The visions of high-school teachers on Virtual Reality in education

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Abstract

This present study investigated the visions of high-school teachers on Virtual Reality (VR) in education. Nine teachers were interviewed to determine the opportunities, drivers and barriers that they see for educational VR. These interviews were subjected to thematic analysis and four themes were generated from these interviews. The first theme indicated that the teachers thought that the current iteration of VR is not yet ready for education, it is too expensive or not interactive enough. The second theme tells how teachers do see that VR can add value to their lessons. This added value would express itself through helping students with the mental visualization process or by giving them an interactive role in the learning process. The third theme tells how students need no help with learning VR. The final fourth theme is on what the teachers need from the development of educational VR. They expect that the developers of the course material should be more involved in the creation process of VR material. The VR hardware should become less expensive and have opportunities for the students to interact with the virtual world.

Keywords: Virtual Reality, VR, education, teachers, high-school, Perceptions, technology, drivers, barriers, needs

INTRODUCTION

High school life has changed a lot over the past decades. Back in the 90s children were told that they could not rely on their calculator for math because they would not have it with them all the time, but nowadays most of them own a small computer with more computational power than the biggest supercomputer of last millennium. This phenomenon of technological advancement is classified as Moore's law (1965), where every two years the computing power of a new processor roughly doubles. This technological revolution has also influenced the classroom. Where teachers used to rely on themselves, books and a simple chalkboard, nowadays the classroom also contains tablets, Smartboards (Molnar, 2007) and clickers. The next big technological development that might be valuable for education is Augmented and Virtual Reality (VR) (Martín-Gutiérrez et al., 2017), an innovative technology that has the potential to add unique advantages to the traditional way of teaching. Martín-Gutiérrez et al. (2017) describe the advantages of VR as something which can improve students' academic performance and motivation or help them out with developing skills. It encourages students to take on an active role in their learning process.

For a successful implementation of VR, it is important to know the perceptions of teachers, but in the literature their perceptions are not well researched. Searches for specific literature on high school teachers' views on VR resulted in very little findings. Most of the research was done on either younger teachers (Sardone & Devlin-Scherer, 2008, Park et al.,2019) or on teachers that were specialized in technological innovations (Ausburn & Ausburn, 2004). The importance of research including a representative sample of teachers was found by Cope and Ward (2002) who found, with other new technologies, that the perceptions of teachers were important for a successful integration process. In addition, other research from Zhao and Cziko (2001) also tells that the perceptions of the teachers were so unique that they did not always line up with those from technology developers and researchers. Teachers gave insights that the latter two groups were not able to envision. Therefore, this project tries to fill up the gap by interviewing high school teachers on their drivers, barriers and opportunities for VR in education.

Teachers and Technology

As the visons of teachers on the subject of VR are not that well represented in the literature, a look is taken at other technologies that were integrated. VR is not the first technology that has been implemented in education and we can learn from the adoption process of different technologies. If you take a look back at the start of technology in education, even before the dotcom boom that happened in the 90s, there was skepticism about the usefulness of technology in education. Cuban (1986) doubted that computers would add something to the classroom. He found that they were hard to use and they were incompatible as a medium for student learning. The people that were pushing for the use of computers in education were mostly the innovators, not the teachers. According to Cuban, computers were a mismatch with the conditions of teaching.

Almost 15 years later, Becker (2000) wanted to find out if the findings of Cuban (1986) still held up. He used the 1998 national of Teaching, Learning and Computing (TLC), which researched the use of computers in the classroom, to determine whether computers were indeed incompatible with the conditions of teaching. He concluded that computers still had their issues in the classroom, but that there was a new style of teaching on the rise. He also noticed that teachers who used the computer a lot at home where more likely to integrate it into their lessons. Apparently, those teachers knew how to combine their own pedagogical knowledge with the computer which made the implementation possible.

Around the same time, Tapscott (1998) investigated the readiness of students for the digital revolution. He found that having access to a computer with an internet connection was greatly enhancing the learning skills of young users. The internet was an interactive tool that stimulated critical thinking and problem solving. He noted that schools had to change to adapt to this new digital age or else they would fall behind in this new era.

Both the reports of Becker (2000) and Tapschott (1998) show that there is a discrepancy between what the teachers and researchers saw as the future of education. A similar conclusion was also drawn from a survey of the Office of Technology Acceptance (Smerdon et al., 2000) where they looked into the drivers and barriers of computers in education. The drivers that teachers saw for the computers in education differed from the drivers that researchers envisioned. This was mainly caused by the lack of technological skills of the teachers, they could not use the computer as effective and easily as primitive teaching methods.

Eventually though, teachers followed with this development and started using computers in education. Bebell et al. (2004) used multiple surveys to investigate how teachers used computers in their work. He discovered that the computers were used for more things than just for the lessons. It was also used to support other aspects of teaching, like grading students, communication or the preparation of lessons. Each teacher had their own purposes for the computer and if they used the computer for a specific purpose, that would not increase the use of other purposes. In other words, teachers were applying the technologies for different goals and at different rates.

Aldunate and Nussbaum (2012) also noticed that technology was not used as much in education as in other fields. In this paper they researched the barriers that teachers had with integrating an electronic whiteboard, digital cameras, or an education website. They found that teachers struggled a lot with the basics of the integration, i.e. they did not know how to use the technology and lacked the experience to reach the full potential of the technologies. Exceptions to this were teachers that defined themselves as early adopters or innovators, since they were more likely to adopt technology regardless of its complexity. If a school had more early adopters than average the technology was also more likely to be adopted with the majority of the other teachers. The majority of the teachers also indicated that the adoption process required most effort at the start, but the keeping up to date with technology required substantially less labor. It was also discovered that the complexity of technology determined part of the adoption rate, where more complex technologies were more likely to be abandoned in the process.

Zhao and Cziko (2001) looked into the adoption process from a different angle. They used a perceptual control theory (PCT) perspective to explain why some technologies were adopted and others were abandoned. PCT states that human behavior is caused by their goal of changing their actions so that the perceptions line up with their internal goals. Each person has a higher-level goal in mind, which is then split up in multiple lower-level goals that are easier to achieve. For the teachers that means each time they are presented with a new technology for their education, the consideration is made whether they need to improve their lessons, which is a higher-level goal. When they are convinced that this higher-level goal needs to be achieved, they consider how effective that new technology would be for improving. Zhao and Cziko used PCT to highlight 3 focus points that could be used to convince the teachers that a new technology is needed in their lessons:

1. The teacher must believe that technology is more effective at maintaining a higher-level goal than what is currently being used

2. The teacher must believe that using this technology will not cause disturbances to other important higher-level goals

3. The teacher must believe that he or she has the abilities and resources to use the new technology.

Sandholtz and Reilly (2004) also investigated what was needed for teachers to adopt new technologies. They used a framework from the Asian Center of Technology to determine the bottleneck for the adoption process for new technologies lies. In this case there was a discrepancy found between what teachers needed for proper integration and what was offered to them. Many of the instructions that were meant to help them with this process taught them basic commands and the technological knowledge of the new technology. But teachers themselves favor a more practical explanation of how they can use the new technology into their lessons. If they received the latter, combined with help for the technical problems, the integration of the technology would speed up and usually there were less technological problems than expected by the developers of that specific technology. So, it is important that the teachers can use the technology to facilitate their instruction, meaning that there is a smaller focus on the technological knowledge. This also came forth from a survey that they did under high school teachers, which showed that teachers that had help with technological aspects from the schools were faster with the adaptation process than teachers that were trained on those aspects.

Besides these findings on a group level, there are also large differences between teachers on how technology is adapted. One potentially important factor for this difference is the age of the teachers. Prensky (2001) discussed the difference between people that were born in the digital age, which happened during the digital boom of the 90s, the so-called digital natives, and people who were born before that. The fact that young people are were raised in a time where technology was everywhere would result in that they can learn new technology faster and easier than their older counterparts. O'bannon and Thomas (2014) tested this hypothesis by looking at the usage of mobile phones across teachers. They checked if the teachers used the phones themselves and if they also used in their lessons as an educational tool. They did find that older teachers were less likely to use a mobile phone, incorporate the mobile device into their lessons and saw more barriers. But the age from which this became significant was 50, not

the expected age of 32. So middle aged teachers were more flexible than expected and they seem to be able to incorporate new technologies just as well as young teachers.

A related important potential factor to age is the experience of the teachers. Smarkola (2007) used a survey to see how well the Technology Acceptance Model (TAM) worked on both student teachers and experienced teachers. The TAM model (Davis, 1989) says that when users are presented with a new technology, they will use it based on the perceived usefulness and the perceived ease-of-use they see for the system. These two variables are influenced by external variables like social environment and internal variables like personal beliefs. In Smarkola's research no statistically difference was found in the use between the two groups. However, the student teachers had a higher intent to use computers in their teaching. This result could translate to VR where unexperienced teachers will be more likely to incorporate this new technology.

Pedagogy and Technology

New technology has had a huge influence on how the teachers approach teaching, but some aspects have stayed the same. One of these aspects is pedagogy, which can be defined as 'any conscious activity by one person designed to enhance learning in another (Watkins & Mortimore 1997). Pedagogy is more expansive than just teaching, it is about the science and art behind it. A teacher with a good understanding of pedagogy is able to adapt his lessons to the needs of the students. Entz (2007) discussed how teaching was more than just telling the course content to the students. She used the framework of the Center For Research On Education, Diversity and Excellence to put an emphasis on the bond between the student and the teacher and the fact that teaching could be described as a two-way process.

Pedagogy has also been investigated as a factor influencing the implementation of technology into education. Loveless (2011) did a literature review on the importance of pedagogy in this process of technology in education. She found that the stance on the pedagogical advantages of technology in education were governed by three different dimensions. The first dimension is the wider context for technology, the perception of technology outside of the classroom. This dimension influences what teachers might think about the pedagogical value of technology through the cultural and societal stance of technology, the possibility of technology as a resource for learning and teaching, and as a new field of technology concepts for teaching. The second dimension is the metaphor that the teacher uses to describe technology. Does the teacher see potential for it as a resource, tutor, a

teaching environment or a tool? The third dimension that she found in the literature was the Technological, Pedagogic and content Knowledge (TPACK) framework, which is the new knowledge which emerges when a teacher combines his knowledge on the technology, his knowledge on the course content and his knowledge on pedagogy.

The TPACK framework was designed by Koehler (2009) and it is used by educators to evaluate their use of technology in the lessons. The focus of this framework lies on the interactions between the teacher's technological skills (TK), pedagogical knowledge (PK), and knowledge on the content that is taught (CK). This framework was built from the PCK framework of Lee Shulman (1986), which just focusses on PK and CK. CK is how well the teacher knows the content of the course: whether they know all there is to know and which information is relevant for the students. The PK concerns whether they know how to transfer the knowledge to the students, how students learn and what the differences between each individual one of them are and how these differences need to be approached. TK is more general, where the teacher knows the general capabilities and limitations of a certain technology. TK is also the one that changes the most over time, since new applications for each technology are found every day. So, if a teacher is not constantly updating his knowledge of the possibilities of technologies his knowledge will fall behind and become irrelevant.

The main value of TPACK lies in the interactions that TK, PK and CK have with each other. It states that when a teacher has mastered all three of these knowledges separately that the quality of their teaching does not become the best it can be. It is important that they are aware of the interactions and how to apply one type of knowledge to another. For example, a teacher that knows how to correctly combine PK with CK will select the course content that is relevant for the students and present it in a way so that each student can build their own representation of the knowledge.

This framework shows that teachers need more than just knowledge of the new technology to implement it into their lessons. They need to be aware of how well it fits with the content that is presented in their lessons and how well it works with their way of teaching.

Virtual Learning Environments

As mentioned before, there is little research on the opinions of teachers on VR in education, but there is a technological predecessor that has a lot in common with it. This is desktop virtual reality, where a user views a virtual world through the display of a computer, without the use of a head mounted display (HMD) . These so-called Virtual Learning

Environments (VLE´s) and their effects on education have been researched excessively. Dillenbourg (2002) defined the definition of VLE's as a designed social information space, where students are explicitly represented and they are active actors in the virtual space. This indicates that VLE's have some level of interactivity and agency in the virtual environment, just as in VR where these properties are some of its main characteristics.

The main difference VR and a VLE is the way the environment is experienced, via the screen of a computer of via a headset which offers complete immersion. This difference has some effect on how these environments are experienced. Santos et al. (2009) did research on the performance of people on a navigation task in both a VLE and in immersive VR. The focus on navigation was chosen because of the importance of this task in virtual environments. The interesting finding was that many aspects were the same, the participants indicated that immersive VR felt more natural and intuitive, but the results showed that they performed better on the desktop VLE. The data suggested that the better performance was caused by a training effect, since the effect was more present in people that play computer games a lot.

As VLE's have been around for a longer time than VR with an HMD, there is also more know on the opinions of teachers. Sardone and Devlin-Scherer (2008) studied preservice teachers in a VLE where they had to puzzle and find the cause of an illness running amok in a town. After completing a 60-minute session the participants were asked about their experiences. Most participants told that they saw potential to engage the students in their learning. This was supported by Rappa et al. (2008) when they used Second Life as a VLE. In Second Life the player gets to control an avatar in a virtual world and they were given an assignment to complete in pairs. This assignment was on creating a profitable business by selecting the correct and most cost-efficient tools for a farmer.. The researchers found a potential increase in motivation and help out with skill development, findings that are similar with VR. But a third of the respondents was afraid that management of the class would become more difficult during a lesson where they use a VLE. One of them also wondered if the costs of the system wouldn't be too high for a school. As the positive effects of motivation were similar between VR and VLE's, so is the possibility for the negative effects of difficult class management and high costs of the systems.

Background of VR

Before we can look at VR in education, we have to learn what kind of technology this is. There are many definitions for VR, but this paper handles the definitions proposed by Steuer (1992): A real or simulated environment in which a perceiver experiences telepresence. Steuer also described how each technological system providing VR has a different effect on that telepresence through two different variables: vividness and interactivity. Vividness describes how the environment presents information to the senses and interactivity describes the extent to which uses can participant in modifying the form and content of a mediate environment in real time. One of the first times that interactive VR was talked about was in a 1935 science fiction story of Stanley Weinbaum, *Pygmalion's Spectacles*. In this story the main character Dan puts on a set of goggles which overtake his senses and take him away into a movielike world where he can freely interact with the actors. In this his actions influence the story and the illusory world feels just as realistic as the real one.

Over the years, VR has been applied for a variety of purposes, one of the first mentions of VR for training is found in 1966, where it was used to train pilots (McLellan, 1996). They used a HMD to show a stereoscopic image to a pilot that was sitting in a training plane. Over the past decade the role of VR has only become more prominent for training professionals. The big flying simulators that are used to train pilots are being replaced by a smaller HMD with a few additions to simulate the experience of flying (Valentino, 2017). Walmart is using VR to train their employees to handle exceptional situations (Carruth, 2017). Medical students get to experience a surgery without the consequences of making an error (Falah et al., 2014) or they get to learn the anatomy of the body without using corpses (Khan et al., 2014). Doctors can even use it to train themselves to spot Covid-19 symptoms (NOS, 2020).

Another place where companies experimented with VR is in the gaming world. Nintendo released the Virtual Boy in 1995, where a player could see their games through a limited stereoscopic lens. In all these areas of use VR has evolved immensely over the last two decades (Anthes et al., 2016) . The increased processing power of computers have made the virtual worlds more realistic and interactive. Where the Virtual Boy had a monochromatic view that brought the virtual world to life, the PlayStation interactive VR shows vivid worlds with incredible amount of detail.

The price of VR has dropped down significantly over the last few years. It has dropped from thousands of euros to hundreds, making VR available for almost everyone. Examples of

devices that are available to the public are the HTC Vive(€692,-) and the Oculus Rift(€449,-), which come with controllers with which the user can influence the virtual world. If someone has a smaller budget, there even is Google Carboard that uses a smartphone to experience VR for the price of only €15. Even though cardboards do not offer the same level of interactivity as an HMD with a controller, most apps that are compatible with cardboard use gaze direction, thereby providing some sort of control. As the prices drop, the availability and quality of VR increase, increasing the potential of interactive VR to be used as an educational tool (Brown & Green, 2016).

The potential of VR in education

Back in the 90's the potential for VR in education was already discussed by Pantelidis (1997). She named a few of the potential advantages of VR: Helping out with the mental visualization process of the students, increasing motivation in students and the opportunity to show perspectives that are inaccessible in real life. Since then more in-depth research has been done on these effects and the roles that VR can take on.

To see what roles VR could take in education, I first discuss multiple roles that this technology can play in education. The findings of Stevenson (2008) can be used for this classification. He used activity theory to define 4 different ways in which a teacher could incorporate technology into the classroom. These can be also applied to see what role VR could fulfill in the classroom. The roles are as follows:

- A resource: presenting information to the students
- A tutor: actively teaching a student a skill
- An environment: a place where the student can explore based on their knowledge and experiment with the environment
- A tool: a tool that helps students with an overarching task

VR has the potential to fulfill all these roles in many different ways. VR, both the interactive and passive variants, in the classroom mostly has been found a positive effect on the study results of the students (Martín-Gutiérrez et al., 2016).

Research on student perceptions and effects of VR in education

First, VR can help students with the final step of learning new information: Winn (1993) discussed the potential advantages that VR could offer students with conceptualizing their gained knowledge by offering a more constructivist approach of the course material. Roussou

(2006) researched the effect of studying in a VR environment on primary school students where the students were put in a VR environment to build a temple. There were three different conditions: one where the students were building in VR, one where students observed a robot building in VR, and one where they had to build with LEGO bricks in real life. VR facilitated conceptualization of knowledge, although not in the way that they expected it. The active roles, like tutoring or tools, that were implemented to help the students with the process, did not have a significant improvement over the passive role in VR, i.e. using it as an environment. The environment of VR was all that was needed to help the students out with conceptualization of their newly gained knowledge.

The next way that VR can benefit students is an effect on their motivation, which increases high-quality learning (Deci et al., 1991). Sattar et al. (2019) let medical students study similar subjects in three different environments: VR, text, and video based. A self-report of the students on their motivation and competency showed higher values for VR compared to the other two environments. The effect of increased motivation in VR was also found by Garris et al. (2002), and Freina and Ott (2009).

The third positive effect of VR is its ability to represent abstract information (Huang et al., 2010, Southgate et al., 2019) and help students with the understanding of complex scientific concepts (Dede et al., 1999). The unique ability to explore a 3D environment in a natural way helps students with visualization. For example, for the subjects of physics and math it can show what happens when the gravitational force of the earth is changed. This gives a clear example of how gravity works and what happens when an exponential variable is changed. This supports students that have issues with visualizing concrete information.

Last, VR can also allow the user to navigate environments that are impossible to experience in real life (Boyels, 2017). Examples of this are history lessons where students can visit ancient battlefields as the fights are unfolding, a biology class can go into a body to explore the circulatory system and geography can take a look inside an active volcano. All of these visits create experiences for the students that are better remembered through the uniqueness provided by VR, thereby providing another potential benefit to the learning process.

Besides the potential for VR in regular education, there are also opportunities in education for students with special needs. Dolan et Al. (2005) show multiple VR applications for special needs education. VR can help student that have physical limitations to explore virtual environments. It offers them the opportunity to experience the vantage point of a person that

does not have those limitations (Cromby et al., 1996). Rizzo et al. (2004) tell of the opportunity to offer better specialized help to each student, making it possible for each student to have the same experience. An additional advantage of this is that teachers can teach in a more general way, instead of focusing on the need of every specific student, which results in less time required to prepare the lesson for each student.

VR can also help out teachers that educate students that are on the autistic spectrum. Parsons and Cobb (2011) indicates a great advantage of VR for these students is the ability to create controlled environments. In these controlled environments stimuli that are problematic for the autistic students can be removed so that they are able to focus on the task at hand. It can also help these students by training them for social interactions (Parsons et al., 2007).

Although the perspectives from a sample of all teachers are missing, the perspectives of undergraduate students were researched by Rasi et al. (2000). They investigated if certain factors, like gender, previous experience with VR, and the kind of course that the students attended, influenced the possibilities that they saw for VR in education. A significant difference between humanities students and engineering students was found for seeing cognitive advantages for VR in education. The findings suggested that engineering students envisioned more opportunities for courses where learning difficulties were caused by visual conceptualization.

The implementation of VR into the classroom

Although there are many advantages to VR in the field of education, the implementation will not be a simple task. Lee et al. (2010) suggested that a switch of teaching style from teacher-centered to student-centered is needed for a correct implementation. The old setup of a classroom, with the teacher in the center, is well known, it has been around for a very long time: the teacher stands in front of the blackboard and every student pays attention to them, the whole classroom is built around the teacher. The tools that are available are meant to help the teacher out. On the other hand, with the student-centered style, a look is taken at the needs for each individual student and how to fulfill these needs using different items like a personalized planner that helps out with the specific problems that the student is dealing with. The teacher becomes one of these items, where he can help out with specific problems that the students have. VR is not the only technology that would benefit from this switch, many other technologies would also benefit from a switch to a more student-centered style (Rakes et al. 2006).

The aim of this research

As stated before, very little research has been done on the visions of teachers on VR in education while it has a lot of potential to help students out. The research that has been done were too narrow, where they looked at a small set of technology-savvy teachers like pre-service teachers or teachers that had an extensive knowledge of VR (Molnar 2007, Ausburn & Ausburn 2004, Cooper & al. 2019). In addition, Zhao and Cziko(2001) concluded that the visions of teachers are essential for a correct implementation of the technology in VR. Therefore, the current study aims to address the research question:

> What are the opportunities, drivers and barriers that teachers see for Virtual Reality in Education and how is this perception influenced by their age, experience and the subject that they teach in?

The effect of age is included because of its influence on previous technologies (O'bannon & Thomas, 2014). Course subject is researched because the visual advantage that VR offers can be higher with courses where learning difficulties can be caused by mental visual conceptualization process.

The research question is accompanied by the following hypothesis:

- The main barrier with the implementation of VR is the lack of technological skills and knowledge regarding VR.
- Younger teachers see more use for VR and that they will have greater interest for it and have higher technological knowledge and technical skills in general.
- Teachers will see opportunities on the implementation of VR into their courses, but their struggles with the technical aspects are holding them back

These hypotheses come forth from the research question and literature which suggest that there are factors (technological knowledge, age, courses that they teach) that could help with finding how ready teachers are for the implementation of VR into their lessons.

METHOD

Design

This study used a qualitative descriptive approach based on semi-structured interviews with high school teachers in the Netherlands. The fact that the in-depth opinion of general teachers was missing in the literature combined with the fact that there was no clear classification for their level of acceptance for VR gave rise to the need for interviews.

Sample size

To determine whether enough teachers were interviewed the framework Francis et al. (2009) have developed was used to determine data saturation. This framework describes the use of a stopping criterion pro to determine whether data saturation has been reached. Before the interviews an initial analysis sample is set based on similar research. For this a look was taken at the previous research of Keskitalo et al. (2011), where teachers were interviewed about a specific VR environment in pedagogical settings. She found that enough participants were interviewed after 8 interviews. Next to the initial analysis sample of 8 a stopping criterion of 2 was selected. So, each interview after the eight I checked whether the last two interviews resulted new codes compared to the codes form other interviews. This was already reached at the eighth interview, but at that point only one of the interviewed teachers was classified as a teacher with low technical skills. So, a ninth interview was planned in with someone that fell into this category. This interview did not result in new codes, resulting in a sample size of 9.

Recruitment

The teachers were recruited by different means. Three of them were approached via personal contact, two reacted to a request for “teachers wanted for their opinion on VR in education” on the social media platform LinkedIn. School were also approached by mail and phone to see if they had teachers that would be interested in an interview. Most schools reacted that their teachers were busy dealing with the unique situation that Covd-19 had created, but four teachers reacted on the mails. At first a lot of younger, tech-savvy, teachers reacted, so later invites asked specifically for older teachers and teachers that were less experienced with technology.

The educators that were approached for the interviews taught a set of specific courses(Physics, Math, Science, Geography, History, Technology and Biology). These courses were selected because of the possibilities for VR implementation into the lessons due to the added value of

Table 1. Demographic details of the participants n=9).

Characteristic	N(%)
Age (Years):	
20-29	3(33)
30-39	1(11)
40-49	2(22)
50-60	3(33)
60+	0(0)
Gender	
Male	5(55)
Female	4(44)
Course they teach*	
Biology	1(11)
Chemistry	4(44)
Geography	1(11)
Math	2(22)
Physics	2(22)
O & O	1(11)
Teaching experience	
0 - 5 years	3(33)
6 - 10 years	1(11)
11 - 15 years	1(11)
16 - 20 years	2(22)
21 -24 years	1(11)
25+ years	0(0)
Working background	
Teaching education	4(44)
University background	2(22)
Worked at a company	2(22)
Entered education later in life	1(11)
Self reported tech expertise	
Above average	4(44)
Average	3(33)
Below average	2(22)
VR experience	
Taught with it	3(33)
Has seen it outside of school	4(44)
No experience with it	2(22)

***One teacher can teach multiple courses**

VR to the visual conceptualization. Most of these courses were covered within the teachers, except history and technology. This criterion was dropped because the teachers were talking less about their own subjects, but more about all possibilities within Dutch high schools. So, for example, a few teachers covered the possibilities and barriers for the courses technology or arts and crafts, even tough that was not the main subject that they themselves teach.

Procedure

All of the interviews happened via Microsoft Teams, but during one the audio was transmitted via telephone because of a technical issue. The recording of the interviews was done through the option that Teams offers after the consent of the participants was given. In all the cases the interviewees and the interviewer could see and hear each other.

The questions asked during the interviews were based on previous literature on technology acceptance and innovation management in education. The interview started with asking some background questions for the teachers. This was to determine their age, teaching experience, teaching style and the courses that they teach. After these questions were asked to determine their technological capabilities. These questions were part based of TPACK and part of the TLC survey. During this the

question was also asked how Covid-19 influenced their views on technology, this was because in the Netherlands many teachers were forced to teach online during a lockdown. This forced use could have had an influence on the perceptions (Code et al., 2020). Next the questions about VR were asked. First, the teachers were asked to tell what they already knew about VR in general, this was to see how well they knew the technology, followed what they knew about VR in education. Next set of questions were adapted from the literature. The interest of the teachers in VR was determined based on questions from the US IT survey by Smerdon et al. (2000). This survey researched the interest of teachers for technology use in their classroom and the questions of it were made specific for VR. TAM was used for questions to determine what the perceived usefulness and perceived ease of the teachers was for VR in education. The choice for this was made because of the possibility to use TAM to determine what two drivers could be for VR for the integration into the classroom. The TPACK framework to see if they saw pedagogical added value for VR and what their technological knowledge on the subject was. For another set of questions to determine pedagogical potential of VR Klafki's (2006) 5 basic questions for didactic analysis were used. These five questions are something that can be applied to all new ideas in education, but they can also be adapted for VR in education. The last literature that was used to create questions was perceptual control theory. This was mainly done to determine potential barriers and the needs of the teachers concerning VR in education. The complete interview guide can be found in the appendix. After the questions were answered, the participants were thanked for their time and answers, and they were debriefed.

Analysis of interviews

After the interviews the recordings were transcribed using VLC and Microsoft Word. During this process personal data that could be traced back to the participants, i.e. what school they worked at and collaborations that they did, was removed so that the final data would be anonymized. This data then was subjected to a thematic analysis as described by Braun and Clark (2012), starting off with coding the data, for this process NVivo, from QSR International, was used.

The codes were identified with an inductive mindset, meaning that the codes were strongly liked to the data themselves, instead of being theoretical where a more top-down approach would be used. This choice was made there was no previously established theoretical framework. These codes were checked by a second coder that received a codebook, instructions on what each code meant, and the transcripts of three interviews. The second coder then coded

the three interviews and the differences in codes were discussed. There was a small difference between the codes of the first and the second coder. The second coder had some suggestions for codes that were not in the first coding, so after a discussion those were added. The other differences were discussed and reviewed. After this process some codes that differed were rewritten or merged together.

These codes were then used to generate potential themes, looking for overarching elements that codes shared. These elements that emerged focused more on the semantics level, where no look was taken beyond the nature of what teachers said. The questions of the interview were not asking for information that would require subtext. The teachers were asked about things that they could openly speak about. The analysis also relied on an essential nature to determine the meaning of the answers, where motivations experience and meanings are generated in a straightforward way. This instead of the other option where the answers given were a result of the social environment of the teachers.

These themes were reviewed and a look was taken into how the themes fit together or how multiple themes could fit together in a bigger theme that told the story of the teachers. Some of the smaller themes became subthemes that served the story of the greater themes. The greater themes were defined and named. They will be presented in the next section.

RESULTS

The thematic analysis of the interviews generated 4 main themes from the answers that that the teachers gave:

- VR is not ready yet for education
- VR can add value to current education
- Students will benefit from VR in their lessons
- The development of VR needs teachers in the process

Within these themes, several subthemes were identified that provide more information and difference that were occurring between teachers.

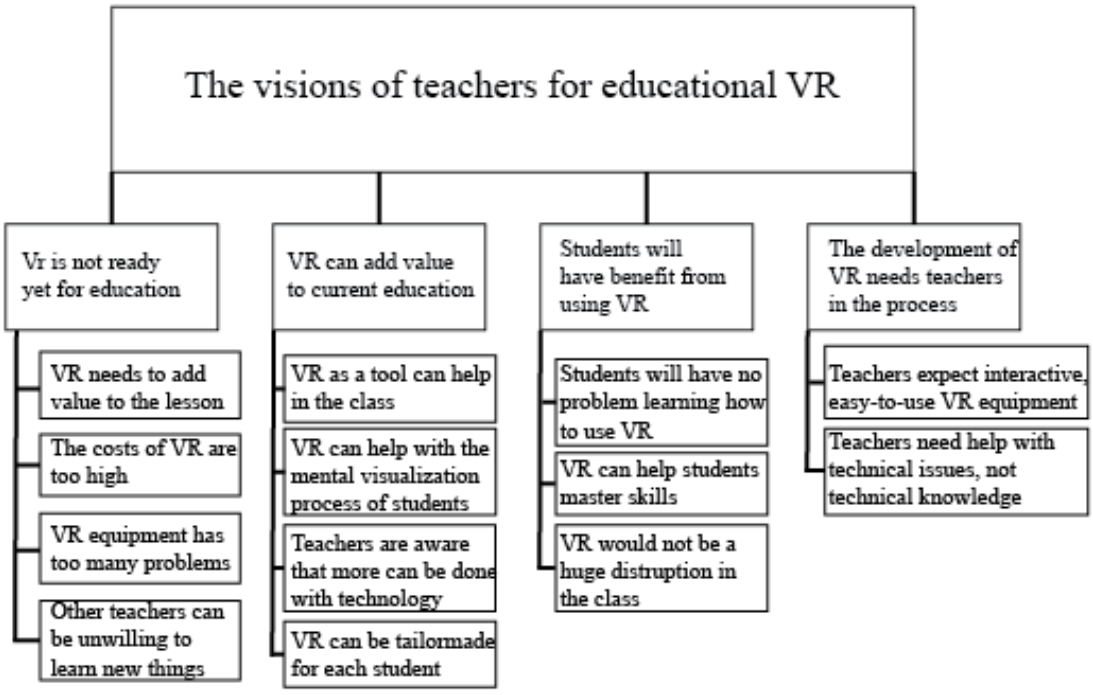

FIG 1. Overview of the main- and subthemes.

VR is not ready yet for education

Only the question remains, is it already interesting at this moment, or will it be interesting in 2, 3, 5, 10, I don't know how many years? [Male, 50, Math, Has not taught with VR]

This question asked by one of the teachers can be coined as the biggest overarching question that teachers are asking themselves: Is VR ready for education or does it need more time? Six of the nine participants teachers mentioned that educational VR still needs development or that it will take some time before it will have its place in the classroom. Four of them saw VR being used in the future after it has improved a bit. Four of the six teachers also mentioned that at this moment no perfect VR system for education exists and that the currently available systems need more development before they can add value to the lessons.

VR clearly needs to add value to the lesson

This brings us to something that all of the interviewed teachers noted: it should be clear what VR brings for added value to their lessons. One participant mentioned:

It needs to be helpful, it really needs to add something and not just being used because it is fun or something like that [Female, 50, Math, Has not taught with VR]

Teachers have the clear requirement of VR that it should add value to their lessons. Five of them explicitly stated that VR needs to have an improvement to their lessons or else they would not be interested in using it. Currently not all teachers have a clear picture of what this added value of VR is or could be. Four of the teachers indicated that they did not have a specific indication on what the added value of VR to their lessons could be. They want to see concrete information on what VR bring them for their lessons: what are the unique advantages that it can bring, how can it potentially improve their teaching, and how VR measures up against their current equipment. There were differences between the teachers that correlated with their demographics. Younger and less experienced teacher were more convinced that VR had this added value. The older, more experienced teachers, believed that the added value could be there, but they had not seen it yet. All of them did mention that when a student would be helped out in the learning process because of the use of VR that they would be convinced of the added value of this technology.

The costs of VR are too high

But the biggest change that teachers ask of educational VR before it can be used in education is a reduction in its cost. For four of the teachers the price of VR was the main direct limiting factor for the current use of it. One other teacher envisioned it being a problem, but the problem that he saw with VR was that he was not convinced that it had to be used. The teachers mentioned that the initial costs for integrating VR into their lessons was too high, this combined with the limited budget of some schools prevented three of the teachers from starting of with it. The costs of the equipment were also too high to ask the parents to buy it.

Two other teachers, who had experience using VR in their lessons, mentioned that one of the obstacles was that the equipment was not available for all the students at the same time. This created situations for them were one part of the class was working within a virtual world, while the other students were working on other assignments. One of the two teachers solved this by making sure that the other assignments focused on co-operating with the student that was in the virtual world, but he did say:

One of the biggest obstacles that you have at this moment is that not very student can work at the same time with a VR headset [Male, 26, Chemistry, Taught with VR]

The one other teacher that had experience with teaching in VR solved the problems of the costs and unavailability by using a cheaper cardboard-like option like Google Cardboard. She felt that this was the only realistic option because of the high costs of other VR equipment. This less expensive option was also discussed with other teachers and six of them told that it was not an option because it lacked interaction, one of them mentioned:

You could say, we solve this problem with the google cardboard where they can put their phone to use(..), but that is not real VR and it is not the magical experience of the Occulus Rift. [Male, 26, Chemistry, Taught with VR]

VR equipment has too many problems

There were also problems with VR equipment that five of the teachers saw with current VR equipment were the technological capabilities of the devices. Two teachers mentioned that some of the VR equipment required a computer that has a graphic card is that capable of running VR. They saw this as an extra obstacle that could create new points of failure. One teacher experienced that some devices would not work when they were using it, giving the students less time to learn with VR. Another one mentioned bad internet connection at her school, which

needs to be upgraded to start working with VR. Three teachers also mentioned that some of the devices they were familiar with had problems with running specific software or with running VR at all. Related to this, three teachers also mentioned that the producers of VR equipment were limiting the use of the devices making it harder to use a VR device for education. They either asked for a login to a Facebook account or limited users to only use software that the developer allowed on their platform.

Other teachers can be unwilling to learn new things

The interviewed teachers also discussed that their colleagues were dealing with other obstacles regarding educational VR. Seven teachers reacted that most other teachers would have similar reactions to VR as they had, but four of the teachers mentioned that this would be different for older teachers. They said that it would be unlikely that older teachers at their schools would put in the time to learn how to work with VR. All four did mention that this unwillingness was not specifically because of VR, but mostly because they were unwilling to learn new things. One of them described it as:

I do not think that the elderly [will learn it], because they are almost retired at our school and they think: "I am not going to do any new things." [Female, 50, Math, Has not taught with VR]

Two of the teachers even mentioned that the problems that some of older teachers had should be ignored, since they thought that those problems were not real issues and more a fear of the unknown. Three teachers expected that the fear of the unknown would disappear when teachers would just start working with it, they based this expectation on the how older teachers handled distance education during Covid-19. Their elderly colleagues were forced to work with new programs to facilitate their lessons and that went smoother than expected. One teacher described it as:

I did not expect that the old guard would be able to come along but I notice that older teachers are getting used to Teams[Male, 26, Chemistry, Taught with VR]

VR can add value to education

Even though the previous theme suggests that VR still has to be developed before it can offer added value to a lesson, eight of the teachers that were interviewed expressed positive interest in educational VR and the other one was indifferent about it. Some of the teachers did express that they felt that VR could add value to their lessons, this potential added value was seen more by the younger teachers. Another determinant that influenced the potential added value of VR was the area of expertise of that the teachers. Courses that use visual tools to explain concepts, for example biology or science, saw more possibilities than other courses, like for example math. The teachers described different possibilities on how VR could add value to their lessons, but all of them came down to if it was an improvement for the learning process of the students. That when they used VR that their grades would improve. One teacher described this as:

If you have results that VR is effective [and that the grades of the students improve because of it], then you have to be able to use it in your lessons [Male, 50, Math, Has not taught with VR]

VR as a tool can help in the class

Four of the teachers talked how they would use VR in their class specifically, where they discussed the different roles that it could fulfill in their lessons. They saw the most potential for it as a didactive tool, where it could explain the course material to the students, but there was also some potential for VR to be used as a test tool. The teachers then described what a VR lesson should look like and they made a comparison to a practical lesson. Mainly because the VR lesson would be similar in structure. The students would get instructions at the start of the lessons on what they should do before they can enter the virtual world. Then the students would be free to work in VR to solve the assignments. A teacher described this similarity as follows:

Making assignments would be possible, like a variation on a practical lesson and I think it can also be used as some sort of learning through discovery [Male, 38, Physics and O&O, has not taught with VR]

This interactive element of VR that teachers compared to a practical lesson was something that four of them saw as a huge benefit compared to regular learning. Usually learning is something passive that the students do, but with VR they become an active part of the process. This gives them a unique point of view. A teacher described it as:

It [VR] has way more interaction, the learning is active instead of passive. [Male, 26, Geography, Experienced VR outside of school]

The teachers did make a comparison between VR and a practical lesson, but some advantages for VR were seen. Three teachers also mentioned how VR could help out with some ethical dilemmas that they face during practical lessons. One mentioned how VR gave the opportunity for the students to be in a safer environment during lab sessions by letting them get some experience with dangerous equipment before they get to use it in real life. The two others discussed the dissecting of body parts during biology lessons, where they currently use real animal parts. This was something that a teacher was struggling with:

I tell them: This is your impact on the environment when you keep eating animal-based products(…), but how are you going to justify them that you are working with offal? [Female, 24, Biology, Experienced VR outside of school]

Three teachers also talked about how VR in high school can prepare the students for their future education, where they expect VR to have a bigger role in the curriculum. They mentioned how in flight school people start of with learning how to fly with VR flight simulators and doctors in training perform operations in VR. Two of these teachers also mentioned how VR is becoming something that the students can work with in their professional life, so some expertise for this can be gained in high schools.

Two teachers also mentioned how VR could able to motivate the students more during their lessons. They told how the VR experience made the student enthusiastic to learn and that the experience by itself was a huge motivating factor for them.

VR can help with the mental visualizing process of students

This opportunity to visualize was the most discussed positive advantage of educational VR. All the teachers mentioned it and for most of them it was point they elaborated on the most. They described that the 3D environment and the freedom of movement that VR offered are upgrades from the current equipment. One teacher described it as:

I use VR to make my lessons more visual, so something which is usually hard to explain on a flat screen(..) that is very easy to visualize in VR [Male, 26, Chemistry, Taught with VR]

As the teachers put it, some of the students were struggling with translating text and pictures from their books into a usable concept in their head. Six teachers saw potential for VR to help out with this problem by using VR to show something that is not visible in real life. For

example, one physics teacher discussed how electrical currents have three different directions and how it is hard to visualize all three in a single picture. He noted:

Normal blackboards are 2D, so you always have a [static] point of view and those are per definition confusing. Some students don see how that works. And when you can walk around something you can imagine how it all is made up[Male, 38, Physics and O&O, has not taught with VR]

Other teachers discussed this as well for their courses, where the 3D environment VR could help with putting abstract facts into concrete concepts that they could apply. The need for a good spatial insight would disappear, removing a potential limitation in the learning process of the students. For example, in a VR world students could make changes on a microscopic level, e.g. to cells or molecules, and then see what kind of effect those changes would have in the real world without having to apply abstract knowledge.

There was also another suggestion on how VR could help through visualization. Two teachers mentioned how VR could take the students to faraway places that would be hard to visit regularly. One described how students could discover the flora and fauna of another country and the second one went into detail how students could do a city tour from their classroom.

Teachers are aware that more can be done with technology

The five teachers that were technologically skilled and used technology often in their lessons saw more opportunities for technologies in their lessons and they were also more enthusiastic about VR. The other teachers, which had low technological skills, did not mention that their technological knowledge was something that was holding them back from their interest in VR. A similar effect was visible with the teachers who received help and funds for the implementation of VR from their school, where they saw bigger opportunities for VR in their lessons.

The Covid-19 pandemic was also something that was mentioned as something that opened the eyes of the teachers to new technologies. Teachers were forced to teach their students from home and this showed them what technology could achieve in their lessons. One teacher described the switch as:

It has not changed [the amount of technology used], at most it has accelerated the adoption of it.(…). It showed that we did not have the devices and that we used it pretty embarrassingly[Male, 38, Physics and O&O, has not taught with VR]

But it also revealed the importance of properly regulated technology. Another teacher mentioned:

Especially through corona schools have realized more how important it actually is to have their ICT in order. [Male, 26, Chemistry, Taught with VR]

So, while Covid-19 may have opened the eyes of teachers for the use of new technology in their lessons, it also has shown how important it is that it works properly.

Two teachers also mentioned why VR could be interesting for the school when used as differentiation device to stand out from other schools. They saw it as something that could be used to make the school more interesting for upcoming students.

VR has the opportunity to be tailormade for each student

Two teachers also mentioned the student-centered teaching style that VR facilitates. They noted that every student would have the opportunity to select a more difficult part of the assignments or that they would not have to listen to all the instruction but just start with their work. Gifted students can take a more in-depth look at the material, preventing them from becoming bored by something that they already understand and students that are struggling can be helped out by the teachers.

Students will have benefit from using VR

All of the interviewed teachers expect that the students will have a positive reaction on VR in their lessons. As discussed before, the visual aspect that VR can offer can help out every student in some sort of way. But they expect a difference between how much profit each student will have: Students that are on a more practical level of education (VMBO in Dutch high schools) would profit more from this visual enhancement. They also mentioned that students that are already visual learners would benefit less from VR, but it would still have a positive effect. One of the teachers said:

VR is such a big distraction that the students don't know that they are working on their school assignments. Normally they are distracted by their phones, but they don't even look at that because VR is much more interesting at that moment [Male, 26, Chemistry, Taught with VR]

Higher motivation of the students for a VR lesson was expected by three teachers in total, but there were some concerns about a potential novelty effect. One of the teachers was afraid that when VR would just be used for fun that the students would be getting bored of it very quickly, and one of the teachers who had actually used VR in the class noticed how a small novelty effect happened. He said:

I had a class (…) that had worked with it more often and they (…) wanted to see it and they had to make an assignment as well, so they looked at it and worked functionally with it and that was it. While I had other classes that never worked with a VR set and (...) those were a bit less working on the assignment and more distracted, but they were super enthusiastic. [Male, 44 Physics and Chemistry, has taught with VR]

This suggests that even when a novelty effect happens, VR can add something for the students.

Students will have no problem learning how to use VR

All but one of the teachers expected that the students could easily learn how to use VR, provided that they would not have to bother about the technical side of things. The teacher that did expect that the students need more time to learn it, was one of the teachers who had no experience with VR. Teachers described VR as very intuitive for the students and the expertise that students have with other technologies will transfer over to VR. Students grew up with using tablets and smartphones, so they are familiar with what inputs are expected of them. They were fast with learning similar technologies and one teacher expected that students would need no instruction at all. One teacher described how students would learn to use VR as:

Students are very adaptive, so they pick it [VR controls] up really fast. I expect no problems with it. I think that it is harder to teach them how to ignite a burner.[Female, Chemistry, has not taught with VR]

VR can help students master skills

Seven teachers did see opportunities for VR to help student with mastering soft and hard skills. For the hard skills a teacher noted:

You can master those skills through VR, but then you have to make clear before the students start what those skills are[Male, 38, Physics and O&O, has not taught with VR]

So specific hard skills could be learned in VR, but the teachers have to make sure that the students focus on the correct aspect of it. Most of these hard skills that were discussed were learning how to make connections between two phenomena or learning how to perform certain actions.

Teachers saw less problems to handle soft skills with VR. The two most discussed soft skills were learning how to cooperate and how to think in a more creative way. The cooperation aspect came up when not all students could work with the VR equipment. Teachers could make assignments where the students that are in the VR world would be guided by the other students. These other students could give instructions or read the assignment out loud so that the student that was in the VR world would know what to do.

Creativity could be stimulated by building something in VR. One teacher described advantage of being creative in VR compared to working with pen and paper as:

You let them build something and that stimulates creativity(…) and then they see that you can't build something in the air(…). When you make something in the virtual world, that also has gravity (…), you gain insight[Female, Chemistry, has not taught with VR]

VR would not be a huge disruption to the class

The teachers had different visions for how a class as a whole would react to a lesson in VR. Three of them expected that a class would become somewhat noisier, but not to the extend that it would be a problem to teach them. They also noted that this noisiness would probably become less when the students would get used to working with VR. The expectation of two others was that the class would be quieter because they were busy with VR, the students would be so immersed in VR that they would not even bother with other things. Two teachers did note

that they saw problems with keeping track of the progress of what students would be doing, but they also noted that this was a problem that is not bound to VR. They see that some students are more easily distracted by their laptop or smartphone and they expect that this would happen as well with VR. One teacher suggested that this could be solved by some form of evaluation at the end of a lesson with VR, where the students could tell what they had done in the virtual world.

The development of educational VR needs teachers in the process

So as most teachers expressed in the first theme, improvements should that need to be made to educational VR and they had their opinions on how this should be done and who should be responsible for it. Seven of the teachers mentioned that they would like to rely in some form on others for the development of material for VR lessons. They would not like to be responsible for the complete creation process of putting all the course materials in VR and they do not have the technical background to completely integrate this into VR. The teachers would like to see that some company that would be responsible for the development of the software and hardware so that teachers could focus on the teaching. Four of the teachers specifically suggested that the developers of the teaching method should also be developing the VR lessons, because of how well these are already known with the teaching materials. One said:

The best thing would be in my opinion, when it comes with the teaching method.[Female, 50, Math, Has not taught with VR]

The teaching method knows a lot on the course content, but four of the teachers did mention that they thought would like to see that the teachers could bring some sort of personal input into VR. So that they get to decide what a specific class gets to see in their lessons. Two out the three teachers that were already working with VR were also changing the lessons in VR based on what they saw fit for that specific class.

The two teachers that did not see the help of others as necessary for the development of VR: one of them was technologically capable to create his own lessons using existing applications and the other experienced that companies who were creating VR lesson methods were too expensive to use.

Teachers expect interactive, easy-to-use VR equipment

The teachers also were clear in what they expect from VR devices, but there were some differences in between what those expectations were. Two teachers were of the opinion that

cardboard VR, where you use your mobile phone, was sufficient enough to add value to their lessons. But six other teachers considered it important that the environment was interactable with, something which is seen with the Oculus Rift. One teacher described it as:

When you just enter a [virtual] world, I think that is too much effort for too little gain, so I would like that you have real influence on it yourself [Female, 50, Math, Has not taught with VR]

So, the plurality of the teachers requires VR to have an interactive element through some sort of controller. These controllers should be able to change the virtual world so that the students can shape it to their liking. This way a student could really work within the virtual world instead of looking at movie with 360 degrees VR.

Teachers also required that VR would be easy-to-use. Five teachers want a device that only has to be powered on before they can start their lesson. The students should not have to worry about calibrating the device or changing the settings before they can use it. One of the teachers said:

It has to be plug and play like we used to say, it has to be simple and has to work fast.[Male, 38, Physics and O&O, Experienced VR outside of school]

Teachers get limited time during their lessons and when they want to want the students to spend their time as efficient as possible. So, the technical setup of VR is something that would take this valuable time away.

Teachers need help with technical issues, not technical knowledge

The skills that the teachers thought they needed to work with VR was also discussed. Five teachers that were more capable with technology told that they just need a bit of time to play with VR before they could use it in their lessons. They told that they would not need specific instructions on how to use this. The other teachers did also discuss the skills that they thought they needed to work with VR was also discussed. Four teachers expected that they needed more help with learning how to use VR and that they required some sort of training before they could actually handle the devices. The teachers also discussed the help that they would need from outsiders. Four of all the teachers stated that a good IT department that could help them with technical problems would be necessary or that it would be a great benefit. One described it as:

I would not be able to do it[VR lesson] alone, I need other people that can help me with it. [Male, 26, Geography, Experienced VR outside of school]

The IT department would mostly help them out with the technical problems that VR could have. So, when a device would not work the IT would solve this so that the teachers could keep focusing on instructing the students. Four of the teachers also expected that VR would have some effect on their workload. At the start it would require some time investment, but in the long-term the workload would reduce. One of them did mention that for this to happen it would be essential that they would receive sufficient help from the IT department.

DISCUSSION

Principle findings

The four themes that were generated from the data told the story how VR is not ready yet for education, even though it can add positive value for students and teachers. The concrete added value of VR is not always clear, the costs are too high, and some teachers do not want to invest time into learning it. But the teachers do see potential for VR in their lessons, mainly as a tool to help in the mental visualization process. The teachers expect that the students will have no problems with adapting to this new technology. Some tech company should be responsible for the development in combination with teachers. They should work together to create interactive, easy-to-use, low-cost VR equipment.

VR has potential for education as a supporting tool for teachers and the teachers were convinced that VR could add value to their lessons. They were really enthusiastic about using it for educational purposes. These findings can be evaluated through the TAM framework (Davis, 1989). In this framework the actual system use is predicted by the behavioral intention, which is influenced by the attitude that the person has of the technology. This attitude is mainly formed by external factors, the perceived usefulness of this technology, and the perceived ease-of-use that this technology. A teacher being convinced of the added value of VR can be seen as perceived usefulness and help with technology from the school and technical skills can be seen as perceived ease-of-use. These three variables will be discussed in more depth in the next paragraphs.

Teachers needing to see added value for new technologies has been discussed before by Forsblom and Silius (2004). They found that the added value of a new technology relied on the context in which it was used. Four different contexts were defined for web-based learning environments: Flexible organization of learning, improvement of teaching quality, the development of learning and communication skills, and the innovative use of information and communication technologies in teaching. In the interviews the teachers mentioned the possibility of VR to improve teaching quality the most. They hoped that VR could help out with the education of the students and improve their school results. VR has shown a lot of potential for this in research where it could improve motivation (Sattar et al. 2019), stimulate the conceptualization process (Helsel, 1992) and help out with the mental visualization process (Curcio et al., 2016). But not all teachers are aware of these advantages that VR has for them, something which is very little researched in the literature. Here lie some

opportunities for further research. So if you want to raise the adoption rate of educational VR the teachers should be convinced of the added value that VR can offer to their teaching quality. Frosblom and Silius (2004) did mention that that background information, i.e. structure of the course, the roles of teachers, and planned learning methods, was needed when transferring one successful added value to another similar context.

The biggest added value of VR that teachers did see is the potential to help with the visualization process, mainly so that it could help students that are not strong visualizing certain concepts. When this aspect is seen from the perspective of the TPACK-model it shows how it fits into all of the different types of knowledge, where it increases the pedagogical aspect by giving the teacher a new tool for visualization, the technical aspect by being a new technology and the content aspect by giving an unique new experience on the information.

How well the ICT was handled at the schools could increase how much trouble teachers saw with the implementation of VR. Hu et al. (2003) also discussed how external help in the form of training or help with technical problems can increase the perceived ease of use. A similar conclusion was also made by Sandholtz (2004). She found that teachers were better off when they were focusing on the educating and not on technical issues and that when teachers received help with the technical problems that they were more likely to use technology in their lessons. She concluded with saying that whether the students learning opportunities are enhanced through classroom use of technology is the measure of success, not how quickly a teacher can repair a jammed floppy disk. So, this is in line with what the teachers said in this project, where more of them preferred help with technical problems over training to hone their technical skills.

But when a teacher had enough technical knowledge themselves it seemed like the help of the school was less of an issue. These teachers assumed that they only needed a bit of time with the VR equipment to learn how to use it. When comparing this with the literature, mainly with the TPACK framework of Koehler (2009), this was expected. There technical knowledge is indicated as one of predictors of the use of new technology in education and it can also have interactions with the perceived pedagogical value for the device.

Although help with ICT and technical knowledge were influencing the perceived ease-of-use a lot, the biggest barrier that was found was the high costs of VR. Previous research has discussed how the costs have been lowered from thousands to hundreds of euros, but for high schools hundreds of euros for one piece of equipment is still a high price. For example, Teach

VR offers the opportunity to buy a VR education kit for €11.150,- for 30 devices. These devices come with a controller, but this one gives only a small amount of interactivity with the environment. Teachers told during the interviews that they saw more added value for VR with high levels of interactivity, so this solution is too expensive or not interactive enough. The request of for high levels of interactivity from teachers is something which contradicts findings in the literature, where just being in a virtual environment was enough to add value. This was also the reason why low-cost cardboard solutions that are discussed by Brown and Green (2016) were not as interesting to the teachers.

It was discussed that the older generation of teachers would be unlikely to learn new things. Two explanations were given and both will be discussed. First the teachers said that the older teachers would not be able to handle the new technology. This stereotypical view of older generations is something that happens more when a new technology is presented. Redman and Snape (2002) used a survey under teachers to ask them of their opinions on teachers that were above the age of 50 compared to younger teachers. They noticed that the elderly were kept in high regard to their work effectiveness, but they were not seen as adaptable as the younger generations. This was not the case when the elderly teachers were asked about this themselves, they thought that they were just as adaptable as the younger teachers.

The second explanation that was given for why older teachers would be less likely to adopt VR was that they were unwilling to put in the time to learn something new. This is something which can be compared to a cost-benefit analysis (Layard, 1994). The older teachers have to invest time and effort in learning how to use VR in their lessons, but they will use this new technology for just a few years until they retire. Retirement was also mentioned as a reason why the older teachers would be unwilling to put in the time to learn how to use VR.

Directions for future research

Most of the teachers made it clear that VR is not completely ready for education, it is too expensive and what it can add to their lessons is not completely clear. So, what needs to happen before VR can be used? The first step lies with the developers of VR hardware, they should be more aware of the needs that educators have for a VR system, like low costs and high interactivity. The focus now lies either on a increasing the display quality of the device, trying to increase the frame rate and the resolution (Anthes et al., 2016) which would benefit the vividness of VR. This is considered important for gaming, where a big focus lies on how well it all looks visually, but this study shows that in education teachers would rather see an option that is more interactive and less expensive.

The added value of VR is also something that can be researched in future works. Teachers mentioned often that VR had to add something to their lessons, but they were not clear on what the added value should be. They did mention improvement for students' grades, increase in student motivation, and student engagement as potential added value of VR. There was no real specification on these values, something which might be looked into.

For the future someone has to be responsible for the development process of the material for educational VR. The teachers indicated that the developers of the teaching methods would be a good fit for this process. Since they are the ones that already deliver the course material, they can make sure that the VR material connects to this. But during this development the teachers want to be involved, they want to be able to tell what they think what is important for the system. As stated before, teachers have a unique point of view for VR in education, one that is not covered by the developers or researchers of VR(Anthes et al., 2016).

Teachers also mentioned that they wanted help with implementing VR into their lessons, but a few things about this help remains unclear. The teachers that indicated that they would need help with technical issues did not know enough about VR to specify which problems they would need help with. This can be researched by running a pilot with VR in education, where the obstacles that the teachers face during a VR lesson can be measured.

LIMITATIONS

This study has a number of limitations, the biggest one being the time we live in right now. The Covid-19 pandemic was happening during the time that this research was done and it had a big impact on education. First the schools were closed for four months last year, giving teacher the task to teach from a new unfamiliar situation. Related to this, the teachers had to learn how to use teleconferencing software to keep in touch with their students (Daniel 2020). At last the differences between the home situations of the students became much more of a factor in their learning during this crisis (De Witte & Maldonado, 2020). These were all huge obstacles for teachers and it required a lot of their time to fix this. This lowered the time they had for other things, like being interviewed for this research. This gave a lot of trouble during the participant gathering phase, were schools reacted that their teachers were too busy with other stuff to be interviewed. The pandemic also required that the interviews were done online due to safety regulations. The online aspect of the interview also made it impossible for some sort of demonstration of VR. This made it harder to explain what VR would be like for teachers that had no experience with it. One teacher noted that the vague image that she had of VR was hindering for giving answers.

At the start the participants that did react to the requests were enthusiastic and really interested in educational VR. They also recommended other teachers, which shared similar visions. To prevent a bias in the data the later searches for participants were explicitly looking for teachers that were not that familiar with VR. This resulted in more teachers in the age range from 30 to 60, but the 60+ range did not respond. Even while people in the age range 55-65 make up 23% of the teaching population(DUO, 2018). Since older teachers that were interviewed showed less interest in VR it can be expected that the teachers in the 60+ range have even less interest. This is also somewhat supported by what the teachers told about their older colleagues, where one said that they would not want to try it, but another said that they could easily learn it. So, this is something where more research is needed.

The interviews were held via the teleconferencing tool Microsoft Teams. In two of the cases this resulted in technical problems which either interrupted the interview or required that the interview was held via telephone. Because seeing each other during an interview is hugely important for non-verbal and social cues(Janghorban et al., 2014) a video connection was made with every interview so that the participant and interviewer could see each other. Although the communication is not as smooth as it is in face-to-face situations, mainly due to

internet latency, findings of Shapka et al. (2016) say that there would be no differences between the themes emerging with face-to-face or online interviews.

CONCLUSION

By interviewing teachers in high schools on their perspectives on VR this study gave rise to four interesting themes regarding the adoption of VR into education. These themes show a road that educational VR can walk in its future into becoming an educational tool. For this road it still needs to complete a few steps before it can be done. At first there are some developments that still need to happen to make sure that educational VR becomes a real educational tool and not just general VR applied to education. They need to keep in mind that teachers want interactive and easy-to-use VR equipment to work with. Secondly, cost reductions are necessary before it can be used in all the schools at the level that teachers want. They want VR to be available for all the students at the same time. And at last the teachers see that VR can bring some form of added value into their lessons. They see potential that VR has to help out with the mental visualization process and the interactive role that it offers students in their learning process.

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Appendix 1:

Interview guide

Goedendag, welkom bij dit interview over Virtual Reality in het onderwijs. Ik ben Teun Timmermans en als eerste wil ik u bedanken voor het meedoen met dit onderzoek. Ik doe onderzoek naar hoe docenten staan tegenover VR in het onderwijs. Veel onderzoek is al gedaan op de effecten dat het heeft op de leerlingen en hoe het in trainingen kan worden toegepast, maar de meningen van docenten over dit onderwerp ontbreken. Bij het eerdere technologieën bleek dat het belangrijk is om deze groep bij de ontwikkeling en implementatie te betrekken.

We gaan als het volgt aan de slag, eerst zal ik u wat vragen stellen over uw algemene ervaringen in het onderwijs gevolgd door vragen over de mogelijkheden die u voor VR in het onderwijs ziet. Het doel van dit interview is om uw mening te horen, dus u mag gewoon zeggen wat u denkt en hoe u zich er over voelt. Er zijn geen foute antwoorden of antwoorden die ik liever hoor. Als u liever geen antwoord wilt geven op een vraag dan mag u dat gewoon aangeven, u mag ten alle tijden stoppen met het interview.

Als u het goedvindt dan neem ik dit gesprek ook op. Het doel hiervan is zodat alle details van ons gesprek opgenomen worden, terwijl ik wel alle aandacht op dit gesprek kan vestigen. Ik beloof u dat alles wat in dit gesprek besproken zal worden confidentieel zal blijven en dat uw data geanomiseerd zal worden. Aan het einde van mijn onderzoek zal niemand kunnen achterhalen wat er precies door u is gezegd.

Voordat we beginnen wil ik u vragen of u het Informed Consent wilt doorlezen en of u het ook wilt ondertekenen.

Wat is uw achtergrond in het onderwijs?

Omschrijf uw vakgebied, welke vakken geeft u les?

Heeft u altijd in deze richting gezeten?

Wat is uw leeftijd?

Ervaring/hoe lang geeft u al les(op de huidige school)?

Welke klassen geeft u les?

Wat is de stijl waarop u les geeft? (actief/passief, samenwerken/alleen werken)

Hoeveel technologie gebruikt u in uw lessen?

Hoe vaak gebruiken leerlingen computers bij huiswerk/samenwerken/informatie opzoeken/aantekeningen te maken

Hoeveel gebruikt u het in vergelijking met standaard items?

Welke technologie gebruikt u vooral?(computers/tablets)

Wat vindt u van de rol van technologie als onderwijsmiddel?

Hoe gebruikt u de computer/smartboard/ educatieve spellen/communicatiemiddel/ toetsmiddel in de lessen?

Is het een goede toevoeging op wat er vroeger was of zijn er juist dingen die u mist?

Hoe heeft het uw manier van lesgeven verandert?

Wat zijn de moeilijkheden/mogelijkheden die het oplevert?

Hoe schat u uw technische vaardigheden in?

Hoe gebruikt u technologie die door uw collega's ook wordt gebruikt?

Hoe gebruikt u technologie die door de school wordt aanbevolen voor de les?

In vergelijking met de mensen om u heen hoe schat u uw technische vaardigheden in?

Heeft u mensen in uw omgeving die u kunnen helpen met technische moeilijkheden?

Hoeveel technologie gebruikt u in uw dagelijks leven?

Corona heeft een grote invloed gehad op het lesgeven afgelopen tijd, kijkt u hierdoor anders tegenover technologie in het onderwijs?

Hoe ging deze wissel naar het online leren voor u?

Wat waren de dingen die u vooral miste in de les?

Waren er dingen die u fijn vond om te hebben

Wat kunt u allemaal vertellen over VR?

Weet u voor wat voor doeleinden VR wordt ingezet?

Heeft u het zelf al ooit eens gebruikt(VR/ Virtual environments)(Voor uw vrije tijd)

Wat is uw houding ten opzichte van VR in het onderwijs?

Heeft u het al ooit eens gebruikt in deze context? Hoe was deze ervaring?

Heeft u het ooit ergens gezien?

Ziet u mogelijkheden ervoor in uw lessen? (als leermiddel/toetsmiddel/opdrachtenmiddel)

Hoe ziet u het voor zich als hulpmiddel?

Hebben alle leerlingen er dezelfde reactie op of zijn er leerlingen die er anders mee om zullen gaan?

Hoe ziet u VR in verhouding tot de technologie die op dit moment in het onderwijs aanwezig is?

Zou het bepaalde technologieën kunnen vervangen?

Op welke technologieën, die op dit moment in het onderwijs aanwezig zijn, sluit VR aan

Met welke technologieën zou VR frictie veroorzaken?

Denkt u dat uw VR geschikt is voor uw vakgebied?

Op welke onderwerpen zou u VR willen toepassen?

Is er behoefte aan VR excursies/tijdreizen/inzoomen op chemische reacties/ natuurlijke fenomenen/het lichaam doorreizen? Zijn er specifieke onderwerpen die zich hier goed voor lenen?

Hoe ziet u een les met VR voor, hoe denkt u dat les met VR zal zijn?

Denkt u dat VR juist buiten de les een plek zal hebben, bij bijvoorbeeld huiswerk?

Hoeveel VR zou u in de les willen gebruiken?

Zou VR van evenveel toepassing kunnen zijn op de verschillende niveaus(VMBO HAVO VWO)

Hoe zal VR u helpen om bepaalde aspecten beter te illustreren?

Hoe zou VR kunnen helpen bij abstracte aspecten van uw vakgebied?

Denkt u dat andere docenten binnen uw vakgebied VR ook goed zouden kunnen gebruiken?

Wat zijn volgens u de voordelen die VR u in de les zal bieden?

Zou het een verbetering voor de leerlingen zijn?

Denkt u dat VR een goed middel zal zijn om leerlingen te stimuleren?

Denkt u dat VR een goed middel is om leerlingen beter te laten leren?

Zou het makkelijker maken om informatie over te kunnen brengen?

Zou het uw werklast verlichten?

Welke aspecten van uw lesgeven zal het versterken?

Wat zijn volgens u de grootste obstakels om VR in de les te gebruiken?

En wat zou u tegenhouden als u wordt geholpen met de technische aspecten van VR?

Al zou dit obstakel er niet zijn, wat zou u dan tegenhouden?

Welk onderdeel van uw lessen zullen moeilijker worden door VR?

Hoe zou VR afbreuk kunnen doen aan uw manier van lesgeven?

Wordt het moeilijker om de klas onder controle te houden?

Hoe denkt u het overzicht te kunnen houden van de voortgang van alle leerlingen?

Denkt u dat u met VR leerlingen goed vaardigheden kunt bijbrengen?

Hoe denkt u dat VR zal bijdragen aan samenwerken/uitdrukken/creativiteit/reflectie/kritisch denken

Hoe brengt u nu deze soft skills bij aan de leerlingen

Hoe kan VR gebruikt om de lesstof beter af te stellen op de individuele leerling?

Hoe zou het uw manier van uitleggen veranderen?

Welke vaardigheden en middelen heeft u nodig om VR in het onderwijs te implementeren?

Heeft u een idee wat er allemaal nodig is om dit te kunnen doen?

Bied de school u mogelijkheden om hierin te verdiepen?

Welke andere partijen zouden u hiermee kunnen helpen?

Hoeveel instructie denkt u dat uw leerlingen nodig zullen hebben om VR te kunnen gebruiken?

Hoe goed pakken uw leerlingen soortgelijke technologieën op?

Hoeveel mensen

Zou u hierbij hulp willen hebben?

Ziet u mogelijkheden voor VR om u zelf te trainen?

Trainingen om een moeilijke klas les te geven

Reflecteren op uw eigen les door te kijken door de ogen van een leerling

Zou u zelf VR in de klas gebruiken?

Wat zijn de voorwaarden waaraan VR voor u zou moeten voldoen om het te kunnen gebruiken?

Wie gaat de VR ontwikkelen?

Hoe moet de VR eruit zien?

Heeft u nog andere opmerkingen die u graag kwijt wilt over VR in het onderwijs?

Dan wil ik hartelijk bedanken voor uw tijd en uw antwoorden. Als u wilt kan ik u nog op de hoogte houden van de uitkomst van mijn onderzoek en kan ik het uiteindelijke paper naar u opsturen.