ACCEPTANCE OF IMMERSIVE VIRTUAL REALITY IN SECONDARY EDUCATION TEACHERS. AN EXPLORATIVE STUDY OF PERCEPTIONS FROM TEACHERS, IT-STAFF, PRINCIPALS AND TEACHERS' TRAINERS

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Abstract

Recently, immersive virtual reality has become very popular. Though this new technology has become affordable for education, actual use in the classroom remains low. In this explorative study we investigate which factors contribute to teacher acceptance of immersive virtual reality (iVR) in secondary education. Semi-structured interviews were based on the *Unified Theory of Acceptance and Use of Technology 2* (UTAUT2). In order to fully understand which factors impact teacher acceptance, 5 teachers, 5 principals, 5 IT staff members and 5 staff members of supporting educational organisations were interviewed. Interview transcripts were analysed using *NVivo12*. No new benefits were identified, but several elements were identified accounting for effort expectancy, facilitating conditions, price value, hedonic motivation and habit. Social influence was seen as only marginally influential. Results show how UTAUT2 can serve as a model to understand acceptance factors for immersive virtual reality in secondary education teachers. However, factors going beyond UTAUT2 could also be retrieved, such as user attributes, organisation attributes and location attributes. The interviews also indicate relationships between factors, helpful to design strategies to support the adoption of the iVR technology by the teachers. Most important seems the emphasis to show teachers iVR affordances. This study is, to the best of our knowledge the first qualitative study that deepens our theoretical understanding of which factors affect the acceptance of secondary education teachers of immersive virtual as an educational tool.

Keywords: Adoption, educational technology, interview, technology acceptance, UTAUT2.

1 INTRODUCTION

Immersive virtual reality (iVR) has gained maturity lately, following major technological advancements by big tech companies such as Facebook, HTC, HP and Lenovo. Advancements are observed in the domain of usability and satisfaction, such as improved wearing comfort, less screen-door effect, improved graphic representation and better tracking. But, since the introduction of affordable consumer market VR such as the *Oculus Quest* leading to mass sales in 2020 [1], VR has jumped forward as an educational tool. Although primarily designed as an entertainment system, VR is growingly used as a tool for learning, training, meeting and collaboration, designing and prototyping [2], [3]. iVR adoption in education is largely dependent on acceptance by teachers. The aim of this exploratory study is to map factors affecting teacher perceptions leading to the potential adoption of immersive virtual reality in secondary education.

1.1 Immersive virtual reality

Immersive virtual reality is to be distinguished from desktop virtual reality. In desktop VR the user interacts with a virtual world, delivered via a desktop screen, such as a desktop computer or a tablet. The user still has a strong connection with the surrounding environment. This awareness sets it apart from immersive virtual reality in which a user is fully surrounded by the virtual reality through the use of a virtual reality headset, called a head-mounted display (HMD). These two types are typically distinguished from each other in terms of immersion and presence. Although both terms are often used intermittingly, a clear distinction is to be made. Presence is seen as “a state of consciousness,

the (psychological) sense of being in the virtual environment." [4, p. 4]. Immersion on the other hand centres on "the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant." thus making it a more "objective and quantifiable" construct [4 p. 3] suiting the need for distinction between different ranges of immersive technologies. These particular iVR affordances should be considered when studying iVR acceptance.

1.2 Immersive virtual reality in education

As a result of the improved affordability and usability, a growing interest can be also be identified in the domain of education [5]. Several benefits, generally called affordances [6], have been identified in the literature. For instance, students are able to 'travel' to other places or timeframes, they can train safely in otherwise dangerous or even impossible situations and they cause no harm to themselves or others while making mistakes [7], they can train for rare cases, visualise invisible objects, experience no limitations in training machines or materials and can be offered personalised learning and continuous feedback [8]. Dealing with the affective domain, students using iVR mostly react very enthusiastic and seem intrinsically motivated [3]. Although both students and teachers generally reflect positive attitudes towards immersive virtual reality, we also observe drawbacks. First of all, the efficacy of the iVR learning experience is questioned, owing to a wide range of factors such as cognitive load and instructional design [3], [9]. Next, several contextual barriers, such as access to the internet, account management and classroom space come into play when implementing immersive virtual reality in a real life classroom setting [10].

1.3 Theoretical models of technology acceptance

As argued by Janssen et al. [11] future adoption of new technologies strongly depends on factors affecting usage and user acceptance. In the domain of information systems (IS) research, acceptance and use of technology studies dominate the literature [12]. Over the years, several models have been developed, which were – among other attempts - synthesized into the *Unified Theory of Acceptance and Use of Technology* (UTAUT) by Venkatesh et al. [13]. This model, combining elements from eight previous models on IS acceptance, was developed concerning organizational contexts. The model seems adequate and fitting the underlying latent constructs as reflected in studies explaining up to 70% of the variance in intention to use and 50% of the variance in actual use variables [14]. In 2012 the original UTAUT model was extended into *UTAUT2* mainly aiming at consumers, and incorporating new elements, such as hedonic motivation, price value and habit [14]. As the original UTAUT model was developed for consumer contexts, the moderator variable *voluntariness of use* was left out. Four years later, Venkatesh et al. [12] developed a more empirical approach to their model, incorporating contextual factors, such as environment, location, task and event/time attributes, resulting in the *Multi-level Framework of Technology Acceptance and Use* (MLF) (Fig 1). This multi-level model fits the educational context in which we work, given the multi-level nature of teachers working with pupils in classes/class groups and schools.

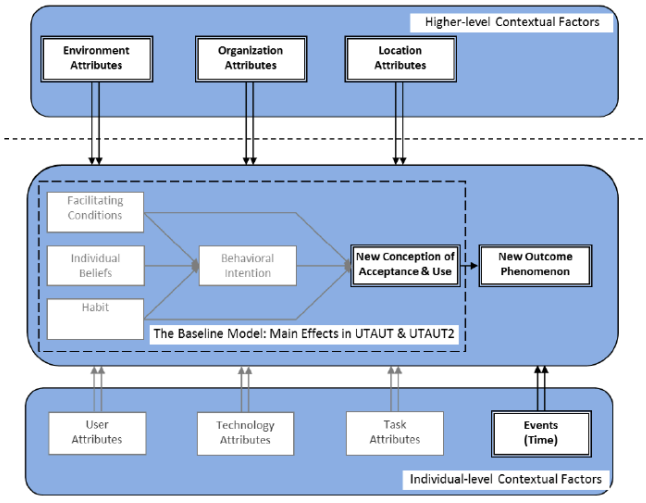

Figure 1. Multi-level Framework of Technology Acceptance and Use – Adapted from Venkatesh et al. [12]

1.4 Acceptance and use of immersive VR technology

This MLF model was already used by Mütterlein and Hess [15] while investigating factors affecting the acceptance and use of immersive virtual reality. Their findings are important since they stress how elements such as content quality, initial excitement, isolation, distraction, task attributes, organization attributes and location attributes have been neglected so far, calling for "qualitative studies to explore causality of variables" [15, p. 7]. To the best of our knowledge a qualitative study on the acceptance and use of immersive virtual reality in secondary education teachers has not yet been undertaken. The present study seeks to fill this gap in the literature.

2 METHODOLOGY

2.1 Data collection

A semi-structured interview protocol was developed, following the UTAUT2 model (Fig. 2). The UTAUT2 model was chosen as the framework for the relevant factors and moderators concerning IS. Although a school is to be conceived as an organization, the UTAUT2 model was chosen over the original UTAUT. iVR is at this point in time a deliberate and autonomous choice by the teacher and not yet being implemented at an organizational level, as opposed to for example a schoolwide implementation of a learning management system, e.g. [16]. This preposition, emanating from field experience by the researchers, proved right during the interviews. Due to the constraints of the Covid-19 pandemic, it was not possible to expose the participants to an actual VR experience.

The UTAUT2 model consists of 7 factors and 3 moderators.

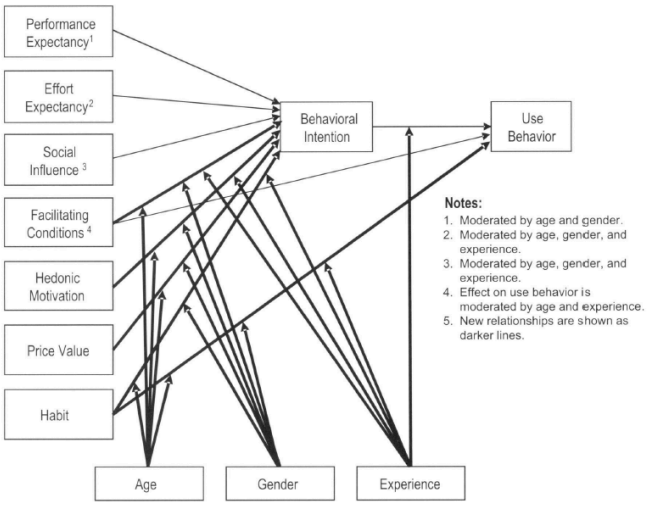

Figure 2. UTAUT2 – Adapted from Venkatesh et al. [14]

Venkatesh et al. [13] defined the factors as follows. *Performance expectancy* deals with "the degree to which and individual believes that using the system will help him or her to attain gains in job performance" [13, p. 447]; *effort expectancy* is "the degree of ease associated with the use of the system" [13, p. 450]; *social influence* deals with "the degree to which an individual perceives that important others believe he or she should use the system" [13, p. 451] and *facilitating conditions* are "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" [13, p. 453]. *Hedonic motivation* refers to "the pleasure derived from using the technology"; *price value* deals with "whether the user thinks the technology is worth the investment"; and *habit* concerns "the extent to which a user needs to be familiar with IT to use the new technology" [14, p. 161]. Moderating elements are age, gender and experience with the technology. The thin lines in the model refer to the relationships from the original UTAUT model as the bold lines indicate the new relationships.

In total 20 semi-structured interviews were taken. In order to be as comprehensive as possible in exploring which factors might determine the acceptance and use of immersive virtual reality in secondary education, not only teachers were questioned, but also principals, school IT administrators and staff members of external pedagogical organisations supporting schools. For each group, 5

participants were recruited of which at least 3 had prior VR experience, but not necessarily in an educational context. All participants were 25 to 45 years old, 5 were female, 15 male and all had at least 3 years of experience in their occupation in education.

All participants were interviewed by one of the researchers, during an online *Microsoft Teams* meeting. All interviewees were asked to sign an online informed consent prior to the interview. The interviews were recorded and converted to MP3 files.

2.2 Data analysis

For the analysis of the interviews, research directions for content analysis as articulated by Erlingsson and Brysiewicz [17] were followed. In order to allow for an in-depth analysis, all interviews were fully transcribed. All texts were imported into *NVivo12*, a software package allowing for the analysis of qualitative data. Next, all interviews were read thoroughly to get a general understanding of the main ideas and concepts. As a third step, meaning items were identified; meaning items are seen as fragments in the interview which address the research questions of the interview. As we used *NVivo12*, no condensation of the meaningful items was needed. All identified units were labelled with codes. These are seen as a descriptive label about a unit's meaning. We stress in this context that we did not aim for the UTAUT2 model to predict all factors. The UTAUT2 rather served as a framework supporting the first analysis phase of deductive coding, followed by an inductive coding phase allowing us to fully capture teachers' perceptions about iVR use. The individual, *child codes* were then categorized into more general *parent codes* on the basis of their interrelatedness.

In view of studying interrater-reliability, four interviews were independently coded by four researchers. The four coding files were compared to develop a shared codebook. Next, again four interviews, one from each group, were coded to establish whether using the codebook resulted in a shared perspective. This resulted in some adjustments in naming and categorization of codes. This final codebook version was used for the coding of all 20 interviews. This procedure is in line with guidelines concerning qualitative research [17] and other research of the acceptance of immersive virtual reality [15].

3 RESULTS

Table 1 documents a part of the UTAUT2 factors which could be identified. Following Mütterlein and Hess [15] we only included elements when they were seen as important to the interviewee. When an element was named several times, but was perceived as less impactful by a number interviewees, it was left out.

Table 1. Part of the UTAUT2 factors identified

Element (= code)	Factor (= category)	Exemplary quote (= meaning unit)
Learning by doing	Performance expectancy	"you can actually grab things and do something with them"
Visualisation	Performance expectancy	"specific learning concepts can be visualized better"
Setup	Effort expectancy	"it has to be easy to set up and get started. That's a big conditional"
Usability	Effort expectancy	"the more user friendly and easier to handle, the better"
Enterprise content	Facilitating	"there is a lot of

	conditions	protectionism in the market"
Management	Facilitating conditions	"who will maintain this technology? This is very important"
Colleagues same course	Social influence	"some in the department have to be addressed to introduce the technology. If they have started with it, the rest will follow."
Principal	Social influence	"the principal will be supportive, but cannot force it to teachers"
Pleasure	Hedonic motivation	"I was really impressed… overwhelmed… very positive indeed"
Initial investment	Price value	"on the one hand you have to buy sets, and on the other hand experiences too"
Return	Price value	"the more we use it, the less it will cost"
Prior experience	Habit	"it will be easier if they have the habit of using new technologies"

All factors within the UTAUT2 framework, apart from *social influence*, were identified as important by the interviewees in view of acceptance and use of iVR by teachers in secondary education. The factor valued the most was *performance expectancy*. Several learning affordances were identified such as practicing safely, unlimited learning opportunities, travelling to other places, the visualisation of abstract concepts, and increased motivation and engagement in students. No additional elements were identified. In general, these results confirm findings from earlier research, e.g. [19], [10] *Effort expectancy* was conceived differently, as only participants with actual iVR experience reflected upon the usability of the iVR experience itself and of setting up the iVR installation before the class starts. Usability can be seen as part of technology attributes, but as it was not linked to a specific experience and as it was mentioned specifically within the context of effort, it was categorised under *effort expectancy*. Participants with no iVR experience also mentioned struggling with how to manage the classroom in contrast with participants who had integrated iVR before and had clear views on how to organise their class. The results suggest a moderating effect in the factor of *facilitating conditions* as participants with iVR experience articulated concerns such as the distribution of software over different platforms, the English language of most content, the poor educational value of most iVR experiences and the inability to use iVR software from enterprises although they have great educational value. They also talked about the need for charging and storing, the need for complementary hardware such as projectors, the need for an assistant, time needed for the iVR administrator and the need for adjusting the time schedule to be able to have several hours within one course. Participants with no iVR experience mainly talked about the need for technical support and the need for pedagogical guidance and stressed the importance of support more explicitly. As expected, *social influence* was generally not seen as an important factor as iVR at this moment is not yet at a mainstream level of integration due to price, lack of content etc. but also because it is currently not a tool at an

organizational level, leaving it up to the initiative of the 'willing'. People seen as influential are colleagues teaching the same course, over all others. Principals and IT staff are seen as supportive, not as decisive. External influencers are experienced iVR teachers and educational organizations supporting schools through professionalization. The principals also identified policy makers as influential actors, which can be linked to the *location attributes* which will be discussed later. *Hedonic motivation* was taken into account as the use of iVR is not mandatory in any school at this moment within the context of this study. The pleasure or fun associated with this technology is perceived as an important element in the intention to use as teachers decide which technology will be used in their classroom. Another decisive factor was *price value*, although opinions differed greatly. Participants with no iVR experience stressed the cost of the HMD devices, whereas the other participants perceived it as an expensive but valuable investment. *Habit* is the last construct in the UTAUT2 model and is seen by all participants as an important factor, as they see prior experience with educational technology and the actual habit of using this technology in the class as conditional for integrating iVR in their pedagogy.

4 CONCLUSIONS

4.1 Factors affecting potential acceptance and use

Although all factors from the UTAUT2 model, apart from social influence, were seen as playing an important role in the potential acceptance and use of immersive virtual reality by secondary education teachers, several factors relating to the more contextualized Multi-level Framework of Technology Acceptance and Use [12] were identified (Table 2). This was surprising, as an educational iVR educational experience was not used in this study, thus leaving out the specific context of actual use. A possible explanation is the prior experience of 12 out of the 20 participants with iVR. The remaining 8 participants at least had experience with educational technology at an operational level and they had a basic understanding of what iVR is. As a result, they possibly drew analogies from educational technology practices to iVR.

Table 2. Factors exceeding the UTAUT2 framework

Element (= code)	Factor (= category)	Exemplary quote (= meaning unit)
School's innovativeness	Organisation attributes	"we have the ambition to be progressive"
Digital innovation strategy	Organisation attributes	"we work with satellites strategically"
School pedagogy	Organisation attributes	"we have an open culture of learning"
Budget of schools	Organisation attributes	"we're in a sector with limited financial resources"
Scale	Location attributes	"we need an overarching, central hub to share materials"
Government policy	Location attributes	"the government should provide for freedom in educational curriculum policy"
Own pedagogical views	User attributes	"it should fit the way how I want to teach"

Personal innovativeness	User attributes	“the interest of a teacher plays an important role”
Authenticity	User attributes	“if you don’t show passion, enthusiasm will be adversely impacted”
Need for control	User attributes	“a teacher wants to have control on what students are doing”
Personal motivation	User attributes	“an open attitude will ensure teachers not to quit, when the first experience was not a success”

At the higher-level in the MLF *Organisation attributes* were identified, such as the extent to which a school as an organisation is innovative in its nature, how it introduces digital innovation, the pedagogical culture of a school and its (limited) financial resources. As for *Location attributes* two elements were articulated: the need for the educational government to allow iVR to be introduced in the curricula and the need for a central organisation of iVR support, exceeding the school level for instance at the level of counties. *Environment attributes* were not found as the participants were not exposed to an actual iVR experience. As a consequence, no elements at the individual level within the category of *Task attributes* or *Events/time* were found. Several *User attributes* were named, such as the need for a fit within a teacher’s own pedagogical views, the extent to which a teacher shows personal innovativeness, the extent to which a teacher is authentic in his teaching practices, the extent to which he wants to exert control over his students and the motivation as a teacher to find the best way to support students in their learning.

When looking for relationships between the factors, we can build on the work of Mütterlein and Hess [15]. Specific results were found. A key finding was the fact that interviewees stress that iVR is unknown by most teachers. They have not yet experienced it themselves and therefore they both underestimate the possibilities (*performance*) and overestimate the constraints (*effort*). Participants with iVR experience, from all groups, agreed that showing the possibilities of iVR to teachers would create a base for acceptance, if they feel supported in their first steps by an experienced person or team. Doing so, teachers will think of iVR as a powerful tool. In order to do so, iVR should be introduced ideally by a colleague who teaches the course. After the first initiation to the willing, supported by the IT staff, those teachers can act as anchors or buddies spreading the word, as teachers tend to accept change more easily from colleagues, as opposed to IT staff or the principal. However, both IT and principal have an important role to play. The IT team is considered as essential for both exploring the pedagogical possibilities and technical support, especially in the first stage of adoption. They are also seen as responsible for the management of iVR infrastructure in all aspects. Principals are seen as crucial in deciding whether or not to invest in the iVR technology, but the initiative for adoption is situated at the teacher level. Teachers expect principals to be supportive in integrating iVR in their school policy, especially in their digital innovation strategy, and in allocating time and money for IT staff or an iVR team to allow for the efficient integration of this technology. If principals integrate iVR in their school policy, thus embedding it structurally, it is believed the price value will also be positively affected. However, principals and supporting educational organisations look at both governmental institutions and enterprises to integrate iVR in their policy in the context of digital innovation, and to allocate budget for investments in iVR equipment at a larger scale. In return, enterprises will benefit from well-trained, skilled students. For example, enabling teachers to use existing enterprise iVR trainings, would greatly impact the actual use of iVR in school settings. Lastly, the VR developing industry could contribute to creating authentic educational experiences.

As for patterns in demographics we did not retrieve any remarkable differences, not in gender or age, which is in line with Mütterlein and Hess [15]. However, our sample was somewhat limited, especially in the distribution over gender. No distinct differences in the perceptions of the participants could be

attributed to their role in education. The only manifest distinction could be drawn between participants without and with iVR experience.

4.2 Implications for research and practice

The findings described above are important contributions to both practice and research. First, these results give a clear view on the identified perceived benefits and constraints of iVR and indicate how to address these in a successful way. These findings address the need for more practical contributions from actual classroom use as articulated by Southgate et al. [10]. The role of all stakeholders in the uptake of iVR as an educational technology and the strategy to do so is described. Secondly, the results of the analysis identify elements which contribute to the factors from the theoretical models of acceptance and use of information technology, in this case immersive virtual reality in secondary education. This study can be a starting point to explore the importance of and relations between each element in larger - whether or not quasi-experimental - quantitative or mixed-method studies. A limitation of our study is the fact that the COVID-19 pandemic situation did not allow us to let participants experience an iVR application. However, 12 out of 20 interviewees did already have experience with iVR.

In this explorative study we investigated which factors affect secondary education teachers' potential acceptance and use of immersive virtual reality, by interviewing four groups of stakeholders: teachers, IT staff, principals and staff members of supporting educational organisations. The study was guided by the UTAUT2 model, which proved being useful to identify factors at play. Such factors could be identified. However, we also found additional elements impacting the acceptance and use of iVR. Especially user attributes, organization attributes and location attributes, part of the Multi-level framework [12] were added. All identified elements help to understand how teachers perceive iVR as an educational technology tool and contribute to both research as to educational practice. No relevant distinctions could be found between the participants apart from prior experience with iVR. "Ignorance breeds fear" also applies here. However, this can be overcome and we articulated several directions on how the acceptance and use of immersive virtual reality by secondary education teachers could be enhanced, addressing all stakeholders.

REFERENCES

[1] Lucas Matney, Oculus surpasses $100 million in Quest content sales, TechCrunch, 18 May 2020. Retrieved from https://techcrunch.com/2020/05/18/oculus-surpasses-100-million-in-quest-content-sales/

[2] E. Hu-Au and J. J. Lee, "Virtual reality in education: a tool for learning in the experience age", *International Journal of Innovation in Education*, vol. 4, no. 4, pp. 215-226, 2017.

[3] L. Jensen and F. Konradsen, "A review of the use of virtual reality head-mounted displays in education and training", *Education and Information Technologies*, vol. 23, no. 4, pp. 1515-1529, 2018. Retrieved from https://doi.org/10.1007/s10639-017-9676-0

[4] M. Slater and S. Wilbur. "A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments", *Presence: Teleoperators and Virtual Environments*, vol. 6, no. 6, pp. 603-616, 1997. Retrieved from https://doi.org/10.1162/pres.1997.6.6.603

[5] J. Radianti, T. A. Majchrzak, J. Fromm and I. Wohlgenannt, "A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda", *Computers and Education*, vol. 147, 2020. Retrieved from https://doi.org/10.1016/j.compedu.2019.103778

[6] J. J. Gibson, "Chapter 8: The Theory of Affordances" In *The Ecological Approach to Visual Perception*, pp. 119-135, Hove: Psychology Press, 2014.

[7] L. Freina and M. Ott, *A Literature Review on Immersive Virtual Reality in Education: State Of The Art and Perspectives*, 2015. Retrieved from http://www.google.com/patents/US3050870

[8] M. Thisgaard and G. Makransky, "Virtual Learning Simulations in High School : Effects on Cognitive and Non-cognitive Outcomes and Implications on the Development of STEM Academic and Career Choice, *Frontiers in Psychology*, vol. 8, no. 805, 2017. Retrieved from https://doi.org/10.3389/fpsyg.2017.00805

[9] G. Makransky, T. S. Terkildsen and R. E. Mayer, “Adding immersive virtual reality to a science lab simulation causes more presence but less learning”, *Learning and instruction*, vol. 60, pp. 225-236, 2019. Retrieved from https://doi.org/10.1016/j.learninstruc.2017.12.007

[10] E. Southgate, S.P. Smith, C. Cividino, S. Saxby, J. Kilham, G. Eather, … and C. Bergin, “Embedding immersive virtual reality in classrooms: Ethical, organisational and educational lessons in bridging research and practice”, *International Journal of Child-Computer Interaction*, vol. 19, pp. 19-29, 2019. Retrieved from https://doi.org/10.1016/j.ijcci.2018.10.002

[11] D. Janßen, C. Tummel, A. Richert and I. Isenhardt, “Towards measuring user experience, activation and task performance in immersive virtual learning environments for students”, *International Conference on Immersive Learning,* pp. 45-58, 2016.

[12] V. Venkatesh, M. G. Morris, G. B. Davis and F. D. Davis, “User acceptance of information technology: Toward a unified view”, *MIS quarterly*, vol. 27, no. 3, pp. 425-478, 2003.

[13] V. Venkatesh, J. Y. Thong and X. Xu, “Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology”, *MIS quarterly*, vol. 36, no. 1, pp. 157-178, 2012.

[14] V. Venkatesh, J. Y. Thong and X. Xu, “Unified theory of acceptance and use of technology: A synthesis and the road ahead”, *Journal of the association for Information Systems*, vol. 17, no. 5, pp. 328-376, 2016.

[15] J. Mütterlein and T. Hess, “Immersion, presence, interactivity: Towards a joint understanding of factors influencing virtual reality acceptance and use”, *AMCIS32*, 2017. Retrieved from https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1022&context=amcis2017

[16] B. Pynoo, P. Devolder, J. Tondeur, J. Van Braak, W. Duyck and P. Duyck, “Predicting secondary school teachers’ acceptance and use of a digital learning environment: A cross-sectional study”, *Computers in Human behavior*, vol. 27, no. 1, pp. 568-575, 2011.

[17] C. Erlingsson and P. Brysiewicz, “A hands-on guide to doing content analysis”, *African Journal of Emergency Medicine,* vol. 7, no. 3, pp. 93-99, 2017.

[18] M. J. Maas and J. M. Hughes, “Virtual, augmented and mixed reality in K–12 education: a review of the literature”, *Technology, Pedagogy and Education*, vol. 29, no. 2, pp. 231-249, 2020.