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Constantine the Philosopher University in Nitra
Faculty of Natural Sciences and Informatics
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XR Applications for the Education and Entertainment of Hospitalized Children

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Abstract

Applications based on virtual, extended, or mixed reality are rapidly gaining momentum in the sector of education worldwide because they have the potential to allow new forms of education and transform educational experiences into a new quality. Their use is expanding from commercial games and services to various science-research areas (healthcare, economy, space) as well as to the area of education at the universities, high schools and nowadays also to primary schools (mainly due to low hardware prices). In this article, we focus on primary school children, who are being hospitalized due to various health problems. We pilot-created an experienced laboratory for them with the necessary hardware, in which they have the opportunity to use our applications, adapted to their needs and requirements, among other activities. In the paper, we deal with the use of VR, AR, and MR in various areas of education and present selected applications that we make for children in primary school (located in a hospital area). Regarding the protection of the health of hospitalized children during the Covid -19 pandemic, we have only found opinions on the success of our applications among teachers, students, and students in primary schools. We present the results of the questionnaire in the discussion part of our article.

Keywords

Virtual reality. Augmented reality. Extended reality. Game-based learning. Primary education.

INTRODUCTION

Due to the pandemic situation of Covid-19, our daily social routines changed completely - our communication and education moved mainly into the online environment. Teachers, as well as pupils and students, were forced to adapt to changed conditions and quickly learn to work with new technologies. However, many technology visionaries expect that this is not the last change that has meet us. In the future, we probably will not miss most of the work and leisure meetings in the Metaverza environment[1], which will allow us to replace our own physical avatars with artificial intelligence in the form of a digital assistant. It relieves us by automating the exchange of information, managing tasks and deadlines, and helping to make education more fun, interactive, and therefore more interesting. Young

[1] Metaverzum is basically a digital world full of digital duplicates of people, cities and things. It is a version of the Internet where people's avatars can be virtually gathered to communicate, collaborate and share information on any device. This could lead to the adoption of VR headsets that would become as common as smartphones are now. (Metaverzum, 2022).

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people between the ages of 18 and 25 (Z Generation) attach more importance to their digital self, but at the same time, virtual interactions suit them better than they do in real life. Dissatisfaction with their physical appearance, as well as a number of complex problems and "uninteresting" life, they solve by escaping into a virtual world where no restrictions and laws apply, where everything is allowed, more beautiful, more perfect, and more fun. There is nothing easier than putting on virtual reality glasses and escaping from the problems of our planet into a world of endless possibilities.

The world of virtual reality is described (Sherman and Craig, 2002) in 'Understanding Virtual Reality' as a medium consisting of computer simulations, giving the user a sense of presence in the simulations. Other authors (Carter and Potter, 2016) claim that it is the completely virtual world made by a computer in which the user interacts only with virtual objects. The Virtual Reality technology has traditionally consisted of cumbersome created environments and has often required complex sensors worn on the body for an individual to interact with the environment. The emergence of head-mounted virtual reality devices is shifting the technology into the commercial consumer area. The number of users who experience the feeling of being immersed in the virtual world is growing rapidly.

Users experience similar impression with an unconventional feeling of augmented reality AR. It is due to interactive digital elements such as pictures, 3D models, sounds, and text, by which our perceptions of the real world are enriched in real-time. The difference between these two technologies (VR and AR) is that virtual reality requires special headsets that allow the user to feel immersed in another - digital world, while augmented reality offers interaction with digital objects in the real world. Hardware of AR is more available because the most popular applications require just a mobile device (tablet or smartphone with a camera, which inserts digital content into the captured image).

The use of web platforms to share virtual environments and user interaction is possible thanks to a high level of network infrastructure and technologies. In this way, systems to support global virtual collaboration are rapidly formed, where users can access a common virtual space. (Hudák and Sobota, 2021)

We have already dealt with the unifying concept of the mentioned technologies in the article (Horváthová et al., 2020). This term refers to all combined real and virtual environments and human-machine interactions generated by computer technology and wearables. It includes representative forms such as AR, MR, and VR (Gownder et al., 2016) and the areas interpolated among them. It is called eXtended Reality (XR). The levels of virtuality range from partially sensory input to immersive virtuality. XR is a superset that includes the entire spectrum from "the complete real" to "the complete virtual" in the concept of reality–virtuality continuum introduced by Paul Milgram (Milgram and Kishino, 1994). Still, its connotation lies in the extension of human experiences, especially relating to the senses of existence (represented by VR) and the acquisition of cognition (represented by AR). With the continuous development in human–computer interactions, this connotation is still evolving. XR is a rapidly growing field being applied in a wide range of fields, such as entertainment, marketing, real estate, training, and remote work (Hui-Wen, 2018).

All these realities have huge potential and in many cases prove to be successful in the context of education (Douglas-Lenders, et al., 2017), (Shen, et al., 2017) a (Fotaris et. al., 2017). In Slovakia it is very successful, for example, Human Anatomy VR application (Brngál,

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2020), used since 2016 and spread to more than 140 countries around the world. A similar example of the use of AR in biology is Arlearning (Arlearning, 2022). Other examples point to the possibilities of using XR in military training (Pallavicini, et. al., 2016), teaching astronomy (Yen, et. al., 2013), chemistry (Nechypurenko, et. al., 2019), history (Barreau, et. al., 2015) (Nicolas, et. al., 2015), (Persofoni and Tsinakos, 2016), geography (Shall, et. al., 2011), languages (Shih and Yang, 2008), mathematics (Yingprayoon, 2015), or Pocket tutor - Math Help (Augmented reality, 2022) and many others. These applications serve not only to train and teach, but also to observe and discover.

New XR technologies are also a challenge for us teachers, didactics, and application developers, to know how to use them to make teaching more attractive. We should turn our attention to where the whole world is headed. We should prepare not only teachers, university and high school students for another form of information interaction, but also primary school children for a new phenomenon that they are likely to encounter soon. With the effort to introduce XR technologies into education, the weaknesses of this process also appear, which are mainly related to the insufficient technical equipment of schools, as well as the reluctance of teachers to solve unknown challenges and accept new technologies into their teaching process. Another disadvantage can be the creation of addiction to mobile devices or headsets, leading to many health problems. In any case, by gradually overcoming these obstacles, the implementation of XR can be very beneficial for both students and teachers.

In this paper, we present our efforts, which began several years ago with the creation of a new VR subject, gradually building a VR and UX laboratory, and finally focusing our attention and efforts on creating XR applications, especially in education. At our department, in cooperation with the Rotaract Club and the Rotary Club in our city, we focused on primary school children who are hospitalized due to various health problems. Last year, we created an experiential laboratory at this school, which allows such children to break away from their illness, immerse themselves in a completely different world, cheer up, and play in educational games through the modern virtual and augmented reality technologies, as well as 3D pens and various games. We want the children to learn something new and forget, at least for a moment, why they are where they are.

In cooperation with the teachers of the Primary School at the medical facility, which is located in the Children's University Hospital with a polyclinic in our city, we have created several applications that are aimed at repeating and expanding knowledge in various subjects (Slovak Language and Literature, English, Homeland Studies, Natural Sciences, Chemistry, Mathematics, etc.) as well as to entertain and cheer up sick children, to engage and detach them from an often serious illness or immobile condition. The applications are adapted to the hospital environment, different ages of children, their limitations in movement, or sad mood. At the mentioned primary school, a very large number of children have attended during one school year, so the idea of getting children acquainted with modern technologies and the virtual world is spreading very fast.

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METHODS

Hardware for VR/AR

We decided to use a headset, Oculus Quest 2, for the development of our applications. This headset was released at the end of 2020 and is therefore a relatively new VR kit that uses software based on the Android 10 mobile operating system and will have a guarantee of long-term support from the manufacturer in the form of updates. The glasses themselves have a Qualcomm Snapdragon XR2 processor, which provides high performance in conjunction with 6 GB of RAM and an Adreno 650 graphics chip. The display is provided by two LCD displays with a resolution of 1832x1920 and a refresh rate of up to 120 Hz. The glasses also have built-in speakers directly in the glasses. Two Oculus Touch controllers are used for control, with each controller having its own 4 programmable buttons. There are 4 built-in cameras directly in the glasses to capture and control the motion in the room, so the user does not have to install various auxiliary cameras in the motion capture room as with other VR kits. Due to this, the use of Oculus Quest in various spaces is a very practical and pleasant experience. It could therefore be said that this is one of the most portable VR kits on the current market. One of the best features is the ability to use glasses without controls, so the user's hands will be used directly with the help of cameras, which almost 100% reliably monitor every single finger on the basis of visual contact.

Another hardware component that we use to create AR applications is the Merge Cube, which was introduced to the market in 2017. The cube itself is nothing special. It is made of durable foam material. What makes this cube interesting is its unique shapes on each side of the cube, which, in conjunction with the right hardware and software, can turn the cube into a hologram. This requires powerful cameras in devices such as mobile phones, tablets, computer cameras, etc.

RESULTS

VR and AR applications

QuizBow (VR)

The first created application is used to learn students' new knowledge using a playful form. After turning on the application, the user grabs the bow and uses an arrow shot to select the area in which he wants to check or expand his knowledge. Subsequently, a quiz is run in which the user gets a question and must choose one correct answer from among the other 3 incorrect ones. After successfully answering and hitting the question, the user is rewarded with a positive point. Otherwise, the correct answer is displayed, and the user has the opportunity to see the answer in front of him within 5 seconds. This whole thing is repeated until all the questions for the given category are missed. Finally, the user will see the earned points and can choose another category.

Each time you select a category, all questions and answers are shuffled to change their display order. This will prevent the manual reselection of responses, and the user must be careful. A huge advantage of this application is that it uses .csv or .json files to work with issues. This means that every time the application is turned on, the current questions are loaded, and thus the application itself is a system that is very easily extended by new

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categories, questions only with the help of a pre-created question template. This can make it very easy to work with the application, especially for laypeople and primary school teachers, and it creates a reliable extension for possibly downloading questions directly from the cloud.

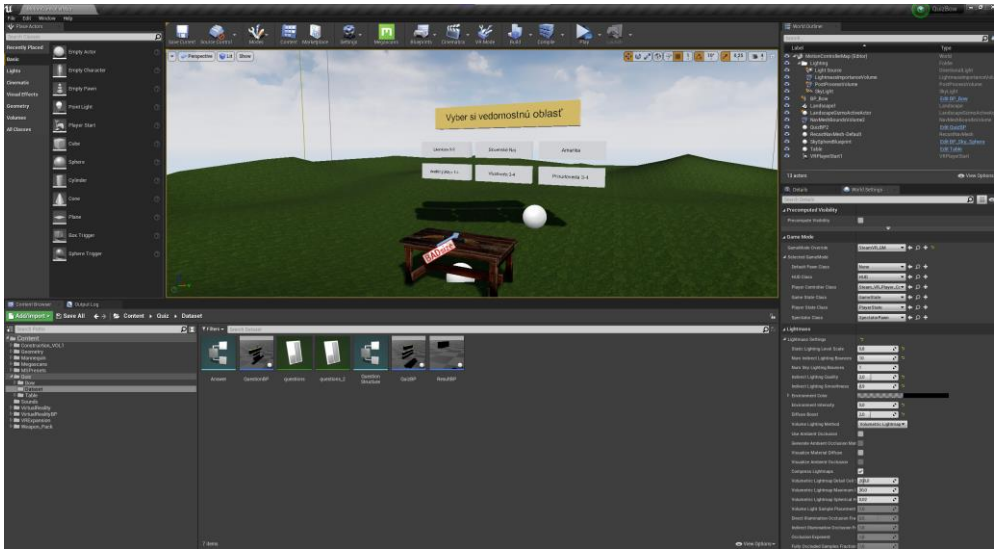
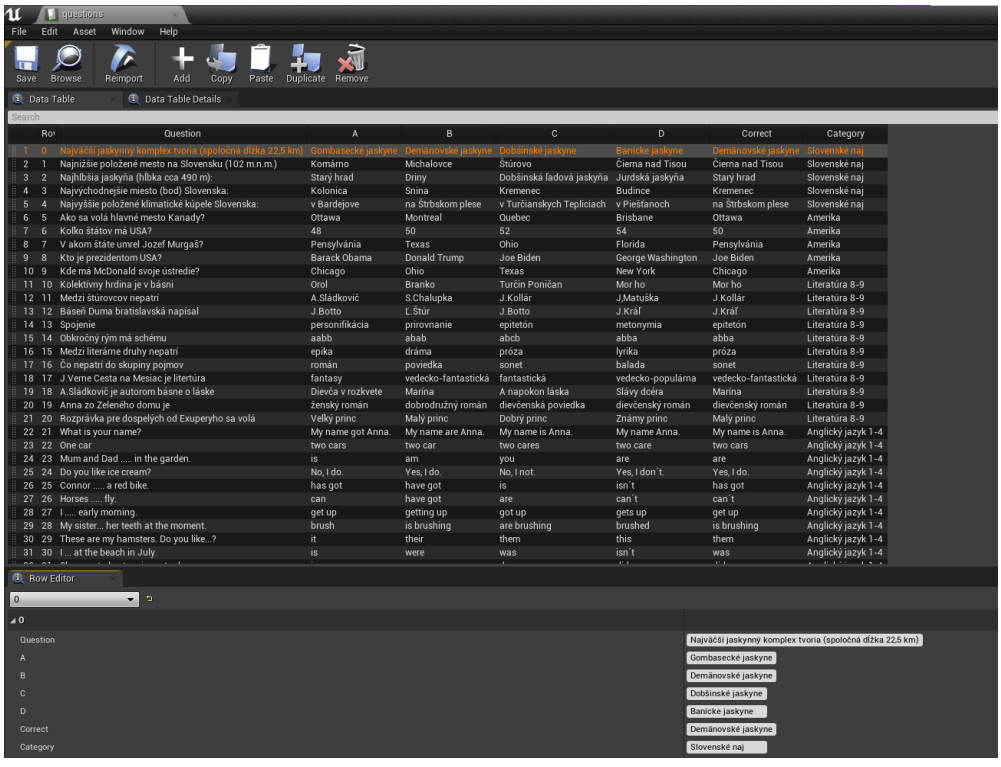


Figure 11 Demonstration of creating a QuizBow application in the environment Unreal Engine



Ro	Question	A	B	C	D	Correct	Category
0	Najväčší jaskynný komplex tvoria (spoločná dĺžka 22,5 km)	Gombasecké jaskyne	Demänovské jaskyne	Dobšinské jaskyne	Banícke jaskyne	Demänovské jaskyne	Slovenské naj
1	Najnižšie položené mesto na Slovensku (102 m.n.m.)	Komárno	Michalovce	Štúrovo	Čierna nad Tisou	Čierna nad Tisou	Slovenské naj
2	Najhlbšia jaskyňa (hĺbka ca 490 m):	Starý hrad	Driny	Dobšinská ľadová jaskyňa	Jurdská jaskyňa	Starý hrad	Slovenské naj
3	Najvýchodnejšie mesto (bod) Slovenska:	Kolonica	Snina	Kremenec	Budince	Kremenec	Slovenské naj
4	Najvyššie položené klimatické kúpele Slovenska:	v Bardejove	na Štrbskom plese	v Turčianskych Tepliciach	v Piešťanoch	na Štrbskom plese	Slovenské naj
5	Ako sa volá hlavné mesto Kanady?	Ottawa	Montreal	Quebec	Brisbane	Ottawa	Amerika
6	Koľko štátov má USA?	48	50	52	54	50	Amerika
7	V akom štáte umrel Jozef Murgaš?	Pensylvánia	Texas	Ohio	Florida	Pensylvánia	Amerika
8	Kto je prezidentom USA?	Barack Obama	Donald Trump	Joe Biden	George Washington	Joe Biden	Amerika
9	Kde má McDonald svoje ústredie?	Chicago	Ohio	Texas	New York	Chicago	Amerika
10	Kolektívny hrdina je v básni	Orol	Branko	Turčin Poničan	Mor ho	Mor ho	Literatúra 8-9
11	Medzi štúrovcov nepatrí	A.Sládkovič	S.Chalupka	J.Kollár	J.Matuška	J.Kollár	Literatúra 8-9
12	Báseň Duma bratislavská napísal	J.Botto	Ľ.Štúr	J.Botto	J.Kráľ	J.Kráľ	Literatúra 8-9
13	Spojenie	personifikácia	prirovnanie	epitetón	metonymia	epitetón	Literatúra 8-9
14	Obkročný rým má schému	aabb	abab	abcb	abba	abba	Literatúra 8-9
15	Medzi literárne druhy nepatrí	epika	dráma	próza	lyrika	próza	Literatúra 8-9
16	Čo nepatrí do skupiny pojmov	román	poviedka	sonet	balada	sonet	Literatúra 8-9
17	J.Verne Cesta na Mesiac je literatúra	fantasy	vedecko-fantastická	fantastická	vedecko-populárna	vedecko-fantastická	Literatúra 8-9
18	A.Sládkovič je autorom básne o láske	Dievča v rozkvete	Marina	A napokon láska	Slávy dcéra	Marina	Literatúra 8-9
19	Anna zo Zeleného domu je	ženský román	dobrodružný román	dievčenská poviedka	dievčenský román	dievčenský román	Literatúra 8-9
20	Rozprávka pre dospelých od Exuperyho sa volá	Veľký princ	Malý princ	Dobrý princ	Známy princ	Malý princ	Literatúra 8-9
21	What is your name?	My name got Anna.	My name are Anna.	My name is Anna.	My name Anna.	My name is Anna.	Anglický jazyk 1.-4
22	One car	two cars	two car	two cares	two care	two cars	Anglický jazyk 1.-4
23	Mum and Dad ..... in the garden.	is	am	you	are	are	Anglický jazyk 1.-4
24	Do you like ice cream?	No, I do.	Yes, I do.	No, I not.	Yes, I don´t.	Yes, I do.	Anglický jazyk 1.-4
25	Connor ..... a red bike.	has got	have got	is	isn´t	has got	Anglický jazyk 1.-4
26	Horses ..... fly.	can	have got	are	can´t	can´t	Anglický jazyk 1.-4
27	I ..... early morning.	get up	getting up	got up	gets up	get up	Anglický jazyk 1.-4
28	My sister... her teeth at the moment.	brush	is brushing	are brushing	brushed	is brushing	Anglický jazyk 1.-4
29	These are my hamsters. Do you like...?	it	their	them	this	them	Anglický jazyk 1.-4
30	I ... at the beach in July.	is	were	was	isn´t	was	Anglický jazyk 1.-4

Figure 12 Question and answer table

GuessFlag (VR)

Like the previous application, this one uses a playful form to learn new knowledge, in this case national flags. Using a weapon that shoots foam balls, the user selects the language in which he wants to learn the flags. Currently, the application has English and Slovak

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languages, but adding a new language is not a problem with similar structures as the QuizBow application. After selecting the language, the user is asked to select the flag of the country that is displayed. After the correct selection, a point is added to the user's account. Otherwise, the series of correct answers is deleted and the user starts from 0. This element is to motivate the user to learn all the flags without being mistaken. If the user answers incorrectly, the correct flag is displayed and the user can remember it.

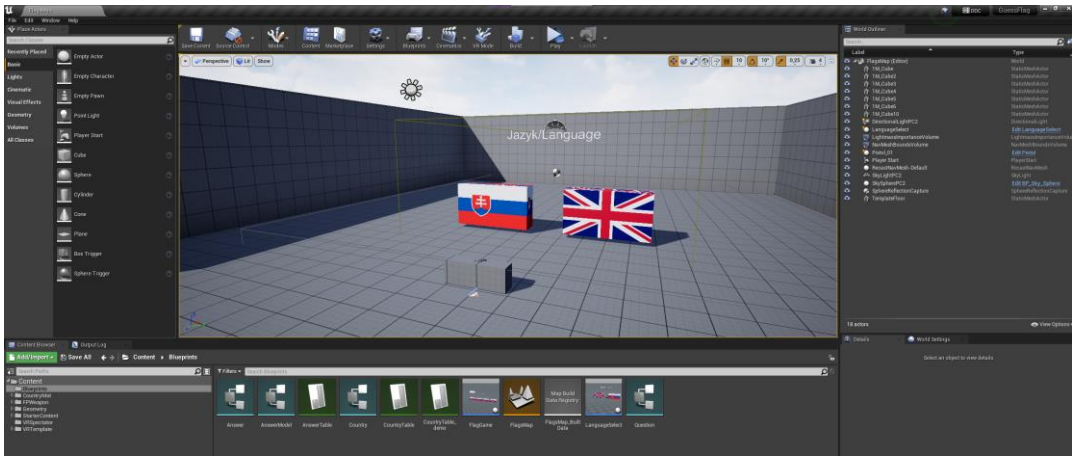

Figure 13 Demonstration of creating the GuessFlag application in the Unreal Engine environment

The generation of combinations is based on an algorithm where a four of the current bank of 44 flags are always randomly selected. The correct answer from these four random generated flags will be added in the list of used answers, and the system will use 1 flag less in the next round. If there are the last 4 flags in the system, after this round the list is reset and returned to the beginning of the count. In this way, it is guaranteed that, despite the random and mixed order, the user actually goes through each of the 44 flags, thus increasing the likelihood of comprehensive learning.

FindAndGrab (VR)

The last VR application is a focus on fun learning, it helps users orient themselves in space and at the same time improves the level of foreign language (English).

Figure 14 Children's playroom in application Find and grab

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The user finds himself in the children's playroom, where he is given the task of finding an object, while the name of this object is given in a foreign language (it is displayed on the board in front of him). As a result, he is forced to translate what he is looking for and then find this item from among the 15 randomly generated items. After successfully finding and grabbing the item, the user proceeds to the next round, where he searches for another item. In this case, the application requires movement and therefore uses one of the best ways to move - teleportation in virtual reality, which does not cause nausea like some of the other options of movement in VR. More about the comparison of individual ways of movement in the VR can be found in the article (Voštinár et. al., 2020). The user simply presses a button on the remote control and selects the place where he wants to find the object he is looking for and then moves to a new location using a blink simulation, which prevents nausea. After grabbing the correct item, another item will appear on the board that must be found in the game room.

Development tools for merge cube and our applications (AR)

Explorer an Object Viewer are official applications of MergeEdu, which offer a huge database of education materials through animate scene. All scenes and objects support the merge cube. Applications are available on common hardware, and they are categorized into areas. In addition to animated scenes, the applications are complemented by various knowledge quizzes. The CoSpace Edu application is more focused on self-creation using a comprehensive editor for augmented reality, which is accessible to the user after logging in. Other tools are Unreal Engine and Unity with Vuforia extension.

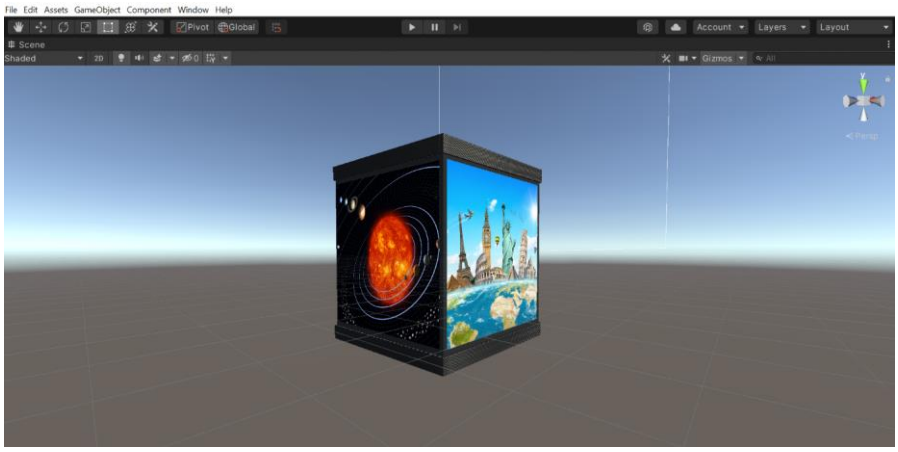

Figure 15 Demonstration of AR applications for a Merge cube (Solar System, World Monuments)

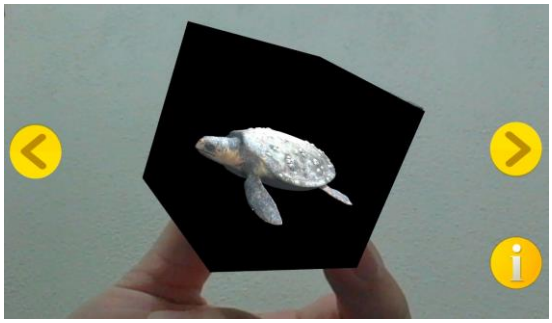

Figure 17 Merge cube animal app

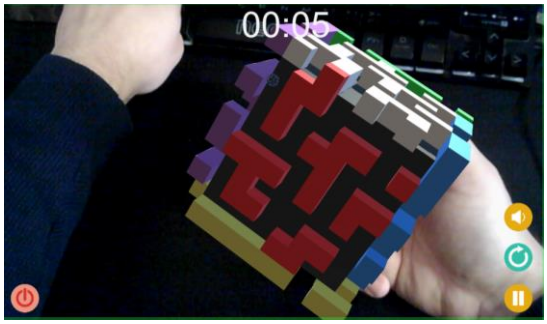

Figure 16 Merge cube application Labyrint

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Here are some examples of AR applications that use the Merge Cube to get acquainted with the solar system, some of the world's famous monuments, and sea animals. One application is used to train and rehabilitate the children's hands while watching the falling ball in the labyrinth.

DISCUSSION

Due to the Covid-19 pandemic situation, we cannot visit the pupils of primary school at the children's hospital for the second year. We could only reach teachers who had the opportunity to assess the suitability of applications for hospitalized children. Based on their requirements and input data for the quiz, the applications were modified to suit the needs of the children as much as possible. We also involved teachers and students of our department in obtaining feedback and we are still waiting for more answers. So far, more than 30 respondents have been acquainted with the applications and 22 of them have completed the questionnaire, at most at the age of 20. All respondents were already familiar with the concept of the VR, but only 64% of them already had personal experience of immersion to the virtual world. We think that the younger generation of primary school students will have even less experience with VR/AR. Although the way young people like to learn today is related to the Internet and the You Tube channel, in third place they indicate the possibility of learning through VR/AR applications and more than 90% of respondents think that this way of learning is promising mainly for hospitalized children. It was also surprising to find that none of the respondents had a problem with control in any of the applications, or with the way they moved in FindandGrab using teleportation. We believe that the limited possibility of movement in applications will be appreciated especially by children strapped to the bed, even if in a virtual environment they will be able to at least rotate, or control hand movement. The evaluation of all assessed applications was also gratifying, because in terms of fun, instructiveness or attractiveness, they passed the evaluation in a very balanced way.

Language is a major barrier in the education of young children. There are a large number of applications in the world that have been created in English and other world languages and our children do not understand them. Although the most common media element of XR applications is a 3D object that everyone understands, in communication (in the main menu, quizzes, or in other communication tools) we cannot avoid the Slovak language. This is one of the reasons why we try to create our own applications that are always tailored to the needs of hospitalized children. Another reason why we make applications for this target group is the effort to divert children's attention from their unpleasant conditions, examinations, and interventions and long-term experience with friendly medical staff and a fantastic teaching staff of our partner’s primary school.

Our applications are intended to serve not only as educational applications to expand knowledge in various fields, but also as a motivational tool to diversify education, a distracting tool to distract from illness, or for fun and entertainment. This intention of ours is also continuing. The annual topics of the bachelor's and master's theses receive a different dimension and a vision of meaningful use in practice.

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CONCLUSION

In our article, we have presented the possibilities that virtual, augmented and mixed reality technologies could bring to education. We have outlined several advantages, but also disadvantages, which must be taken into account when introducing them into the teaching process. The main part of our article was a description of tools and methods and the creation and description of applications that are designed for education and entertainment of hospitalized children in primary schools. Due to the increasing trend of using XR technologies in all areas of our lives, there is also growing interest from schools in purchasing these technologies. However, the hardware itself will not bring the expected satisfaction of their needs in the hands of teachers. More important is the targeted creation of applications that can be used in several schools at the same time. Therefore, we believe that our efforts to continue to create such applications in the future will bear the "desired fruit".

ACKNOWLEDGMENTS

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REFERENCES

Metaverzum je budúcnosť aj keď nie ste pripravení, 2022. Technologický magazín Nextech, 1-2/2022, XXIX. ročník, str. 12-13

Arlearning, *Augmented reality learning,* 2022. [Online] Available at: http://arlearning.co.uk/ [Accessed 25 February 2022]

Augmented Reality to Learn Math - Pocket Tutor for iOS [Online] Available at: https://www.youtube.com/watch?v=tDDkSYLF3vM [Accessed 25 February 2022]

Barreau, J. B., Nouviale, F., Gaugne, R., Bernard, Y., Linares, S. and Gouranton, V., 2015. *An Immersive Virtual Sailing on the 18 th-Century Ship Le Boullongne,* Presence: Teleoperators and Virtual Environments, vol. 24, no. 3, pp. 201–219, Jul. 2015

Brngál, T., 2022. *Human Anatomy VR* [online] Available at: <https://www.oculus.com/experiences/gear-vr/1658650407494367/> and Virtual medicine <https://www.medicinevirtual.com/> [Accessed 25 February 2022]

Carter L., Potter L.E., *Designing Games for Presence in Consumer Virtual Reality*, In: Proceedings of the 2016 ACM SIGMIS Conference (2-4 June 2016, Virginia, Alexandria, USA), Association for Computing Machinery, 2016, 141–148

Douglas-Lenders, R. C., Holland, P. J. and Allen, B., 2017. *Building a better workforce*, Education Training, vol. 59, no. 1, pp. 2–14, Jan. 2017.

Fotaris, P., Pellas, N., Kazanidis, I., Smith, P., 2017. *A Systematic Review of Augmented Reality Game-Based Applications in Primary Education.* [online] Available at:

ISBN 978-80-7676-410-1 ISSN 2464-7470 (Print) ISSN 2464-7489 (On-line)

https://www.academia.edu/35343049/A_Systematic_Review_of_Augmented_Reality_Game_Based_Applications_in_Primary_Education, [Accessed 25 February 2022]

Gownder, J., P., Voce, Ch., Mai, M., Lynch, D., 2016. *Breakout Vendors: Virtual And Augmented Reality.* 2016.

Horváthová, D., Voštinár, P., Mitter, M., 2020. *Extended reality in education,* In DIVAI 2020 : 13th international scientific conference on distance learning in applied informatics, conference proceedings, September 21 - 23, 2020, Štúrovo, Slovakia. - 1. vyd. - Prague : Wolters Kluwer, 2020. - ISBN 978-80-7598-841-6. - ISSN 2464-7470. - S. 327-338.

Hudák, M., Sobota, B., 2021. Kolaboratívna virtuálna realita a rozhrania systémov. Technická univerzita v Košiciach. ISBN 978-80-553-3974-0

Hui-Wen, Ch. S., 2018. *Why and Who Will Adopt Extended Reality Technology?* Literature Review, Synthesis, and Future Research Agenda. 2018.

Milgram, P. and Kishino, A. F., 1994. *Taxonomy of Mixed Reality Visual Displays.* s.l. : IEICE Transactions on Information and Systems, 1994, pp. 1321–1329.

Nechypurenko, P. P., Starova, T. V., Selivanova, T. V., Tomilina, A. O. and Uchitel A. D., 2019. *Use of Augmented Realityin Chemistry Education.* Педагогіка вищої та середньої школи 2019. Випуск 51. С.25–36

Nicolas, T., Gaugne, R., Tavernier, C., Petit, Q., Gouranton, V. and Arnaldi, B., 2015. *Touching and Interacting with Inaccessible Cultural Heritage,* Presence: Teleoperators and Virtual Environments, vol. 24, no. 3, pp. 265–277, Jul. 2015

Pallavicini, F., Argenton, L., Toniazzi, N., Aceti, L. and Mantovani, F., *Virtual Reality Applications for Stress Management Training in the Military*, 2016. The Journal of Strength and Conditioning Research, vol. 29, pp. S77–S81, Oct. 2016

Persefoni, K. and Tsinakos, A. 2016. *A Mobile Augmented Reality Application for Primary School's History*, IOSR Journal of Research & Method in Education (IOSR-JRME) e-ISSN: 2320–7388, p-ISSN: 2320–737X Volume 6, Issue 6 Ver. III (Nov. - Dec. 2016), PP 56-65.

Schall, G., Schöning, J., Paelke, V., Gartner, G., 2011. *A survey on augmented maps and environments: Approaches, interactions and applications.* Advances in Web-based GIS, Mapping Services and Applications – Li, Dragicevic & Veenendaal (eds), 2011, Taylor & Francis Group, London, ISBN 978-0-415-80483-7

Shen, C. W. Ho, J. T. Kuo, T. C. and Luong, T. H., 2017. *Behavioral Intention of Using Virtual Reality in Learning*, presented at the the 26th International Conference, New York, New York, USA, 2017, pp. 129–137.

Sherman, W. R., Craig, A. B. 2002. *Understanding Virtual Reality: Interface, Application, and Design,* Elsevier Science, 2002, ISBN: 9780080520094.

Shih Y. and Yang, M., 2008. *A Collaborative Virtual Environment for Situated Language Learning Using VEC3D*, pp. 1–13, Mar. 2008.

Voštinár, P., Horváthová, D., Mitter, M., Bako, M. *The look at the various uses of VR, De Gruyter,* Open Comput. Sci. 2021; 11:241–250, Available at: <https://doi.org/10.1515/comp-2020-0123> [Accessed 25 February 2022]

ISBN 978-80-7676-410-1 ISSN 2464-7470 (Print) ISSN 2464-7489 (On-line)

Yen, J.-C., Tsai, C.-H. and Wu, M., 2013. *Augmented Reality in the Higher Education: Students' Science Concept Learning and Academic Achievement in Astronomy,* Procedia - Social and Behavioral Sciences, vol. 103, pp. 165–173, Nov. 2013

Yingprayoon, J., 2015. *Teaching Mathematics using Augmented Reality.* Proceedings of the 20th Asian Technology Conference in Mathematics (Leshan, China, 2015)

ISBN 978-80-7676-410-1 ISSN 2464-7470 (Print) ISSN 2464-7489 (On-line)