Virtual Reality in the Classroom: An Exploration of Hardware, Management, Content and Pedagogy

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Abstract: In this study we sought to investigate how teachers implement virtual reality into the classroom. Participants were seven middle and high school teachers who were given virtual reality hardware to augment their teaching. Pre and post interviews were conducted and analyzed to understand how teachers implemented VR, technological hurdles they encountered and how they incorporated content. Results revealed how teachers overcame hardware challenges, managed their classrooms, the importance of scaffolding the learning, and interesting effects on classroom collaboration. A key finding was that more content is needed in order to make VR a truly useful mechanism for learning in the non-tech classrooms but content creation is a viable option for tech-based classes.

Introduction

When considering the implementation of new technology within a school setting, it is vital to remember that what sounds appealing in theory might look very different when applied in real classrooms. Schools face pressure to conform and respond to external demands from the communities in which they are stationed (Cuban, 1990), and the introduction of new technology to the classroom is often one of those pressures. Successful implementation of a new technology is grounded in the understanding that it enables, if not demands, new ways of thinking, especially from the teachers who implement it (Prensky, 2013). With the introduction of *virtual reality* (VR), an immersive digital experience affected by the actions of the user, on both commercial and educational levels, a new technology with new opportunities is more accessible. As Prensky noted, "It's important to understand that technology isn't just a 'new way to do old things." (2013) and with the emergence of VR into the educational scene, we wanted to investigate how these "new things" might look when placed into the classroom. Given the essential role of teachers in the education setting, it is important to examine the ways in which teachers implement a cutting edge technology, such as VR, so that we can better understand what this looks like in practice. By doing so, we aim to identify strengths and potential pitfalls that other teachers can reference when incorporating VR into their classrooms.

There is much variation in the types of research conducted on effective technology use in educational settings, so it can be difficult to distill what is effective and what is not (Ross, 2010). Despite the range of research, an overarching finding is that technology is more successful in enhancing learning when the environment and culture of the classroom is considered during implementation (Ross, 2010). Considering key learning objectives and how a variety of methodologies and technologies, in conjunction, may serve to augment or enhance student learning is vital (Clark, 1983). Virtual reality may be a technology that proves useful in terms of improving teachers' abilities to help students think differently about subject matter or to augment other subject areas (Winn, 1993; Psotka, 1995). VR could be a technology that is transformational in learning, such that it can provide innovative educational opportunities that encourage students to approach problems from alternative perspectives (Hughes, 2005). These benefits are contingent upon the technology's successful implementation into the classroom.

There can be many barriers in the successful implementation of a new technology. The lack of resources and technical skills, institutional barriers, and student as well as teacher attitudes and beliefs can be challenges to the successful integration of new technology in the classroom (Hew, 2006). Fostering enthusiasm in teachers, students, and administrators makes it more likely that technology is successfully integrated into the classroom (Bitner, 2002).

Instructors must make numerous choices, and given the novelty of VR, there has yet to be much research focused on the applied implementation into the classroom. It is intriguing to think that virtual reality could augment or transform learning. As educators, however, we wondered what that looks like in actual practice. We wanted to interview classroom teachers, who had visions for what VR could do in their educational environments, to see how they set-up, implemented and began to use VR to create learning experiences with their students. We explored the challenges of hardware, management, content and the role of the teacher in a virtual reality setting.

Methods

Participants

The study consisted of seven teacher participants from six schools across North America (see Table 1). Four participants primarily worked with middle school students in seventh or eighth grade, the other three instructed high school students. Participants' teaching experience ranged from 4-25 years. In-person or phone interviews were conducted with all participants, both pre-VR implementation and post-VR implementation. Due to variations in school schedules, the length of time between pre and post varied from one month to three months. We identify participants by state or province. VR technology was provided through our organization.

Equipment

Teachers were allowed to select their own hardware based on their assessment of learning objectives, interest areas and familiarity. At the time of this study, the two most accessible VR platforms were the Oculus Rift Developer Kit 2 (DK 2) and Google Cardboard. In addition, the HTC Vive had just begun its developer-only distribution and the Samsung GearVR was commercially available. HTC donated a Vive that we rotated through the North American mainland classrooms, 2-3 weeks at a time, throughout the year.

Teacher Interviews

Teacher interviews were conducted twice, shortly after the VR hardware was delivered to the teacher and around 6-8 weeks after delivery. Our goal was to complete the second set of interview questions after teachers began using VR so they were more familiar with it. Interview questions were open-ended and focused in four major areas: the technology itself, classroom management, content, and pedagogy (the method and practice of teaching and engaging with learners). Specifically, in the pre interview we asked about their technical backgrounds, self-efficacy, challenges, VR knowledge, classroom objectives, strategies, expectations, and management techniques. In the second round, teachers were also asked to reflect upon: implementation, their enjoyment and sense of efficacy with VR, challenges, maintaining their own knowledge, logistics, content and curriculum. Interviews were conducted either in person or over the phone.

Interviews were coded thematically. We identified trends in the responses that suggested ideas that might be relevant for other educators and researchers to consider. We focus here on four themes (i) challenges of working with the hardware, (ii) basic management ideas, (iii) content, and (iv) pedagogy.

Teacher	School Type	Subject	Class Size	Hardware
New Jersey	Middle	Technology; Game design	25	Oculus DK 2, one headset; Google Cardboard, one; HTC Vive
Washington	Middle	Social Studies	25	32 Google cardboards; HTC Vive
Washington	Middle	A.P. Computer Science; Exploratory Computer Science	28	Oculus DK 2, four headsets; Google Cardboards, two; HTC Vive
Hawaii	Middle	Advanced Design; Thinking	10	Oculus DK 2, Jump rig; Gear VR
Hawaii	Middle	Digital Media Design	10	Oculus DK 2, Jump rig; Gear VR
Ohio	High	Technology	7	Oculus DK2, one headset; Ricoh Theta camera; Google Cardboard, two; HTC Vive
Ontario	High	Technology integration with humanities teachers	30	Oculus DK 2, two headsets; Google Cardboard, two; HTC Vive

Table 1. Characteristics of the teachers, classes, and VR hardware

Results

Theme: Hardware

Teachers had limited prior experience with VR hardware. With several different commercial models of equipment available, teacher selection varied slightly. The most affordable option was Google Cardboard. Five of the seven teachers used it in class, although four of them used the Cardboard as a supplementary tool with limited scope. The middle school instructor from Seattle was the only one who used Cardboard as his primary hardware. This was a pedagogical decision based on his desire to allow all students to access content in a large group simultaneously using student smartphones. Out of the 99 students in his four classes, 87 had smartphones. However, only 77 students had phones with compatible operating systems. Although the ratio was fairly high (78%) there were still hardware issues. Overall access was improved, but additional logistical challenges were obviously apparent from the sheer number of phones to manage.

The remaining six teacher participants selected the Oculus Rift DK 2 partly due to its availability. Teachers also had the opportunity to work with the HTC Vive DK 1 for a couple of weeks. Due to the Vive's limited availability, only one headset was procured along with a mini-computer that was fast enough to support the processing. We rotated it through the mainland classrooms so that students could experience a more advanced VR technology.

Both the Oculus DK 2 and the Vive DK 1 have cords attaching them to the computer which teachers found a bit restrictive. Teachers were less concerned with the cords in the Oculus DK 2, because students did not need to walk around while engaged in simulations. Space limitations were much more of an issue with the Vive. It requires the placement of two LIDAR sensors that must be mounted in a stationary position and users must be able to walk within a minimum space of 9 x 12 feet for simulations. Teachers noted this logistical limitation was off-set by the higher caliber experience (e.g., higher resolution, faster refresh rate, use of hand controllers) of Vive simulations. Additionally, teachers from New Jersey, Hawaii and Toronto mentioned that the Samsung Gear VR provided them with a portable cordless headset that relied solely on a smartphone. The set-up was useful for toting around and ideal for sharing with others. A big drawback was the cost of the phone, heat and battery drain when used for extended periods of time.

Computer processing speed and graphics capabilities were a large issue for teachers. All teachers in the study experienced at least some difficulty obtaining computers capable of running the more advanced headsets. In three of the classrooms, teachers could only run the headsets off of more powerful computers, often the teacher computer. The school in Hawaii had multiple computers specially upgraded for this purpose as their focus was film and they required a great deal of memory in order to store the footage. In one classroom, the teacher computer still lacked the capacity to run the VR equipment, so we helped alleviate this barrier by donating a faster computer capable of running the VR equipment more seamlessly.

Logistically, teachers had to identify locations within their learning spaces that would be conducive to the setup of the hardware. In some rooms, the teachers had separate areas cordoned off in the back of the classroom; other teachers had a centralized space for set-up; in other cases, a desktop sufficed (often the teacher computer). This need for specific space was eliminated in the classroom that only used the Cardboard, although physical storage was a bit more cumbersome.

All seven teachers initially expected that this technology, regardless of hardware type, would be difficult to get functioning reliably. One teacher described their VR setup as “finicky.” All seven educators reported that a team effort, often involving students, was required to get it up and running again. In the tech specific classes, the ability to troubleshoot the hardware issues was essential for both the implementation and for the students’ own understanding of what it means to be a computer scientist. One teacher stated, “I tell students if you are going to be a computer scientist, you have to expect things not to work right the first time; if you are going to build new things that no one has done before or be cutting edge and create value; you have to expect things not to work the first time.”

Theme: Management

With the hardware in place, six of the teachers commented that establishing clear guidelines for use at the time of setup was imperative. The management of the gear was something that continued to evolve as the students interacted in more and different ways with the technology. For hardware that had controllers, guidelines had to be established for how to use, store, and retrieve them. Particularly with middle school students, setting a clear system for transitions into and out of hardware usage was pivotal to classroom management. At the middle school in Hawaii, students developed “Commandments” for hardware usage. In the high school in Seattle, students setup a routine for cleaning the lenses, retrieving the headsets and returning them to their locations. In Ohio and Seattle, the high school teachers established routines for when students could “test” content on the shared headset so that there wasn’t a line of students waiting.

Six of the classrooms did not have a one-to-one ratio of equipment to student, so structuring the experience so everyone felt like they had something meaningful to contribute was important. The various teachers addressed this limitation differently. Several teachers set up their equipment so the images in the headset were projected onto an external screen. The advantages of this set-up, according to those instructors, were: (i) all of the students could see the experience, (ii) if it was an intense simulation and some students wanted to just "check it out" without experiencing the immersion, they still could, and (iii) the entire group could discuss an experience at the same time and draw distinctions between watching and experiencing. Teachers in the study found the optimal small group size to be four students. They could take turns, observe one another and discuss without losing focus or interest in the simulation. This small group size worked even in classes with only one headset. Teachers would have VR be a station that groups could rotate through. If students weren't working with VR they were engaged with other material. Once students were used to the headsets, having them in use by some students in class was not overly distracting to the other students.

Teachers indicated that another important aspect was to manage students' expectations for what was possible with the technology. Demonstrating that existing virtual simulations can actually be quite basic helped students understand what might be achievable from the outset. It also helped to give individuals specific tasks. In Hawaii, one technique to keep all students engaged in the process involved dividing up the tasks associated with creating a 360degree video. Students took roles like camera setup, camera starter, clearing the area for the shoot, director, editor, etc. An added advantage of this method was that after students had a bit more experience, they became student-experts that could share skills and advice with others.

Theme: Content

Teachers pursued multiple avenues for having their students experience a variety of simulations and experiences with VR. For example, four of the seven teachers had their students produce their own VR content in addition to using pre-made simulations. Students explored themes in history, science, art and social issues. Having audio via headphones substantially enhanced students' immersion. All teachers noted that content selection took a significant amount of additional time. A chief complaint among the teachers was the lack of available content which posed challenges for true integration and extension of curriculum.

With regard to content creation, two instructors found that simple modifications of existing content in *Unity* was a good way to start. Other teachers dove into actual programming versus starting with asset modification. The middle school teacher in N.J. gave his students 20% free-time and several students decided to use *Sketch-Up* drawings they had made as the foundation for 3D experiences in *Unity*. A critical element in content creation was setting manageable goals. All of the teachers felt they had to figure out how to scaffold instruction to maintain student focus. If it took students multiple days to create an asset in *Unity* or to upload a film clip students felt frustrated or lost interest in the process. As expected, all of the teachers discussed the challenges of trying to figure out the scaffolding and pacing. They tended to find that focusing on a concrete output at the end of each day was helpful for students in terms of overall focus and progress. One instructor noted, "My scaffolding was a little off; we did the playing and learning but it was important to have students start to modify existing content in *Unity*. The creating was 7 or 8 school days to get something for them to try; I needed to take smaller steps, we bit off more than we could chew." Another, made a similar observation, "I'm hesitant with my students, throwing them into new software; sometimes it takes too long and we don't get much done in 45 min. It was important that we can get the stuff rendered; they get to see things the next day."

Theme: Pedagogy

VR led to an interesting dynamic where teachers and students learned alongside each other and functioned very collaboratively on all fronts in terms of hardware, software and curriculum. Since the teachers were not "VR experts," they found themselves on a closer technical level to their students. Although each of the teachers referenced spending ample time outside of class figuring out how to use the technology themselves, they openly acknowledged their own limitations and the steep learning curves. Students were very eager to engage in the mastery of using VR. One teacher remarked, "They've really got a different level of maturity; they don't just ask me first; they try to find the answer on their own first. They are collaborating really well. They identify student experts, creating little collaborative communities. They want to see that they made it, they want that ownership."

Research on incorporating video games with student learning has shown that simply inserting a game into curriculum without a clear connection to the material is ineffective; the teacher must scaffold and take the time to debrief and discuss (Robertson & Howells, 2008). We felt that work with VR would likely be analogous, and it was. That being said, teachers felt it was important to have an initial period of open-exploration. This time to "play" in virtual reality was noted by four of the teachers as a useful way to help students build familiarity with the basic controls and acclimate to the headsets while exploring a wide range of content freely, without explicit direction. One teacher, when asked to give advice to other educators, said "Play, play, play...four or five days with structured play while going over how to critique a simulation by using measurable criteria shows the students some simple experiences that are incredibly fun." The exploration period ultimately served as a useful transition to design thinking in the more computer science based classes. In three high school classrooms, the teachers and students tried simulations so that they could discuss and constructively criticize the experiences. They reflected and debriefed on what they would change, the impact the experiences had on users and what they liked/disliked in the design.

The lessons students learned encompassed much more than just working with virtual reality. Aside from the obvious knowledge needed to program in *Unity*, some students explored visual programming in *Unreal 4* or modeling and art through *Blendr,* and those who worked in film used *Kolor* and *After Effects.* Students effectively used all of the software although *After Effects* proved to be a bit complex for middle schoolers. Teachers also referenced skill development in collaboration and teamwork, participatory design, work habits, persistence, maturity, artistic design, project management and iterative design. It seemed that being pioneers working with VR technology lent a perception that the work students were completing had a higher level of legitimacy and credibility.

All seven educators noted the lack of existing resources for the tech they were using. Google wasn't always helpful. Students had to try to find their own solutions. Some reached out to professionals online and in-person and took pride in knowing they figured things out that others, even professionals, may not yet have solved. In the humanities classrooms, it was disruptive when the content did not work as planned because VR was augmenting the main curriculum. Two of the schools worked to create VR tutorials and videos to share their newfound knowledge. This was not only content creation, it was also knowledge creation, teaching others how to overcome some of the challenges. A teacher commented, "At least once every day I am telling them, 'Just a reminder. I am a colleague of yours. There are no tutorials out there. We could wait six months or we could piece it together as we go along."

Although VR is very much an individual experience in the present format, interesting types of collaboration emerged that are worth considering further. Students became experts within a wide-range of VR related specialties because the teachers allowed them to focus on areas of specific interest. In fact, five teachers specifically referenced the emergence of student in-class experts. In addition, all teachers in the study found experts in their communities or online to assist them with technological challenges. Several used sites like Reddit, user forums, and others found people on YouTube (e.g., Jimmy Vegas) to use as reference points. Lack of technical support, in general, was an issue.

Although the vast majority of students wanted to actively engage with VR not all were eager to do so. In every class, there were students who wanted to watch from the sidelines and not be immersed. Motion sickness was not a huge issue for any of the students. Occasionally, VR content contained stronger emotional content and teachers made sure to discuss before and debrief afterwards. Students in all classrooms were given the option to opt out of VR content which we believe is essential.

Discussion

Teachers play a pivotal role in the implementation of new technologies. The teachers in this study selfidentified as 'tech-experts' within their schools and were called upon to share and teach VR to their peers. Teachers informally engaged in the practice identified by Frank (2004) of designating time for professional development among their peers to interact and share expertise. This occurred both across schools (a middle school and high school in the same district) as well as within schools (a technology teacher assisting non-technology teachers in the incorporation of VR). This type of diffusion was identified by Frank and colleagues (2004) as a key mechanism for encouraging interactions across departments. This led to a stronger sense of leadership for these teachers.

Teacher leadership is considered one of the most fundamental components of effective school reform (Crowther, 2009), and technology is often the focus of reform efforts. By empowering interested teachers with technology and gathering feedback we can document and share useful pedagogical approaches. In this study, teachers were able to make hardware decisions and we found decisions were strongly driven by course objectives. Teachers carefully considered how hardware could help them reach pedagogical goals. Although we provided some technology for all the teachers, it was interesting to see how the teachers were able to leverage this initial technology to help get additional donations, discounts or pre-market hardware for educational use.

Teachers in this study felt that VR lent itself to democratic classrooms and partnered with students to learn and navigate the new tech together. Technical challenges were expected and were ever-present. Teachers in the study found that technology challenges could be used as teachable moments and that students were enthusiastic about figuring out solutions. This was less true of the humanities classrooms where the technical issues often sidelined VR experiences. As commercial VR becomes more prevalent, we are hopeful that these challenges are resolved.

Even though VR is an “individual” experience, a high level of community between teachers and students emerged in each classroom as they collaborated together, in groups, to create and interact with content. Shared experiences through VR appeared to strengthen the relationship between students and their teachers. The majority of the teachers mentioned how their peers and other students would see what was going on and ask to participate and learn more about VR thus engaging additional community members.

A challenge faced by teachers was the significant amount of time required to prep the VR experiences. Although these teachers were all enthusiastic about the time spent to learn the hardware and find content, it was still far above and beyond what their normal curriculum would demand. Obtaining solutions to challenges encountered when attempting to run simulations on certain equipment or issues like hardware becoming outdated also required time and energy to resolve.

We wanted to see what happened when we put virtual reality hardware, of a teacher’s choice, into a classroom setting. One challenge the teachers in the present study all had was how to assess whether or not students had “learned” the content. In some cases, such as in a programming class, assessment largely consisted of whether or not specific assets or actions were introduced into the simulation. The middle school that focused on film did peer critique sessions. In the humanities classrooms, there was no specific assessment tied to the VR content consumption. An area for further research to consider is how to assess student learning in immersive environments. The use of simulations in learning environments enable students to both apply knowledge they have acquired and to experiment in a safe environment as they explore different outcomes and experiences (Pivec & Kearney, 2007). The potential for learning is there, the questions stem around how to make it work in practice within a real classroom setting.

In addition, finding how to change the ways we conceptualize curriculum and learning through the contributions of VR will be important. Both students and teachers in the present study made it clear that they do not want VR to be “the same old way of teaching and learning.” The teachers were extremely optimistic in stating that instruction with VR might be an entirely new way to teach and learn. It is our hope, that this initial work can begin the conversation about virtual reality in applied classroom settings.

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