows active learning as a first person experience (Savičić & Egić, 2010), which is contrary to what schools usually promote (learning by using symbols and the "third person" experience) (Winn, 1993). Auditive one-way approach (mostly engaging students' hearing) dominates in traditional educational process while virtual education provides more substantial possibilities and it is more visually advanced (Jorgić, 2014). Most researchers agree that there are important educational and motivational potential in utilisation of immersive virtual reality in teaching and learning (Freina & Ott, 2015; Hussein & Nätterdal, 2015; Martín-Gutiérrez, Mora, Añorbe-Díaz, & González-Marrero, 2017; Mikropoulos, 1996; Pantelidis, 2009; Savičić i Egić, 2010; Yap, 2016; Youngblut, 1997).

Constructivism stands out as the best theoretical basis for the development of VR educational contents (Martín-Gutiérrez et al., 2017; Pantelidis, 2009; Savičić & Egić, 2010; Winn, 1993; Youngblut, 1997).

VR Systems and Devices

The roots of immersive VR can be traced to the development of HMDs (Winn, 1993). Ivan Sutherland constructed the first HMD device in 1968 that could track position of the user and generate stereoscopic image for left and right eye (Gatalo et al., 2006). Over the past decades a lot of different (diverse software and hardware) devices based on HMD system were developed, which allowed the user audio and visual experience of virtual environment where navigation and interaction was possible by head motion or by haptic accessories, mostly haptic gloves (Savičić & Ergić, 2010). Small screen resolution (HMD consists of a helmet with two displays, one for each eye) represented significant problem in the past (Gatalo et al., 2006), as well as the price which amounted to more than 15,000 USD at the end of the past century, preventing massive use (Youngblut, 1997).

Besides HMD devices for immersive VR, CAVE (Cave Automatic Virtual Environment) system was also developed. CAVE is a device for immersive VR where virtual environment is projected in square space. Users wear polarised glasses in order to obtain 3D virtual environment, and by assistance of additional equipment they perform navigation and interaction with the environment. However, high price of CAVE device prevented the widespread use (Gatalo et al., 2006).

In the beginning of the 1990s massive use of devices for immersive VR was announced, but due to the high price and numerous limitations and imperfection of HMD devices from that time which couldn't fulfil user's expectation this attempt failed on the market (LaValle, 2016; McLellan, 2004). Afterwards, the use of immersive VR was limited to VR laboratories at universities, and in specialised military, engineering and medical fields (McLellan, 2004). Until few years ago, immersive VR was not available to most of the population, especially was not available for application in elementary and high schools (Hussein & Nätterdal, 2015; Merchant et al., 2014; Yap, 2016).

Intensive development of new devices for immersive VR started with Oculus Rift, and accelerated in the year 2014 with occurrence of Google Cardboard HMD. LaValle (2016) pointed out that we are attending the rebirth of immersive VR.

Oculus Rift (https://www3.oculus.com/en-us/rift/) was the first affordable, comfortable and lightweight computer assisted HD VR HMD device with stereoscopic displays and ultra wide field of view. The first prototype version of this device occurred in the year 2012, after successful Kickstarter campaign by Palmer Luckey, where 2.4 million dollars were collected for realization of this project, and the company was sold later on to Facebook (Hussein & Nätterdal, 2015; LaValle, 2016). Success of Oculus Rift reverted the interest of this technology and set the immersive VR together with augmented reality (AR) into the focus of investments in new technologies (Martín-Gutiérrez et al., 2017). "Health and safety warnings" guidelines for the Oculus Rift recommend that children under 13 should not use the device (Freina & Ott, 2015).

Samsung Gear VR (https://www3.oculus.com/en-us/gear-vr/) is a smartphone assisted wireless HMD VR device that uses the Oculus platform (LaValle, 2016; Martín-Gutiérrez et al., 2017). Until now seven models of Samsung Galaxy smartphones support different versions of this device. Like the Oculus Rift, the Samsung Gear VR is not recommended for children under 13.

HTC Vive (https://www.vive.com/eu/) is a computer assisted VR HMD device, providing 360º immersive experience and with the help of laser position sensors users can move within the tracking space (Martín-Gutiérrez et al., 2017).

Google Cardboard (https://vr.google.com/cardboard/) is a platform for immersive VR developed by Google in 2014 which uses smartphone and cheap cardboard (or plastic) HMD. Due to its popular price (cheapest models are few dollars only) it enables anyone in possession of supported smartphone to jump into the world of virtual reality (Defanti, 2016; Papaefthymiou, Plelis, Mavromatis, & Papagiannakis, 2015). The Google Cardboard HMD is produced by various manufacturers and can be used with both Android and iOS smartphones (Yap, 2016). Instructions for independent development of the Google Cardboard HMD viewer is available at: https://www.google.com/get/cardboard/get-cardboard/. One of the most comprehensive lists of mobile devices that work with the Google Cardboard HMD viewers is available at: https://www.freeflyvr.com/compatible/.

Google also developed new platform for immersive VR called *Daydream* (https://vr.google.com/daydream/). Daydream is more enhanced version of Google Cardboard, but currently the biggest lack of this platform is that Daydream HMD operates only with Google Pixel and Motorola Moto Z models of smartphones.

New VR HMDs devices are available in massive proportion, more advanced and cheaper than similar devices available in previous decades, but still there are certain problems such as demanded computer features in order to support the Oculus Rift and the HTC Vive (computers in our schools probably do not meet requested demands), also the Samsung Gear VR and the Daydream HMD operates only with few smartphone models which are very pricey. Currently Google Cardboard is the most suitable option for use in schools.

For successful learning by applying immersive VR devices, proper preparation is required (Vilotijević & Vilotijević, 2008). Implementation of immersive VR technology besides financial investment demands thoroughly planning, training of teaching staff and students, as well as continued support in order to ensure efficient and safe use (Savičić & Egić, 2010).

A Brief Review of the Literature

Following the history of virtual reality McLellan (2004) pointed out that during the 60s and 70s of the 20th century Air Force established a laboratory at Wright-Patterson Air Force Base in Ohio in order to develop flight simulator using the HMD device with aim to ease on learning.

Taking into account sources about the usage of immersive VR in education Pantelidis (2009) stated that significant use and researches started during the 1980s, but McLellan (2004) noted that popularity lasted up to the beginning of 1990s only, when due to unfulfilled expectation the interest for this technology decreased, however researches continued in smaller extent mostly at universities.

Mikropoulos (1997) conducted pilot research in which 8 physics students participated. Students were presented with the content of laser principles and engineering by application of desktop computer assisted HMD device. Results showed that students successfully mastered VR educational content. One of the students had problem with navigation, while half of the students felt occasionally disoriented in virtual environment. VR is important, as the author stated, since it enables understanding through research and it can help in processing the abstract educational contents which are often in the science education (Mikropoulos, 1997).

Natsis, Vrellis, Papachristos, & Mikropoulos (2012) researched the importance of presence and application of various viewing conditions (stereoscopic vs. monoscopic) in educational virtual environment (EVE). Research was conducted on 98 students from the University of Ioannina (Greece) with the educational content on ancient Greek pottery, but 2 students gave up due virtual sickness. This research showed that learning outcomes were better with monoscopic display. The level of interaction, realistic presentation and clarity of the virtual environment and its objects, as well as students' engagement in learning are more important than stereoscopic view. The authors pointed out that stereoscopic display can significantly influence learning outcome, but it depends on the topic of the learning units (Natsis et al., 2012).

Passing (2009) in his meta-analysis criticised numerous papers since they created methodological confusion in the literature on usage of VR in education. Significant number of authors didn't use appropriate methodologies in forecasting trends for future usage of VR in education. The author also provided detailed overview of studies in which use of virtual reality in educational settings was successful (Passing, 2009).

There is a growing number of studies and papers dealing with the implementation of new HMD devices (Oculus Rift, Samsung Gear VR, HTC Vive, Google Cardboard HMD and others) in teaching and learning (see Bastiaens, Wood, & Reiners, 2014; Bower & Sturman, 2015; Castaneda & Pacampara, 2016; Defanti, 2016; Freina & Ott, 2015; Hussein & Nätterdal, 2015; Lartigue, Scoville, & Pham, 2014; Polcar & Horejsi, 2015; Schuster, Groß, Vossen, Richert, & Jeschke, 2015; Yap, 2016).

Freina & Ott (2015) analysed literature published during 2013 and 2014 related to the use of immersive VR in education. Significant number of papers was written on usage of this technology in university and high school education (especially in the field of medicine, physics, astronomy, chemistry and computer science). Notable number of published papers was in the field of adult education and training. Much lesser number of published papers was related to elementary education (authors explained this with the facts that Oculus Rift is not recommendable for children under 13 years of age, and they didn't find any paper dealing with the usage of immersive virtual reality in teaching and learning process with children under the age of 10). The smallest number of papers was related to the use of this technology with children with special needs (Freina & Ott, 2015).

Polcar & Horejsi (2015) researched differences in cyber sickness and knowledge acquiring by applying PC (non-immersive VR), stereoscopic wall projection with 3D glasses (type of CAVE system) and Oculus Rift DK2. This research included 45 students and the results showed that stereoscopic wall projection caused the most of cyber sickness, thus Oculus Rift DK2 caused considerable discomfort and the least inconvenience is caused by PC. Equally good results in terms of knowledge acquiring showed the use of stereoscopic projection and PC, while the result of the Oculus Rift DK2 was failed for one third. The authors explained worse results with the use of the Oculus Rift with the facts that the respondents were not accustomed to this new technology, that they used a DK2 version of the Oculus Rift which is not the final version but development one, and that the cyber sickness is distracting obstacle (Polcar & Horejsi, 2015).

Hussein & Nätterdal (2015) conducted a qualitative research (by interviewing the participants) to determine the difference between mobile non-VR application and VR application with the same educational content in astronomy. Total of 25 students (from Gothenburg University and Lagmans High School in Vara) and teachers/researchers (from university of Gothenburg and Chalmers and Lagmans High School) participated in this research. The Samsung Gear VR was used. When it comes to usefulness, 11 participants stated that VR app was more useful than non-VR app, 6 participants stated that both applications were equally useful, while 8 of them selected mobile non-VR app as more useful. When it comes to effectiveness 21 participants selected VR app, while 3 of them stated that both applications were equals effective. Answering to the question which application they would rather select, 23 participants selected VR version of the application. As advantages of VR application participants stated that they were more focused and that they felt as if the content presented via virtual reality was more interesting comparing to the same contents presented via mobile application, and that virtual reality could provide a different perspective of the educational content. As disadvantages of VR application, participants stated that it was hard for them to read the text and that safe environment is a must while using VR apps, because they lost the touch with real environment. The results of this study also showed that 16 out of 25 participants had no negative symptoms while using VR app, 6 felt slight inconveniences, while 3 participants felt motion sickness (Hussein & Nätterdal, 2015).

Yap (2016) conducted a research using the Google Cardboard HMDs and 360º video processing the module on history of Hawaii. The results of this research showed that all participants (26 in total, grade 9) were satisfied by using the Google Cardboard HMDs. Post-test results were significantly better comparing to the pre-test results and 83% of participants believed that the use of Google Cardboard could make it easier to remember the educational content due to the 3D factor. It is important to emphasise that 75% of students expressed that this platform should be used in English, Math, Science, and Social Studies, and 87% of students independently downloaded additional VR apps for Google Cardboard (Yap, 2016).

Martín-Gutiérrez et al. (2017) extracted four main aspects of advantages in using virtual technologies (VR and AR):

- Virtual technologies raise motivation and engagement of students since immersive experience makes them feel like protagonists, and 3D models enrich learning experience.
- Virtual technologies enable a constructivist learning approach. Students have free interaction with virtual objects which enables them to research, experiment and receive feedback.
- Virtual technologies (VR/AR) became available and it is of significant importance that they are available via smartphones, tablets and consoles.
- Virtual technologies enable more interaction comparing to traditional learning means.

Immersive experience is very important when studying the environment (with real objects) which can't be approached in another way.

Google Cardboard VR Apps Suitable for Use in Geography Teaching

Mikropoulos (1996) pointed out that the need for utilisation of various media in school geography is obvious and that virtual reality is a powerful teaching tool assisting to overcome lacks of traditional instruction. Romelić (2005, p. 29) noted that the geography classes should be based on observation and that observation is "in the base of every teaching situation in didactical practice of geography". Virtual reality in the geography classes opens up possibility that allow students to observe geographical objects, phenomena and processes directly in the classroom, as well as to perform analysis and synthesis (Mikropoulos, 1996).

It is not appropriate to use VR devices with every teaching material. Educational contents must be carefully selected in order to application of immersive VR increase their obviousness and understanding (Pantelidis, 2009). When selecting VR educational content it is necessary to take into account that they have to be in compliance with the objective of the lesson and must contribute to the achievement of educational outcomes and standards of the subject.

Google Cardboard is a VR platform which due to its low cost, mobility and simplicity to use can be used in geography classes and for independent learning (in case when schools, students or teachers are in possession of applicable smartphones). This VR platform can be used with children over the age of 7, but under teacher or parent control.

Many mobile apps that support Google Cardboard VR platform were developed in recent years, and some of them have educational features. VR apps which can be used in geography education are:

- *Cardboard application* (https://vr.google.com/cardboard/) is the basic app for Google Cardboard and it is important for geography teaching because it contains VR version of Google Earth. The Google Earth program provides possibility of detailed view of earth surface and certain parts, which makes them more visible, and at the same time lectures are more interesting (Ivkov-Džigurski et al., 2009).
- *Expeditions application* (https://www.google.com/edu/expeditions/) was developed as part of the Expeditions Pioneer Program, which began to develop in mid-2015 under the section of Google that deals with education. This VR app offers the possibility for teachers to take their students on virtual tours. Each trip is collection of several 360º VR panoramic photos on particular topic. With each VR panorama text is stated as an explanation together with questions for students on three levels. Teacher on his/her tablet (which controls the expedition and what students see on their devices) may also mark important points on the VR panorama (Yap, 2016). There are more than 200 expeditions available within this VR app (Defanti, 2016) and new ones are added continuously. Some of the expeditions which could be used in geography classes are: Astronomy; The Solar System; International Space Station; Earth Timeline; Rocks, Minerals, and Gems; Fossils; A Journey to the Mesozoic at the Senckenberg Nature Museum in Frankfurt; Volcanoes; Volcanoes Around the World; Mount Everest; Mont Blanc; Dolomites; Mount Fuji; Grand Canyon; Slovakian Caves; Earthquakes; Stratosphere; Clouds; Wind; Underwater Excursion; Lake Baikal; Angel Falls; Coral Reefs; Biomes; Biodiversity and Preservation; America`s National Parks; A Trip to North Pole; Antarctica; Greenland; Amazon; Iceland; Greece; Canada; Ethiopia; Farming in Tanzania; Namibia; Egypt; South Africa; Singapore; Kathmandu; Moscow; Venice; Sites

Along the Thames River; Aztec and Mayan Ruins; Machu Picchu; Petra; Native American Cultures; 7 New Wonders of the World; Taj Mahal; The Great Wall of China and many more. Each panorama can be used individually, so teachers can use them flexibly. Numerous blogs and groups on social networking sites are dedicated to the use of VR and the Google Cardboard HMDs in teaching. Besides of exchange of teaching experiences, additional materials can be also found, as well as numerous written preparation for classes with Expeditions VR app.

- *Street View Application* provides possibility to display all contents of this app in stereoscopic view. Cities, world sightseeing places, nature, museums and galleries can be explored with this mobile app. Also, this app provides possibility for making VR panoramic images (Defanti, 2016).
- Mobile apps such as: *Titans of Space*; *View-Master® Space*; *Mars is a Real Place VR*; *Star Chart VR*; *StarTracker VR* and similar can be used in processing certain contents of mathematical geography.
- *EON Experience AVR* (http://www.eonreality.com/eon-experience-avr/) is a mobile app which combines augmented and virtual reality and contains gamified educational contents in the field of anatomy, biology, geography, history, physics, astronomy and other subjects. Some of the contents of this app which can be used in geography teaching are: Planetarium, Earth Continents, Earth Tropics, Earth Oceans, Arizona Crater as well as numerous VR video materials from different countries.
- *SitesVR* is an app that provides the possibility of sightseeing religious objects, archaeological sites, museums, fortifications, and nature in many countries (Turkey, Egypt, Saudi Arabia, Syria, Morocco, Kuwait, Yemen, Macedonia, Belgium, and France).
- *Cardboard Camera* is an app that enables capture of 360º panoramic images. This app may have application in the realization of the contents about local environment, and also can be used during the fieldwork or excursions. It is also possible to make 360º video materials with special cameras like: Samsung Gear 360, LG 360 CAM, Giroptic 360cam, GoPro Odyssey, Nokia OZO and similar.
- Other mobile VR apps that can be used are: *YouTube - 360° Videos*; *Discovery VR*; *View-Master® Destinations*; *VR Cities*; *Ascape*, etc.

Possibility that the users can make immersive VR contents has become a reality (Martín-Gutiérrez et al., 2017). Teachers and students in addition to making VR 360º photos and videos can build VR apps for the Google Cardboard HMD, and game engine Unity can be used for this purpose. Also, teachers can create educational VR contents through various mobile apps and their corresponding creators (such as CoSpaces, ENTiTi, CrowdVR 360, EON Studio and similar).

Navigation provided by the Google Cardboard HMD (head motion and magnetic trigger or button for touching the screen) is not suitable for all VR apps. Some VR apps require additional controllers, such as cardboard controller with QR codes, or using Bluetooth gamepad or keyboard (other mobile device can be used as a controller as well). Leap Motion VR, which is assessed as one of the best options for interaction in immersive VR, can be used with the Google Cardboard HMD, but must be connected with the computer and the smartphone (Papaefthymiou et al., 2015). Certain applications offer possibility of voice utilisation.

The Google Cardboard HMD is the most applicable device for immersive VR that can be used in our schools, however it should be stressed out that the disadvantages and possible obstacles are still numerous:

- School regulations and teachers often prohibit the use of mobile devices during the classes (Kőrösi & Esztelecki, 2015). Also, implementation of BYOT/BYOD programs is still not recognised as an option in the educational system of the Republic of Serbia.
- Problem with availability of the WiFi Internet in the classrooms (because most VR apps requires connection to the Internet).
- Costs of purchasing applicable smartphones and the Google Cardboard HMDs (for classroom group work it would take at least 6 mobile devices and 6 Google Cardboard HMDs, as well as a tablet for teacher).
- Limited digital competencies of our teachers and their insufficient knowledge of VR technology represent a significant problem. Trainings for teachers should be organized.
- Children safe use of the Google Cardboard HMD is possible by adult assistance only, also time limitation is recommended.
- Google Cardboard uses the built-in accelerometer of phones which can lag causing discomfort and motion sickness for many users (Hussein & Nätterdal, 2015). There is a solution for this problem because most of the VR apps (including the Expeditions app) provide possibility to switch view from stereoscopic to monoscopic (in such cases VR contents can be followed only on a mobile device without a Google Cardboard HMD).

Conclusion

Due to its unique features virtual reality differs from other information and communication technologies (Mikropoulos & Bellou, 2006). The level of interactivity which virtual reality can provide is way beyond traditional multimedia programs (McLellan, 2003) and VR can change the way of interaction between students and teaching materials (Pantelidis, 2009). Virtual environments and 3D objects can explain certain educational contents that text cannot, and those are unique benefits of VR applicable in education (Hussein & Nätterdal, 2015). Bastiaens et al. (2014) pointed out that VR software tools can be used to bring textbook content to life. Virtual reality promotes active learning and enables better concentration since students are focused on virtual environment with a strong sense of presence within (Hussein & Nätterdal, 2015).

Non-immersive (computer-based) VR has already found its place in education via application of simulation, games and virtual worlds, however immersive VR had no significant application up till now. Advantages of immersive VR were marked in past decades, together with disadvantages, but massive application in education was left out due to insufficient development and high price. Success of Oculus Rift in 2012 led to new interest for this technology. In the past few years, especially in 2016, a lot of new devices and platforms for immersive VR were developed (commercial version of the Oculus Rift, new version of the Samsung Gear VR, the HTC Vive, Daydream, etc.).

Google Cardboard VR platform which uses smart mobile phones is currently the most cost-effective for use in schools. More than million students worldwide had the opportunity to test and use virtual reality with Google Cardboard HMDs via Expeditions Pioneer Program, since schools received equipment from Google.

Expeditions and other VR apps for Google Cardboard can enhance geography education as well as to increase obviousness and interestingness of educational contents. Experience and the extent of realisticity that can be obtained by VR cannot be compared to other teaching tools traditionally used in geography instruction, but good selection of VR educational resources with keeping in mind educational outcomes and standards is necessary. The changes that took place in technology and in the global society and economy also have changed the roles of teachers in schools. Teachers in modern classrooms are more facilitators than lecturers, and application of new technologies can help them with new roles.

Most previous studies on the usage of immersive VR in educational settings were performed on small samples. Results of large-scale studies are needed. Common feedback from participants in the previous studies showed that the teaching content became more interesting with VR and that students' motivation was increased, while significant drawbacks such as motion sickness still exist.

Pantelidis (2009) pointed out that disadvantages of introducing immersive VR in schools are above all price of devices and need for training of the end-users, together with safety and health issues which might occur and possible repulsion against new technologies. Listed disadvantages are present even today but in various degrees.

Further development of immersive VR will continue to bring new devices and improved VR educational software, but empirical testing of efficiency of this technology in geography teaching is required.

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References

Andevski, M., Vidaković, M., & Arsenijević, O. (2014). Internet u nastavi i učenju [Internet for teaching and learning]. In *Proceedings of Sinteza 2014 - Impact of the Internet on Business Activities in Serbia and Worldwide* (pp. 368-374). Belgrade, Serbia: Singidunum University. doi: 10.15308/SINTEZA-2014-368-374.

Arnold, P. L. (2015). *Rural high school faculty perspectives on bring your own device implementation: A phenomenological study* (Doctoral dissertation, Liberty University). Retrieved from http://digitalcommons.liberty.edu/doctoral/1029

Bastiaens, T. J., Wood, L. C., & Reiners, T. (2014). New landscapes and new eyes: The role of virtual world design for supply chain education. *Ubiquitous Learning: An International Journal*, *6*(1), 37-49.

Bower, M., & Sturman, D. (2015). What are the educational affordances of wearable technologies?. *Computers & Education*, *88*, 343-353. doi: 10.1016/j.compedu.2015.07.013

Castaneda, L. & Pacampara, M. (2016). Virtual reality in the classroom - An exploration of hardware, management, content and pedagogy. In G. Chamblee & L. Langub (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2016* (pp. 527-534). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

Defanti, A. (2016). Using augmented and virtual reality to bring your geography classes to life. *Interaction*, *44*(3), 43-46.

Freina, L., & Ott, M. (2015). A literatrure review on immersive virtual reality in education: State of the art and perspectives. In *Proceedings of the 11th International Scientific Conference "eLearning and Software for Education" (eLSE)*, *1*, (pp. 133-141). doi:10.12753/2066-026X-15-020

Gatalo, R., Navalušić, S., Zeljković, M., Milojević, Z., Megađa, I., & Košarac, A. (2006). Virtualna realnost - Novi prilaz u projektovanju i proizvodnji [Virtual reality - A new approach to design and manufacturing]. In *Zbornik radova naučno-stručnog Simpozijuma Infoteh®-Jahorina*, Vol. *5*, (pp. 184-188). Retrieved from http://infoteh.etf.unssa.rs.ba/zbornik/2006/

Golijanin, D., Miljković, M. Z., Alčaković, S. S., Gavrilović, J. M., Savković, M. Z., & Stamenković, D. J. (2014). Generacija Z, internet i obrazovanje [Generation Z, Internet and education]. In

Proceedings of Sinteza 2014 - Impact of the Internet on Business Activities in Serbia and Worldwide, (pp. 506-509). Belgrade, Serbia: Singidunum University. doi: 10.15308/SINTEZA-2014-506-509

Hussein, M., & Nätterdal, C. (2015). *The benefits of virtual reality in education: A comparison study* (BSc thesis, University of Gothenburg, Chalmers University of Technology, Göteborg, Sweden). Retrieved from http://hdl.handle.net/2077/39977

Ivkov-Džigurski, A., Ivanović, LJ., & Pašić, M. (2009). Mogućnosti primene računara u modernoj nastavi geografije [Possibilities of computer application in modern geography teaching process]. *Glasnik Srpskog geografskog društva*, *89*(1), 139-150. doi:10.2298/GSGD0901139I

Jorgić, D. (2013). Vrijednosti i protivrječja virtuelnog obrazovanja [Values and contradictions of virtual education]. In *Zbornik radova Vrijednosti i protivurječja društvene stvarnosti* (pp. 149-163). Banja Luka, Bosna i Hercegovina: Filozofski fakultet.

Kőrösi, G., & Esztelecki, P. (2015). Implementation of mobile phones in education. *Research in Pedagogy*, *5*(1), 98-108. doi: 10.17810/2015.08

Lartigue, J., Scoville, T., & Pham, M. (2014). Promoting k-8 learning using Oculus Rift: Employing virtual reality to increase learning outcomes in elementary biology. In T. Bastiaens (Ed.), *Proceedings of E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2014* (pp. 1100-1105). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

LaValle S. M. (2016). *Virtual reality* (draft). University of Illinois. Retrieved from http://msl.cs.uiuc.edu/vr/vrbook.pdf

Martín-Gutiérrez, J., Mora, C. E., Añorbe-Díaz, B., & González-Marrero, A. (2017). Virtual technologies trends in education. *EURASIA Journal of Mathematics Science and Technology Education*, *13*(2), 469-486, doi: 10.12973/eurasia.2017.00626a

McLean, K. J. (2016). The implementation of bring your own device (BYOD) in primary [elementary] schools. *Frontiers in Psychology*, *7*:1739. doi: 10.3389/fpsyg.2016.01739

McLellan, H. (2004). Virtual realities. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (2nd ed., pp. 461–497). Mahwah, NJ: Lawrence Erlbaum Associates.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29-40. doi: 10.1016/j.compedu.2013.07.033

Mikropoulos, T. A. (1996). Virtual geography. *VR in the Schools*, *2*(2). Retrieved from http://vr.coe.ecu.edu/vrits/2-2Mikro.htm

Mikropoulos, T. A. (1997). Virtual environments in science education. In M. Bevan (ed.), *Proceedings of the International Conference on Virtual Reality in Education & Training*, (pp. 43 – 48). Loughborough, UK.

Mikropoulos, T. A., & Bellou, J. (2006). The unique features of educational virtual environments. In P. Isaias, M. McPherson, & F. Banister (Eds.), *Proceedings of the IADIS International Conference on e-Society* (pp. 122–128). Dublin, Ireland: IADIS - International Association for Development of the Information Society.

Milutinović, J. (2008). Futurološka dimenzija ciljeva obrazovanja i učenja [Futurological dimension of aims of education and learning]. *Pedagogija*, *63*(1), 41-49.

Nadrljanski, Đ. (2003). Prilozi za strategiju informatizacije obrazovanja (II deo) [Supplements for Strategies of Applying Information Technology on Education (part two)]. *Pedagogija*, *41*(3-4), 34-54.

Natsis, A., Vrellis, I., Papachristos, N. M., & Mikropoulos, T. A. (2012). Technological factors, user characteristics and didactic strategies in educational virtual environments. *In 2012 IEEE 12th International Conference on Advanced Learning Technologies* (pp. 531-535). doi: 10.1109/ICALT.2012.67

Pantelidis, V. S. (2009). Reasons to use virtual reality in education and training courses and a model to determine when to use virtual reality. *Themes in Science and Technology Education*, *2*(1-2), 59-70.

Papaefthymiou, M., Plelis, K., Mavromatis, D., & Papagiannakis, G. (2015, December). *Mobile Virtual Reality featuring a six degrees of freedom interaction paradigm in a virtual museum application*. Technical Report, FORTH-ICS/TR-462. Heraklion, Greece: Foundation for Research and Technology – Hellas (FORTH), Institute of Computer Science. Retrieved from https://www.ics.forth.gr/tech-reports/2015/2015.TR462_Mobile_Virtual_Reality_Freedom_Interaction.pdf

Passig, D. (2009). The future of virtual reality in education: A future oriented meta analysis of the literature. *Themes in Science and Technology Education*, *2*(1-2), 269-293.

Polcar, J., & Horejsi, P. (2015). Knowledge acquisition and cyber sickness: A comparison of VR devices in virtual tours. *MM Science Journal*, 2015 (June), 613-616. doi: 10.17973/MMSJ.2015_06_201516

Popadić, A. (2011). Primena informaciono-komunikacionih tehnologija u nastavi geografije. *Globus*, *36*, 175-182.

Romelić, J. (2005). Metode rada u nastavi geografije koje utiču na aktivizaciju učenika. *Globus*, *30*, 21-38.

Savičić, J., & Egić, B. (2010). Pedagoški i kognitivni aspekti virtuelne realnosti [Pedagogical and cognitive aspects of virtual reality]. *Pedagogija*, *65*(4), 684-691.

Schuster, K., Groß, K., Vossen, R., Richert, A., & Jeschke, S. (2015, June). Preparing for Industry 4.0 – Collaborative virtual learning environments in engineering education. In *Proceedings of the International Conference on E-Learning in the Workplace (ICELW 2015)*, New York, USA. Retrieved from http://www.icelw.org/proceedings/2015/ICELW2015/papers/Schuster_Gross_et_al.pdf

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, *94*, 252-275. doi: 10.1016/j.compedu.2015.11.008

Vilotijević, M., & Vilotijević, N. (2008). *Inovacije u nastavi*. Vranje, Republika Srbija: Učiteljski fakultet u Vranju.

Winn, W. (1993, August). *A conceptual basis for educational applications of virtual reality*. Human Interface Technology Laboratory Report TR-93-9. Seattle: University of Washington. Retrieved from http://www.hitl.washington.edu/research/education/winn/winn-paper.html~

Yap, M. C. (2016, April). *Google Cardboard for a K-12 social studies module*. Paper presented at TCC 2016 Worldwide Online Conference. Retrieved from http://scholarspace.manoa.hawaii.edu/bitstream/10125/40604/1/LTEC-690-Yap-Scholarspace.05.04.16.pdf

Youngblut, C. (1997). Educational uses of virtual reality technology (Executive summary). *VR in the Schools*, *3*(1). Retrieved from http://vr.coe.ecu.edu/vrits/3-1young.htm

Zavod za unapređenje obrazovanja i vaspitanja (2014). *Katalog programa stalnog stručnog usavršavanja nastavnika, vaspitača i stručnih saradnika za školsku 2014/2015. i 2015/2016*. Beograd, Republika Srbija: Zavod za unapređenje obrazovanja i vaspitanja, Centar za profesionalni razvoj zaposlenih u obrazovanju. Retrieved from http://www.zuov.gov.rs/wp-content/uploads/2016/08/Katalog-2014-16.pdf

Zavod za unapređenje obrazovanja i vaspitanja (2016). *Katalog programa stalnog stručnog usavršavanja nastavnika, vaspitača i stručnih saradnika za školsku 2016/2017. i 2017/2018*. Beograd, Republika Srbija: Zavod za unapređenje obrazovanja i vaspitanja, Centar za profesionalni razvoj zaposlenih u obrazovanju. Retrieved from http://katalog2016.zuov.rs/

Zavod za vrednovanje kvaliteta obrazovanja i vaspitanja (2013). *Opšti standardi postignuća za kraj opšteg srednjeg obrazovanja i vaspitanja i srednjeg stručnog obrazovanja i vaspitanja u delu opšteobrazovnih predmeta: Standardi opštih međupredmetnih kompetencija za kraj srednjeg obrazovanja*. Beograd, Republika Srbija: Zavod za vrednovanje kvaliteta obrazovanja i vaspitanja. Retrieved from http://www.ceo.edu.rs/images/stories/obrazovni_standardi/Opsti_standardi_postignuca/MEDJUPREDMETNE%20KOMPETENCIJE.pdf

Živković, Lj., & Jovanović, S. (2006). Realizacija oblika i metoda rada upotrebom kompjutera u nastavi geografije [Realization of the form and methods of work through the use of computer in teaching geography]. *Zbornik radova - Geografski fakultet Univerziteta u Beogradu*, *54*, 249-260.

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