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Utilization of Virtual Reality for General Education Purposes

Amit Lal
University of the Pacific

UTILIZATION OF VIRTUAL REALITY FOR GENERAL EDUCATION PURPOSES

By

Amit Lal

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Amit Lal

APPROVED BY:

Dissertation Advisor: Robert Calvert, Ph.D.

Committee Member: Delores McNair, Ed.D.

Committee Member: Ka L. Ramirez, PSY.D., L.M.F.T.

Dean of Benerd College: Patricia Campbell, Ph.D.

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Dedication

This dissertation in its entirety is dedicated to my service animal, Pluto. Without Pluto, none of this would have been possible.

Acknowledgments

My deepest gratitude goes to the late Jerry Post, Ph.D.

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Abstract

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The use of Virtual Reality (VR) in a variety of professional, military, governmental, and educational fields has continued to expand over the past several decades, and the recent Covid-19 pandemic has brought attention to this field. This study surveys 154 college students over 23 questions that include various demographics that can be used to look for discriminators, multiple-choice VR-related questions, as well as a few free-form questions about use of VR in learning environments. The students' experience with, interest in, and thoughts on how to best use VR vary considerably. The Covid-19 pandemic is found to have limited impact thus far in terms of VR use, but the interest in using VR in schools since then has generally increased quite a bit. Commitment to invest in VR were it to be expanded and provide continual feedback varies quite a bit as well but is strong. A statistical χ^2 analysis shows that, at a high confidence level, males generally are more experienced with VR in general, have a greater interest in seeing VR implemented further, and are more committed to radical changes in educational methodology than females are. In addition, it is found that Hispanics/Latinos, Black / African Americans, Pacific Islanders, and those of mixed race are more inclined to provide continual feedback as regards the implementation of VR in the school curriculum than (non-Hispanic) White and Asian people are.

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List of Abbreviations

AI	Artificial Intelligence
df	Degrees of Freedom
HMD	Head-Mounted Display
LA	Learning Analytics
LMS	Learning Management System
MC	Multiple-choice
OE	Open-ended
p	Statistical Confidence Level Index
RQ	Research Question
TF	Theoretical Framework
VR	Virtual Reality
2D/3D	Two-Dimensional/Three-Dimensional

List of Symbols

χ^2	Chi-square

CHAPTER 1: INTRODUCTION

Over the past several millennia, humans have passed down knowledge from one generation to another. The exact means thereof have varied, from stories told and retold to later more permanent storage of knowledge by way of anything from cave paintings to retold legends and actual books being written and disseminated. This passage of knowledge has required not just dedication from those possessing it, but also those interested in and dedicated to absorbing it and subsequently passing it on with their own flavor/learnings added in. This sounds simple, but as technology progresses ever so fast, complications amass. Not only do teachers need to be educated in new means of delivering knowledge, but they must be finely attuned to the efficacy of both individual and collective perceptions of students who are often overwhelmed with just traditional means of learning (Luckman & Krajnc, 2012; Velev & Zlateva, 2017). In short, successfully introducing a new technology into the learning process and classroom is a non-trivial effort with significant hurdles to overcome. This includes understanding, acceptance, distribution, and regular utilization of a new teaching method, as well as carefully gaging its impact and making adjustments accordingly. Immersive virtual learning, and in particular virtual reality and virtual world concepts, which are often not even always well-defined, have come a long way, but still face broad utilization and acceptance in the field of education. This research proposal seeks to find a deeper understanding of why this is so and propose ways to combat time-honored perceptions and culture to suggest how VR can help students learn more effectively within allocated school budgets within and outside of traditional school settings. In addition, care must be taken to closely monitor any such programs to ensure that ethical boundaries are respected, that use of new technology does not serve to divide people of different

socio-economic background, and in some cases also to put control measures in to try to ensure that no harm comes to students from being exposed to more realistic and immersive environments. The hurdles are significant, but the potential rewards certainly justify more thorough studies in this field.

An early adopter and developer of virtual reality simulations has been the military force, and soon thereafter, the civil aerospace industry, mainly to train pilots for high-risk, high-cost missions. Another example is the medical field, training surgeons and other medical professionals in complex procedures that could lead to maiming and worse if not cautiously practiced and based only on theory and/or cadaver procedures (Barnard, 2019; Folio, 1997). Yet another early VR adopter example is the videogame/entertainment industry, allowing individuals to 'experience' realistic (and unrealistic) situations, providing captivating and exciting situations that are either highly realistic or would be quite unlikely in the real world (Barko & Sadler, 2013; Johnson & Levine, 2008; Padmanabhan, 2008). The use of immersive virtual reality and virtual worlds for less 'mission-critical' education has, understandably, received a bit less attention over the years, and forms the basis upon which this research proposal is based. The guiding principle in this study is to identify areas where important learning can safely and cost-effectively be achieved with the use of VR.

Background

Virtual Reality technology can be traced back to Sir C. Wheatstone, who first described stereopsis in 1838, for which he was awarded the Royal Society Medal 2 years later. His research showed that when showed two photographs taken from different points, the brain combines the two images, and the person thus experiences a sense of three-dimensional (3D) depth and immersion (Barnard, 2019). Almost a full century later, in 1935, S. Weinbaum

released a science fiction short story named Pygmalion's Spectacles in which the main protagonist is outfitted with a pair of goggles that transport him to a fictional world that include holographic and haptic feedback. A couple of decades later, the first actual VR 'machine' in the form of a large booth was created and patented by Sensorama cinematographer M. Heilig (Barnard, 2019). This allowed a person to experience a stereoscopic 3D screen while sitting in a vibrating chair surrounded by stereo speakers and even scent producers. In all, six short films were produced for interested audiences that could view these one at a time.

The first head-mounted display (HMD), at the time named the "Telesphere Mask" was patented in 1960 by M. Heilig, which provided stereoscopic 3D images in a wide vision format with sound, but without any motion tracking. That was developed the following year, 1961, by two Philco Co. engineers, with individual video screens for each eye and a head-tracking system (Barnard, 2019). This HMD (dubbed "Headsight") was developed not for VR applications per se, but for the military to allow for remote views of hazardous situations. This helped pave the way for the first Air Force flight simulator in 1966, and with the substantial military funding, VR technology was fundamentally improved. In 1972, General Electric extended the HMD approach to flight simulators by installing three screens in a mock cockpit, allowing for more realistic pilot training with a 180-degree field of vision (Rohani & Puthusserypady, 2015).

Over the next several decades, as computers were rapidly becoming faster and smaller, and significant progress was made in picture projection and mechanical engineering related to VR, a number of ever-improving applications started emerging for use in primarily flight simulators and in the game and entertainment industry, with added components like more compact VR goggles, haptic feedback gloves, and real-time computer-generated graphics based

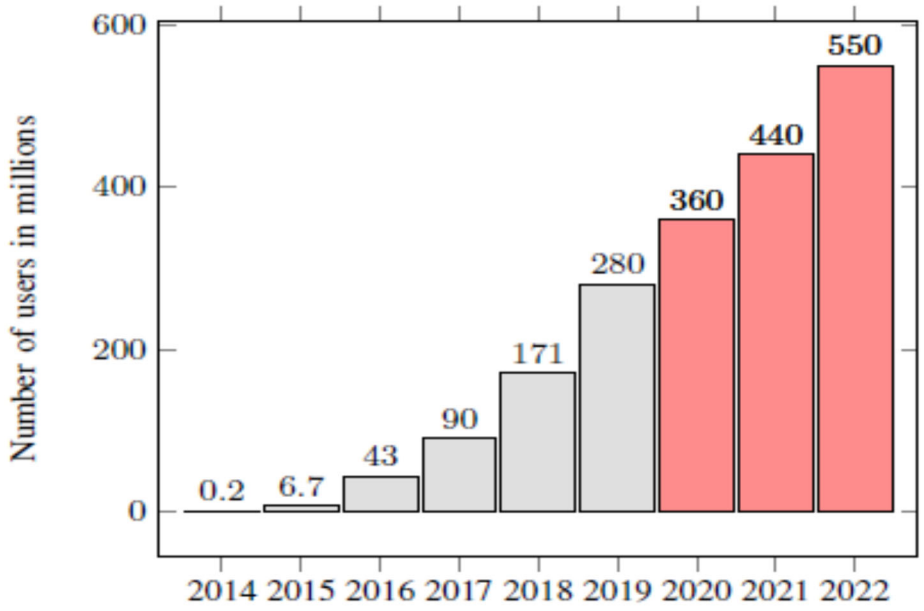
on the user's input. By the end of 2020, several millions of VR sets with much-increased capabilities had been sold, primarily to video gamers.

Definitions of what exactly constitutes VR vary, but always consist of a hardware and software combination, and many people even view Zoom® and Skype® multi-person media as a form of virtual reality. As the 2019 Covid-19 pandemic became a reality and is still ongoing at the time of this writing, an unprecedented resurgence in the interest and development of VR technology has been seen, with an estimated market of about $62B by 2027 (Jochum, 2020). The main focus of this proposal is the use of VR for educational purposes. As described previously, VR allows users to experience immersive, three dimensional visual and audio simulations. According to Pinho (2004), virtual reality is characterized by immersion in the 3D world, interaction with virtual objects, and involvement in exploring the virtual environment. The feasibility of the virtual reality in education has been debated due to several obstacles such as affordability of VR software and hardware. The psychological effects of virtual reality are also a negative consideration. For example, research has shown that participants who play video games in VR can experience stronger negative emotions afterward compared to those who play it in 2D (Lavoie et al., 2020). A study by Lavoie and colleagues found that VR enhanced the level of absorption into the scenario, mediating an increase in the shame users felt about their actions during gameplay, and that the enhanced negative emotions resulting from the use of VR had a positive correlation with negative rumination, a maladaptive form of self-reflection characterized by repetitive and passive thought patterns focusing on the symptoms and causes related to the distressing event. However, recent technological progress has made VR more viable and promises new learning models and styles for students. These facets of virtual reality have found applications within the primary education (K-8th grade) sphere in enhancing student learning,

increasing engagement, and creating new opportunities for addressing learning preferences. Many students today already have significant experience with VR through gaming primarily, and so transitioning from using VR in gaming only to education is likely to be much smoother than otherwise. It is important to realize, however, that many teachers do not have a similar history of VR use, and that considerable effort must be put on remedying that before rolling out a broader use of VR for learning purposes. Figure 1 illustrates the increase in virtual reality users since 2014.

Figure 1

The Number of VR Users in Millions Since 2014



Note. From *Virtual Reality and Education: Survey*, by B. Kenwright, 2020, Communication Article, p. 2.

Statement of the Problem

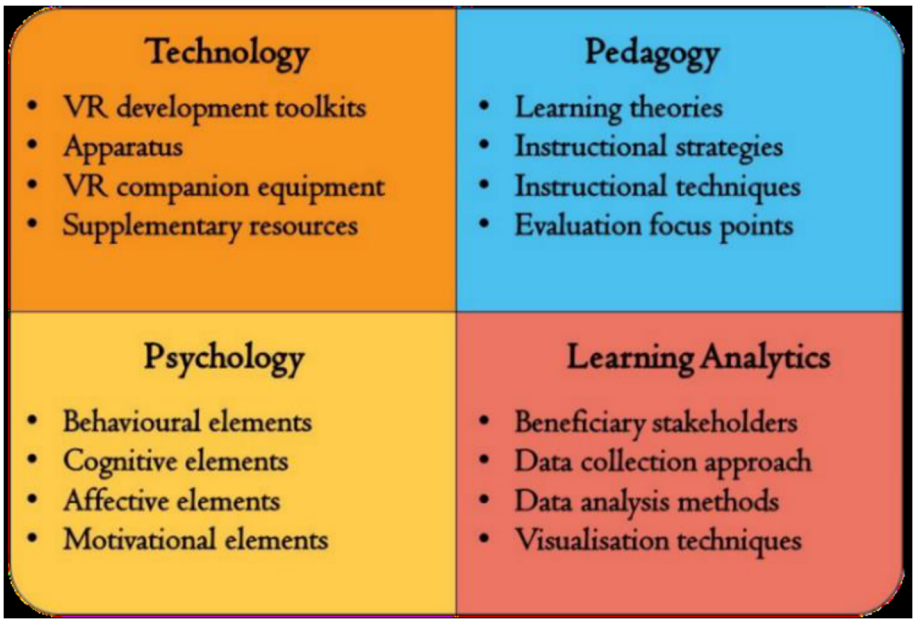
The advancement of VR technology, such as miniaturization, better resolution, smaller price-tags, more comfortable to use, etc., should make it increasingly easier to introduce it to a considerably broader extent in education. With the current COVID-19 pandemic that has raged on for over 1.5 years now and forced a massive shift to virtual learning from home rather than in the classrooms across many schools and universities across the country and globally, the urgency to improve on virtual reality is higher than ever before. Even if this particular pandemic eases up some time in the reasonable future, there is nothing to say that we will not experience similar pandemics in the future, especially as traveling is made more affordable to a broader clientele continually. The main obstacles to introducing VR as a mainstay technology in classrooms appears to be the associated cost of equipment and software required for that purpose, the training of both teachers and students in how to use VR effectively, and a necessity for good planning and oversight to ensure minimal misuse or negative consequences from too much VR exposure.

Theoretical Framework

To enhance student learning using VR, a theoretically sound framework must be employed in an engaging manner to teach the curriculum to the students. A number of theoretical frameworks that involve VR-assisted learning have been proposed over the years. For this study, it is proposed to adapt a recent one developed by Christopoulos and colleagues (Christopoulos et al., 2020), as it is specifically developed as a learning analytics framework to assist with instructional applications using VR. Within this theoretical framework (TF; see Figure 2), VR assisted learning is defined as a computer-supported environment that helps enhance standard learning by providing additional visual, audio, and motion stimuli.

Figure 2

4D Learning Analytics Framework



Note. From *A Learning Analytics Theoretical Framework for Virtual Reality Instructional Applications*, by A. Christopoulos, N. Pellas, & M.-J. Laakso, 2020, Preprint, (10.20944/preprints202010.0176.v1), p. 6.

This theoretical framework is considered particularly well-suited for this proposed study because it addresses some fundamental issues with previously proposed frameworks:

1. Learning Analytics (LA) models are applied principally to data stemming from the Learning Management System (LMS) without supplementary or alternative tools.

2. Data collection sources rely on information from technological or pedagogical perspectives, yet tend to at least to some degree disregard psychological aspects.

3. Prior studies often look for correlations between dependent variables (such as grades, demographics, etc.) vs. non-classified parameters, thereby undermining effective use of LA by preventing collection/sharing of large datasets.

4. In comparing previously published suggestions for TFs, there appears to be a lack of a universally accepted comprehensive framework regarding to the type of data that needs to be collected and interpreted so as to lead to improvements.

Using the TF proposed by Christopoulos et al. (see Figure 2) remedies many if not all of these gaps by using LA models for processing and correlating collected data related to technological, pedagogical, and psychological aspects that affect the learning process with the aid of VR.

For clarification, there are always some key variables in undertaking any scientific study. The most important distinction is between independent and dependent variables. As always, it is important to be very specific about defining the relevant variables for a study and map out how these may relate to each other. In this case, that could be taken to mean the amount or type of use of VR vs. resulting grades, credits, or exam scores. The control variables typically have an independent impact on direct variables, whereas mediators and moderators are variables of interest in the study. For example, a moderator variable (not affected by the independent variable) can easily influence the dependent variable (in this case, e.g., the IQ, interest, or savviness using VR for learning purposes), as can a mediator variable which is affected by the independent variable (in this case, e.g., the amount of time put into learning how to use VR technology), and then other factors, such as state of health, home situation (distractions), etc.

Purpose of the Study

The purpose of this study is to examine how virtual reality tools can be better used to augment and assist student learning, by way of extensive surveys, proper data processing, analyses, and fact-based conclusions. The perceptions, grades, and futures of students are too important to experiment with haphazardly, and thus at the very heart of this research proposal is a thorough analysis based on data collected from a diversely and fairly represented body of students, so as to suggest pilot and hopefully larger studies that involve a greater use of VR in general education.

Research Questions

The overarching questions can be condensed to three main questions, although the actual survey consists of 26 questions comprised of nine demographic-related questions, 12 multiple-choice questions, and five free-form questions that were sent out to 154 students, with the results analyzed, illustrated, and with a conclusion based on that.

1. What do students in general education feel the main barriers and worries about VR adaptation is in terms of improving learning effectiveness?
2. What realistic suggestions do they have to improve on that?
3. Would students be open to commit to some radical changes in educational methodology, and provide regular feedback to aid improvements?
4. Does experience with VR in gaming environments influence perceptions about the use of VR in educational settings?

Significance of the Study

The efficacy of teaching students to absorb not just new material, but process it rapidly, draw conclusions, contemplate and suggest changes, and apply these learnings in real life is a principal goal of any learning institution. The key question here is whether virtual reality learning, remotely and in-class, can help accelerate and improve on traditional methods. Perhaps never before has this question been as pertinent and urgent to address as it is now, when hundreds of millions of children are forced to do virtual schooling due to an (in modern time) unprecedented pandemic, which nobody can assure will not repeat itself in perhaps an even more devastating form. So, whatever conclusions can be drawn from this study, if done well enough, statistically significant, and well-explained, should be significant to any and all learning institutions world-wide, even if the targeted audience in this limited study is the US population.

Summary

A number of uses have been developed for the use of VR in the military, medical, gaming, entertainment, cinematography, etc., and spurred on not least by the global Covid-19 pandemic, and an increasing number of researchers at various institutions are looking for ways to deploy and effectively use VR in an educational environment for students. This study proposes a way to further this inquiry and suggests ways to help improve the deployment of VR tools and analyses in everyday general education.

CHAPTER 2: REVIEW OF THE LITERATURE

Virtual and augmented reality represent an emerging and advanced technology suite that has significant potential to create real value-add in several fields beyond its already demonstrated realms, not the least education. At one level, VR-related innovations create new options for gaming and entertainment. At another, they also benefit a range of industries by creating options for learning, training, and user engagement. One emerging area impacted by the technology includes education, as emerging VR platforms prospectively create new learning opportunities for students and innovative pedagogical approaches and strategies for educators (Harmon, 2011; Neulight et al., 2007). A review of current educational research related to virtual reality includes assessments of the technology's current and future value in classroom settings. At the same time, other analyses emphasize the challenges and constraints that potentially limit the technology's likely benefits. As educators and school administrators assess VR's likely value and balance its potential benefits against its potential drawbacks, they implicitly address many questions that remain unsettled (Gregory et al., 2015). First, it is imperative to outline the specific uses that the technology can serve in the classroom and the functions that it can provide. As VR technology advances, it creates an increasing number of specific applications that can be used to achieve a diverse set of educational-related outcomes. Second, VR's ability to generate diverse educational benefits requires planners to determine the specific strategies that they will use in promoting specific types of learning (Hanson & Shelton, 2008). While immersive and experiential technologies often create unique learning opportunities, these outcomes frequently need to be connected to broader pedagogical strategies that frame the learners' experiences in a broader context. Both of these broader questions relate to the issue of VR's likely effectiveness

in the context of language learning. While the technology's role in improving language learning represents an emerging area of study, it also tends to be underexamined.

The purpose of this analysis is to address these gaps by applying current assessments of VR's current and prospective educational value to a specific examination of its likely benefit to language teachers and students. This literature review examines analyses that are directly and indirectly related to this theme. The sources examined provide an in-depth discussion of the issues that frame these discussions and those that are specifically related to VR's application in language learning environments. The literature review examines the themes generated by the reviewed sources, identifies the macro-level issues deriving from their aggregate assessments, and links these findings to a synthesis that examines the themes' relevance to language learning and teaching.

Overview of Sources

In examining the issues directly and indirectly related to the challenges of virtual reality's prospective value in the language learning classroom, the researcher examined a diverse set of sources. This research specifically entailed an analysis of 51 specific works, the majority of which derived from academic and professional field journals. Since the concepts related to virtual reality's application as a teaching and learning tool tend to be complex and multidimensional, the sources examined diverse aspects related to these concerns. Their emerging themes can be subdivided accordingly.

- Descriptions and definitions of VR-related technologies and concepts
- Guiding theoretical concepts and assumption
- Prospective educational benefits and applications
- Likely barriers to the technology's implementation or to the generation of its prospective benefits.

Individually and collectively, these themes promote a holistic view of VR's current and emerging pedagogical value. The definition of its related technologies and concepts provides a foundational level of knowledge that is essential to any discussion of its varied applications. An assessment of its guiding theoretical concepts and assumptions identifies how these views impact the innovation's use within varied classroom settings. Finally, comparative analyses of VR's prospective benefits and challenges promote an in-depth and multidimensional discussion of the considerations that affect administrators and teachers as they make decisions regarding the technology's application in specific educational contexts. Both assessments are equally critical as decision-makers typically need to balance VR's purported strengths against considerations of its likely limitations and drawbacks. Collectively, the themes deriving from these analyses can contribute to both scholarship and to field-based discussions of pedagogic strategy and learning assessment. The findings can be similarly applied to language teaching and learning scenarios.

Theme One: Definitions of Virtual Reality and Education-Based Applications

Analyses of education-based virtual reality applications require a foundational understanding of the technology and systems employed within these scenarios. Scholarship related to the issue frequently indicates that this information is critical from a practical perspective and equally important from a pedagogical and classroom management standpoint (Wiśniewska-Paź, 2018). Fernandez (2017) noted that teacher knowledge and awareness of virtual reality at the operational and educational level represents a critical factor that can affect the quality of specific applications. The same author noted that these levels of knowledge tend to be layered and mutually impactful. Instructors need to possess a foundational knowledge of the technology and basic and advanced-level functions, in brief, before they can understand the ways in which specific applications benefit various dimensions of student learning. For these

reasons, a basic review of foundational concepts can often enhance more complex discussions of the technology's applications.

One of the broader trends associated with the literature related to virtual reality from a technological standpoint includes its longer-term existence as a potential instructional methodology. As Noureddine (2019) observed, VR as a base-level concept has a history that dates back to 1968. At the same time, its application has required the invention of supporting technologies that can implement and improve its ability to immerse a user into a visualized and projected world. These observations are important from a concept definition standpoint as they inform and contextualize the work of theorists that define the technology, distinguish it from related applications, and prospectively identify its value in the context of education. Helsel's (1992) analysis represents early work that defined VR based on its hardware and software dimensions and that identified its prospective value in an educational context. The author noted that the feature that distinguishes VR from other simulated media and technology includes its headset and its ability to imaginatively transport the user into an alternative reality. Helsel (1992) linked these technological capabilities to the themes of immersion and focus from a cognitive learning standpoint. In brief, the technology's physical and logical dimensions create a set of conditions in which a user can be temporarily removed at the experiential level from his/her physical surroundings and transported into a virtual realm that enhances the same user's sensory and cognitive processes. Educational-based applications include the use of this level of immersion to promote new forms of learning and assessment. VR programs, in brief, can virtually present abstract concepts and conditions and contribute to the user's understanding of specific topics.

Psotka's (1995) analysis elaborated on these same observations and additionally identified how VR applications can enhance training and educational modules. Like Helsel (1992), Psotka (1995) identified user immersion into a virtualized setting as an intrinsic feature that defines his/her experience and that promotes specific types of learning. The latter author similarly contended that the heightened forms of experiences generated through VR application tend to improve a learner's cognitive functions and memories when performing specific key tasks. Virtualized instructional models, in brief, are likely to appeal to a learner's imagination, enhance their experiences when engaging in the lessons, and to improve their memory and recall during exams or graded simulated activities. Notably, both Helsel (1992) and Psotka (1995) identified technological limitations and instructor knowledge of VR technologies as potential mediating factors that can negatively impact an application's educational value.

Rohani and Puthusserypady (2015) provide a more recent description of an applied VR model that addresses the learning needs of students with attention deficit-related problems, and indicate how older discussions of the technology remain pertinent even as their assessments of its educational value provide valuable insights. In their analysis, they provided a description of the application's hardware and software dimensions and explored how its applications address learning needs among a specific population (Rohani & Puthusserypady, 2015). Their work specifically identified how VR's technical features can be used to create immersive environments that help users impacted by attention deficit disorders to cultivate skills in the area of focusing on select objects and ignoring the distractions occurring in the virtual environment. The authors similarly noted that the technology is uniquely capable of redirecting student attention away from distractions and utilizing visual and sensory-based content to improve their concentration. While their discussion relates to a specific VR application, it additionally

summarizes the technology's related components and illustrates its potential for improving learning across varied educational contexts.

Theme Two: Guiding Theoretical Concepts

Understanding the value of VR applications in an educational context requires an assessment of the theoretical concepts that underline its role in delivering unique educational experiences to users. Studies that assess these guiding concepts can be subdivided into two categories. This includes the studies that examine the impact that virtualized environments have upon learners as they are immersed in these settings, and the analyses that discuss the technology's impact from a theoretical perspective. Both works contribute to an emerging model that emphasizes the connection between virtual reality core technologies, guided educational applications, and the combined engagement of learners and teachers in these unique contexts.

Discussions of virtual reality's role in educational settings often begin with a foundational discussion of how users engage with and operate in the mediated environments generated through the models' technology. In their discussions of mediation in democratic societies, Swartz and Hatcher (1996) noted that individuals often participate in complex social, experiential, and linguistic arrangements that connect themselves to their external world. A speaker's role in these environments tends to be affected by the dimensions of societal expectation and an individual's overt and implicit compliance with them. The authors noted that VR applications create constructed scenarios that reify aspects of these same processes. While individuals engaged in real-world settings are likely to be less cognizant of how external social variables influence their behavior and aspects of self-presentation, the digitalized worlds created through VR applications provide a unique environment that requires a user to focus on their presence within the setting and their patterns of engagement with their imagined surroundings.

Other scholars expand on these same concepts. Blascovich and Beall (2010) argued that virtualized settings create unusual conceptual spaces that enable users to focus on the interrelated variables of self-presentation, engagement with the constructed environment, learner engagement with simulated activities, and the outcomes generated through the learner's input. Harmon (2011) identified these same variables as elements that allow for unusual forms of transformative learning that heighten a user's ability to engage in a constructed space through his/her reliance on a self-constructed identity. Other scholarship, however, indicates that the user's experience within the virtual setting can be contingent on certain predetermining personal factors. The analysis provided by Padmanabhan (2008) indicated that such human factor variables as an individual's familiarity with VR technology and comfort level in using the technology can impact their broader experience and effect a guided program's outcomes. Barko and Sadler (2013) similarly observed that users tend to construct their own meaning when using varied simulation technology in educational settings. Both analyses, in brief, suggest that a student's guided experience in using VR educational programs may require preceding structural inputs that orient the learner in the application's broader use. Garland et al. (2012) noted that an absence of preparatory coaching tends to negatively affect student performance when relying on trial-based VR applications in clinical training contexts.

Other theory-based analyses examine the connection between the simulated worlds generated through VR applications and the real world-based conditions that frame and contextualize these models and their role in an educational setting. An experimental study conducted by Harley et al. (2016) noted that users were best able to achieve the targeted learning outcomes associated with a combined simulated and real-world based history assignment when they were able to combine the information stemming from both components into their aggregate

learning experience. Franceschi et al. (2008) critiqued current educational VR applications based on their inability to interconnect with collaborative-based learning models utilized in physical and real-world classrooms. Schmid's (2008) analysis similarly contended that a physical text's meaning and significance might transform when placed within a VR context.

Theme Three: Envisioned Educational Benefits

The critical themes deriving from theoretically oriented studies include the following. First, these studies indicate that VR technology potentially provides intensive forms of immersive learning experiences that allow for the users' unique engagements within simulated programs. Secondly, the works highlight the importance of connecting applications to structured components that train and ready learners for a program's use. Finally, they indicate the ways in which the simulated content presented within VR contexts often complexly aligns with real-world variables. Analyses that describe the specific educational benefits deriving from the technology's application frequently build upon these same concepts. These studies provide in-depth assessments of how educational planners incorporate VR applications and platforms within a classroom setting and simultaneously explore how these innovations benefit student learning in diverse contexts.

Discussions of virtual reality's educational dimensions often begin by identifying the strategic approaches that educators and administrators use when incorporating the models into a classroom setting. The work of Antonioli et al. (2014) explored how instructors operating in both traditional and specialty fields adopted and incorporated VR applications into their teaching. The authors noted that typical methodologies in this context include practices that outline the technology's specific value in achieving targeted objectives and that connect the applications to broader pedagogical strategies. The same authors noted that immersive VR

programs can benefit student learning and development within and outside of the classroom. In the latter context, students can utilize the same training modules to practice the guided lessons taught within the physical classroom. Bailenson et al. (2008) explored the ways in which applied virtual programs can improve and enhance social interactions within physical classes through several distinct applications. Examples included the use of augmented visual programs for teachers that enabled them to recognize students who require more attention; the use of virtual space to conceptually move students closer to the teacher's field of vision; and programs that reconfigure the space between learners. The latter application serves the primary purpose of creating optimal patterns of social learning: e.g., environments in which problematic students can learn from their model classmates' examples.

While strategic assessments of VR's potential role as an educational tool are important from a planning and pedagogical standpoint, the task of understanding the physical and structural requirements necessary for successfully implementing the technologies into a classroom represent an equally critical issue. Accordingly, an emerging set of studies examined the role that technological changes and network design have in achieving targeted educational objectives. The analysis provided by Isenhour et al. (2000) explored the physical dimensions and requirements for effectively connecting student learners via network to the educators delivering lesson plans through a remote-based virtual application. Makransky and Lilleholt (2018) similarly compared desktop-based and immersive VR in a science classroom. Their findings noted that immersive programs were more efficient in terms of improving student theoretical knowledge and in eliciting learners' cognitive and emotional responses. Finally, Elliott et al. (2018) identified how the cultivation of freeform optical technologies in VR applications improve the user's experience and increase a program's ability to impact learners at a cognitive

level. Each of these studies highlights the role that network configurations, hardware, and software have in improving the learner's experience.

Other assessments identify the ways in which other structural design components impact the quality of VR-generated education. The analysis provided by Kapp and Mcaleer-Balkun (2011) highlighted the importance of adopting diverse VR applications within the classroom to support the learning needs of specific students and to accommodate varied learning styles. Luckman and Krajnc (2012) similarly recommended that teachers interconnect virtual and real-world pedagogical strategies as this approach will enable instructors to mitigate the risks and drawbacks associated with both methodologies. The same authors additionally emphasized the need for cultivating collaborative-based approaches in both virtual and real-world learning environments.

While discussions of VR's broader educational value and the optimal strategies that can improve learner engagement provide an essential function, discussions of the technology's specific applications identify the diverse ways in which the model can support unique educational outcomes. At one level, these analyses are diverse and address a complex set of issues. At the same time, they are interconnected by their focus on specific applications, selected educational settings, and on the specific student/learner populations targeted by each approach. These works, additionally, indicate that the concept of educational goals tends to vary by context. In some cases, these objectives were academic in nature while in other contexts educators utilized VR applications to achieve student development or behavioral-related goals. The analysis provided by Satsangi et al. (2014) examined a case in which the specified goals related to the technology's application include a set of academic and behavioral-based objectives. The authors specifically explored VR's potential benefits among special needs

students. Findings deriving from the analysis indicated that a diverse set of programs benefited the students as they obtained specific academic goals and as they achieved desired emotional and developmental outcomes. At the same time, the authors identified student preferences for selected VR programs as a primary variable that would improve educational outcomes in this scenario. Satsangi and his coworkers' (2014) findings align with Gadelha's (2018) primary contention that increased instructor reliance on VR applications across educational settings represents an important development that will address the specific learning needs among varied student populations. The latter author specifically identified the ability of programs to help students cultivate improved competencies in key areas and to simultaneously develop complementary skills that enable them to ignore distractions. These capabilities, in brief, contribute to the technology's value in educational contexts involving special needs students and learners impacted by ADHD and related disorders (Rohani & Puthusserypady, 2015).

Discussions related to other fields additionally focus on VR technology's capacity for fostering targeted skills among discipline-specific learners. Bennet and Saunders' (2019) analysis emphasized how a VR-based educational science program enhanced learner abstract and applied knowledge of biological cellular structures. Borrero and Marquez (2011) described similar outcomes among a group of engineering students who relied on VR applications to enhance their field-related problem-solving abilities. The findings deriving from both studies paralleled Folio's (1997) contention that virtual programs create effective and enhanced training modules for complex fields such as medicine and aviation.

While VR programs have been shown to improve a user's cognitive functions and improve specifically targeted skillsets, they also promote other types of educational outcomes. An emerging theme within the literature refers to the technology's ability to enhance user

dimensions of empathy and emotional intelligence. Dyer et al. (2018) noted that a recent program applied in medical school settings promotes empathy among learners by presenting them with virtualized images of health conditions and challenges affecting elderly patients. Johnson (2018) contended that a religious studies-based virtual reality program helped enhance students' awareness of other traditions through a similar methodology. Sosnoski's (2008) in-depth discussion of the Virtual Harlem program similarly emphasized the platform's ability to promote empathy and understanding of African American history and culture among students. These collective findings echo the work of Johnson and Levine (2018). The latter authors explored the role that VR applications have in promoting learner social awareness and empathy in specific contexts.

Finally, analyses that evaluate the potential for language learning within virtual reality programs highlight the technology's ability to improving key areas of a student's core skills. In their emphasis on the historical evolution of VR-based language learning programs, Lin and Lan (2015) noted that program emphasis has transitioned from modules that emphasize student abstract knowledge of language system features towards immersive-based programs that emphasize the role of social context and setting in virtualized scenarios. These modules, in brief, require learners to apply their abstract awareness of an acquired language in ways that enable them to navigate simulated challenges. These findings parallel those deriving from Ibanez et al.'s (2011) analysis of the Open Wonderland VR program. The latter authors identified how this program interjects learners into a simulated environment that requires them to utilize their developing linguistic skills when solving problems generated by the module. The authors identified the program's principal value in its ability to help students rely on the dimensions of collaborative decision-making and constructivist-based principles as a means for resolving the

program's simulated challenges. The descriptive data deriving from both analyses aligns with Winn and Jackson's (1999) predictive assessments that emerging VR educational programs will emphasize constructivist-based learning on the part of the students engaged in the modules.

Theme Four: Potential Barriers to Virtual Reality Applications in Education

Discussions of VR technology's potential role and benefits in education need to be balanced by assessments that identify and evaluate the likely risk factors, barriers, and drawbacks that can impact the quality of educational outcomes. Literature that examines this aspect of the technology's educational role indicates that existing platforms can be potentially impacted by variables deriving from multiple sources. Stewart et al. (2010) summarized this trend in their evaluation of a pilot program designed to provide college undergraduates with access to a virtual reality program. Their findings indicated that such diverse barriers as software and technical issues, student attitudes towards the platform's value, implementation-related problems, and institutional barriers represented the most impactful challenges that affected the platform's ability to generate benefits for its users. While these findings derive from the analysis of a single program, they also identify a salient theme located in other analyses: namely, that the barriers impacting VR applications are both considerable in their effects and diverse in nature.

One critical barrier in this respect includes the issues of technology and support that can affect a program's quality. Wu et al. (2013) noted that while educators increasingly have access to a diversity of VR educational modules, that this development creates problems for administrators and planners as it requires them to be specific and selective when adopting a selected program to achieve stated educational goals. Villarreal (2016) similarly noted that among the most pressing challenges impacting educators and planners includes VR's growing complexity and the need for determining how specific applications will benefit selected groups

of students. Abdeleziz et al. (2014) contributed to these same discussions by emphasizing the need for educator and student-support based training as a means for preparing these stakeholders for a model's integration. Martin and Taylor's (1997) commentary identified a potential gap between advancing VR technologies and the economic discrepancies that can impact regional and school access to the internet. From this standpoint, the quality of applied VR programs can depend upon macro-level support-based issues that exceed the scope of district and institutional decision-makers.

Related scholarship additionally identifies the potential barriers at the administrative and planning levels that can affect VR applications. Isenhour et al.'s (2000) analysis identified the need for effectively structuring and preparing classrooms for the technology's integration. A failure to do so can create significant performance gaps that negatively affect a model's performance. Wei-Lai et al.'s (2016) analysis identified the core technologies required to manage the cloud-based VR science educational module. Implicitly, these same findings indicate the core technological and support-based requirements needed for implementing and maintaining programs of this type in an educational setting. West's (2007) analysis, finally, addressed the need for instituting VR training programs within teacher education and professional development courses. This view posits that educator knowledge and competencies in using and applying VR modules represent a factor that can greatly impact program outcomes.

Other works also identify educator-related factors as a significant potential barrier to VR-based educational strategies. Both Velev and Zlateva (2017) and Fernandez (2017) indicated the need for specialty educator training that will ensure faculty's ability to apply VR in their classrooms. Greiner-Winther (1999) and Tolentino et al. (2009) identified the pedagogical challenges of interconnecting virtual and real-world based instructional models in a broader

educational strategy. Weiss et al. (2017) noted that the challenges of using VR programs in special educational contexts include the need for selecting appropriate technologies that reflect a learner's specific needs. Implicitly, this view identifies the need for educators to be aware of the technologies that they implement within their classrooms. Kenwright's (2018) analysis identified the likely risks and ethical challenges that are associated with VR applications. Educator training and awareness, in brief, would also need to incorporate these considerations into a broader strategy. The work of Satsangi et al. (2014) similarly noted that student responses to VR applications can affect learning-based outcomes in special needs educational contexts.

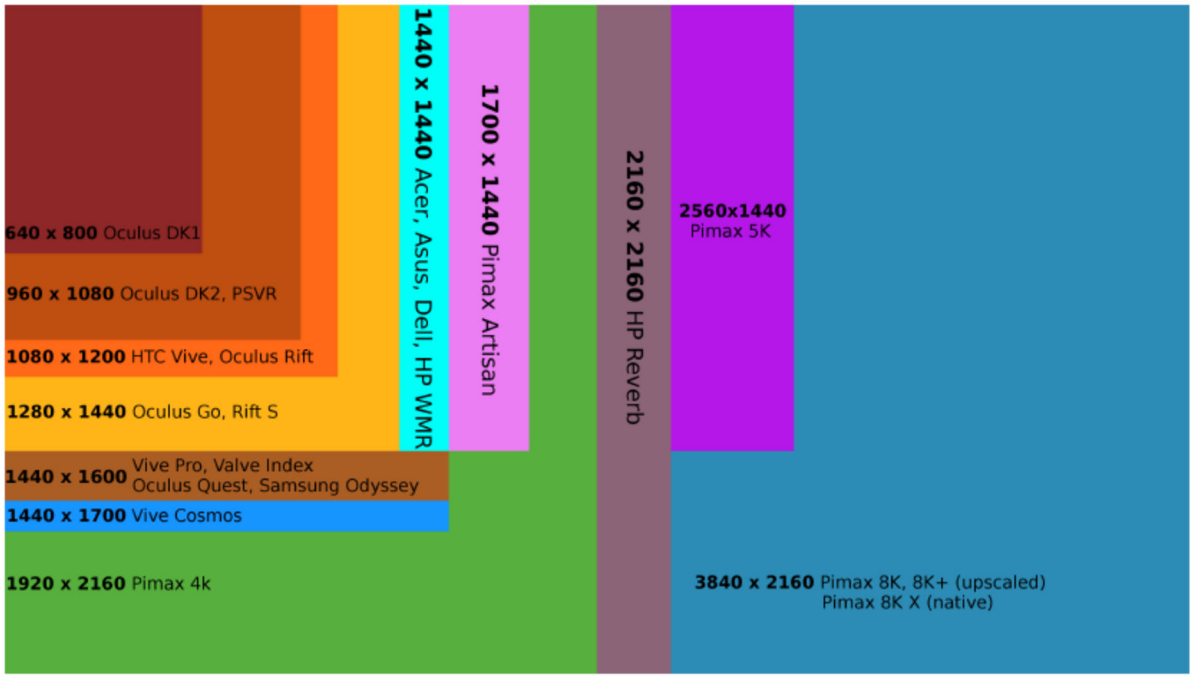
Summary of Key Themes and Implications for VR-assisted Learning

The themes generated by the literature review include the following. First, these analyses identified VR technologies as an essential tool that can benefit the work of educators operating in diverse contexts. Psotka's (2013) definition of the technology as a positively disruptive development represents a case in point. The analyses identified the technology's unique ability to generate immersive simulated environments and to affect cognitive and emotive areas of learner development represents salient examples of its proposed benefits. These aggregate findings indicated that VR's core technologies allow for its application in diverse settings and contexts. This includes its specific application as a tool that focuses on specific coursework. Specific analyses that discussed the technology's value in a language learning context emphasized VR's ability to cultivate multi-dimensional skills among students who rely on virtual training programs. These same findings additionally reference the applications' capabilities in cultivating constructivist and collaborative learning environments. Based on these assessments, VR represents a potentially valuable tool that will improve the quality of language learning programs. However, these views need to be tempered by an instructor's awareness of the

technological, pedagogical, and student response challenges that can impact a proposed strategy's outcomes. While these barriers may not represent insurmountable challenges, they nevertheless illustrate the levels of planning that would be necessary for a language-based VR program to achieve targeted educational and developmental outcomes. A quick glance at the evolution of VR resolution alone (see Figure 3) illustrates the optics development alone, together with some of the key technology developers. What this figure shows is the progression to lateral view of field resolution and number of pixels with newer and improved technology, allowing for a more realistic experience for its users.

Figure 3

VR Resolution Based on Technology and Next Generation Development



Note. From *Virtual Reality and Education: Survey*, by B. Kenwright, 2020, Communication Article, p. 7.

CHAPTER 3: METHODOLOGY

How the Methodology Was Chosen

One always has to make a judgment about how to collect data in a study. If it is too fine-grained, it will provide details that may not be relevant. Conversely, if the data is not fine-grained enough, important information and thus consequently pertinent conclusions may be lost. There are four hierarchical levels of measurement used in studies, in general. At the categorical level, there are the nominal and ordinal scales. Nominal data cannot be ranked, as the order is irrelevant (e.g., preference for red, green, blue, etc.) Next up, the ordinal scale does present order, such as "do not like at all," "like somewhat," "like," "like very much," and "like the most." Another common example is "strongly disagree," "disagree," "either disagree nor agree," "agree," and "strongly agree." As can be noted, the number of options provided to a respondent may vary from at a minimum of two to as many as the researcher prefers, typically five or rarely more than seven.

At the other end of the scale are quantitative data – interval and ratio data, which ask individuals to rank questions on scales 1-10 and 0-10, respectively. This may seem as a subtle and perhaps irrelevant difference, but it is not, and since this study proposes to use ordinal data, the focus remains on ordinal data only. Ordinal data, which as mentioned are categorical in nature (leaning towards qualitative, as is nominal, but is more revealing and fine-textured) differs from interval and ratio data in that the differences between adjacent scores may not be equal yet can be ordered (unlike nominal data).

Ordinal data collection also tends to be less stressful on survey participants, because they can often answer exactly (e.g., what is your highest attained education level), and there are fewer

choices to fret about (e.g., on a scale from 1-10 how did you like your last car – people can get hung up on whether it is a 5 or 6 or 7 etc. and get de-enfranchised in completing the survey. Ordinal data is hence not just a way to keep things a bit simpler, yet useful for a researcher, but it generally tends to yield higher response dates compared to interval and ratio date.

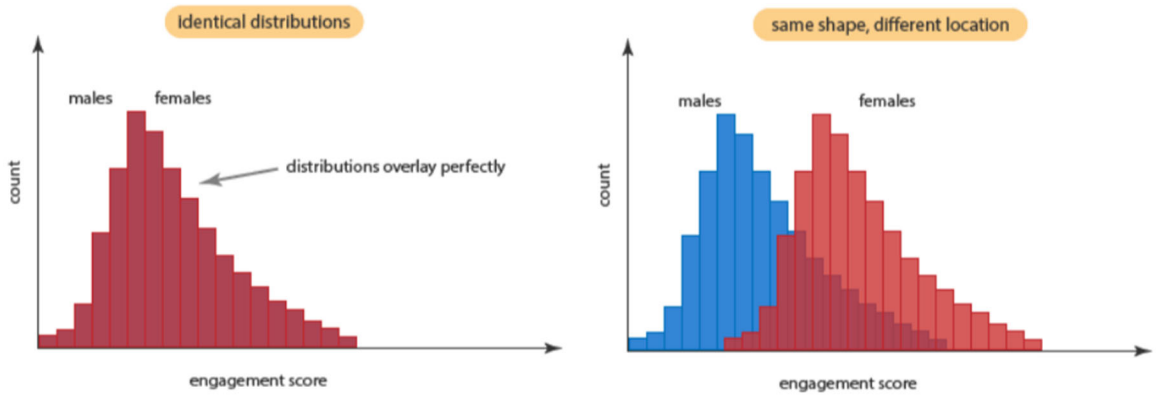
Almost all surveys include what is by many considered a fifth category of data collection – open-ended questions (e.g., "what do you suggest the company should do to improve its brand recognition?"). These can often be very informative but are more difficult and time-consuming to analyze and quantify or visualize in graphs and draw conclusions from.

There are a number of drawbacks with surveys as well. For one, the response rate can be very low, and one often sees deadline extensions and second surveys sent out to ensure that the data collected is statistically relevant. Moreover, there is a natural tendency for survey takers to take the time to respond if they are emotional about a product or service, meaning most of the survey takers are upset about some aspect and that motivates them to take the time to fill out the survey. In addition, if the survey is too long, or it is constructed in a way that server response takes too long, individuals tend to abandon them. Rarely is there any incentive for those affected to take a survey if they do not get something in return. To compound the problem, in some cases, as an example, surveys who ask about, e.g., sexual harassment, will naturally tend to be biased because the ones that have experienced it in a bad way have either already left the institution, are in a lawsuit and thus by law not allowed to comment, either which now biases the survey results to being more positive than they are.

There are several common ordinal statistical data analysis tools such as the Mann-Whitney U test, the Wilcoxon t test, the Kruskal-Wallis t test, and the Friedman R test (see Figure 4 for the Mann-Whitney U test example.

Figure 4

Example of How the Mann-Whitney U Test Can Identify Gender Differences in Answers to a Question



Note. From *Mann-Whitney u test using SPSS statistics*, by Laerd Statistics, (n.d.), https://statistics.laerd.com/spss-tutorials/mann-whitney-u-test-using-spss-statistics.php

The statistical test chosen for this study, the chi-square, also written as χ^2, test, is another non-parametric statistical test, also called a distribution free test which is used when the level of measurement of all the variables is nominal or ordinal (the latter pertaining to this study). The (Pearson's) χ^2 test is particularly suitable for the statistical analysis of the survey results as it is used to determine whether there is a statistically significant difference between the expected frequencies and the observed frequencies in one or more categories of a contingency table. This makes it amenable to study the influence of discriminators like gender, race, age, etc. to an arbitrary degree of confidence. The null hypothesis H_0 is always worded in a way that states that there is no statistically significant difference between groups subdivided by, say, gender. By comparing the calculated χ^2 statistic with the critical χ^2 value (from a table that states that value based on the degrees of freedom and the desired accuracy), one can thus either accept H_0 and conclude that, in this case, gender does not significantly affect the outcome, or fail to reject H_0

and thus accept H_1, the alternative hypothesis, which concludes that gender does indeed to a statistically significant degree make a difference as to the students' cumulative answers. We adopt a standard scientific accuracy of p=0.05 as the cut-off, but also report in each case the p-value so that the reader can distill more information out of the results (e.g., a calculated $p = 0.06$ means that H_1 is appropriate to adopt, albeit at a slightly more relaxed confidence interval than $p = 0.05$.

Research Questions and Hypotheses

As reviewed in Chapter 2, there are still considerable gaps in our understanding how better to phase in VR technology into education in a prompt, safe, economical, ethical, and socio-economically fair manner. The principal research questions to be addressed, as discussed in Chapter 1, are thus:

1. What do students in general education feel the main barriers and worries for VR adaptation are in terms of improving learning effectiveness?
2. What realistic suggestions do they have to improve on that?
3. Would students be open to commit to some radical changes in educational methodology, and provide regular feedback to aid improvements?
4. Does experience with VR in gaming environments influence perceptions about the use of VR in educational settings?

Participants

Data Sources

This study is focused on college students, in terms of how they can be assisted by VR in learning their curriculum more effectively, especially in times when schools may be partially open and subject to going virtual intermittently. It is therefore necessary to look at what their perceptions are about such kind of augmented and additional learning tools. To keep the study reasonable, the focus was on US students only, particularly those attending schools within a

network based on advice from VR education professors, and while any feedback from other sources is more than welcome, only students were actively queried. Specifically, the student body that was polled about VR use in general education using a survey (see details below) was arrived at by asking fellow instructors at the university in the business school to probe for voluntary sophomore and junior students in their respective classes. The limitation to second- and third-year college students was made because they are typically in general education classes, unlike freshmen and seniors that tend to be in concentrated classes. Besides the obvious limitations imposed by sticking to one particular university in a single state, beyond what was already mentioned above, other factors need to be considered when evaluating the results and ensuing analyses in terms of extrapolation and generalization. For one, only volunteers were part of the study. On one hand, this helps improve the response rate; in addition, non-volunteers, based on forced participation, may lead to a negative bias in terms of VR/education. On the other hand, this could obviously lead to a positive bias, as presumably students with an initially positive attitude with regard to VR could lead to a higher volunteer and response rate. Moreover, the time period allowed for the study, including the survey, the analysis, and the writing-up of the conclusions imposed a clear limitation as the study involved a single university with a limited number of students and limited number of students per classroom. Furthermore, even though the student body that was polled is a diverse combination of students with quite varying backgrounds, ethnicity, race, etc., by the aforementioned limitations in the number of participants, certain categories of students (such as minorities based on race/ethnicity) often turned out to be too small to allow for a statistical differentiation (see $\chi 2$ analysis in forthcoming sections), and thus a lumping of these categories often followed to ensure that any differentiation with statistical meaning (sufficient confidence) could be undertaken.

It is well understood that for VR learning to be effective at any school, there needs to be a buy-in from parents and/or caretakers of students, as well as from school leadership. Moreover, whereas at least in this generation, students are exposed to electronic devices, apps, learning experiences, etc. from a very young age, that is not necessarily true for their teachers. Hence, there is a very important element of teacher preparation and training to be had ahead of any significant VR education roll-out, as well as a best-effort assessment of how to use the results that come in to not just further improve VR learning, but also include results from VR learning fairly and efficiently into the current grading system. As discussed, there are also other aspects that pertain to socio-economic, ethical, and other "gray-area" aspects that need to be taken into account before any measures are taken, and actively monitored throughout the whole roll-out process and evaluation to safeguard against unfair or unjust treatment of a diverse body of students. It is also strongly recommended to pilot any trials on a smaller group, evaluate the results, and ensure that students are not unfairly graded because they are subjected to a new type of learning that may yet be proven to be effective.

Rights of Human Subjects

The study was reviewed and approved by the Institutional Review Board, a university-wide committee. The participation of involved subjects is voluntary, and anonymity is guaranteed. Each individual asked to participate in the proposed study is provided a brief explanation about the purpose of the study, how individual data will be used statistically only, fully anonymously, and all personal data privacy laws, federal, state, and University Governing Board related, will be abided by. All data are stored in encrypted files, and any paper versions locked up in a secure storage facility.

As discussed earlier, the survey was based on targeting a specific body of students and the data be collected in qualitative (really semi-quantitative) ordinal fashion. In this study we used SurveyMonkey (n.d.) to distribute the survey and to collect and organize the data. Subsequent analyses are all done in Excel, including segmentation, graphing, statistical analysis, etc. The survey questions that address the four Research Questions are found in Chapter 4.

Data Analysis Overview

First, the results are reported, with general segmentation represented using pie charts. Next, a general analysis is made of the responses. Then, a dissection is made in terms of discriminators such as primarily gender and race/ethnicity, but this can be expanded to include other discriminators such as age, GPA, study major, etc. All analyses were made using Microsoft Excel®, which was also used to create graphic representation of the data.

As mentioned earlier, all names of individuals are completely masked. The study includes categorization of responders with regard to gender, age, grade, college major, voluntary provided race/ethnicity data, GPA, etc. (in a manner that ascertains that no single result can be traced back to any given individual student). This is why the chi-square (χ^2) test is particularly attractive; an example of gender bias or other kind of dependence on independent factors can thus be revealed and used to gather more informed and data-based conclusions. Should the number of responders be too low in a certain category, threatening either statistical irrelevance or private data exposure, such groups are either grouped with appropriate other groups of responders, or entirely eliminated; this section is presented right before the deep dive into the answers to the main four research questions.

CHAPTER 4: RESULTS AND DATA ANALYSIS

Descriptive Statistics

The survey was distributed to 154 students, with roughly an equal number of males as females (52% vs. 48%), six distinct race/ethnicities, predominantly Asian, White, and Hispanic/Latino (79%), but also mixed race, Black/African-America, and Pacific Islander students (15%). About two thirds of all students had GPAs >3.2, and the average student age was 19-20 years old. Sophomores made up one third of all students, whereas Freshmen, Juniors, and Seniors each accounted for one fifth of the student pool. The overall response rate was > 90%, which is rather high and quite helpful in ensuring that the statistics are well-grounded, with a 96% response rate on multiple-choice questions and an average 81% response rate where students were allowed to provide open ended answers to several free form questions.

For the to $\chi 2$ analysis to be meaningful and reliable, no single subgroup was allowed to contain fewer than five students. This forced some combinations smaller groups together to be able to carry out the analyses, even more so for looking at race/ethnicity as a potential discriminator than gender, simply because there were six subgroups of race/ethnicity and only two for gender. In addition, the more extreme answers (e.g., “very much agree,” “do not agree at all”) tended to be sparsely populated so the grouping had to occur on several levels (see Tables 1 and 2).

Table 1

Research Question Example Distribution by Race/Ethnicity

	Very experienced	Experienced	Somewhat experienced	Very limited experience	No experience	No answer	Total
Total	6	20	39	47	36	6	154
Asian	3	5	12	16	12		
Hispanic/Latino	0	2	7	12	9		
White	3	9	9	12	10		
Black / African American	0	2	0	1	1		
Pacific Islander	0	0	2	1	0		
Mixed	0	1	8	3	2		
Unclear	0	1	1	2	2		
Sum check	6	20	39	47	36	6	154

Table 2

Consolidated Research Question Example Distribution by Race/Ethnicity to Ensure Acceptable Statistics

	Experienced/very experienced	Somewhat experienced/experienced	Very limited experience	No experience	No answer	Total
Total	26	39	47	36	6	154
Asian	8	12	16	12		
Other	5	17	17	12		
White	12	9	12	10		
Unclear	1	1	2	2		
Sum	26	39	47	36	6	154

As a result, the “experienced” and the “very experienced” groups were combined. In addition, Hispanic/Latin, Black / African American, and Mixed race/ethnicities were combined into one named “other” to ensure we could proceed with analysis (note that we ended up with a pool of 154 (-6 no answers) (-6 unclear answers regarding race/ethnicity) = 142 students. In

other cases, we got away with less course graining and in yet others we had to eliminate certain rows/columns.

A total of 23 questions were sent to each survey participant. The answers and the analyses of these are reported in this chapter, and then discussed in Chapter 5. Of the 23 questions, six (D1-D6) dealt with demographic data such as gender, age, major, race/ethnicity, etc., 12 (MC1-MC12) were multiple-choice questions related to past, present, and future VR use, and five (OE1-OE5) were questions that gave the students an opportunity to respond with open-ended answers. The responses to the demographic questions are provided visually in figures in Appendix A. The free-form answers are often ambiguous, and frequently contain multiple answers to a single question. An effort has been made to categorize the open-ended responses into "themes" as it helps with the overall picture and analysis; regardless all free-form answers are listed in Appendix B. Hence, there are three different numbers that are reported for each question:

1. How many students participated in the survey, which remains constant, and is 154 (N). This number is thus not stated in any of the pie charts further below.

2. How many students replied (Nr), which is reported individually for each question.

3. How many responses were distilled from the categorization of open-ended answers (Ns). Since some students provided more than one answer in the open-ended answers to the free form questions, Ns was often quite a bit higher than N_r.

Findings According to Research Questions

Herewith, we restate the four research questions (RQs) and then provide three tables that illustrate which questions directly address each of those.

RQ1. What do students in general education feel the main barriers and worries for VR adaptation are in terms of improving learning effectiveness?

RQ2. What Realistic Suggestions do Students Have to Improve on VR in Educational Settings?

RQ3. Would students be open to commit to some radical changes in educational methodology, and provide regular feedback to aid improvements?
RQ4. Does experience with VR in gaming environments influence perceptions about the use of VR in educational settings?

Research Questions Aligned with the Different Types of Survey Questions

Table 3

Demographics Associated with Posed Research Questions

	D1	D2	D3	D4	D5	D6
RQ1						
RQ2						
RQ3						
RQ4						

D1. "How old are you? (Please enter age in years)."

D2. "What is your current enrollment status?"

D3. "What is your current major? [please write in your response]"

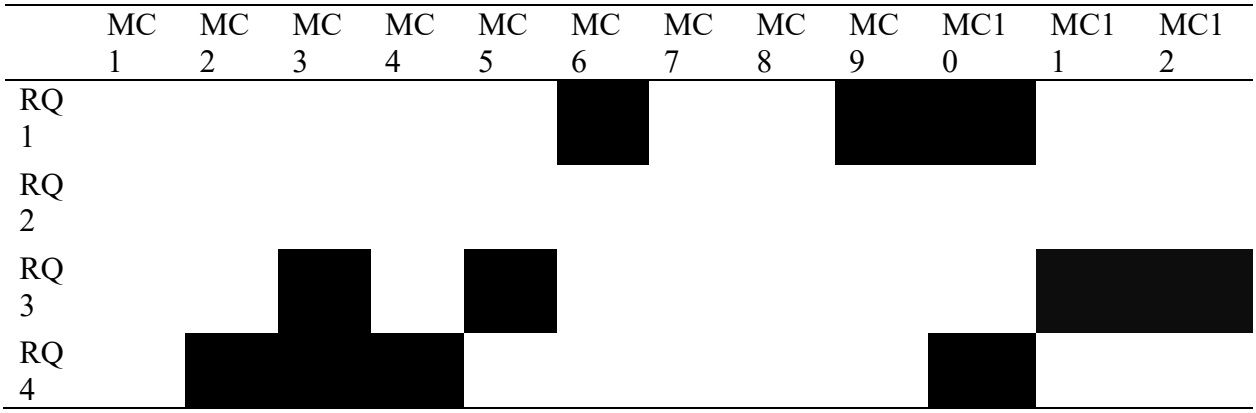
D4. "Which gender do you most identify with?"

D5. "What is your race/ethnicity? [please write in your response, or you may decline to respond]"

D6. "What is your current GPA? [please write in your response]"

Table 4

Research Questions Addressed by Posed Multiple-Choice Survey Questions



MC1. "Do you engage in gaming that uses Virtual Reality?"

MC2. "How aware are you of current use of Virtual Reality (VR) in any applications?"

MC3. "Do you feel that VR is used effectively in today's education?"

MC4. "How experienced are you with any kind of VR in games, learning, etc.?"

MC5. "Would you be interested in further/extended use of VR to help with your learning?"

MC6. "Do you feel that your education center has sufficient resources/capacity to assist with VR learning?"

MC7. "Has the Covid-19 pandemic changed the amount of VR technology you use?"

MC8. "Has the Covid-19 pandemic influenced your views about whether VR should be implemented more aggressively?"

MC9. "How worried are you about VR having a negative impact on your learning and/or grades?"

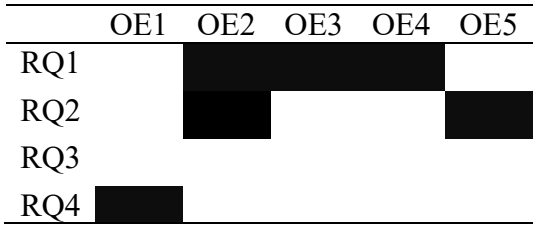
MC10. "Do you feel that VR should be applied in all areas of teaching?"

MC11. "How willing would you be to commit to radical changes in educational methodology (e.g., the use of VR)?"

MC12. "I would be willing to provide regular feedback in order to improve the implementation of VR in the curriculum."

Table 5

Research Questions Addressed by Posed Open-Ended Survey Questions



OE1. "What are your current thoughts about the use of VR in education?"

OE2. "What are your primary concerns about expanding the use of VR in education? What do you perceive to be the main barriers to implementation?"

OE3. "What do you feel would be the greatest benefits of increasing the use of VR in education?"

OE4. "Do you have any other concerns or thoughts about this topic?"

OE5. "What recommendations would you give teachers and others responsible for your schooling when it comes to VR?"

χ^2 Analysis

In the following, we look at the multiple-choice questions and, using the chi-square analysis statistical χ^2 analysis method, determine whether there is a statistically significant difference ($p < 0.05$) between gender and race/ethnicity for the various multiple-choice questions. We can do the same using age, GPA, major, and enrollment status. It is important to re-emphasize that if any answer category has less than five responses, the results are not reliable, and we thus see if we can combine smaller subgroups into a larger group or at worst refrain from

including the data in the analysis. In this study, we use the one-sided χ^2 (chi-square) test with $p < 0.05$. This means that our null hypothesis states an assumption, namely that there is no difference between the groups we are comparing with regard to the results, and that our alternative hypothesis is that there is indeed a statistically significant difference between the studied groups. In this study, we have chosen $p < 0.05$, which is a very frequently adopted confidence level in scientific studies. In the following, we analyze the 12 multiple choice questions MC1-MC12 in brevity.

MC1. "Do you engage in gaming that uses Virtual Reality?"

In terms of gender, we have a sub-group of (female, "yes, currently") that has only one count, so we combine the "yes, currently" and "yes, in the past but not currently" answers. The analysis is thus made using all $N_r = 148$ answers in a 2x2 matrix (154 minus the six students who did not provide an answer). No statistically significant difference was found between males and females: $\chi^2(df) = 1.650 < \chi_c^2(df) = 3.841$ ($p = 0.199 > p_0 = 0.05$). In terms of race/ethnicity, after removing subgroups with Pacific-Islanders and Black/African American, and combining the "yes, currently" and "yes, in the past but not currently" answers to avoid groups with < 5 answers, we are reduced to 135 students, and found no statistically significant difference between the races/ethnicities: $\chi^2(df) = 1.688 < \chi_c^2(df) = 7.815$ ($p = 0.640 > p_0 = 0.05$).

MC2. "How aware are you of current use of Virtual Reality (VR) in any applications?"

Looking at gender as a potential discriminator, we are again forced to combine the "very aware" and "aware" subgroups, as well as the "not very aware" and "unaware" subgroups. No statistically significant difference was found between males and females for this question as well: $\chi^2(df) = 1.128 < \chi_c^2(df) = 9.488$ ($p = 0.890 > p_0 = 0.05$). In terms of race/ethnicity, no matter how we combine groups, we cannot get all groups to have five or more counts without

mixing categories like degrees of "unaware" with degrees of "aware," which defies the purpose. Hence, the statistical analysis cannot be performed in this case in any meaningful manner.

MC3. "Do you feel that VR is used effectively in today's education?"

In terms of gender, we are again forced to combine some subgroups of fewer than five responses. The only way to achieve that combine the "strongly agree," "agree," and "somewhat agree" subgroups, as well as the "strongly disagree" and "disagree" subgroups, respectively. The "no opinion" subgroup remains as is. No statistically significant difference was found between males and females for this question as well: $\chi^2(df) = 4.034 < \chi_c^2(df) = 5.991$ ($p = 0.133 > p_0 = 0.05$). (Note that if we had relaxed the confidence factor from 0.0 to 0.14, we would see a statistically significant difference where males exude more opinions than females at $p = 0.014$.) In terms of race/ethnicity, after removing subgroups with Pacific-Islanders and Black/African American, and lumping the "strongly agree," "agree," and "somewhat agree" subgroups, as well as the "strongly disagree" and "disagree" subgroups together to avoid groups with fewer than five answers, we are reduced to 121 students. We again find no statistically significant difference between race/ethnicity for this question: $\chi^2(df) = 3.188 < \chi_c^2(df) = 9.488$ ($p = 0.527 > p_0 = 0.05$).

MC4. "How experienced are you with any kind of VR in games, learning, etc.?"

With regard to gender, we are again forced to do some group merging to avoid subgroups of fewer than five responses. In this case that means combining the "very experienced" with the "experienced" subgroups. This means that we are still basing the analysis on 148 students, with a 2x4 χ^2 matrix. A statistically significant difference was found between males and females for this question: $\chi^2(df) = 7.866 > \chi_c^2(df) = 7.815$ ($p = 0.048 < p_0 = 0.05$) – males are on average more experience with VR than females (at $p < 0.05$). As regards race/ethnicity, the only way to

draw any meaningful conclusion is to coarse-grain the data into "Asian," "white," and "other," the latter group consisting of Hispanics, Pacific Islanders, Black/African-Americans, and Mixed race/ethnicity. We also had to combine the "very experienced" and "experienced" subgroups to allow for a valid analysis. The combined pool of students thus shrank to 142 (as there were six students with an unclear answer). We again find no statistically significant difference between race/ethnicity for this question: $\chi^2(df) = 6.117 < \chi_c^2(df) = 12.592$ ($p = 0.410 > p_0 = 0.05$). The combined pool of students thus shrank to 142 (as there were 6 students with an unclear answer).

MC5. "Would you be interested in further/extended use of VR to help with your learning?"

As usual, we first look at gender as a potential discriminator. In this case, we had to combine the "not interested" and "mildly disinterested" to avoid subgroups of less than 5 respondents. We hence end up with a response pool of 147 (seven students did not provide an answer), and thus analyze a 2x4 χ^2 matrix. We find that there is indeed a clear statistically significant difference between males and females for this question; males are overall more interested in further use of VR in learning environments: $\chi^2(df) = 9.125 > \chi_c^2(df) = 7.815$ ($p = 0.027 < p_0 = 0.05$). As regards race/ethnicity, the only way to draw any meaningful conclusion is to coarse-grain the data into "Asian," "white," and "other," the final subgroup consisting of Hispanics, Pacific Islanders, Black/African-Americans, and Mixed race/ethnicity. We also had to combine the "not interested" and "mildly disinterested" subgroups to allow for a valid analysis. The combined pool of students thus shrank from 147 to 141 (as there were six students with an unclear race/ethnicity answer). Here we find no statistically significant difference between race/ethnicity for this question: $\chi^2(df) = 3.492 < \chi_c^2(df) = 12.592$ ($p = 0.745 > p_0 = 0.05$).

MC6. "Do you feel that your education center has sufficient resources/capacity to assist with VR learning?"

As always, we first look at gender as a potential discriminator. For once, each subgroup had a population of five or more, so we did not have to combine any answers. The response pool remains at 147 (seven students did not provide an answer), and thus analyze a 2x5 χ^2 matrix. In this case, we find no statistically significant difference between gender for this question: $\chi^2(\text{df}) = 5.271 < \chi_c^2(\text{df}) = 9.488$ ($p = 0.261 > p_0 = 0.05$). Pertaining to race/ethnicity as a potential discriminator, the only way to draw any meaningful conclusion is to coarse-grain the data into "Asian," "white," and "other," the final subgroup consisting of Hispanics, Pacific Islanders, Black/African-Americans, and Mixed race/ethnicity. We also had to combine the "excellent resources" and "some resources," as well as the "limited resources" and "no resources" subgroups to allow for a valid analysis. The combined pool of students thus shrank from 147 to 141 (as there were six students with an unclear race/ethnicity answer). We find no statistically significant difference between race/ethnicity for this question: $\chi^2(\text{df}) = 3.400 < \chi_c^2(\text{df}) = 9.488$ ($p = 0.493 > p_0 = 0.05$).

MC7. "Has the Covid-19 pandemic changed the amount of VR technology you use?"

The first potential discriminator we look at is gender. To avoid too small groups, we had to combine the "absolutely" and "yes," as well as "to some extent" and "no" subgroups. As seven students did not answer, the data pool consisted of 147 answers in a 2x3 matrix. We find no statistically significant difference between race/ethnicity for this question: $\chi^2(\text{df}) = 0.623 < \chi_c^2(\text{df}) = 5.991$ ($p = 0.732 > p_0 = 0.05$). Turning to race/ethnicity, we were forced into some serious lumping. The only way to draw any meaningful conclusion is to coarse-grain the data into "Asian," "white," and "other," the final subgroup consisting of

Hispanics, Pacific Islanders, Black/African-Americans, and Mixed race/ethnicity. We also had to ignore the "absolutely" and "yes" subgroups, as even if combining them we did not have all subgroups greater than five, and there was no logical way to lump these answers with any of the other subgroups. We also had to lump the "to some extent" and "no" subgroups, ending up with 127 answers in a 3x2 χ^2 matrix. We find no statistically significant difference between race/ethnicity for this question: $\chi^2(df) = 1.217 < \chi_c^2(df) = 5.991$ ($p = 0.544 > p_0 = 0.05$).

MC8. "Has the Covid-19 pandemic influenced your views about whether VR should be implemented more aggressively?"

The first potential discriminator we look at is gender. To avoid too small subgroups, we had to combine the "yes, convincingly" and "yes" subgroups. As seven students did not answer, the data pool consisted of 147 answers in a 2x3 matrix. The first potential discriminator we look at is gender. To avoid too small subgroups, we had to combine the "yes, convincingly" and "yes" subgroups. As seven students did not answer, the data pool consisted of 147 answers in a 2x3 matrix. As regards race/ethnicity, to avoid too small groups, we had again to combine the "yes, convincingly" and "yes" subgroups, as well as combine all non-white and non-Asian subgroups (Hispanics, Pacific Islanders, Black / African Americans, and Mixed race/ethnicity) into one group. The χ^2 analysis thus yielded a total pool of 141 student answers (as six were unclear in terms of race/ethnicity), ending up with a 3x4 matrix. We find no statistically significant difference between race/ethnicity for this question:

$\chi^2(df) = 2.302 < \chi_c^2(df) = 12.592$ ($p = 0.890 > p_0 = 0.05$).

MC9. "How worried are you about VR having a negative impact on your learning and/or grades?"

In terms of gender, to avoid too small subgroups, we had to combine the "one or two worries" and the "very worried" subgroups. As eight students did not answer, the data pool consisted of 146 answers in a 2x5 matrix. We find no statistically significant difference between race/ethnicity for this question: $\chi^2(df) = 7.436 < \chi_c^2(df) = 9.488$ ($p = 0.114 > p_0 = 0.05$). As regards race/ethnicity, to avoid too small groups, we had again to combine three subgroups this time: the "one or two worries", the "very worried," and the "some worries" categories, as well as combine all non-white and non-Asian subgroups (Hispanics, Pacific Islanders, Black / African Americans, and Mixed race/ethnicity) into one group. The χ^2 analysis thus yielded a total pool of 136 student answers (as six were unclear in terms of race/ethnicity), ending up with a 3x4 matrix: We find no statistically significant difference between race/ethnicity for this question: $\chi^2(df) = 1.854 < \chi_c^2(df) = 9.488$ ($p = 0.763 > p_0 = 0.05$).

MC10. "Do you feel that VR should be applied in all areas of teaching?"

In terms of gender, to avoid too small subgroups, we had to combine the "agree" and the "strongly agree" subgroups, as well as the "somewhat disagree" and "strongly disagree" categories. As eight students did not answer, the data pool consisted of 146 answers in a 2x4 matrix. We find no statistically significant difference between the two genders for this question: $\chi^2(df) = 1.637 < \chi_c^2(df) = 7.815$ ($p = 0.651 > p_0 = 0.05$). Turning to race/ethnicity, to avoid too small groups, we had again to combine the "agree" and the "strongly agree" subgroups, the "somewhat disagree" and "strongly disagree" categories, as well as combine all non-white and non-Asian subgroups (Hispanics, Pacific Islanders, Black / African Americans, and Mixed race/ethnicity) into one group. We also had to ignore the "no opinion" subgroup entirely. The

χ^2 analysis thus yielded a total pool of 128 student answers (as six were unclear in terms of race/ethnicity and 12 "no opinion" answers were not included in the analysis), ending up with a 3x3 matrix. We find no statistically significant difference between race/ethnicity for this question: $\chi^2(df) = 5.004 < \chi_c^2(df) = 9.488$ ($p = 0.287 > p_0 = 0.05$).

MC11. "How willing would you be to commit to radical changes in educational methodology (e.g., the use of VR)?"

As regards gender, to avoid too small subgroups, we had to combine the "very willing" and the "willing" subgroups, as well as the "somewhat resistant" and "unwilling" categories. As 8 students did not answer, the data pool consisted of 146 answers in a 2x3 matrix. This turned out to be a border case with $\chi^2(df) = 5.89 \sim \chi_c^2 = 5.99$ and $p = 0.0526 \sim p_0 = 0.05$. By relaxing the p cutoff from 5% to 5.3%, we find that there is indeed a clear statistically significant difference between males and females for this question; males are overall more open to radical changes in educational methodology, including VR. As regards race/ethnicity, to avoid too small groups, we had again to combine the "very willing" and the "willing" subgroups, the "somewhat resistant" and "unwilling" categories, as well as combine all non-white and non-Asian subgroups (Hispanics, Pacific Islanders, Black / African-Americans, and Mixed race/ethnicity) into one group. The χ^2 analysis was thus based on a pool of 140 student answers (as six were unclear in terms of race/ethnicity), ending up with a 3x3 matrix. We find no statistically significant difference between race/ethnicity for this question: $\chi^2(df) = 5.279 < \chi_c^2(df) = 9.488$ ($p = 0.260 > p_0 = 0.05$).

MC12. "I would be willing to provide regular feedback in order to improve the implementation of VR in the curriculum."

In terms of gender, to avoid too small subgroups, we had to combine the "strongly disagree" and the "somewhat disagree" subgroups, and since eight students did not answer, the data pool consisted of 146 answers in a 2x4 matrix. We find no statistically significant difference between race/ethnicity for this question: $\chi^2(df) = 3.785 < \chi_c^2(df) = 7.815$ ($p = 0.286 > p_0 = 0.05$). Changing focus to race/ethnicity, in order to avoid too small groups, we had to actually eliminate fully the "somewhat disagree" and "strongly disagree" to ensure sufficiently large groups, making this an exercise in three levels of agreement. As so often, we also combine all non-white and non-Asian subgroups (Hispanics, Pacific Islanders, Black / African Americans, and Mixed race/ethnicity) into one group. The χ^2 analysis was thus based on a pool of 121 student answers (as six were unclear in terms of race/ethnicity), ending up with a 3x3 matrix. The statistics yield $\chi^2(df) = 9.12 \sim \chi_c^2(df) = 9.49$ ($p = 0.0564 \sim p_0 = 0.05$). Again, this is a borderline case because we are very close to the cutoff $p < 0.05$. If we relax it to $p < 0.057$, we find that there is indeed a clear statistically significant difference between race/ethnicity for this question: the group of Hispanics/Latinos, Pacific Islanders, Black / African Americans, and Mixed race/ethnicity are overall more inclined to provide ongoing feedback regarding the implementation of VR in the curriculum. Table 6 summarizes the results, with all instances where gender and/or race/ethic background is highlighted.

Table 6

Key χ^2 Statistics for Establishing Potential Gender and Race/Ethnicity Discriminators in Multiple-choice Survey Questions

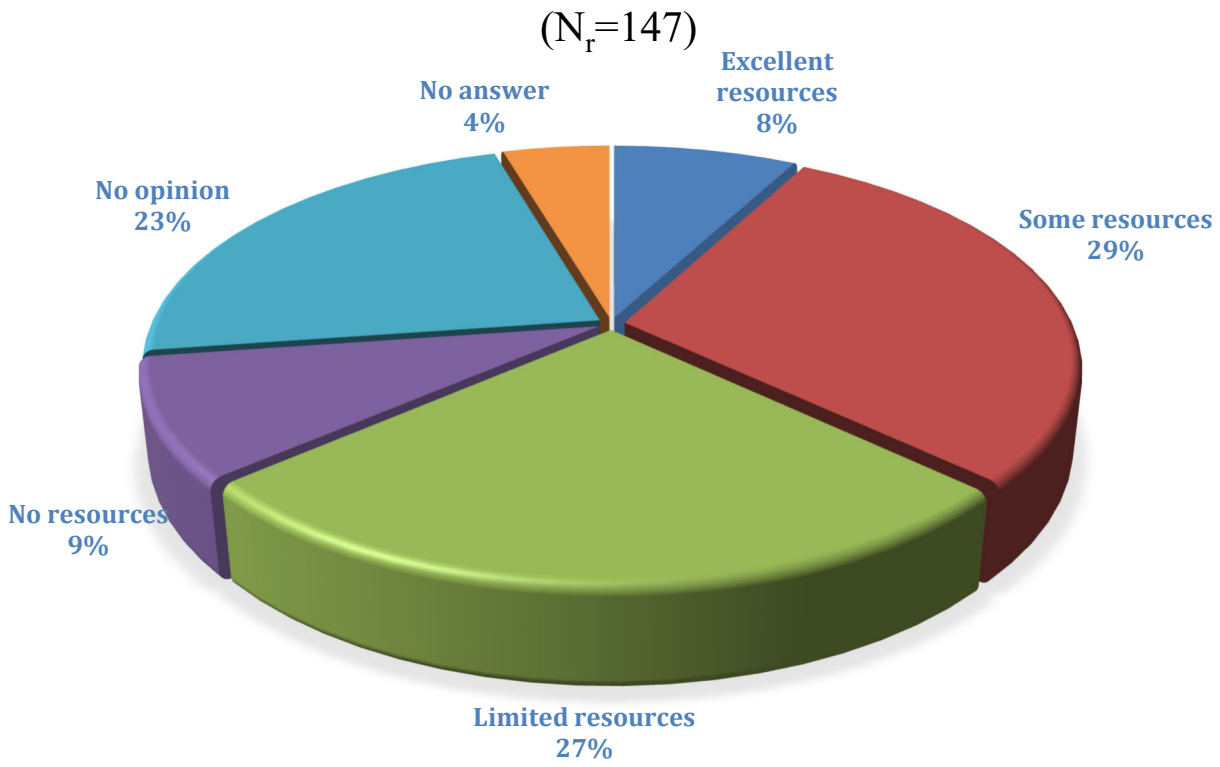
		MC1	MC2	MC3	MC4	MC5	MC6
Gender	χ^2 (df)	1.650	1.128	4.034	7.886	9.215	5.271
	χ_c^2(df)	3.841	9.488	5.991	7.815	7.815	9.488
	p	0.199	0.890	0.133	0.048	0.027	0.261
Race/Ethnicity	χ^2 (df)	1.688	N/A	3.188	6.117	3.492	3.400
	χ_c^2(df)	7.815	N/A	9.488	12.590	12.59	9.488
	p	0.640	N/A	0.527	0.410	0.745	0.493
	p_0	0.050	0.050	0.050	0.050	0.050	0.050
		MC7	MC8	MC9	MC10	MC11	MC12
Gender	χ^2 (df)	0.623	4.353	7.436	1.637	5.889	3.785
	χ_c^2(df)	5.991	7.815	9.488	7.815	5.991	7.815
	p	0.732	0.226	0.114	0.651	0.053	0.286
Race/Ethnicity	χ^2 (df)	1.217	2.302	1.854	5.004	5.279	9.198
	χ_c^2(df)	5.991	12.59	9.488	9.488	9.488	9.488
	p	0.544	0.890	0.763	0.287	0.260	0.056
	p_0	0.050	0.050	0.050	0.050	0.050	0.050

Research Question 1. What do Students in General Education Feel the Main Barriers and Worries for VR Adaptation Are in Terms of Improving Learning Effectiveness?

The survey questions that directly address this research question are MC6, MC9, MC10, OE2, OE3, and OE4. MC6 probes the students' perceptions of how well schools are equipped to further the use of VR for learning purposes. Much of the freehand comments discussed later on provide considerable detail to where these answers stem from. At this point, the results show that a bit over a third (37%) feel that schools have some, or excellent resources, 27% feel that there are limited resources, and 9% stated that there are no resources available for such purpose. Twenty-three percent had no opinion, and the remainder provided no answer (see Figure 5).

Figure 5

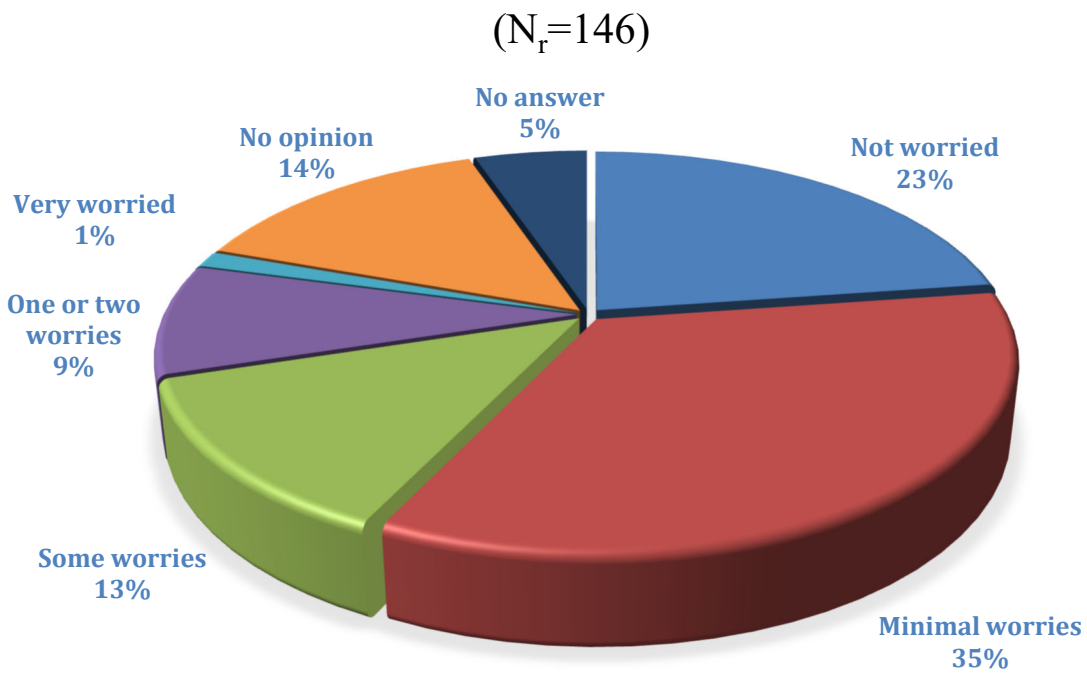
MC6. Are There Sufficient School VR Resources for Learning Purposes?



The purpose of MC9 is to gauge how worried students are about the possibility of VR-based learning negatively impacting their grades. The majority (58%) have no or minimal worries, whereas 22% have some/1-2 worries, and only 1% of students are very worried. The no opinion and no answer together make up 19% of the total (see Figure 6).

Figure 6

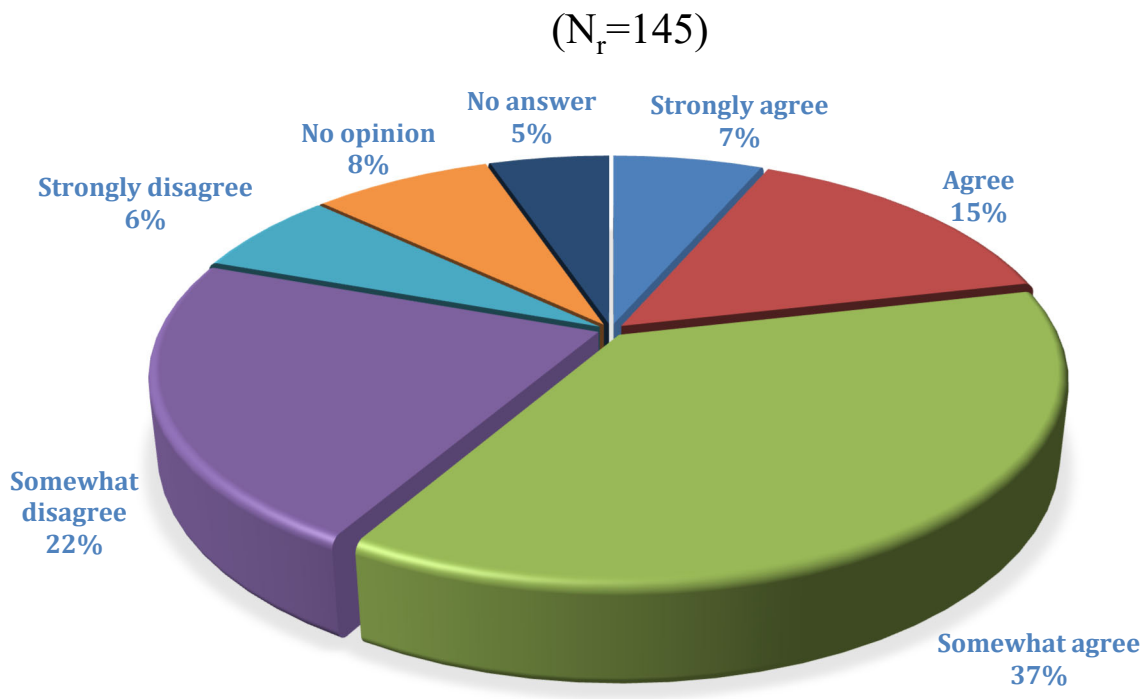
MC9. How Worried Are You About VR Negatively Impacting Your Learning or Grades?



Question MC10 looks into how students feel regarding the extent of VR implementation in teaching. Of the 145 responses, 59% of students feel that VR should be implemented across the board, with varying degrees of conviction, whereas 28% disagree to at least some extent. A full 13% (20 students) had no opinion or did not provide an answer (see Figure 7).

Figure 7

MC10. Should VR Be Applied in All Areas of Teaching??

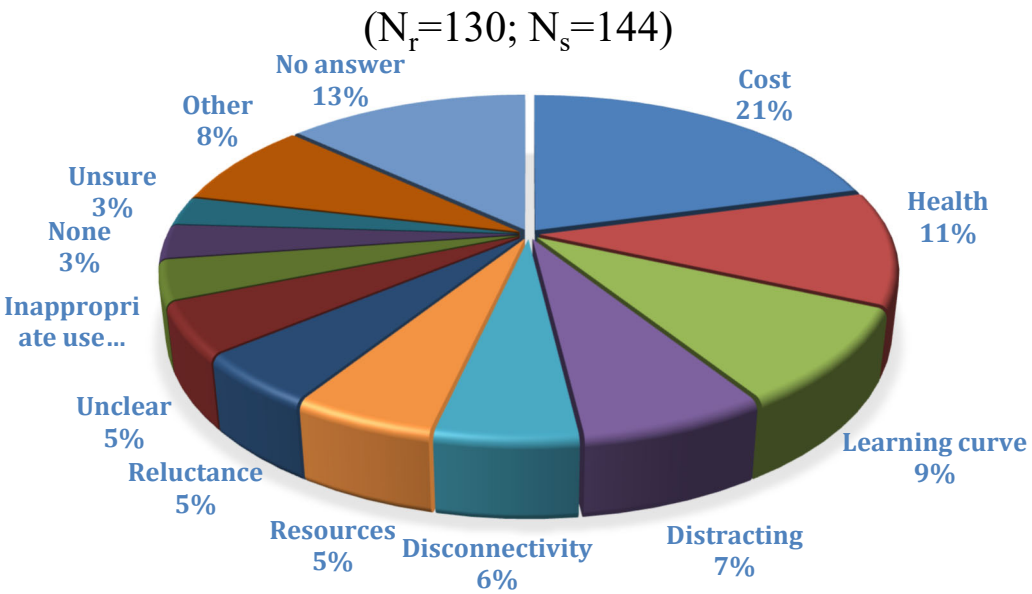


The next question (OE2) probed the respondents in terms of their primary concerns about expanding the use of VR in education and what they perceived to be the largest barriers toward such implementation. The verbatim answers to all free-form questions can be found in Appendix B. Our student pool of N = 154 turned into a respondent pool of N_r = 130 as 24 students abstained from providing an answer; most others had plenty to say though, and we still ended up with a respectable answer pool of N_s = 159 (as quite a few students provided more than one answer). To try to capture the essence of the often-lengthy answers, we made an effort to categorize them based on common threads. Perhaps it should not be a great surprise that the number one concern / perceived barrier was cost (30%). There was then a plethora of other

concerns that contained between 10-20 student respondents each (6-11%), divided among concerns about VR-usage related health consequences, learning curves to overcome, distraction stemming from VR use, and being disconnected from the social aspects of the classical school room learning. The next theme was based on 7-10 open ended answers each and covered such topics as resources (beyond just cost), reluctance among students and staff to change their standard learning methods, fear of inappropriate use of VR, plus some answers that did were either off-topic or so worded that they were unclear. Five to six respondents fell into the groups of unsure and none (no concerns or perceived barriers), and a total of 15 responses could not be combined into big enough subgroups and were thus lumped as "other." As mentioned previously in absolute numbers, 13% of the survey takers provided no answer (see Figure 8).

Figure 8

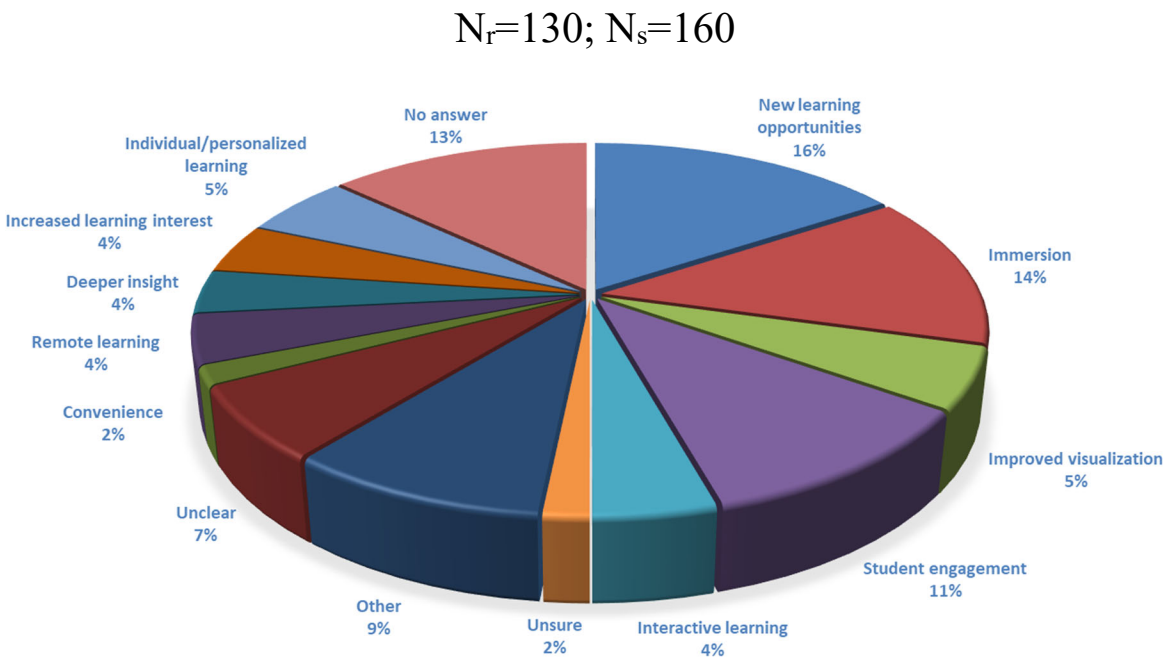
OE2. What Are Your Primary Concerns About Expanding the Use of VR in Education? What Do You Perceive to Be the Main Barriers to Implementation?



Turning to the open-ended answers of OE3, the respondents were asked what they felt would be the greatest benefits of increasing the use of VR in learning settings. We received $N_r = 130$ responses out of N = 154 survey takers, but as in the last question, quite a few students made more than one point, so our final answer pool was constituted of $N_s = 160$ answers from the open-ended questions. About 16% of students named new learning opportunities as the greatest benefit, followed by immersion (basically ability to perform realistic real-world tasks and experiments safely and with more information at hand (14%), improved student engagement (11%), with the rest a scattering of response categories each between 2-5% (3-10 students each) such as improved visualization, individual/personalized learning, increased learning interest, deeper insight, remote learning, interactive learning, and convenience. About 9% of responses were combined into the "other" category, 7% were unclear, and 13% of students provided no answer (see Figure 9).

Figure 9

OE3. What Do You Feel Would Be the Greatest Benefits of Increasing the Use of VR in Education?



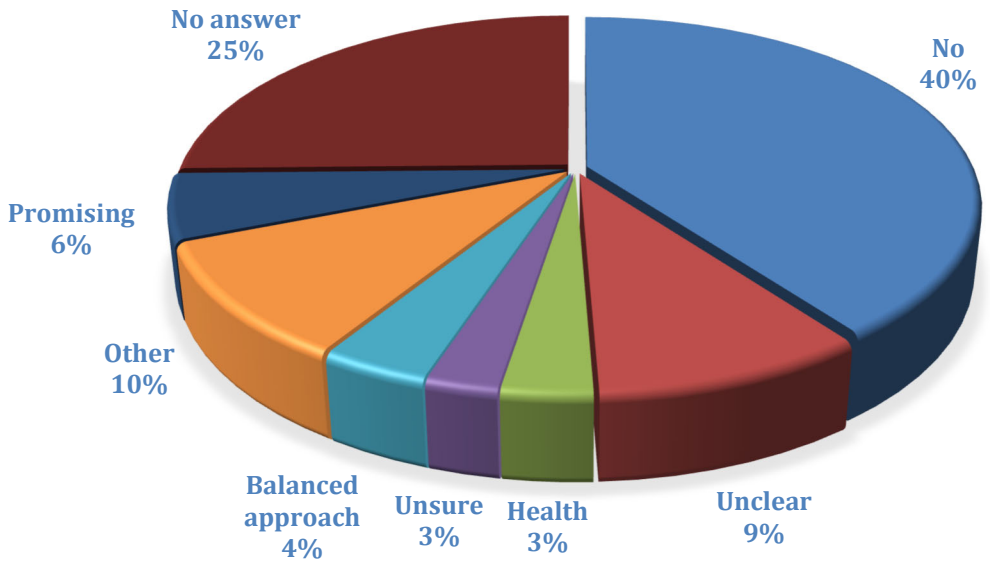
Survey question OE4 was phrased in terms of whether the respondents had any other concerns or thoughts about the topic of the survey. As expected, there are quite a few near-duplicate answers from the other open-ended answers by the 114 respondents (40 abstained from providing any opinions). Since several students had more than one question, we thus end up with a response pool of $N_s = 118$ grouped answers (by $N_r = 114$ students). As in the other open-ended answers, answers were grouped so that they are amenable for an overview and analysis. The first thing that we notice is what is commonly known as "survey fatigue." As in the past few questions, the number of respondents has rapidly been shrinking, but on top of that, in this case, the answers are often one-word answers. Not surprisingly then, the by far largest grouping of students is made up of the 40% who just state "no" when asked about other concerns. A full 9%

of the answers had to be labeled unclear because they were off track or confusing (e.g., as in previous questions, all N/A responses are grouped into "unclear" as it is impossible to surmise what the individual student means when they say N/A [not applicable]). About 6% take the opportunity to reinforce that they find the field promising, whereas 3-4% of N_s in other groups worry about health issues from VR use (dizziness, fatigue, situational awareness), advocate a balanced classroom teaching approach, or are unsure about the topic. The remaining 10% of the responses are combined into "other" as they did not fit with other themes (see Figure 10).

Figure 10

OE4. Do You Have Any Other Concerns or Thoughts About This Topic?

(N_r=114; N_s=118)



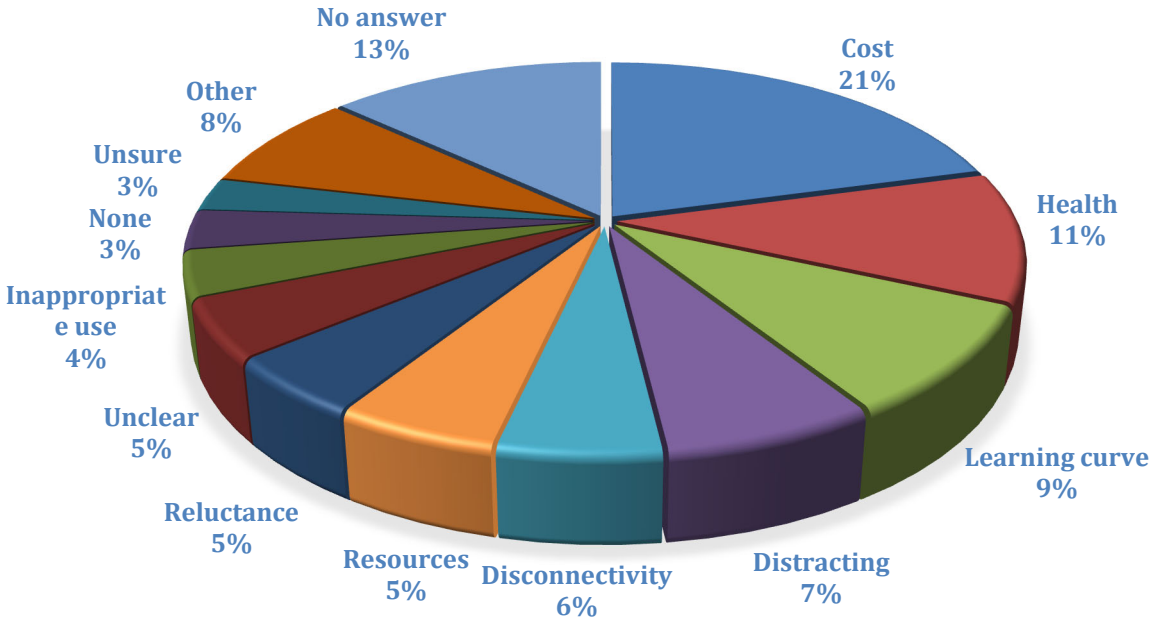
Research Question 2. What Realistic Suggestions do Students Have to Improve on VR in Educational Settings?

The survey questions that directly address this research questions are OE2 and OE5. The answers condensed from the open-ended answers in OE2 were considered previously in conjunction with the analysis pertinent to RQ1, and the findings are summarized below before moving on to OE5. This question queried the survey takers regarding their primary concerns about expanding the use of VR in education and what they perceived to be the largest barriers toward such implementation. The primary concern / perceived barrier was cost (30%), with VR-usage related health consequences, learning curves to overcome, distraction stemming from VR use, and social disconnection forming the next-largest subgroups with about 6-11% of the participants in each group. Following that, concerns/barriers stated included resources (beyond just cost), reluctance among students and staff to change their standard learning methods, and fear of inappropriate use of VR, and no concerns at all, about 3-5% each. The remainder were made up of other/unsure (11%) and 13% of the survey takers provided no answer (see Figure 11).

Figure 11

OE2. What Are Your Primary Concerns About Expanding the Use of VR in Education? What Do You Perceive to Be the Main Barriers to Implementation?

(N_r=130; N_s=144)



The final free-form question (OE5) asks the students if they have any recommendations to give teachers and others responsible for their schooling as relates to VR. Out of 154 respondents, 119 provided any response at all, with about a half-dozen providing more than one answer so that we end up with Nr = 119 respondents and a pool of Ns = 126 grouped answers, again with cautious grouping to the best of abilities.

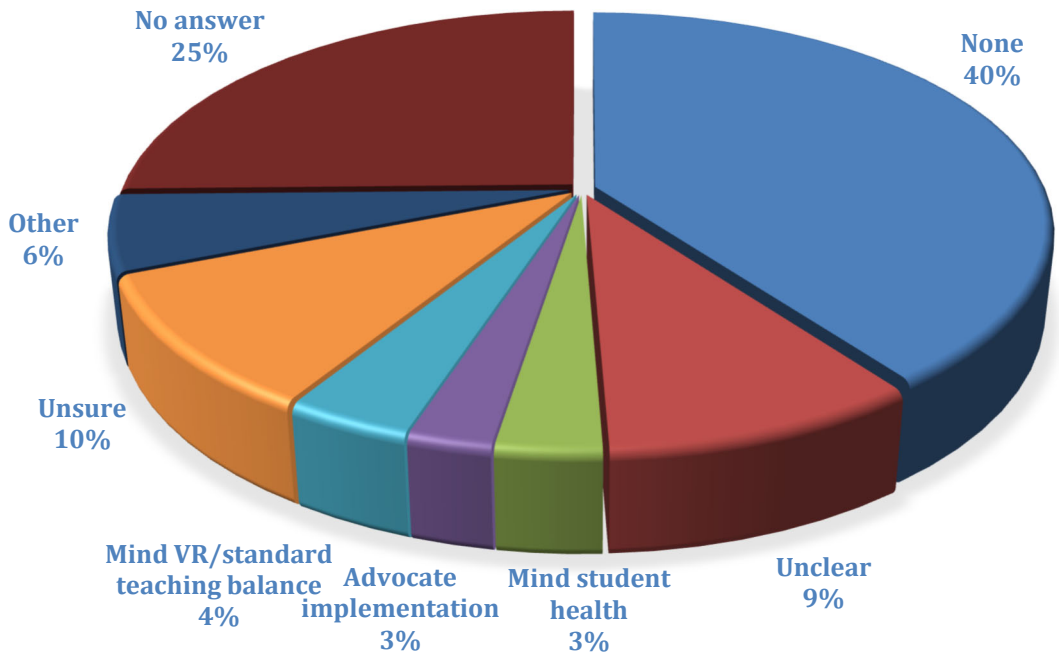
Again, we see evidence of "survey fatigue," not just from the many absent answers, but also from the many one-word answers. For example, a full 40% state "none" when asked if they have any advice for teachers and others responsible for schooling. About 9% provide unclear

answers (off-topic, N/A, etc.), 10% are unsure, and 3-4% each advise the teachers to keep in mind the VR/standard classroom teaching balance, watch out for student health issues, and take the opportunity to advocate more aggressive implementation of VR in education. About 6% of the answers were combined into the "other" group (see Figure 12).

Figure 12

OE5. What Recommendations Would You Give Teachers and Others Responsible for Your Schooling When it Comes to VR?

(N_r=119; N_s=126)

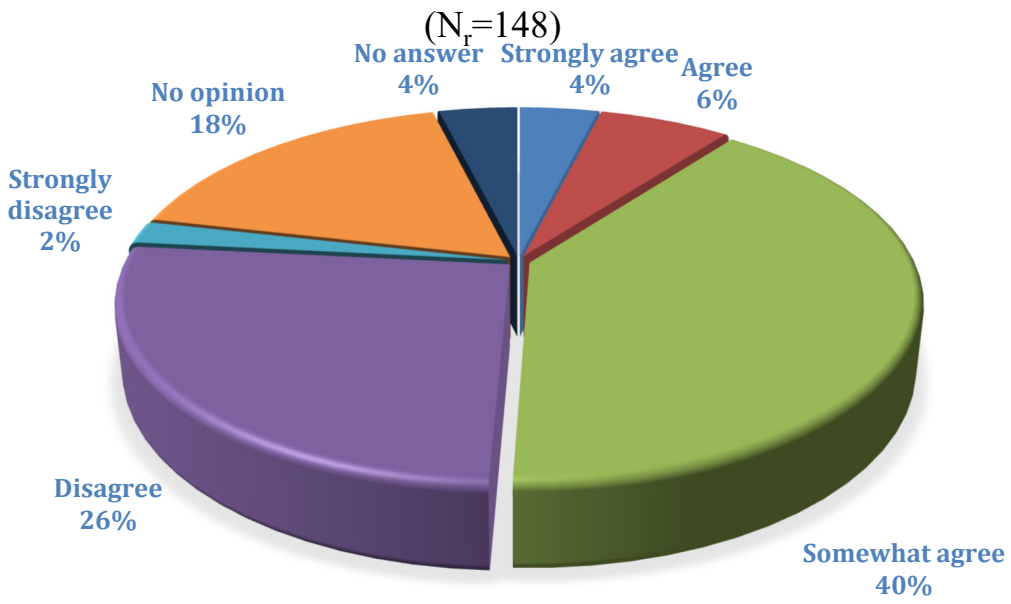


Research Question 3. What do you feel would be the greatest benefits of increasing the use of VR?

The survey questions that directly address this research questions are MC3, MC5, MC11, and MC12. In question MC5, the respondents are asked to look to the future a bit and state their interest in extending the use of VR in learning settings. The results here should be compared primarily with MC3, where students opine on how effectively VR is used presently in education. In MC3, half of the students (50%) agree that VR is used effectively, with varying conviction thereof; 22% either have no opinion or provide no answer, and 28% disagree. That indicates that more students (78) are satisfied with the level of VR used in education settings, than the 43 students that indicate the opposite, and 27 students have no opinion (see Figure 13).

Figure 13

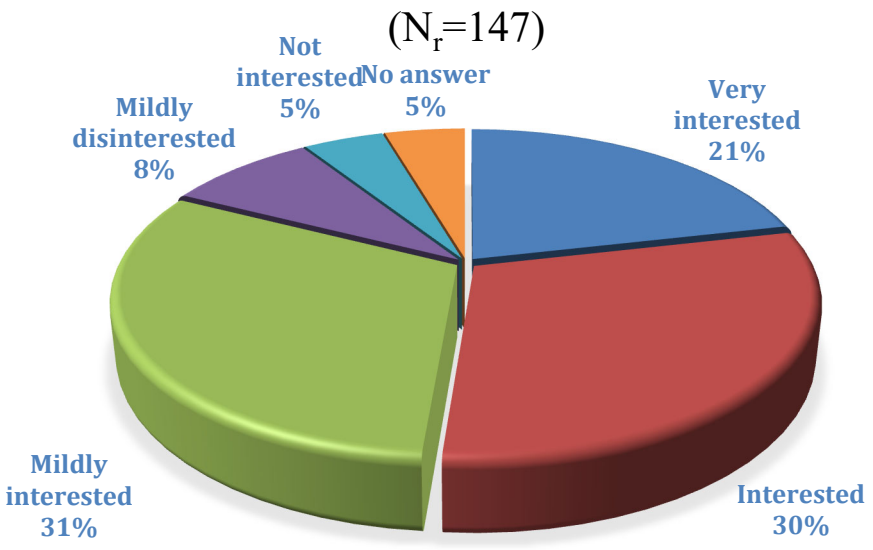
MC3. Is VR Used Effectively in Today's Education?



Turning to MC5, we find consistency; 51% of students are interested or very interested to expand the use of VR in education, to be contrasted against the 50% in MC3 that state that VR-based learning is effectively used today. Again, there is a bit more granularity here as regards the second half of the students. Almost a third (31%) state mild interest, whereas the remainder (18%) state mild disinterest, no interest, or provide no answer (see Figure 14).

Figure 14

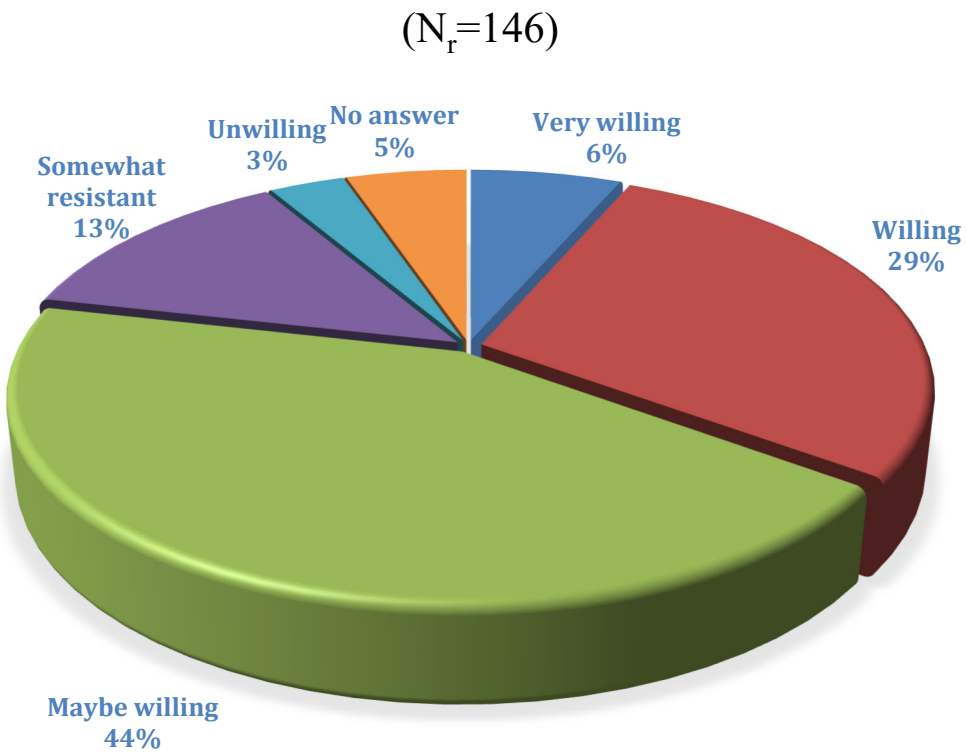
MC5. How Interested Are You in VR for Learning Purposes?



The intent with question MC11 is to get feedback on the willingness of students to adapt to radical education changes such as greater VR implementation. A full 79% of students express that they are maybe willing, willing, or very willing; A total of 16% are either somewhat resistant or unwilling to invest in this subject, and 5% provide no answer. Details can be found in Figure 15.

Figure 15

MC11. How Willing Would You Be to Commit to Radical Changes in Educational Methodology (e.g., the Use of VR)?

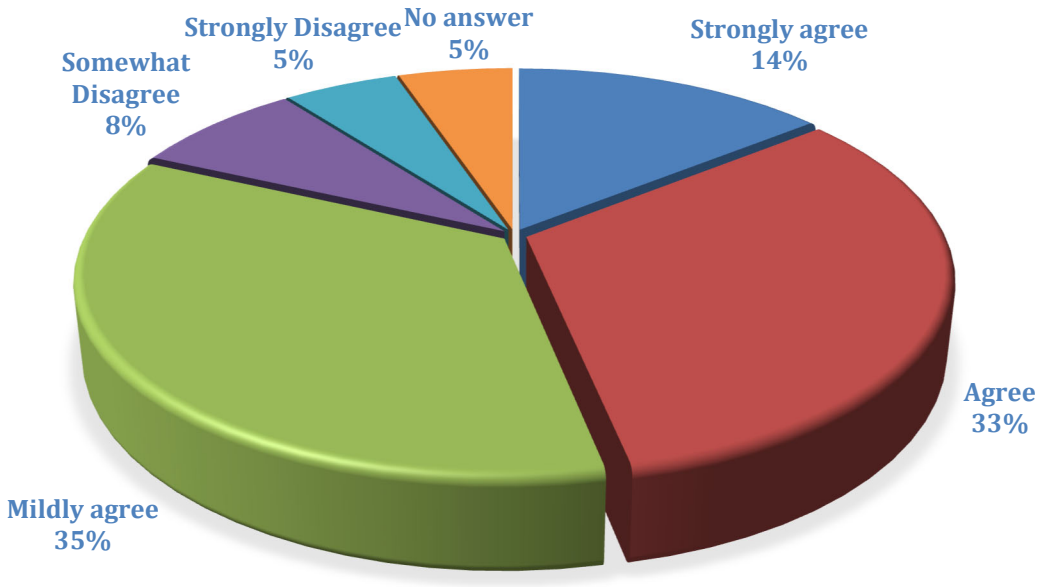


The final multiple-choice question (MC12) probes students' willingness to provide regular feedback in regard to the topic of improving the implementation of VR in their curriculum. Since 8 students abstained from answering, we base our conclusions on a student pool of $N_r = 146$. The majority (82%) agree mildly so, yes, or strongly in favor (35%, 33%, and 14%, respectively), whereas 13% either somewhat (8%) or strongly (5%) disagree; 5% of students provide no answer (see Figure 16).

Figure 16

MC12. I Would Be Willing to Provide Regular Feedback as Concerns VR Implementation

(N_r=146)

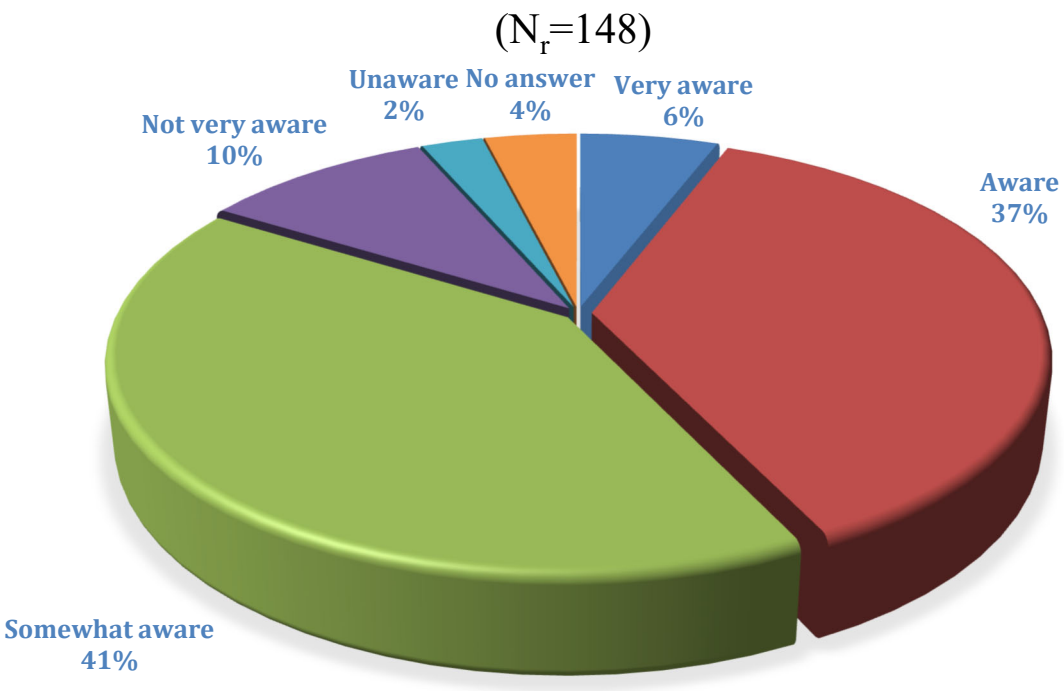


Research Question 4. Does Experience with VR in Gaming Environments Influence Perceptions About the Use of VR in Educational Settings?

The survey questions that address this research questions are MC2, MC3, MC4, MC10, and OE1. Question MC2 asks the respondents how aware they are of current use of VR in any applications. As one might expect, 84% answer yes (to various degrees – see pie chart distribution in Figure 17), 10% state that they are not very aware of it, 2% state no awareness, and 4% do not answer.

Figure 17

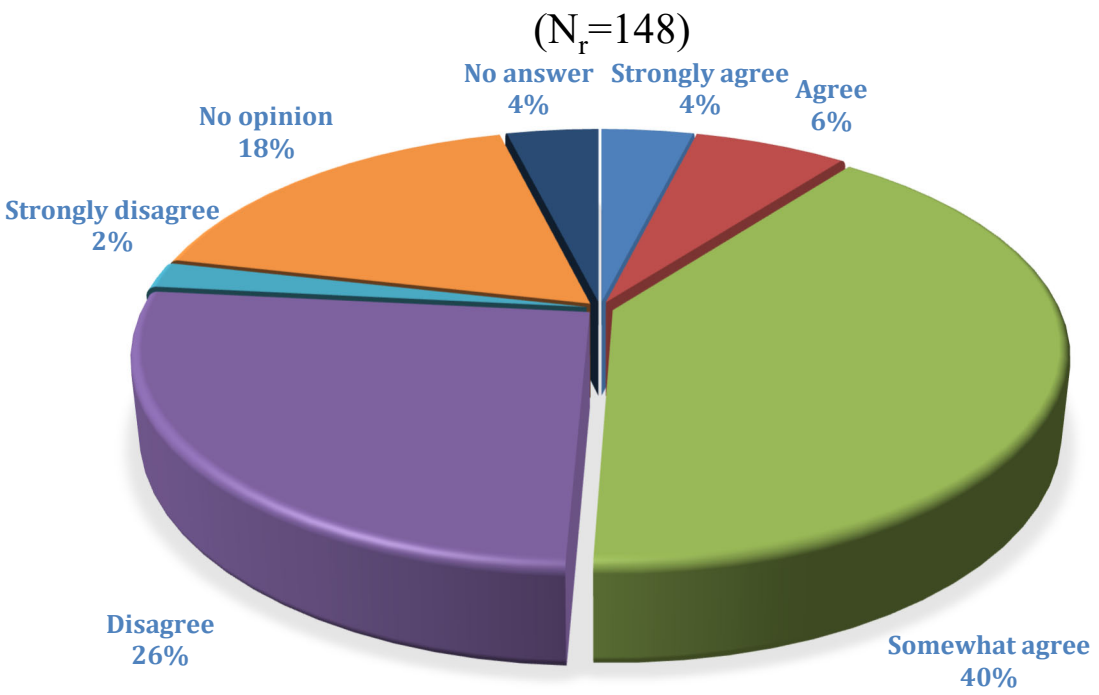
MC2. How Aware Are You of VR?



The following question (MC3) asks the participants in the survey whether they feel that VR is used effectively in today's education. The results were discussed in conjunction with RQ3, and here we recap what was found. Exactly half of the students agree that VR is effectively used, with varying conviction thereof, 22% either have no opinion or provide no answer, and 28% disagree. That indicates that 80% more students are satisfied than dissatisfied (78 vs. 43 survey takers in all) with the level of VR used in education settings, with 27 students voicing no opinion (see Figure 18).

Figure 18

MC3. Is VR Used Effectively in Today's Education?



Question MC4 asks the survey participants how experienced they are with any kind of VR in games, learning, etc. (see Figure 19). The data show that 42% of the participants have some to a lot of experience, 31% “very limited experience” and 23% “no experience” (23%). For comparison, we add the pie chart of question MC1 which is similar to MC4 but restricted to gaming alone (see Figure 20). More about this in the Chapter 5 discussion.

Figure 19

MC4. How Experienced Are You With Any Kind of VR in Games, Learning, etc.?

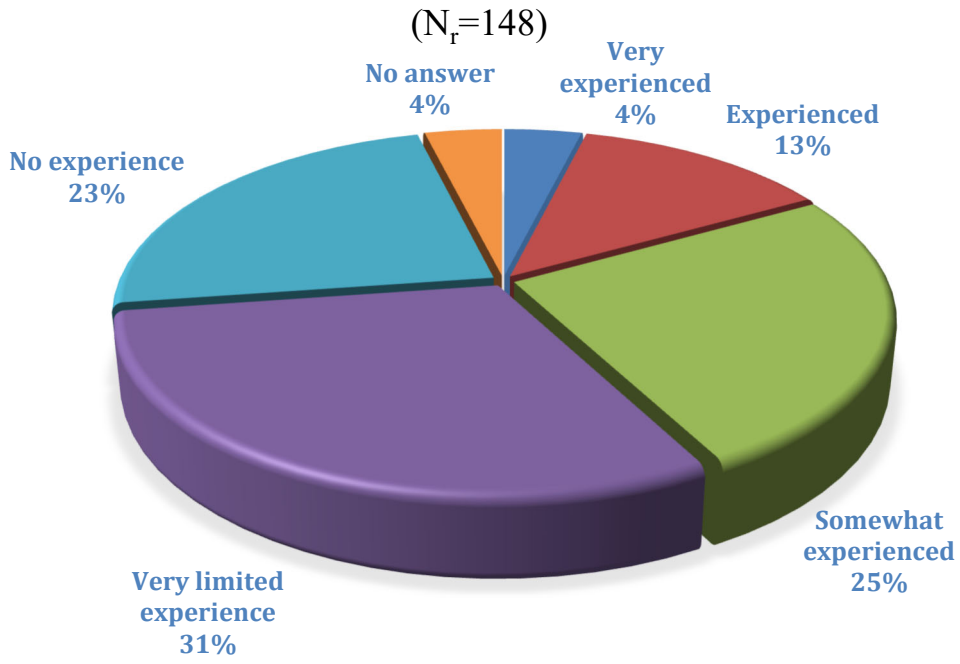
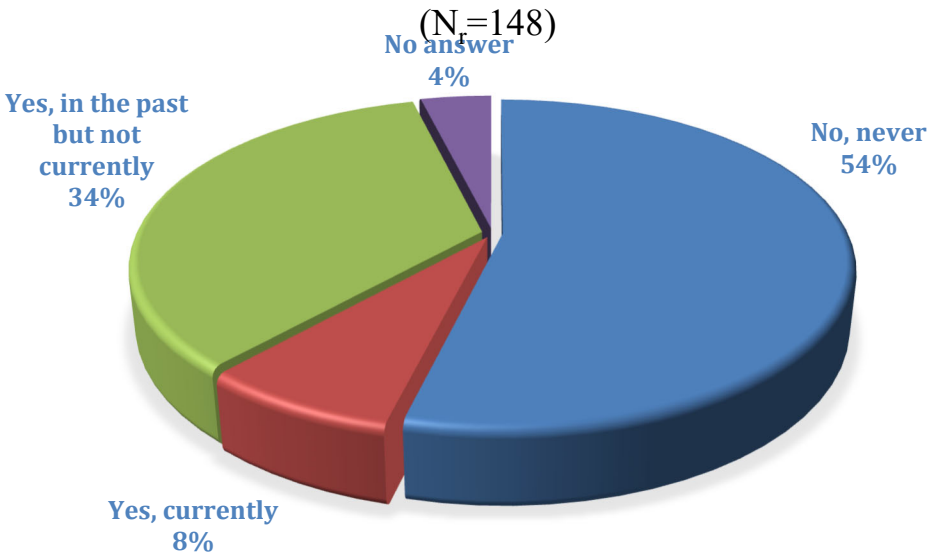


Figure 20

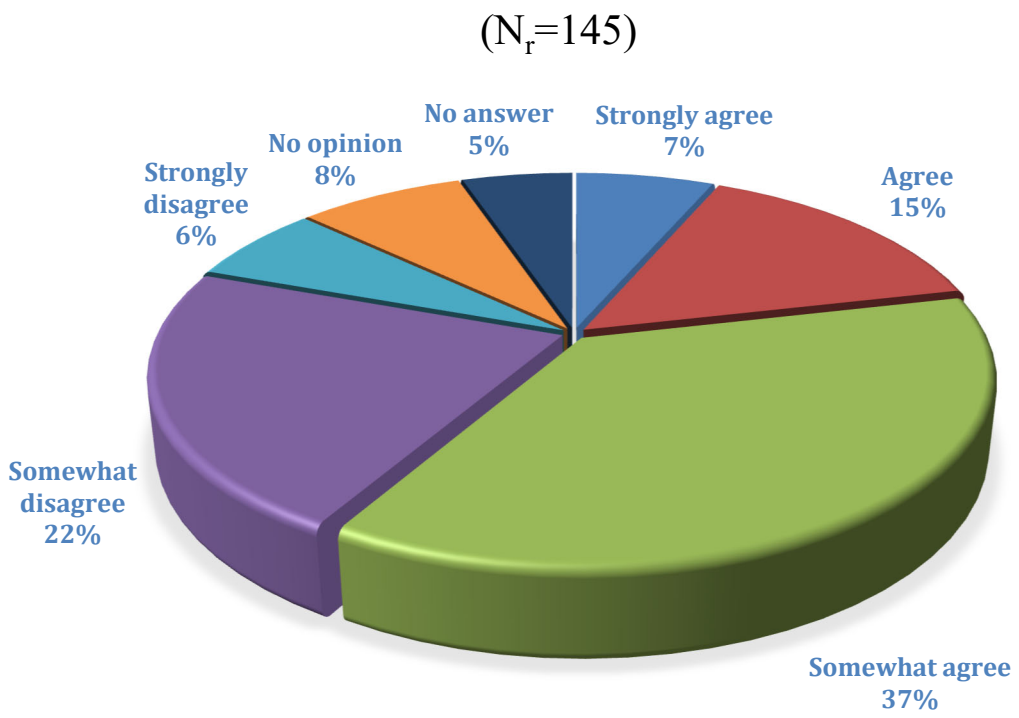
MC1. Do You Engage in Gaming That Uses Virtual Reality?



In question MC10, the survey participants are asked to weigh in on whether VR should be applied in all areas of teaching. Of the 145 responses, 59% of students feel that VR should be implemented across the board, with varying degrees of conviction, whereas 28% disagree to at least some extent. A full 13% (20 students) have no opinion or do not provide an answer (see Figure 21).

Figure 21

MC10. Do You Feel That VR Should Be Applied in All Areas of Teaching?

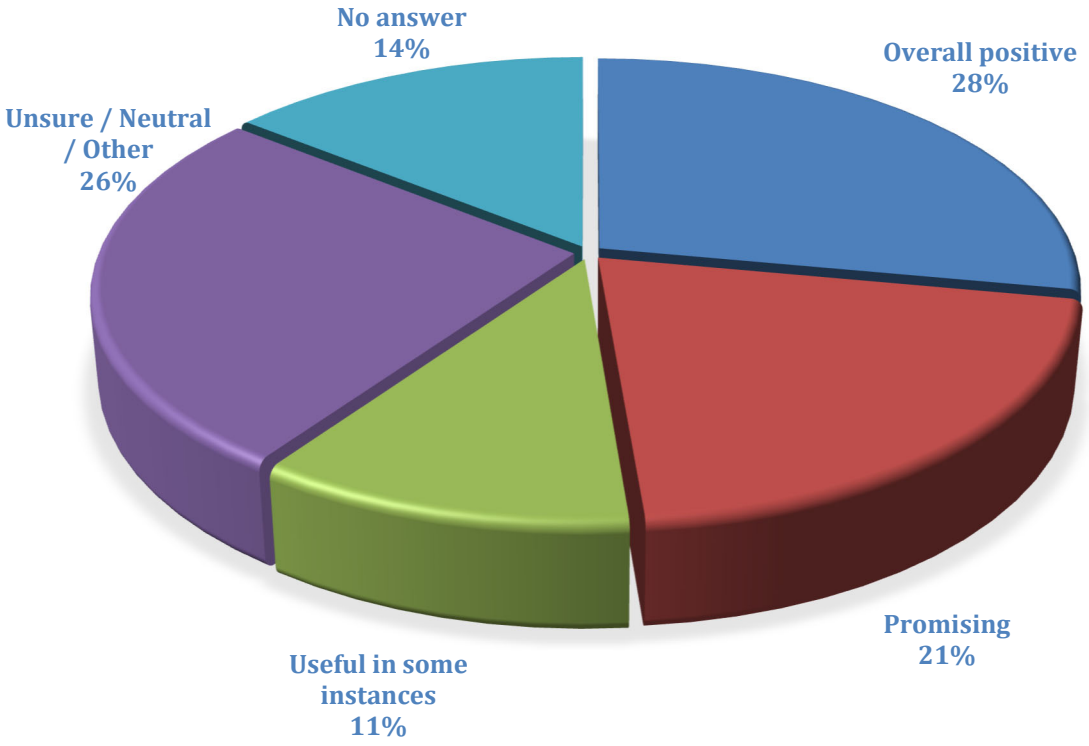


The first free-form question, OE1, as the other four, had to be carefully analyzed to find common threads that could be used to classify answers into several groups for visual presentation and more digestible analysis. As with all open-ended answers, they are reproduced (in random order) in Appendix B. Out of the 154 students, 132 provided an answer and 22 abstained. The classification effort shows that, overall, 28% students were positively inclined toward the current use of VR in learning environments, 21% felt that this was a promising development, with 11% stating that it might be useful in some instances. About a quarter of the respondents (26%) were either unsure, neutral, or had other thoughts, whereas 14% (22 survey participants) abstained from answering (see Figure 22).

Figure 22

OE1. Do You Feel That VR Should Be Applied in All Areas of Teaching?

(N_r=132)



Analysis of Additional Survey Questions

There were two survey questions related to the Covid-19 pandemic that did not map directly on to the research questions, but which are of interest to the topic of the use of VR in educational settings. MC7 and MC8 did not quite fit into any of the research question *per se*, but given how the Covid-19 pandemic has taken the world by a storm, infected and made ill at least 80M US residents, and killed over 980,000 people in this country alone (official data from Johns Hopkins University), it seemed pertinent to get the students view how VR may play into this, not

least with the learning from home mandates and potential for more pandemics. Multiple-choice answer questions MC7 and MC8 address this particular issue. MC7 asked the students "Has the Covid-19 pandemic changed the amount of VR technology you use?" The majority answer no, although it could be useful (41%), or just 'no' (40%). About a tenth (9%) feel that Covid has affected their use of VR (as can be seen from the free form answer further on, this means it has increased the use of VR), and the remainder (5%) provide no answer. MC8 is a follow-up question that looks more to the future and asks the participating student "Has the Covid-19 pandemic influenced your views about whether VR should be implemented more aggressively?". About a third (34%) state "no," 5% do not answer, and the remainder (61%) state "yes," to various degrees. This indicates that virtual learning (from home) that many students have been subjected to has indeed altered the perception of increased use of VR for educational purposes at a ratio of about 3:2 compared with those who feel that their views remain unchanged (see Figures 23 and 24).

Figure 23

MC7. Has the Covid-19 Pandemic Changed the Amount of VR Technology You Use?

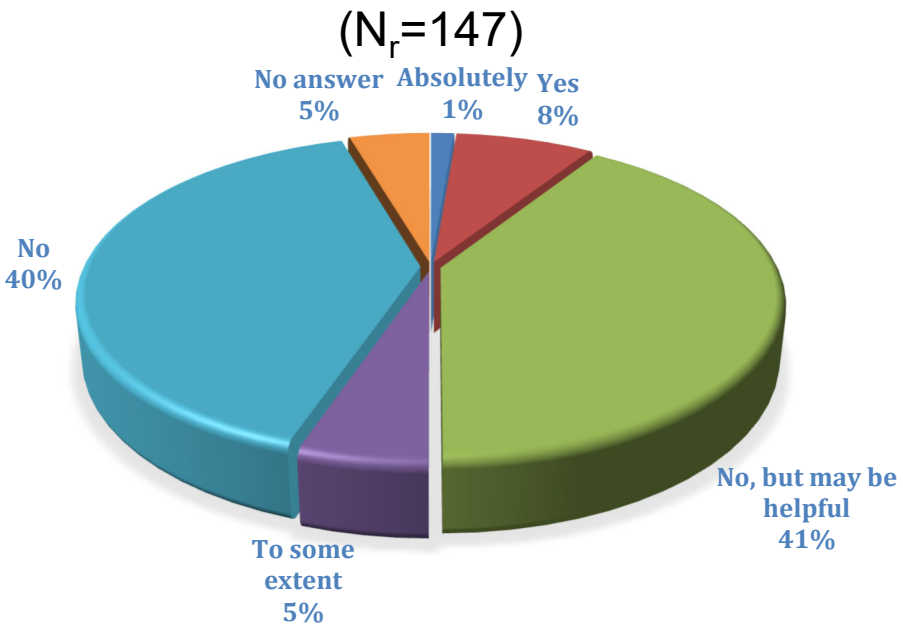
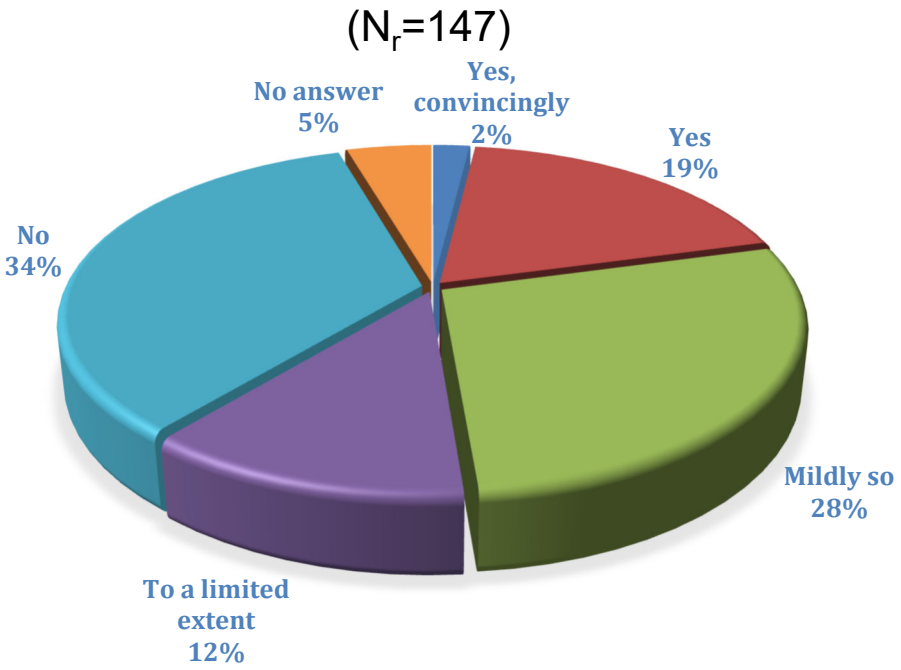


Figure 24

MC8. Has the Covid-19 Pandemic Influenced Your Views About Whether VR Should Be Implemented More Aggressively?



General Remarks on the Results

There are a few immediate conclusions to draw from the Results section above. First, the response rate is rather good, quite a bit higher than what is normally seen in similar surveys. Of the 18 multiple-choice questions, the response rate was >96%, and of the five free-form answers >81%. All students were assigned a unique multi-digit number so we could keep track of each answer, and when doing the statistical analysis each number had associated with it gender, race/ethnicity, age, major, etc. so that we could use the discriminators appropriately and with confidence that we were not mixing up students.

Another noteworthy observation is that there is notable, not exactly linear, but closely so, "survey fatigue" as the survey went on. The response rate from the N = 154 participants began

with $N_r = 154$ and then little by little drops off to a minimum of $N_r = 145$ in the multiple-choice questions. The free-form open-ended answers are widely scattered in terms of amount of feedback provided, yet are about 15%-units lower on average, with OE1 having $N_r = 132$, and OE2-OE5 having $N_r = 130$, 130, 119, and 114, respectively.

Note that first 6 questions (D1-D6) relate to factors like gender, race/ethnicity, age, major, etc. – all meant to be used as needed in the following statistical analyses to see what factors may be significant in terms of responses provided in MC1-MC12 (multiple-choice VR questions) and OE1-OE5 (free-form VR questions with open-ended answers).

Another point worth making is that in some instances, where an answer is difficult to understand, we have labeled it "unclear;" where it has just a letter or symbol, we have labelled is as No Answer, and have taken similar steps for other befuddling, truncated, or non-sensical answers. These are rather rare instances and should thus not affect any of the statistically significant conclusions inferred from the answers. We have also at time grouped very small number of answers into a larger group, with a label like, e.g., "Other" based on having to interpret answers that are not forced into exact molds, as well as to avoid answer groups of less than five responses, because they invalidate the statistical analysis. An explanation of this is provided at the beginning of this chapter.

CHAPTER 5: DISCUSSION

The purpose of this study was to examine student perceptions on how virtual reality tools can be used effectively to augment and assist student learning. We gather data through a reasonably large and diverse college student pool (N = 154) of voluntary participation and use standard analysis techniques including evaluating potential discriminants like gender and race ethnicity in a chi-square ($p < 0.05$) statistical post-analysis to draw fact-based conclusions that help our understanding and point to pertinent next steps. The main goal is thus to get a clear picture as to what VR experience students have in the past, currently, and how they feel it belongs in their worldview in the future, especially with regard to use of VR for learning purposes. Another goal was to gauge general attitudes, worries, perceived barriers, and levels of enthusiasm, commitment to implementation, and willingness to provide ongoing feedback to improve the process as it is being rolled out. A third goal was to determine whether there are any statistically significant differences (at the $p < 0.05$ confidence level) between genders and race/ethnicities, and potentially other discriminators in regard to the findings. Next, we discuss the findings report in Chapter 4, one research question at a time.

Research Question 1. What do Students in General Education Feel the Main Barriers and Worries for VR Adaptation Are in Terms of Improving Learning Effectiveness?

Looking at the preparedness of schools to further the use of VR in learning settings, almost 2/5 of the 154 students participating in the survey consider schools to have excellent resources, about a quarter feel that they have limited resources, and only about 1/10 are under the impression that there are no resources for this purpose. About a quarter have no opinion. So, in general, almost 2/3 feel that schools are indeed well-equipped to handle more aggressive use of

VR for learning purposes. Looking at the associated open-ended answers for further insight, it is a bit remarkable how many students quote cost as a very large barrier (almost a third), and also point out problems that increased VR can cause: health issues (nausea, dizziness, headaches, situational awareness, a feeling of disassociation), a taxing learning curve (both for teachers and students), and distraction from more conventional learning to name a few. While other authors have pointed out cost as a key barrier for VR implementation (e.g., Muscott & Gifford, 1994; Gregory et al., 2015), other authors barely if at all mention cost of implementing or expanding VR use in learning settings (e.g., Helsel, 1992; Martin & Taylor, 1997). From a positive standpoint, students appreciated the level of immersion that VR enables, the ability to safely carry out tasks and experiments that would have been difficult or unallowed outside of VR, the opportunity to receive inputs in such a way that would help them learn more and retain the information, as well as help with student engagement.

One of the potential worries addressed in the survey was how concerned students were about their grades if VR were to become a larger part of the learning curriculum. As it turns out, about 3/5 of students had no or minimal worries, about 1/5 had some/1-2 worries, and only one% were very worried. The no opinion/answer accounted for the final fifth. This is good news in the sense that the majority of the students are not really worried about their grades taking a tumble if more aggressive use of VR in learning is employed. We did not find much prior research specifically tied to the effect of increased use of VR to student grades. However, one study noted that use of VR reduced students' focus on grades with positive effects on motivation and learning (Psotka, 2013).

As one can imagine, some fields are more suitable for taking advantage of 3D VR technology than others, and that is true also withing the broad realm of subject areas that fall

under college learning. Thus, the question of how students feel when it comes to whether VR should be applied in all areas of teaching. Judging from the responses, about 3 in 5 students feel that VR should be implemented across the board, with varying degrees of conviction, whereas just under half as many (about 3 in 10) disagree with that notion to at least some extent. The rest of the survey takers either state no opinion or abstain from answering. None of this is terribly surprising. There are plenty of learning subjects that could and presumably should benefit from more aggressive use of VR, just as there are some subjects where VR is more suitable than others (e.g., studying anatomy vs. studying book-keeping). In general, as is evident in the open-ended answers pertaining to this Research Question, many students call for a balanced classroom teaching approach, quite a few are unsure because they do not know enough about the topic, or just have not thought about it that much. While a number of studies indirectly appear to advocate a balanced approach to standard teaching and the more novel VR approach, some mention it explicitly, albeit in a generic form without data, as far as we have found (Barko & Sandler, 2013; Radianti et al., 2020).

Research Question 2: What Realistic Suggestions do Students Have to Improve on VR in Educational Settings?

The main take-away from the students' open-ended answers addressing this topic is that funds and other resources must be available to further the use of VR in learning settings. Another concern that the students wanted addressed related to what prolonged use of VR could do to your health – dizziness, nausea, spatial awareness, and headaches in the short term, with disconnection, potential for overuse or misuse, and potential negative social aspects in the longer term. Several also voiced concerns over teachers losing their jobs and what parents would think about such a change, as well as the potential/likely reluctance from both staff and students to

change the status quo in terms of learning methods. As previously, many students had not thought about it sufficiently as they took the survey, and/or just did not know enough about it and related items to be able to draw any conclusions, thus staying silent or stating that they were unsure. We have already discussed the issue of cost that seems to linger in students' minds and mentioned prior research related to that, (see above). Dizziness, double-vision, nausea, headaches, vision issues, and other short-term effects students experience, especially when new to VR, have been reported previously (Johnson, 2018; Winn & Jackson, 1999). This something that VR equipment manufacturers are well aware of and have been addressing with each new iterations, and NASA has for a long time been dealing with similar issues and has a big base of knowledge in that area that can be tapped; luckily this seems to affect only about 5% of students (Winn & Jackson, 1999), but should be taken seriously nonetheless, and vigilance is in order to quickly stop a VR session should a teacher notice any malaises.

Research Questions 3: Would Students Be Open to Commit to Radical Changes in Educational Methodology, and Provide Regular Feedback to Aid Improvements?

As we found out from the MC3 and MC5 questions, almost exactly half of the students thought that VR is currently being used effectively in schooling settings and equally many felt interested or very interested to further expand the use of VR for learning purposes. The figures in Chapter 4 provide more granularity, but these are the main trends. On top of that, it is the males that are driving this more than females – a χ^2 analysis shows ($p < 0.05$) that males are to a statistically significant degree more inclined than females to further the use of VR in learning environments. The p value is in fact the smallest one in the study, 0.027, meaning that this statement holds true to an even more stringent confidence parameter.

RQ3 represents a key question in this survey in that it looks for just how committed students are to radical changes in the classroom, including more aggressive use of VR tools and methodology. It further seeks to discover how dedicated and committed the students are not just to seeing this through, but also by being an active part of the system and roll-out by timely ongoing feedback. The multiple-choice question MC11 directly addresses the first part of this question. About 4/5 of the survey participants expressed willingness to adapt to radical education changes including greater VR adaptation. That is a predominant majority that speaks well to the attitude of students in terms of aggressively expanding the utilization of virtual reality tools in learning environments. Also here, according to the χ^2 analysis, gender is a discriminator: At a level of $p = 0.053$, males are more committed to radical changes, such as using VR, in learning environments.

An important part of any non-trivial initiative, especially a radical or aggressive one, is to closely monitor its progress. That includes timely feedback from students as well. Hence, the next survey question is very important in assessing just how willing the students are to be part of the continual active-feedback system in an aggressive VR implementation. Again, we face good news here: Just a bit over 4/5 of the survey takers agree (to varying extent) to provide active feedback in such circumstances. Interestingly, according to the statistical χ^2 analysis, the combined group of Hispanic/Latinos, Black/African Americans, Pacific Islanders, and those of mixed race seem more inclined to provide ongoing feedback regarding the implementation of VR in the curriculum than do either Asians or White (non-Hispanics) [$p < 0.057$]. Most previous studies we have encountered view VR as a progressively introduced technology, although some argue that it cannot be effective unless a coordinated larger-scale effort is employed (Psotka, 2013). While there is a lot of research published around feedback, it often concerns haptic

feedback from the VR system to the user, and frequently also feedback from a third-party observer in teacher learning sessions using VR. On the other hand, several studies focus in on student feedback used to improve the VR learning experience, which is addressed in this study in general and this RQ in particular. Isenhour et al. (2000) stated that focus on the collaborative learning process requires ongoing student feedback (as well as awareness and iterative evaluations. They also advocate more training for teachers and students alike in order to provide more salient feedback to refine existing features and design new ones (Isenhour et al., 2000). Gregory et al. (2015) reported overall positive feedback from students using VR compared to standard practices, similar net outcomes, at a net cost saving (the students were all physicians).

Research Question 4. Does Experience With VR in Gaming Environments Influence Perceptions About the Use of VR in Educational Settings?

The responses to question MC2 show that, not unexpectedly since students this age have had much greater exposure to digital devices, the overwhelming majority (>4/5) state that they are aware or somewhat aware of virtual reality applications, with another 10% stating not to be very aware of VR; the remaining 6% either do not answer or are unaware of VR (as hard as the latter is to imagine really).

In terms of how effectively VR is used in education today (MC3), almost exactly half of the students find that it is indeed used effectively as is (at varying degrees of conviction), 1/5 state no opinion, and a bit over 1/4 disagree. Hence it appears that the ratio of students that agree to disagree is about 2:1. Browsing through the open-ended questions reveals that a good part of this seems to be due to a good number of students who have seen VR used in education and feel that what they have seen is more of its potential than its effective use.

Question MC4 asks the survey participants how experienced they are with any kind of VR in games, learning, etc. This is technically almost a control question, to be compared with MC1 which basically asks the same, but specifically with regard to gaming (the pie chart for MC1 is included below the one for MC4). This broader question shows that 42% of the participants state that they have some to a lot of experience, which is consistent with the exact same percentage in MC1. Here, however, there is a bit more resolution when it comes to the less experienced students. In MC1 54% indicated that they had no prior VR experience, and in this question the "very limited experience" (31%) and "no experience" (23%) subgroups add up to exactly the same percentage again (54%). This is a strong indicator of consistency in answering similar questions reproducibly, which lends a lot of credibility to the answers, as well as provides support for the presupposition that most students' first VR experience comes from gaming.

In question MC10, the survey participants are asked to weigh in on whether VR should be applied in all areas of teaching. As reported under Research Question 1, about 3 in 5 students feel that VR implementation should occur across the board, with varying degrees of support behind that (somewhat agree, agree, strongly agree), whereas about half as many (about 3 in 10) disagree with that notion to at least some extent (somewhat disagree, strongly disagree). The rest of the survey takers either state no opinion or abstain from answering. Contemplating this, both sides make sense. VR could probably have a positive impact if not across the whole board, then at least much of it, but one can also imagine instances and majors where it would not (e.g., accounting, tax preparation, stock projections, etc.).

Looking at the first free-form question, "What are your current thoughts about the use of VR in education?", some carefully chosen classification and grouping had to be done to find trends from the numerous (lengthy yet very informative) open-ended answers. In general, just

about half felt positively inclined towards use of VR or that this was a promising development in learning environments. A quarter were unsure, neutral, or had other thoughts, and 1 in 7 did not provide an answer. It was interesting to note that quite a few respondents felt that VR was "cool" but not important – presumably their impression mainly from a gaming perspective, but impossible to really tell. Many students also commented that they had never seen VR used in education, which begs the question of why the majority felt that it was effectively used for that very purpose in one of the multiple-choice questions. Numerous previous studies have addressed the issue of VR effectiveness compared with standard teaching methods. There is no doubt that the military has been a great test table, a pioneer in the field, and overall, a great success story for safely using technology to train for the real world (e.g., Psotka, 2013). Baxter and Hainey (2019) performed a study in many ways similar in structure as this one (surveys with both close and open-ended answers, ordinal tests like Mann-Whitney and Kruskal-Wallis, etc.), and found that a full 89% of the respondents (N = 100) stated that they strongly agreed or agreed that virtual reality was an innovative application that had pedagogical benefits where, which is on the same order as this study finds in a similar question (82% of students in this study are interested to some degree in further/extended use of VR for general education purposes). The study by Baxter and Hainey also found the same significant gender difference as was found in this study – males are considerably more interested in the future and expansion of VR than females (Baxter & Hainey, 2019).

Implications for Practice

The study finds that, in general, males tend to have more VR background and are often keener on exploring it further. This is useful for other practitioners in terms of being aware of this and taking extra measures to ensure that females are as motivated as well throughout any VR

implementations and pilot programs. Moreover, the findings on students' willingness to provide feedback should be useful in helping prepare teachers to encourage feedback throughout the classes and explain why feedback is so important from the get-go.

In addition, although the answers about the impact of Covid-19 on the use of VR were mixed, a general sense emerged, particularly from the follow-up question regarding whether Covid-19 had changed students' perceptions about the use of VR in learning environments, that remote learning, in particular, may be something that lends itself particularly well to the expanded use of VR for learning purposes. The study can hopefully also be used as a basis for continued research that can fork off in different areas for other teachers interested in using VR effectively in schools and other institutions.

Another finding of the study was students' perception of what expanded use of VR might do to their grades. This information is analyzed in the multiple-choice section and is addressed by several students in the open-ended question section as well. Such information should be valuable to teachers in helping prepare and brief students before they delve into further VR-based studies.

The fact that prior studies have pointed out various malaises that may affect a relatively small percentage of VR users (see above under RQ2), and is supported by this study, as well as quantified in more detail, should help teachers prepare for such occurrences. For one, a thorough briefing should be done about what may happen, and how to stop it. Moreover, teachers should remain diligent and if they cannot always be present, ensure that a responsible party is and knows what to do in such instances.

Limitations of Study

This study had a number of limitations (see Section 3), as is ordinarily the case. For one, the survey had a couple of questions that in hindsight were leading, and thus carried a potential to introduce bias. A couple of the multiple-choice questions were also not written well, allowing students to "color outside the lines" by providing confusing answers to what, if asked correctly, should not have been a problem at all. This was resolved by not counting certain responses in certain cases (e.g., answering Muslim is neither a race nor an ethnicity, but rather a religious following – Muslims live all over the world. The survey was also limited to one particular school and was thus unlikely representative of a larger cross-section of California, let alone the United States. Furthermore, the study was voluntary, which on one hand has several positive aspects to it, but can also potentially lead to some bias, as in that there is a tendency for people who have stronger (and even pre-formed) opinions to step forward, meaning that others who may had other insight did not participate because of their nature to speak up only when asked to. Moreover, while the number of participants was respectable, and the overall response rate high (on average >90%), even though many minorities were represented, in absolute numbers they often fell below the threshold required to do a meaningful statistical analysis and combining small subgroups became the only way most times to be able to carry on with the statistical analysis. The sample size thus leads to a lack of overall generalizations that can be formed from the study. There are clearly a number of additional limitations, many that are not readily apparent and do not spring to mind, but we have tried our best to keep the study focused and manageable and squeeze out as much info as we could from the responses.

Future Research

The immediate and most exciting future research that comes to mind is to pilot a trial using what has been learned in this study. Specifically, it would be rather beneficial to pilot a more aggressive use of VR in education with a suitable sample size of students, initially volunteers only, in order to build momentum and to compare the findings to the survey results. It would ideally also be a group that has a number of students that is sufficient to evaluate the results with similar statistical methods as employed in this study (e.g., five or more students of each gender, race/ethnicity, major, etc.). During such a study it would also be very valuable to receive continual feedback in an open-ended manner both from participants and non-participants to gauge any potential social networking, perceptions, feelings, and/or group mentality that may arise. This would be useful in structuring a larger study down the line in the sense of being aware of potential early pitfalls to give the practical implementation part of the study a better chance to work on its own merits, without unnecessary distractions. This kind of empirical studies in the classroom should provide priceless insight into the dynamics of introducing a new way of learning and the data needed to come to statistically significant conclusions. The origins of this idea for a study started with evaluating the effectiveness of utilizing VR for second language learning, and while this study has grown in scope to be quite a bit broader than that, it was necessary to do so to get a good feel for the overall situation before narrowing down to language learning in particular. Hence, if such a pilot study could be used to focus on using VR to assist students in learning a second language, that would personally be an ideal new project to pursue. This sort of research could help to ensure that there is a control group to compare with and include other classes, and, if possible, schools to provide sufficient numbers of participants

in order to have robust statistics, and the metrics could include grade difference, student engagement, student satisfaction, and student feedback.

Conclusions

In conclusion, we have developed a plan to find out more about students' past, present, and future views toward the use of VR, in particular in learning sets. We have carried out that plan accordingly, gathered a large amount of data, ensured all privacy laws in doing so, and spent considerable time using various math and statistical tools looking for themes that arise, including any potentially discriminating factors such as the effect of gender or race. We believe to have revealed some interesting trends that can be used to streamline future research, as well as any pilot studies carried out in a controlled manner to gain real-world insight into how VR complements standard learning methods.

Looking beyond this study, from every arguable aspect, it appears that studies of the use of Virtual Reality in education are more relevant now than ever. Not only has the field of VR use in many different areas grown rapidly over the past several decades, fueled by tremendous advances in computer power, artificial intelligence, an exponential use of hand-held devices and ever-increasingly more advanced optics, haptic feedback systems, etc., but this is also the first time for many millions of people to be forced to study from afar due to the Covid-19 pandemic. While the future is always uncertain, it is wise to look back at history and note that it has a tendence to repeat itself. Viruses that can decimate huge populations are cyclic; the economy is cyclic; the world is ever shrinking as we can travel farther, faster, and cheaper than ever. It is next to impossible to live in a bubble these days – we are always immersed in and electronically connected, day and night, across the globe, and that is unlikely to change. Hence, there is no better or more urgent time than now to invest into research into how VR technology can be used

to help students continue learning at a reasonable pace, and even accelerate that in the face of unprecedented and uncertain global events.

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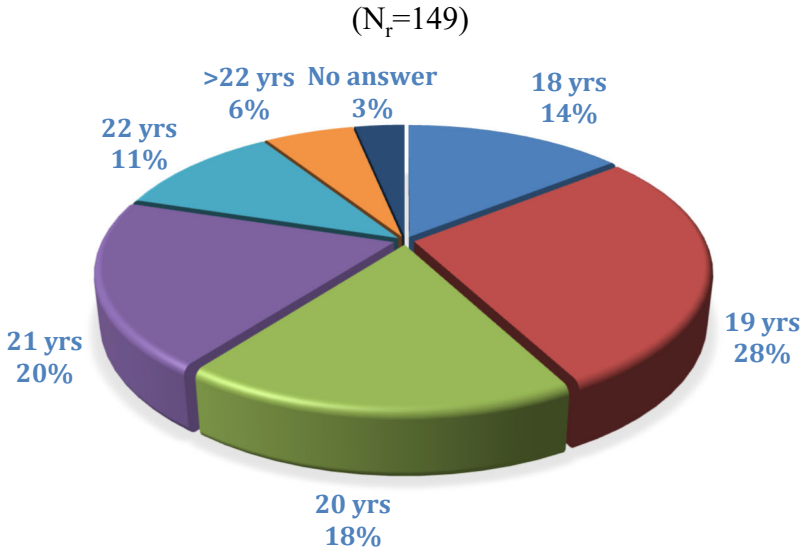
Appendix A. Demographics

Figure 25

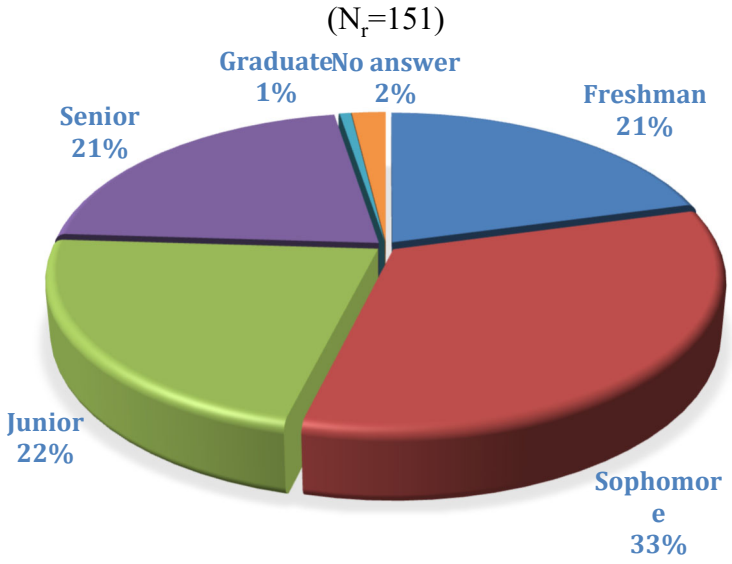
Student Age



Note. D1. How old are you?

Figure 26

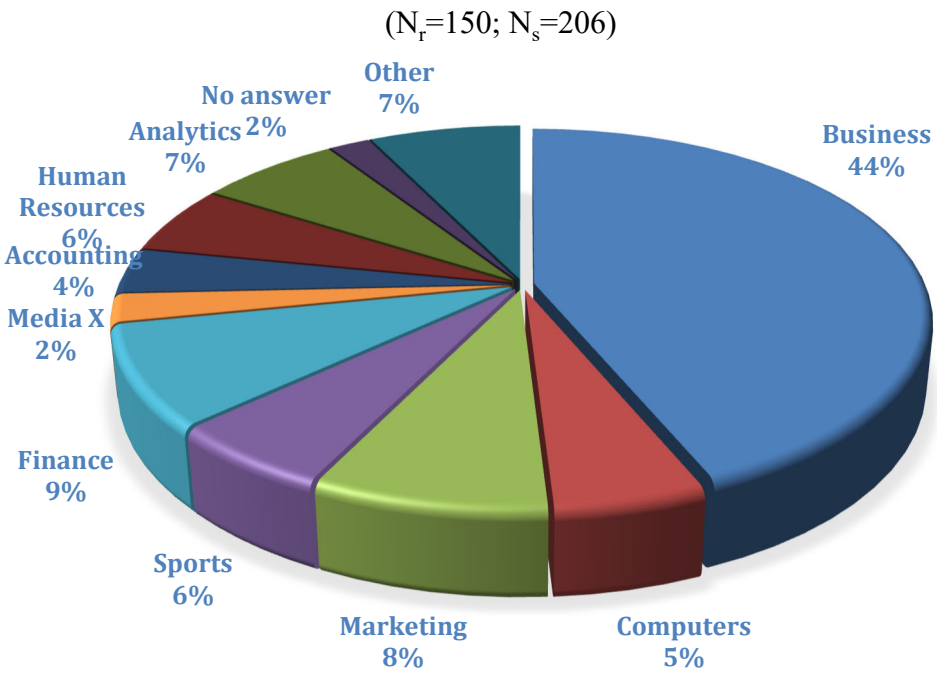
Enrollment Status



Note. D2. What is your current enrollment status?

Figure 27

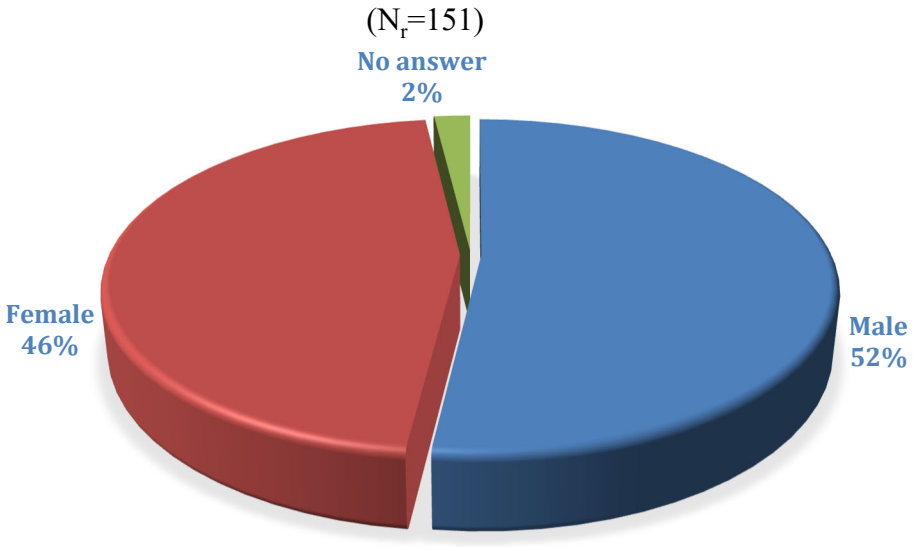
Major



Note. D3. What is your current major?

Figure 28

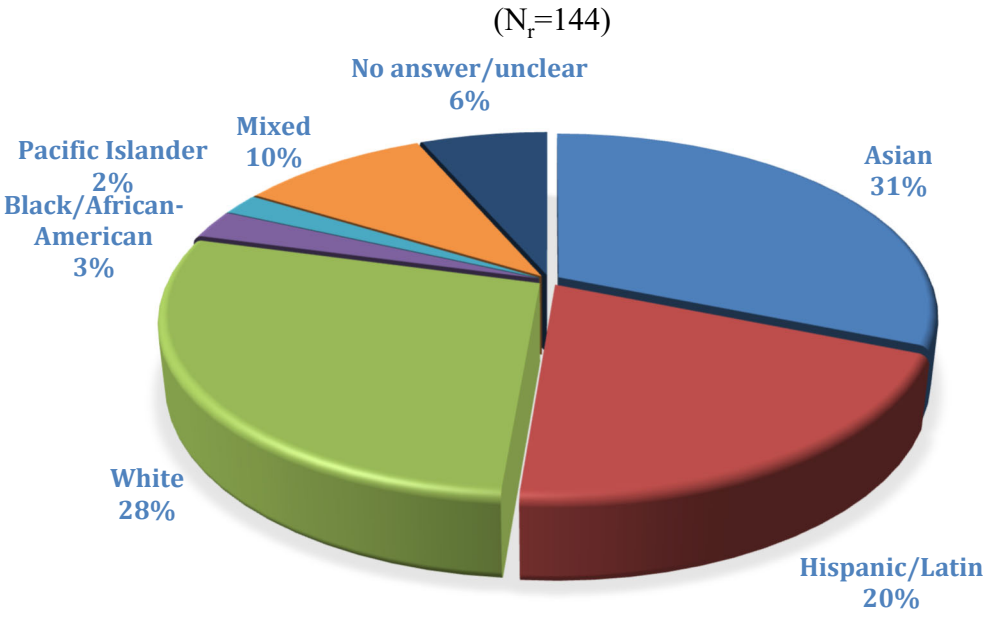
Gender



Note. D4. Which gender do you most identify with?

Figure 29

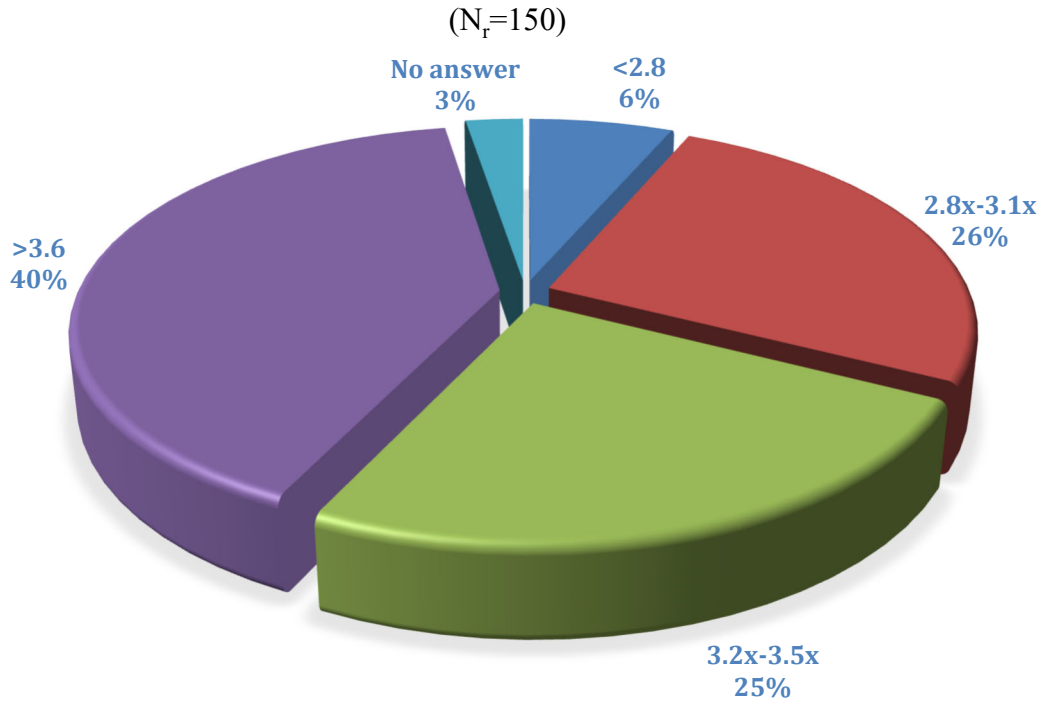
Race/Ethnicity



Note. D5. What is your race/ethnicity?

Figure 30

GPA



Note. D6. What is your current GPA?

Appendix B. Open-Ended Answers

In the following, answers are reported in randomized order, the verbatim answers to the five free-form questions.

OE1. What are Your Current Thoughts About the Use of VR in Education?

- I have no thoughts
- Due to my lack of awareness and knowledge on the subject, I would say that there needs to be more research done on whether or not it is as effective or supplemental for in-person learning. Even if it is proven that it is a reasonable way to earn an education, I do wonder about the negative impacts it could have on one's mental health (due to a change of in-person/human interaction) and one's physical health (i.e. their eyes).
- It is a rather conflicting question, it has its benefits but it also undermines those who struggle.
- I have no thoughts
- I think this is an area that needs more experimentation and study to see if VR can improve learning
- Astonished
- I really like where it is and I would like to see more.
- I think it will be useful
- It would be cool, but not important.
- I don’t much thoughts about however would be interested in learning how VR could be implemented in my educational career and if it would make learning easier.
- The use of VR would be really cool to see in education.
- i don't see how it can really help but I haven't really thought about it before.
- There has to be some limit to what can be used in VR. Nothing can replace the in-person things.
- Great for job training
- I didn't know that VR was thought of to be used in education. It sounds interesting to implement it and see how it either helps or makes it difficult for students to adapt to like anything else.
- I have not seen VR used in education, but I am willing to make changes and implement it in mine.
- I am unclear on where and how it could be used.
- VR education is definitely a new topic, but I am pretty intrigued on the overall application of VR as well as how it can change the educational environment.
- VR is helpful if resources are limited. I understand the use of VR if classes are unable to travel or afford trips. It also seems to be helpful for visualization of ideas that may be difficult to only convey through words.
- it would be interesting in how they can integrate it in education.
- I think VR has a lot potential to improve education.

- I didn't know schools were applying the use of VR's in education. This topic is new to me. I can see how it can help with education but there's also a negative aspect to it.
- I think that is is a cool idea... I believe it will allow history teachers to simulate events in history for people to get a physical experience.
- I do see a potential in using VR in education. However, by nature of the technology, I believe that virtual reality is a poor substitute to in person interactions. Thus, if VR were to be implemented, I would suggest it be gradually introduced.
- It could be effective with a balance. There is a lot of screen time these days already with zoom and digital note taking but if there was a balance I think it would be fun and engaging for students
- I've never seen it happen but it would be very interesting and I could definitely see how it could be useful.
- I feel that its a good idea but not for everyone
- I have only used VR in a recreational setting.
- Don't really know much about VR and how it would be utilized in education
- I can see how VR can help the education, but it's a lot of money and it's easy to make people feel dizzy.
- I have seen VR is used more as a tool to show what it can do in education rather than actually using it to its fullest potential.
- I honestly have not seen many instances of the use of VR in education. I could see it being useful for kinesthetic learners and people who cannot sit and pay attention during a full class period.
- I think that for majors that require hands on experience such as engineering, biology, or chemistry majors would benefit greatly from the use of VR
- interesting depending on how its used
- For certain subjects and courses, the use of VR can allow students to observe and analyse the scenario better as it will allow them as if they are actually present in the setting.
- I feel as if VR in education would be highly beneficial especially with the geometric tools that are implicated within the system. I've seen games and educational tools that have to do with 3D shapes within the VR world which would give younger and older students a visual representation on what they''re learning about
- I have not seen its use in education, but I can see how it can be helpful and interactive.
- Haven't seen VR be used in education before but I believe it can be helpful especially in science classes
- I have no real thoughts about VR in education nor has it occurred to me that it could be implemented into education.
- VR can be useful and successful In education
- Has great benefits
- Since my major is business administration, i don't think VR is useful for my particular major, however I think VR is helpful towards other majors like those pursuing medical.
- I think that it would be an effective resource but should be limited in certain areas of edu.
- we don't really use it at all
- I personally don't think I would use VR but seems interesting
- The technology is still growing, but I can see it being very useful in the future
- Very agree

- I think it's convenient but somehow I still like the teaching tradion method
- I think in STEM environments VR would be fantastic and could become an essential part of learning
- I believe in keeping education and schooling traditional, however I understand that as our world is developing, we as humans need to develop with it. This meaning that the students and young generations need to learn the way of the world in order to be successful. I don't feel we are there YET however.
- I think it can be a helpful tool to use in the classroom
- I feel like it would be a good idea because it can simulate a hands on thing that you can do depending on what you are using it for.
- I think that it could work nicely in some situations. However, I've never seen VR used in education before.
- I never never experienced VR education
- I don't have much experience with it
- VR seems like a nifty idea to implement into learning, however, I feel like in the end it can be hit or miss depending on the person. Most definitely would be beneficial when it comes down to virtual chem or physics labs.
- It's used a bit but not a core focus
- I have not had much experience with the use of VR in education, let alone in general.I would like to see it implemented in more courses overall because as a visual learner, I feel like it would be a more efficient way to grasp the material.
- I think it would be interesting to see it implemented in specific classes, such as history class or language. But I don't think it can work in all teachings.
- I think that in many fields, it has the capacity to provide situational experience without consequence. For example, medical students can use VR to practice surgery, Biology students to perform dissections, and business students to visually experience things like virtual career fairs on a more in depth level.
- I think it could be extremely helpful for hands on learning
- I feel VR is an experience which remains complex enough to say it adds another level of complexity or barrier to entry. Whether it be vertigo, configuration, or price, I think the benefits only outweigh the costs in specific high end learning applications.
- I don't really have much knowledge on the topic.
- Expensive
- Could be very practical for hands-on learning without risk of potential harm/mistakes
- I have no opinion since I haven't experienced it in education
- I think it is a great idea to help students get more involved and give them motivation to go to class.
- I do not have much experience or exposure to current use of VR in education, but I think it can be useful in certain STEM classes.
- I feel that VR in education is a relatively new concept, but I am curious to see how effective it will be in learning and teaching.
- I see some instances where VR may be useful.
- It's a good start to move to the future, which can help in education and also help them understand things by using virtual reality, such as it can make easier for professors to

demonstrate long lectures on topics, for example, using this type of technology can improve understanding power and save time for both kids and professors.

- My thoughts about VR eduaction are reasonable because I could imagine students being more interested and having the VR keeping them more interested which is good.
- the concept of it is interesting, to say the least. I never thought about putting education in the hands of VR. I see the adaptability for students that need the stimulation of VR but I also see it as a step away from the traditional teacher roles.
- I don't have any thoughts but it would be cool!
- The use of VR in education could be very helpful for the younger students so there could be more hands on learning offered.
- It is eye opening what technology can do
- I think it is revolutionary and everyone should try it
- I believe that it allows for more students with disabilities to feel like they are actually part of the classroom. Those physical disorders would be able to partake in the same activities as others, and wouldn't have to feel as though they were left out.
- I don't have thoughts on VR in education.
- I never really knew how effective the use of VR could be in education, but I would be very interested in seeing it be involved more, and being implemented more into our curriculum.
- I don't have many thoughts since I do not know much about the topic. But I feel that it could potentially have a place in education if well used.
- I think it can be used for some learning. Like people trying to become pilots. Otherwise, I'd hate to see it in the k-12 system.
- I think it could be extremely useful considering COVID
- I haven't had any experience with it so I am honestly not sure
- Would be interesting to see it being implemented in certain curriculums.
- Could be improved in areas focused on hands-on areas
- I didn't even know that was a thing before this survey. But it seems quite odd.
- Something new and should try
- I think it could be a very useful tool if used correctly
- I don’t know much about it or how it could be helpful in education.
- I don't see it very often but when I do, I find the the use of it is very interesting and enhances learning.
- I've never seen someone use VR for education purposes. I have used VR before, but only for gaming. I think I can see how it could be used for education though. Especially with the pandemic currently going on, I think using VR could be a good way to teach students, rather than just posting a video online and wanting students to watch and learn from it. It adds interactivity.
- I have no basis for opinion. the only VR I have engaged in is in video games.
- I think it is going to make a huge change
- I have none.
- I never thought about that, but it could be a great idea to try.
- VR being used in education is something that I have personally haven't ever seen, and I don't think it is very common due to potential costs of getting all students access to VR, but I would love to see it.

- My interest is piqued, but I don't understand the impact it may or may not have if implemented and integrated into all facets of teaching.
- In my experience, it is very limited and I don't see it around very often.
- I think it could be a great tool
- I think its a good idea to try
- I feel that it is not utilized at all in my current education, and I feel that it would be helpful if we were to implement it more. For example if we needed to miss class, we can hop on a VR stream or something so it would be like we are in the classroom
- When utilized properly VR in education has a Overall Positive effect on students from different medium. Giving student the possibility of view different ways to acquire the education required in a better environment.
- It isn't really used at the moment because getting access to a head set is so expensive so only one or two people in an entire class can have access at once.
- Benefits of virtual reality in education include the ability to inspire students' creativity and spark their imaginations
- I think it sounds like it could be a good idea. I think in certain classes it could be very helpful but I also think that in many classes it would be unnecessary
- My current thoughts about VR education are neutral.I am not highly a big advocate for vr user.
- I use it for water polo to help me run through plays and I think it could be helpful in that same sense in the classroom
- We should promote the use of VR in education
- I think that VR could be used in classes that teach about it (like the Media X program) but I don't think it's necessary for education in general.
- I never knew VR can be used in a teaching setting. Now, I'm curious to see how it would work.
- I have no current experience with them in educational settings.
- I had heard about VR's increase in popularity and the speculation on how it would affect classroom setting, should it be implemented. However, I never heard more nor did I look for more.
- Innovative
- It should be implemented, specially in when practicing real live situations, like a surgery and so on. However, VR technology isnt that advanced to give such feelings
- I believe it may help the students get more visual feedback.
- There are no uses of VR in education but it would be interesting to see it being used now.
- Not entirely common so I'm not focused on it
- I don't know a lot about it, but I'm sure within the right subjects of learning it could be extremely helpful.
- I don't think it is used enough, I don't know how it can be used effectively but I feel like there is a way to.
- I personally do not have any experience in terms of utilizing VR for my education, but do understand that many topics and subjects can be largely enhanced by VR usage.
- I think it is a great way for students to get hands on experience with whatever they are learning.
- It's different forsure but wouldn't hurt to try it out.

- I think many students would learn better from using VR in education. I may not know a lot about it but I would love to learn more.
- None
- I have not been educated much on VR and how it would help education.
- It seems nice but I have no previous experience
- It will be interesting.
- I think that the concept of VR in education is very interesting, but I am not completely sure about its implementation.
- I have not used VR for educational purposes, but I think that it could be helpful.
- Helpful and effective
- My current thoughts about VR in education is that it can be useful if used correctly. Like most systems that are available to teachers now it is all up to the teacher to decide on how the class is ran and if the teacher uses it correctly I can see a great spike in student participation.

OE2. What Are Your Primary Concerns About Expanding the Use of VR in Education?

What Do You Perceive to be the Main Barriers to Implementation?"

- I just don't see a need for VR in all areas of education. I think it would take away from the interpersonal connections in class if students are wearing headsets in their own space.
- the cost of vr equipment
- I think it will be costly to provide everything for students
- My main concern would be motion sickness, which a personal experience of mine.
- Not having the motivation enough to expand the use of VR.
- people would lose focus
- A VR device is expensive, it is hard to make sure that every can afford it.
- It can cause a lot of issues for the brain especially being in front of a screen for many hours a day.
- it depends on on the VR and how it works. Looking into the health aspect, would e good for children to be using VR.
- It limits hands on learning
- I think its hard to have enough headsets for the whole class as it is expensive and if there isn't enough it's time consuming to readjust to every student
- What will we learn using VR that we wouldn't learn otherwise
- Not too sure, don't really know much about VRs
- I feel like getting the faculty to participate in using it will be the hardest because students are open to it, but many Professors are not willing to offer a virtual option while in person so what more would they not be willing to change in regards to VR.
- Main concern, it would be difficult to use for younger people. The main barriers of entry would be getting the school to allow for this tech... in addition people will need to create virtual lessons... which will take time (could cost a lot of money).
- One of my primary concerns would probably be the health issues that can be caused by VR, for example, students can experience nausea and dizziness. The main barriers that I perceive to be a main barrier to implementation would be the cost.
- Cost, availability

- Primary concerns would be starting out on VR, as it could be difficult for the instructor, or even the students to learn in a different environment.
- I think that people would expect the same simulation they experience in VR as they would in real life. Considering today's current state, I see sharing equipment as a huge barrier since you are wearing and sharing equipment between students.
- Students may get distracted and not focus on class work being that it will most likely be new to all students.
- VR education requires a lot of money to expand, and also people are use to tradition way to study, so it's hard for people to find a reason to use VR on education.
- Not all the people have a good relationship with the technology
- Physical impact on our body.
- I'm not sure what the cost would be as well as if it would be used enough to get your money's worth. Again the over usage of screens
- I think that it could be beneficial but many students might slack off by using it. Its main barriers are cost to implement.
- It could take a while for instructors to get the hang of using it
- My main concern is VR has seemed to become a source of mostly entertainment. Depending on the age it could be very distracting for students and may prevent students from learning important topics. I also feel that the constant use of screens and such technology could become fatiguing, given that many students have been suffering from zoom fatigue and parents push for their children to spend much more time in the "real world". Many people are now much more fond of touching physical objects rather than having it limited to screens.
- Money
- Product cost will be the main barrier to implement
- I feel that kids ability to communicate with people would lessen even more than it is. Using those VR's can case diseases such as cancer from the radiation and more that we may not know of right now but may develop later on.
- The main barrier I think would be program development.
- I don't know enough to know about what to be concerned about here.
- I personally think that it will take some time for students to get used to the experience of VR learning since it is still new to the world and it will be hard for people to get accepted.
- Honestly feel like VR cannot replace the experience of an in person class.
- The main problem with bringing VR in education is cost. The cost of setting up VR, using VR, and having it available to all students. Another big problem I see is the teachers who use this tool. Of course there are teachers that can use this tool to its fullest but there are teachers who dislike change, dislike new technology, or just would fail to use it to its fullest like just put the students in a classroom and do the same lecture or just add a small twist to the class that they can do anytime but is easier with VR. The last problem I see is the students who do not want to use it. Even small in number I can personally think of students who just would not be as excited as some and just view it as another thing to need to get done. For example if theres an assignment in VR they may just want to get the assignment done from point A to B which is fine but the student doesnt fully use its tool to the fullest and it just becomes a waste.

- The main barriers of implementation currently would be the lack of interest the general public has about the same topic. Not only are they hesitant to accept that classes could be taught online, they're finding it difficult to attend to those that had classes online in the previous couple years. As it may seem to many people's eyes, school for children might just be a free daycare deal.
- One of my biggest concerns is the funding and how it is used at schools (not sure if only university or also high school). If just at university, I think it may be difficult for some to navigate it, as well as potential issues for those who prefer traditional forms of education.
- My primary concern is it will make people addicted to it. Definitely don't want students to be dependent on VR for their learning.
- Virtual reality can help kids learn by giving them memorable and engaging experiences that they wouldn't have otherwise. Virtual reality is available to all students and is easily controlled by teachers. Students can be engaged and inspired in a unique and powerful way through virtual experiences.
- It might introduce more technology that disconnects us from real world and real interactions.
- It seems cool
- My main concern would be that they make it for every class. Main barriers would probably be getting everyone to understand how it works, it could take a decent amount of class time.
- Different from reality
- Never worries
- I personally feel it may limit the availability of brainstorming students can do without having a visible context, as they become creative and put critical thinking. There may be possibilities for the diminishing of critical thinking because VR will make things simpler but not challenging which I think college students need to be versatile and experienced.
- I currently suffer from migraines so that might be an issue to not just myself but others who also suffer.
- I think the main barrier would be the amount it would cost and if it would be sanitary
- I am not sure.
- It might not be very accessible to everyone.
- Extensive blue light intake can strain and hurt eyes, especially when used for so long
- I think that environment in learning is very important, and the use of VR could potentially disturb it.
- Personally, I like to stay away from as much technology because it can get tiring. Although in this era technology will only continue to advance, it should be easy to understand in order to be able to grasp it.
- One thing I'm against is the fact that it could take over all forms of education. I don't think VR should be implemented everywhere as I believe it is important to keep the "founding principals" of education that come with using a pen, paper, and a book.
- Would I have to buy my own VR system? What if I'm not able to afford it?
- i think my primary concern is not getting the education you could get in an actual class
- Funding and accessibility so I think resources
- Sudden change
- Teachers will lose their occupations

- The cost. Vr headsets are expensive and many people lack the experience to use them effectively. Having somebody on staff charged with managing VR and its application would be a necessity.
- Some point, the human aspect will go away.
- the adaption of using the VR to teach and understanding withing the teaching of the material on the VR
- At the moment I don't have any concerns about expanding the use because I do not see VR being used in VR personally. The main barriers might be the amount of technology the school has or funds reserved for establishing a new aspect of education.
- I'm worried about kids getting addicted to the technology if they started VR young. I think it's fine if the age is 15+.
- The price of getting good devices.
- Main barriers would probably be expenses related to getting it implemented into curriculums
- There needs to be more real applied teaching rather than VR in our education, as we have plenty of technology outside of the class.
- I'm concerned on if it'll even be effective in learning. Also I'm concerned that what if it ruins eyesite and creates some sort of stigmatism
- It may be hard for teachers to implement this type of technology with skill.
- It seems as if it's a great idea, but not of common use to all due to financial barriers. Low income schools do not have the resources to provide this kind of learning into the classroom, nor be able to provide for all students
- I think that it might be inaccessible to some students. Maybe some will have to many issues using VR. Also, I sometimes get sick while playing VR and have to stop, so that might also be an issue.
- Costs
- distractions
- I do not have any general concerns for expanding VR in education, but a main barrier to this implementation is the resources necessary to properly convey the VR experience in relation to the educational content.
- The fact that only one person may be using the set at a time
- People can get distracted
- I think it would be severely expensive to expand the use of VR, because of the technology it requires to use, and I am worried it might affect grades and students learning habits that they have created already through years of practice.
- I think that kids may think of it more as a recreational thing rather than educational.
- VR in education would increase the costs of education and bring forth significant changes to modern education.
- The main thing would have to be using it for a long period of time because for me after a while I started to feel sick from using it.
- I've never worried about this
- Being too difficult to use and would make learning harder and more of a burden than an ease
- I don't have any concerns

- My main concern would be it being a distraction. Students may be more motivated, but it can also serve as a distraction towards other classes that don't use it.
- I am interested in seeing how vr could be implemented into the classroom setting. It may be a distraction for new users
- n/a
- Price point, cleaning
- None
- Concerned about removing the human aspect to learning. It's not the same learning from behind electronics.
- Time management is really important and such a new form of teaching may take a while to get used to. The main barriers and challenges I'd expect is harsh transitions since it's technology most people aren't accustomed to.
- Easy to understand
- Access to VR, cost, learning curve, learning differences
- I don't believe it should be brought into education as I value a more traditional style
- Having enough for every student.
- My primary concern is that the level of human interaction may not be as engaging as in-person learning. Furthermore, there is a concern of eye strain. How long can a person use the technology before they fatigue?
- That students might lose sight of reality
- I dont know
- I think one of my primary concerns would be just how much technology is being implemented in the classroom. I think that if we rely on technology so much, we won't be able to learn without it.
- I dont have any yet but I would need more experience with it
- For certain ages it may not be as beneficial, also it may be quite expensive.
- where would the teachers go? How can every student get the right equipment to do the VR and run it effectively. how good of quality would the VR be. the hard thing about education is the universal need to help everyone, rich and poor.
- confusion for some regarding tech
- I think the primary concern would be whether or not implementing VR would be affordable. In other words, the main barrier to implementing it would be cost.
- I just believe it takes away from standard learning. Technology is a major distraction and it takes away the student to teacher relationship; eye contact, emotion, communication.
- I wouldn't want my full education to be used through VR but I think implementation for courses that could benefit would be nice.
- Would take a learning curve for people to get used to the technology.
- I think there is not enough research on it or that it is not perfected. I have used VR once, two years ago, and did not find it beneficial.I think the main barriers to implementation would center around how/ under what circumstances it is used and its impact on one's overall health and education.
- The concerns about VR are limited but I did not mind online learning.
- Note taking would probably be the biggest issue for education. Your hands are probably tied up with controllers, and you may or may not be able to see a note pad. In VR note

taking remains clunky and for this reason I feel a video demonstration to outweigh most VR experiences for this reason.

- It could be abused if implemented incorrectly.
- Trigger warnings and making sure people don't get motion sickness.
- The main issue in implementing VR in education is the lack of funding to get the equipment. Once obtained, the learning curve just to use the technology would be hard to gauge from student to teacher.
- Accessibility. VR devices, especially good ones, are expensive it may be unrealistic for all demographics to be able to use them.
- The main barrier to implementation might just be the cost or pushback from teachers/professors that are older and already have trouble understanding technology.
- Wrong use
- Don't really have any other than students might not be on task I guess.
- Expanding VR education can lead to people being dependent on VR.
- The primary concern would be the continuous use of technology in growing children, teen, and young adult's lives.
- Primary concerns include distracting technology, the barriers to entry relative to a pretty standard educational system, and IT issues.
- I'm not sure if people would be opposed to implementing VR into our education, I think it would just be a question of "how do we implement VR into our education." I personally see no negatives to doing such a thin, but I'm not sure how we could go about it.
- My primary concern regarding the expansion of the use of VR in education revolves on the necessity it may become in the future creating multiple harms to the established system, its workers, and students sight after being expose for extensive periods of time. Like-wise the established system may reject the usage of VR as they would cause a change to implement. Such change will take time to function and intergrade to education forum, therefore creating a possibility of having a negative effect on the initial students.
- It seems expensive, perhaps a waste of money.
- I would have to say social skills, since some people do struggle with that in a regular education setting.
- My primary concern about expanding the use of VR in education is that students will get addicted to VR and technology and this can affect their study habits.
- the main barriers would be funding and "defeating the norms" just convincing people it's for the best
- The main barriers would probably be the usage of it. Given the school probably has limited funding, it may be hard for classes to get the access to VR headsets. Also we should clean the VR sets with a UV light box so it does not have to be sprayed and wet for the next person to use.
- I really don't have any
- The main concerns that people might be over-reliant, so people shouldn't always expect that they are fully prepared in a real situation when they practiced in VR.
- Visual problems later on
- using VR on a daily basis would scare me a bit, I don't know how I feel about not being able to see my surroundings at all times. I think the main barrier would be affordability.
- I am concerned about the changes to the current curriculum.

OE3. What Do You Feel Would be the Greatest Benefits of Increasing the use of VR in Education?"

- There are many benefits if VR was to increase within education. Primary revolving the in-person sensation students may perceive when performing an experiment, review historical events, or analyzing an organism via this closer look. The increase in visual and auditory usage would in theory provide the students with a better idea of the topic/subject.
- I think the greatest benefit would be the experiencing the lessons in a Video game way. People tend to be more engaged when something is turned into a competition.
- VR gives you the chance to see and experience things you may not be able to. For this reason I think VR has the most benefit in its ability to put you in places you might not otherwise be able to visit. For example a history major atop the great wall, or and engineer in a car factory abroad.
- I think the benefits would be feeling like you actually are in a classroom setting, even if you are at home.
- The engagement between the class and the material being taught by the teacher
- More experiences
- Experiences
- It is always beneficial to add a sense of verisimilitude and innovation in an academic environment.
- I think it would help students who do zoom at school feel like they are in a more classroom environment
- The greatest benefit would be seeing sights that students never even dreamed of being close to. It allows for visualization of dreams and imagination to really soar and finding a way for students to express their freedom in learning.
    - The greatest benefits of increasing the use of VR would be being able to learn in a very proactive, brain challenging way where we have to pay attention.
    - It would be more hands on
    - It's very convenient for me that students don't have to go to the classroom
    - the change in curriculum and the ability to have lesson plans be adapted for students with disabilities. have the lessons be simplified and altered to fit the student's needs to help them be successful.
    - Students would be able to learn how to use a new form of technology
    - It would probably engage students and give more people opportunity for a "hands on" environment.
    - Maybe to get more familiar with the technology we use today
    - It can benefit many people.
    - There can be no distractions
    - It would give students a view of how places function. For instance now because of COVID school are restricted from field trips so this will help them engage in topics where they can explore.
    - I'm not sure.
    - Children will interesting in the study.

- VR could allow schools and other areas of learning with limited resources show students technology and other ideas. Some locations are very limited in terms of travel and money, therefore restricting them from pushing forward in some areas of learning. This could be fixed with investments in VR and could also provide a much safer learning environment.
- It would help those learning at home feel like they are in the classroom
- real like experience
- Might motivate some young students to enjoy going to school
- To expand our knowledge on surrounding subjects.
- Get lose to the reality beside read from book
- Not sure.
- More "hands-on" learning in a virtual sense
- It would allow students to experience things that they usually can't inside a class room.
- The benefits of increasing the use of VR in education can be to open new opportunities and broaden our ways of education.
- It would be innovated and new and it would be very different compared to the traditional way of learning.
- Helping student seeing the example or lecture in more advance way.
- Collaboration and expanded learning
- New experiences.
- I believe it would be more engaging for students and a memorable learning experience
- Visual and preparation for real situation.
- The greatest benefit of increasing the use of VR in education would be providing more hands-on learning experiences.
- VR in education could give students lab experience in online structured classes.
- Less time consuming, more flexible hours, and each student could learn at their own pace
- Interactive learning could create a love for learning in children
- Trying different ways of learning could highly benefit some different types of learners.
- I think having the immersive experience that comes with VR can be very beneficial to learning certain subjects, especially within Sociology.
- The greatest benefit to VR in education is the ability to learn in a classroom setting without being there. The pandemic caused school closures, but individual students often have a difficult time attending class due to bullying or social anxiety. Both may still happen, but to escape, the student could just remove the equipment.
- I believe that it could be a better way for students to learn my immersing themselves in whatever they are learning.
- Being able to be in a classroom without being in a classroom is a main benefit. For instance, it lowers the risk of students catching viruses because it limits the in person interaction.
- It may allow students to be fully immersed in certain scenes (i.e. geography of the past or historical monuments).

- I feel that it might help students who have a hard time learning in a static environment, to have more freedom with their learning, and it could help them create greater interests into the subject they learn.
- Being able to be hands on without the physicality and the potential burden of costs
- More exploration, can do hands-on training without the need of going to facilities.
- Reduce Covid-19 cases
- It can help with simulations.
- Great training aid
- to reach more learning types in school
- I think the virtual learning will be great for students who cant come to class
- In my field of study, I don't see how exactly it could really help me in learning new things. Other than maybe creating our own programs that involve the use of VR, and then experiencing it ourselves. But, I think for other fields of study, it could be helpful. Not only that, as I already said before, I think it could help with interactivity, especially in a time when we're so engrossed in online education.
- New way of learning
- More lessons and skills would be available to students, and it could reach more student then normal education feels do already.
- I think the greatest benefit would be that VR could help education be more interactive and interesting for students.
- Everyone can work independently using vr and access more online applications
- It could allow student to participate in many different subjects, which could spark a certain interest in one or more of them. This would in turn, better prepare high school students for whichever occupation they'd want to pursue in the future, as the classes allows them exposure to the topic at hand.
- More accessibility, and immersion in the topics.
- Almost hands on experience
- Cutting edge, new educational experience, if successful it may lead to increased learning, more student engagement
- Do something that simulates a hands on activity would be a really good thing for students to use just so that they can see how to work on something in student of just hearing about it or watching a video in class.
- The visual feedback.
- It may motivate students to enjoy and genuinely be engaged as they will be able to visualise situations and scenarios that may not be possible in a regular classroom setting
- I think students might enjoy classes much more.
- History has the best implementation, for ex you can put yourself in the exact space that you are talking about in class.
- Everyone has a different learning style and this could work for someone else.
- Make study more effective
- The time saving aspect for users is a great benefit.
- A new experience for students, breaks the educational norm of pen and paper to learn things. Students will talk about the VR sets, which will bring great attention and likely a good word for the new implementation.

- Easily interact virtually
- It can visualize things very well
- An additional way of learning to more visual learners, and even to audio-based learners as well, if implemented with sound.
- I don't have to go to the classroom, which is convenient for me
- Allowing one to experience a real-life setting
- I can't think of specific benefits of increasing the use of VR, but it would offer a different take on how things are learned.
- People with physical disabilities can still attend class even if they are physically unable to.
- It would be great to see it used in education.
- I think it would allow for a more hands on approach that we otherwise wouldn’t get. Compared to learned from slides or reading, learning from a more stimulating environment would be a lot more memorable.
- The greatest benefits to increase the use of VR in education is vast. Some that I can see as great benefits is having the students more interaction things to do and help visual learners and help solidity concepts that the students learn in class and apply them close to real life as possible. A teacher could take students to vast and places that would normally cost millions only with a program switch away and bam you could be in space and interact with objects and see them float and such. Or have the students go to the moon or to different countries. Show them what happens when one mixes chemicals that could be dangerous normally or just show them normal chemical reactions that would probably be expensive to do but now is possible to show. Rather than showing videos just doing the activity in the video, traveling, science, mathematics, ect. Theres so many courses that could benefit greatly with the implementation of VR
- A more interactive learning environment
- I’m not exactly sure because it is my first time hearing about this topic.
- the greatest benefit would be you can learn anywhere unlike school where you have to be in a designated place
- new techniques
- People would start to appreciate the use of VR.
- As I mentioned previously, one of the greatest benefits I see is that students would be able to visualize situations and figures, allowing them to better understand concepts. For example, if a student is wanting to do an observation assignment, the student can use VR to virtually place themselves into a coffee shop. This would save the student time and allow for convenience because they do not have to physically go to the shop. Another example would be a "Magic School Bus" simulation. As a pre-dental student, memorizing the parts of animal and plant cells is tough because the pictures in textbooks only show one angle of the cell. With VR, we would be able to "walk" through the cell and see the ribosomes synthesizing proteins and vesicles carrying DNA throughout the cytosol.
- Some experience through utilization
- n/a
- It has the ability to give students a new view on what they are learning

- The greatest benefits to increasing the use of VR in education would be having a real life application or a simulation of what is supposed to happen.
- It could help in times where there's online classes or hands-on learning that is unavailable.
- More interaction in learning.
- The ability to take on larger class sizes, the potential to increase technical know-how for future generations, etc.
- Using it.
- VR would definitely benefit learning programs within IT, no doubt. Personally, for my major I'm not sure how helpful it would be considering my future job will be very interactive with others. I'm already a pretty shy person, and thing building my people skills is something I really need to work on. VR wouldn't be very helpful in my area.
- I feel that VR in education would be great for certain majors such as those in STEM. In addition, VR could lead to fantastic and memorable learning experiences.
- Education away from school
- Help students to be more engaged and have more interaction with the learning material.
- The visual experience, the air force and navy have been using VR to train pilots for years. It is the next best thing to actually being there, and can make users more comfortable in the actual situation as they will have experienced it in some capacity already.
- short and sweet
- I think the greatest benefits would be that it will allow for students to be in simulated real world scenarios
- Those with injuries preventing them from physically attending class can hop on VR.
- With remote learning, you can give students more of a classroom feel with vr, and you could also conduct science experiments in vr that you wouldn't be able to do in person.
- Feelings and some experiments that can't be done could be showed in the VR education.
- The only real benefit I see is it being a safer learning option due to Covid.
- N/A
- Learn through actual/real visual aids of things
- Make it more fun to learn
- It would be cool and unique to try
- cool
- the ability to "walk" around a classroom and talk with other people without being physically present in a classroom
- Makes you want to learn more compared to normal classes.
- Could be that people could be physically at home, but be in a class room, as if in real life, virtually. So there would be no need of traveling to school, and it would feel like being in class in person.
- Greater understanding/demonstration of teachings related to hands-on experience (such as labs)

- It could educate us students that there is another way to learn and who knows someone students may find that the most efficient way for them to study going forward.
- New technologies always make everything easier
- Increased engagement, especially for those who are in media production based majors.
- VR would allow us to seemingly firsthandedly experience events that we wouldn't be able to on a normal basis due to safety precautions or other limitations.
- It would be a more hands-on experience.
- It could give us a better view of certain things, as oppose to just book images or imagination.
- I feel that the greatest benefit from an increase in the use of VR would likely be enhanced understanding of certain subjects.
- More awareness of advancing technology and exploration of the VR world.
- Perhaps people would get another experience and figure out how to use VR to benefit the world more.
- The greatest benefits would be that the transition out of the education system into the "Real world" would be smoother and those who had access to VR would be even more advanced.
- It will allow us to experience and learn things that would have otherwise not been possible.
- These new perspectives of learning can result in fostering empathy and cultural competence because they take students outside of their normal daily experience

OE4. Do You Have Any Other Concerns or Thoughts About This Topic?

- No
- No
- None.
- None
- N/A
- no
- learning curve and learning differences
- It could cause headaches for students
- NO.
- Not at the moment.
- None
- I love the idea and would like to give it a try.
- no
- One concern I have on this is how expensive it might be to implement VR into our schools. Especially considering how much of it we'd have to implement in every school to allow for a suitable number of students to participate. I'm not sure just how expensive it could be, but it seems like it could be pretty costly.
- I just think it's a cool technology with a lot of potential.
- No
- no

- no
- None
- Alters reality
- No not really
- No for now
- I do not
- N/a
- I just dont want it to take away the in person value in education
- There is a lot I don't know about the topic to have real concerns. Younger students will learn to use the technology, but social skills that can only happen in person would be lost. There needs to be a setting in which socialization can occur if VR were to be implemented.
- No I do not.
- Excessive use of VR can lead to students being more drawn towards virtual setups and the tech world, which may not be favourable as the attachment towards the natural environment is also important.
- I want to see this being implemented because I feel like it would make me want to learn.
- I am still very unsure about VR because I have limited knowledge of the field. However, I am open to learning more about it and seeing the extent of its effectiveness in the classroom.
- N/A
- N?A
- No
- N/A
- No
- N/A
- not really
- No
- No.
- No
- nope
- N/A
- no
- N/a
- NA
- VR had a lot of room to grow and at the moment, we are just at the beginning of its develoments
- Not that I can think of.
- It may have a lot of technical difficulties.
- No
- No
- No
- No
- People might rely on it too much

- No concerns but I think there needs to be limits on VR in education.
- Not yet
- I have seen VR used for anatomy classes, which really impressed me with the creativity of the idea.
- No
- n/a
- VR is most likely something that would be in the future and possibly will continue to grow.
- My sole concern relies on VR taking the role of the educator thus affecting the economic system within education.
- At the moment I don't have any concerns
- No other concerns.
- No I do not
- No
- I think the government is pushing virtual reality on certain companies that have a lot of power to push a further agenda.
- No
- NA
- No
- No
- I feel that some cultures view technology as an evil thing so just do more culture research.
- I would be interested to see it implemented.
- n/a
- n/a
- I am excited to see more VR learning opportunities in the future.
- Not really.
- VR will be the future trend, it will become the new era of the Internet
- None.
- I just think we shouldn't take away the importance of attending school. These are pivotal years where kids can be kids, where they can safely make mistakes, learn and develop, become who they are, and with VR I feel like there's only "one way" and it is very robot-esc.
- no
- I don't think VR would necessarily be helpful in every class or situation, but I definitely think some types of classes could be improved by implementing it.
- Not really
- No i dont
- No
- Not at the moment
- N/A
- no
- Could their be other distractions. Is it expensive. Will everyone get to uses it.

- VR, personally, makes me dizzy. With that being said, I do believe that a full-fledged switch to VR learning from education can hinder many students in participating due to potential health issues with the technology.
- How would parents feel about using VR in education?
- No.
- I do have one concern about this topic because I myself really enjoy VR, however, I just get a headache after like 30mins of using. So there will be people who can and can't.
- No
- Yeah one concern that what if kids start taking the wrong benefit of VR playing game regular it may effect their health even continuously using of a thing can be dangerous. It is good technology but in specific time and not every time.
- I think that there needs to be more information about VR given to the public in order to raise awareness. Additionally, I think VR companies should focus on the potential negative impacts that could arise due to one being fully immersed in an up-close screen.
- no
- No
- Nope
- No.
- I feel like VR in schools is something that should be avoided unless absolutely necessary. I always felt that students should be able to experience things and touch them with their own two hands without being restricted to aa screen.
- Not really.
- No
- No more than what was said above.
- None
- I didn't know about VR learning until this survey, and I would like to see it more.
- No
- Might be distracting to students.
- I have none.
- None
- The only concern I have for this topic is VR overtaking real life instruction.
- No
- I would like to read more on this topic and all of its pros and cons.
- No.
- application, educational barriers to entry, ability to transition seniors in the educational system, health concerns (flashing lights, strenuous use of tech, blue light exposure, etc.) and it issues
- Other concerns I have and thoughts about this topic is the programming and current software available to teachers and students. While VR can enhance the teaching experience for students what is currently avaliable to them is a different question. Like an idea of going to space or taking students to places to show different shapes and the properties of them. If the software glitches, doesnt work or just not possible with current technology wouldnt the growth of this tech be a failure?
- No

OE5. What Recommendations Would You Give Teachers and Others Responsible for Your Schooling When It Comes to VR?

- Other concerns I have and thoughts about this topic is the programming and current software available to teachers and students. While VR can enhance the teaching experience for students what is currently avaliable to them is a different question. Like an idea of going to space or taking students to places to show different shapes and the properties of them. If the software glitches, doesnt work or just not possible with current technology wouldnt the growth of this tech be a failure?
- No
- I think the government is pushing virtual reality on certain companies that have a lot of power to push a further agenda.
- No more than what was said above.
- No
- None
- I love the idea and would like to give it a try.
- N/A
- no
- Not really
- No other concerns.
- N/a
- Not that I can think of.
- People might rely on it too much
- NA
- No
- Not really.
- No
- n/a
- I would be interested to see it implemented.
- None
- No
- N/A
- No
- VR will be the future trend, it will become the new era of the Internet
- How would parents feel about using VR in education?
- nope
- One concern I have on this is how expensive it might be to implement VR into our schools. Especially considering how much of it we'd have to implement in every school to allow for a suitable number of students to participate. I'm not sure just how expensive it could be, but it seems like it could be pretty costly.
- No
- No
- None

- No.
- n/a
- No
- Not at the moment
- N/a
- No
- No.
- No
- Might be distracting to students.
- VR is most likely something that would be in the future and possibly will continue to grow.
- N/A
- N/A
- No
- No
- NA
- No
- no
- None.
- no
- no
- No
- I just dont want it to take away the in person value in education
- None.
- Not yet
- No
- No
- No I do not.
- I am excited to see more VR learning opportunities in the future.
- Excessive use of VR can lead to students being more drawn towards virtual setups and the tech world, which may not be favourable as the attachment towards the natural environment is also important.
- No concerns but I think there needs to be limits on VR in education.
- I have none.
- NO.
- I have seen VR used for anatomy classes, which really impressed me with the creativity of the idea.
- It could cause headaches for students
- I just think we shouldn't take away the importance of attending school. These are pivotal years where kids can be kids, where they can safely make mistakes, learn and develop, become who they are, and with VR I feel like there's only "one way" and it is very robot-esc.
- No.
- N/A

- no
- None
- application, educational barriers to entry, ability to transition seniors in the educational system, health concerns (flashing lights, strenuous use of tech, blue light exposure, etc.) and it issues
- I would like to read more on this topic and all of its pros and cons.
- Not really.
- I just think it's a cool technology with a lot of potential.
- No.
- No
- No
- None
- Nope
- no
- No for now
- No i dont
- I do have one concern about this topic because I myself really enjoy VR, however, I just get a headache after like 30mins of using. So there will be people who can and can't.
- N/A
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- not really
- Yeah one concern that what if kids start taking the wrong benefit of VR playing game regular it may effect their health even continuously using of a thing can be dangerous. It is good technology but in specific time and not every time.
- Alters reality
- no
- My sole concern relies on VR taking the role of the educator thus affecting the economic system within education.
- N?A
- The only concern I have for this topic is VR overtaking real life instruction.
- VR had a lot of room to grow and at the moment, we are just at the beginning of its develoments
- I feel that some cultures view technology as an evil thing so just do more culture research.
- I feel like VR in schools is something that should be avoided unless absolutely necessary. I always felt that students should be able to experience things and touch them with their own two hands without being restricted to aa screen.
- I didn't know about VR learning until this survey, and I would like to see it more.
- Not at the moment.
- It may have a lot of technical difficulties.
- There is a lot I don’t know about the topic to have real concerns. Younger students will learn to use the technology, but social skills that can only happen in person would be lost. There needs to be a setting in which socialization can occur if VR were to be implemented.

- At the moment I don't have any concerns
- I do not
- No
- No
- VR, personally, makes me dizzy. With that being said, I do believe that a full-fledged switch to VR learning from education can hinder many students in participating due to potential health issues with the technology.
- I think that there needs to be more information about VR given to the public in order to raise awareness. Additionally, I think VR companies should focus on the potential negative impacts that could arise due to one being fully immersed in an up-close screen.
- Could their be other distractions. Is it expensive. Will everyone get to uses it.
- No not really
- I am still very unsure about VR because I have limited knowledge of the field. However, I am open to learning more about it and seeing the extent of its effectiveness in the classroom.
- No
- I don't think VR would necessarily be helpful in every class or situation, but I definitely think some types of classes could be improved by implementing it.
- learning curve and learning differences
- I want to see this being implemented because I feel like it would make me want to learn.
- No I do not
- No
- no