LIBERTY UNIVERSITY

SCHOOL OF MUSIC

Eliciting Music Performance Anxiety of Vocal and Piano Students Through the use of Virtual Reality

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by

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Abstract

Despite the growth of virtual reality technologies, there is a lack of understanding of implementing these technologies within the collegiate classroom. This case study provides a mixed-method insight into a virtual reality (VR) asset deployed in a music performance environment. The study examined the effectiveness of a virtual reality environment as measured by the physiological response and user feedback. Ten voice and four piano college students participated in the study. Each participant performed musical works within an authentic practice room and the virtual concert hall via a Virtual Reality (VR) headset. Data was collected across four criteria. Participants' heart rates were recorded before and after the performances. A State-Trait Anxiety Inventory test was presented to participants before and after the performances. Each performance was recorded and then blindly evaluated by two licensed music adjudicators. After the performances, participants completed a self-evaluation. Results indicated that virtual concert hall sessions caused a change in some categories of physiological, performance, and anxiety compared to an authentic practice room. No statistical difference was recorded in heart rate for vocalists between both environments. This project serves as a proof of concept that VR technologies can effectively elicit change in music performance anxiety. Furthermore, the study could encourage further research on mitigating music performance anxiety through virtual environment exposure.

Dedication

Thank you to my wife and best friend, Alyssa, who has been an enormous source of inspiration and joy in my life. May this dissertation and degree serve as a foundation that my children can stand upon to reach their advanced degrees.

Acknowledgments

I would like first to thank my supervisor, Dr. Lori Danielson, for her support and guidance throughout this research. It was a long process, but her patience and encouragement were greatly appreciated.

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CHAPTER ONE:

INTRODUCTION

Background

Imagine a student enters a virtual concert hall and experiences much of the same emotion and physiological response that an authentic environment would elicit. The student can virtually see an audience of spectators eagerly awaiting a performance. With the audience members focusing intently, the student begins a performance. The student experiences audience members moving, coughing, and listening to what they hear. The student's spatial awareness is heightened as the auditorium is illuminated by theatrical lighting. The student can perform on a stage and for an audience that would otherwise never be accessible. Once the student finishes the performance, the virtual reality headset is taken off – only to reveal the student has been authentically present within a practice room. However, the student noticed an increase in heart rate, anxiety, and a lower overall performance level because a virtual music hall caused music performance anxiety (MPA).

The use of virtual reality (VR) has been shown to elicit authentic physiological experiences in students. Nicholas Burbules defines VR as "a computer-mediated simulation that is three-dimensional, multisensory, and interactive so that the user's experience is 'as if' inhabiting and acting within an external environment."[1] Lila and Ren Bozegeyikli noted, "(VR) Simulations can induce better understanding and engagement of students to learn difficult concepts to grasp."[2] When studying virtual reality exposure training to mitigate music

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[1] Burbules, Nicholas C. "Rethinking the Virtual." *The International Handbook of Virtual Learning Environments* (n.d.): 37–58.

[2] Lila, Bozgeyikli, and Ren Bozgeyikli, eds. *Virtual Reality: Recent Advancements, Applications and Challenges* (Aalborg: River Publishers, 2020), (3), ProQuest Ebook Central.

performance anxiety, Bissonetter, Dube, Provencher, and Maria noted, "results show a notable decrease of MPA over time."[3] Virtual technology's ease of distribution and increasingly cost-effective methods allow students to participate in learning activities that would be otherwise cost-prohibitive. As Micah Castelo notes, "VR allows students to go places and see things virtually without actually having to go there."[4] As indicated by Jaime Donally, the ability for students to virtually relocate is especially helpful when educators "are finding more of schools limiting field trips and outings due to many factors, yet at the same time we face an increased demand for improved student performance."[5] The use of virtual reality technology holds potential in creating an immersive music performance experience that would otherwise never be afforded.

Statement of Problem

VR is poised to radically shift every facet of daily life within the next few decades.[6] When detailing recent advancements in VR, Lila and Ren Bozgeyikli note, "VR is rapidly evolving thanks to technological advancements, and the results could include radically

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[3] Josiane Bissonnette, Francis Dube, Martin D. Provencher, and Maria Moreno Sala T., "Evolution of Music Performance Anxiety and Quality of Performance during Virtual Reality Exposure Training," *Virtual Reality* 20, no. 1 (03, 2016): 71-81, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fevolution-music-performance-anxiety-quality%2Fdocview%2F1793245482%2Fse-2%3Faccountid%3D12085.

[4] Micah Castelo. "How Immersive Technology Champions the Four C's of Learning." *Technology Solutions That Drive Education*. Last modified May 10, 2021. Accessed June 6, 2021. https://edtechmagazine.com/k12/article/2020/03/how-immersive-technology-champions-four-cs-learning.

[5] Jaime Donally. 2018. *Learning Transported : Augmented, Virtual and Mixed Reality for All Classrooms*. La Vergne: International Society for Technology in Education. Accessed June 6, 2021. ProQuest Ebook Central, 21.

[6] Abigail O'Leary. "I've seen the Future and it's Virtually here: HOW FACEBOOK CHIEF'S VISION WILL CHANGE OUR LIVES [Edition 2]." *The Daily Mirror*, Feb 24, 2016. 8, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fnewspapers%2Five-seen-future-virtually-here%2Fdocview%2F1767483692%2Fse-2%3Faccountid%3D12085.

transforming the way people work and live."[7] New VR applications are expected as new low-cost devices appear. In examining the future rapid deployment of VR, Bruno Arnaldi, Pascal Guitton, and Guillaume Moreau contend, "Virtual and augmented reality have existed for some time but were stuck in academia and large manufacturing companies."[8] The evolution of VR's use is shifting towards mobile applications, thus increasing its usability. When examining challenges in VR's adoption, Gregory Schmidt noted, "Many companies are ready to create VR content, but not enough consumers have the headsets needed to experience the immersive performances."[9] This evolution is especially true in education. When examining VR's use in education environments, Dong Hwa Choi, Amber Dailey-Hebert, and Judi Simmons Estes report, "recent quantitative reviews of the field have found that pedagogical agents can have small, positive effects on learning outcomes."[10]

Although virtual reality was introduced in the 1980s, there is a substantial gap in its deployment in music education. First, the use of head-mounted displays (HMDs) presents challenges. The technology is not readily available for students to experience concurrent learning opportunities. Technology is only beginning to emerge that allows students and instructors to share virtual content in a concurrent cohesive fashion. That technology, however, can be cost-prohibitive for instructors to deploy.

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[7] Lila Bozgeyikli and Ren Bozgeyikli, eds. *Virtual Reality: Recent Advancements, Applications and Challenges*, 51.

[8] Bruno Arnaldi, Pascal Guitton, and Guillaume Moreau, eds. *Virtual Reality and Augmented Reality : Myths and Realities*. Newark: John Wiley & Sons, Incorporated, 2018. Accessed June 4, 2021. ProQuest Ebook Central.

[9] Gregory Schmidt. "Virtual Reality Waits for the Music Industry to Catch Up." New York Times Company.

[10] Dong Hwa Choi, Amber Dailey-Hebert, and Judi Simmons Estes, eds. 2016. *Emerging Tools and Applications of Virtual Reality in Education*. Hershey: IGI Global. Accessed June 1, 2021. ProQuest Ebook Central.

Statement of Purpose

Technology should be considered an experience rather than simply a technological artifact.[11] However, immersive technology is lacking in the classrooms of colleges and universities. A deeper examination of the literature reveals that VR technology is being utilized for commercial training simulations wherein an employee can train for specific tasks without being on-location. When examining the use of VR in professional training within various fields, Andrzej Grabowski and Kamil Jach contend that, "it can be used to recreate even the most complex scenarios and surroundings, even those of the firefight in confined spaces where enclosed fires tend to appear and have been considered vastly hazardous for not only civilians or equipment but also to firefighters dispatched to contain them."[12] When considering the advantages of deploying VR in the educational environment, Michael Bodekaer writes, "Virtual simulation technology has the ability to alleviate issues with costs, time, and space that so many educational institutions experience."[13] This ability, however, is often hampered by a lack of teacher skill in practical deployments of the technology.

VR technology has proven to elicit an authentic physiological response. When studying the effects of performance anxiety on subjects in a virtual environment, Christine Crawford writes, "We know that participants do experience some level of anxiety in the VR

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[11] John McCarthy, and Peter Wright. "Technology as Experience", Interactions, Vol, 11 No. 5, pp. 42–43. (2007): https://dx.doi.org/10.1145/1015530.1015549

[12] Andrzej Grabowski and Kamil Jach. "The use of Virtual Reality in the Training of Professionals: With the Example of Firefighters." *Computer Animation and Virtual Worlds* 32, no. 2 (Mar, 2021), http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fuse-virtual-reality-training-professionals-with%2Fdocview%2F2509540426%2Fse-2%3Faccountid%3D12085.

[13] Michael Bodekaer. "EDUCATION AND VIRTUAL REALITY." *Diplomatic Courier*, 04, 2017. 16, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fmagazines%2Feducation-virtual-reality%2Fdocview%2F1999474792%2Fse-2%3Faccountid%3D12085.

environment."[14] Crawford demonstrates that subjects can cognitively blur the lines between virtual and authentic experiences. However, for a virtual reality experience to feel authentic, it must employ secondary effects such as background audio, foley audio, and environmental effects. Adolfo Enrique Samudio Cano writes, "These [secondary] effects are the ones that the person using the virtual environment normally would not notice directly. They influence the environment through the background with things [foley audio and environmental effects]."[15]

This study provides insights into the effect that VR can have on inducing MPA within voice and piano students. This research offers a mixed-method examination of the effectiveness of such virtual technologies. When deploying new technologies, Choi, Dailey-Hebert, and Estes point out, "the question remains as to how we can most effectively design pedagogical agents to best facilitate increased learning outcomes."[16] If a virtual reality system can be deployed that causes MPA, then the value of such a system would become apparent through its ability to create authentic response through a virtual means. Colleges and universities could benefit from more profound research exploring immersive learning environments for students. All education entities will benefit from cross-deploying VR technologies to other subject areas. Universities, colleges, and school districts could benefit from the reduced cost of geographic-bound education

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[14] Christine Rahal Crawford. "Effects of Exposure to Virtual Audience Environments on Performing Musicians." Order No. MR75937, McGill University (Canada), 2011. In PROQUESTMS ProQuest Dissertations & Theses Global, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fdissertations-theses%2Feffects-exposure-virtual-audience-environments-on%2Fdocview%2F902192573%2Fse-2%3Faccountid%3D12085.

[15] Adolfo Enrique Samudio Cano. "Design and Implementation of a Virtual Reality Laboratory for Mechanical Maintenance." Order No. 10810867, Morehead State University, 2018. In PROQUESTMS ProQuest Dissertations & Theses Global, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fdissertations-theses%2Fdesign-implementation-virtual-reality-laboratory%2Fdocview%2F2040890150%2Fse-2%3Faccountid%3D12085.

[16] Choi, Dailey-Hebert, and Estes, *Emerging Tools and Applications of Virtual Reality in Education*.

expenses such as field trips. Jaime Donally notes, "Augmented, virtual, and mixed reality can help bridge the gap of expected knowledge and needed experiences and bring our students to many locations around the world (or even outside the world)."[17] Additionally, Sara K Sweeney, Phyllis Newbill, Todd Ogle, and Krista Terry observe, "By applying course content in the augmented reality or virtual environment, students can find deeper meaning in the content while developing critical observation skills. These skills can transfer when students visit or otherwise study historically significant locations in the physical world."[18]

Significance of the Study

In the 21st century, educators need diverse technology tools to incentivize the learner's attention. School districts often mandate new technology to remain current with technological trends.[19] When attempting to fulfill district technology implementation expectations, technology integration can be a difficult job, especially across diverse educational circumstances. As technology becomes ever-present in the traditional classroom setting, some teachers need new models for incorporating new technologies. The deployment of VR can aid instructors in creating a dynamic learning experience. By incorporating VR technologies, an instructor can increase

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[17] Jaime Donally. 2018. *Learning Transported : Augmented, Virtual and Mixed Reality for All Classrooms*. P. 21.

[18] Sara K Sweeney, Phyllis Newbill, Todd Ogle, and Krista Terry. "Using Augmented Reality and Virtual Environments in Historic Places to Scaffold Historical Empathy." *TechTrends* 62, no. 1 (01, 2018): 114-8, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fusing-augmented-reality-virtual-environments%2Fdocview%2F1984038635%2Fse-2%3Faccountid%3D12085.

[19] Virginia Department of Education, "Technology in Education," *doe.virginia.gov*, Accessed April 29, 2020, http://www.doe.virginia.gov/support/technology/.

student attention retention by creating immersive learning experiences and exposing students to new learning environments.

Research Questions

This study examined the virtual potential for eliciting authentic MPA. This information can be used to increase music education learning opportunities by utilizing virtual environments. John W. Creswell, and J. David Creswell note that a “collection of both quantitative and qualitative data sequentially” employs a mixed-method design.[20] Francesca-M Dagnino, Yannis Dimitriadis, Francesca Pozzi, Bartolom Rubia-Avi, and Juan-I Asensio-Pérez examined the role of a mixed-method approach with the role of support technologies integrated within the classroom and noted, “The use of technologies in the presented mixed-methods research design implicated several advantages.”[21]

The first research question is: Can virtual environments that utilize a head mount display elicit MPA in piano and voice students? The results can better inform how VR can increase collegiate student learning opportunities within music education. The effectiveness of VR technology should be carefully investigated so that further research might occur. The second question is: Can this document serve as a case study in implementing the various emerging technologies? It examines insights into the implementation of VR in a virtual environment within music performance settings.

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[20] John W Creswell, and J. David Creswell. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, CA: SAGE Publications, Inc, 2018. 119.

[21] Francesca-M Dagnino, Yannis Dimitriadis, Francesca Pozzi, Bartolom Rubia-Avi, and Juan-I Asensio-Pérez. "The Role of Supporting Technologies in a Mixed Methods Research Design." *Comunicar: Media Education Research Journal* 28, no. 65 (2020): 53-62, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Frole-supporting-technologies-mixed-methods%2Fdocview%2F2488220569%2Fse-2%3Faccountid%3D12085.

Core Concepts

This study involved human interaction and included surveys and observations to collect data. It employed subject matter experts to adjudicate performances. It compared data sets between authentic and virtual environments.

Survey and interview results informed question one. Question two was informed by literature on technology deployments within commercial and academic settings. Following a thorough investigation of the literature, a plan to explore question one was answered through a mixed-methods research approach that provided a case study concerning MPA within authentic and virtual environments. The data for question 2 was interpreted in several ways; First, by qualitative comparisons of VR deployment, then by comparing the interviews of students about the technology's effectiveness.

Dr. Liz Kolb's learning concepts were created long before the emergence of immersive technology. However, when considered, Kolb's Theory of Experiential Learning might give a foundation for comprehending the learning process in the twenty-first century. Lastly, Kolb's Triple E Framework was applied to the data to understand the effectiveness of the technology's integration to enhance learner outcomes.[22] Her framework asks the following questions:

Engagement

1. Does the technology tool help students focus on the learning goals (content) with less distraction(s)?
2. Does the technology tool help to motivate students to begin the learning processes?
3. Does the technology cause a shift in the behavior of the students, where they move from passive to active social learners (co-use)?

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[22] Liz Kolb. *Learning First, Technology Second: the Educator's Guide to Designing Authentic Lessons*. Portland: International Society for Technology in Education, 2017.

Enhancement

1. Does the technology tool aid students in developing or demonstrating a more sophisticated understanding of the content?
2. Does the technology create scaffolds to make it easier to understand concepts or ideas?
3. Does the technology create paths for students to demonstrate their understanding of the learning goals in a way that they could not do with traditional tools?

Extension

1. Does the technology create opportunities for students to learn outside of their typical school day?
2. Does the technology create a bridge between school learning and their everyday life experiences?
3. Does the technology allow students to build skills that they can use in their everyday lives?

Outliers were noted, and a conclusion was drawn that correlated a virtual learning experience and learner outcomes. Any information gleaned from using a virtual reality system was explained. Student assessment results were entered for easy comparison, and additional observations or information were included.

Definition of Terms

One of the difficulties that instructors and researchers encounter when using immersive technologies is their high learning curve. Technology education and academic knowledge are described using a variety of technical terminology. This section clarifies this terminology based on the research data presented in this study.

- **Authentic Practice Room Environment:** A testing environment wherein students are in a physical music practice room. This environment excludes any virtual reality technology.

- **Augmented Reality (AR):** Technologies that present on a digital device an interactive narrative, navigation means for learners, and/or academic information, all of which are superimposed on (a representation of) a physical location or device.[23]
- **Blended Instruction:** The incorporation of technology into in-person classroom instruction.[24]
- **Broadband:** Internet speeds of at least 25 megabytes per second download and at least 3 megabytes per second upload speed.[25]
- **(Computer) Application (App):** An application, often known as an application program, is a piece of software that runs on your computer. Applications include web browsers, e-mail programs, word processors, games, and utilities.[26]
- **Computer Automatic Virtual Environment (CAVE):** A room whose walls, ceiling, and floor surround a viewer with projected images. Its design overcomes many problems encountered by other virtual reality systems and can be constructed from currently available technology.[27]

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[23] AECT. (2014). *Handbook of research on educational communications and technology.* New York: Springer.

[24] Virginia Department of Education, "Educational Technology Notes," *doe.virginia.gov*, Accessed June 19, 2021, http://www.doe.virginia.gov/school_finance/edu_technology_notes/index.shtml.

[25] BroadBandNow, "Broadband Service in Virginia," *broadbandnow.com*, February 6, 2020, Accessed June 19, 2021. https://broadbandnow.com/Virginia.

[26] Per Chistensson, "application," *techterms.com*, October 12, 2008, Accessed June 19, 2021, https://techterms.com/definition/application.

[27] Carolina Cruz-Neira, Daniel J. Sandin, Thomas A. DeFanti, Robert V. Kenyon, and John C. Hart. "Cave. Audio Visual Experience Automatic Virtual Environment." *Communications of the ACM* 35, no. 6 (1992): 65-72, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fcave-audio-visual-experience-automatic-virtual%2Fdocview%2F25597618%2Fse-2%3Faccountid%3D12085.

- **Extended Reality (XR):** XR is reality-plus tech that employs the use of a screen. It is a term that describes VR and AR technologies.
- **Head mount Display (HMD):** This is a small display or projection technology integrated into eyeglasses or mounted on a helmet or hat.[28]
- **Locationality:** The state of being virtually local. This is often used to convey a geographical placement without the learner being there. Locationality could be an essential part of a learner's experience to bridge feelings of displacement through digital mediums.
- **Music Performance Anxiety (MPA):** An experience of marked and persistent anxious apprehension related to musical performance manifested through combinations of affective, cognitive, somatic, and behavioral symptoms. MPA is a significant problem for many musicians.[29]
- **Virtual Concert Hall:** A testing environment wherein students are in a virtual concert hall through VR technology. This environment resides in an authentic environment wherein a virtual concert hall is reproduced in VR.

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[28] Gartner_Inc. "Definition of Head-Mounted Displays (HMDs) - Gartner Information Technology Glossary." *Gartner*. Accessed June 19, 2021. https://www.gartner.com/en/information-technology/glossary/head-mounted-displays-hmd.

[29] Amélie A.J.A.A. Guyon, Regina K. Studer, Horst Hildebrandt. *et al.* Music performance anxiety from the challenge and threat perspective: psychophysiological and performance outcomes. *BMC Psychol* **8,** 87 (2020). https://doi.org/10.1186/s40359-020-00448-8

- **Virtual Reality (VR):** an artificial environment that is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment.[30]
- **Virtual Reality Exposure Training (VRET):** Virtual reality technology is being used in psychiatric and occupational therapy and virtual rehabilitation. Virtual reality therapy involves patients navigating through digitally created environments and completing specially designed tasks, which are often tailored to treat a specific ailment. It is designed to isolate the user from sensory inputs and create the illusion of immersion inside a computer-generated, interactive virtual environment.

Summary

Technology within music education can be an essential tool for engaging students. The classroom, however, has lagged the commercial section in its incorporation of emerging technologies. Incorporating VR technologies might aid collegiate music instructors in delivering quality student educational opportunities that would otherwise never be afforded. Yet, research is lacking concerning the effectiveness of VR in eliciting music performance anxiety for voice and piano students. A consideration of the background, including modern teaching methods and the incorporation of new XR technologies, has been made to demonstrate a need for research

[30] "Virtual Reality." *Merriam-Webster*. Merriam-Webster, n.d. Accessed June 19, 2021. https://www.merriam-webster.com/dictionary/virtual%20reality.

examining the impact of virtual reality within rehearsal spaces and its authentic implications for education.

CHAPTER 2

LITERATURE REVIEW

Introduction

In 2020, the COVID-19 pandemic dramatically shifted how students were educated. The United States Census Bureau reported, "nearly 93% of people in households with school-age children reported their children engaged in some form of distance learning from home."[31] Even without the 2020 pandemic, music educators could not have predicted how the expedient adoption of technologies was needed to facilitate more efficient online learning. Elliot King and Neil Alperstein insist, "When music education academics thought about the benefits of distance learning, they saw the broad perspective, simple access, and practices technology provided to educators and their pedagogy."[32] As educators adapt to a changing field of education, adopting emerging technologies may facilitate increased learner outcomes.

Simon Gunkel, Hans Stokking, Martin Prins, Omar Niamut, Ernestasia Siahann, and Pablo Cesar detailed the trajectory of the field of social VR applications in their 2018 study in which they aimed to identify research-worthy areas of social VR. According to the findings of this study, the areas of social VR that generated the most interest among participants tended to involve extensive face-to-face interaction, such as video conferencing and education.[33]

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[31] U.S. Census Bureau. "Schooling during the COVID-19 Pandemic." *The United States Census Bureau*. Last modified August 26, 2020. Accessed October 8, 2021. https://www.census.gov/library/stories/2020/08/schooling-during-the-covid-19-pandemic.html.

[32] Elliot King and Neil Alperstein. (2014). *Best practices in online program development:Teaching and learning in higher education*. New York: Routledge

[33] Simon Gunkel, Hans Stokking, Martin Prins, Omar Niamut, Ernestasia Siahaan, and Pablo Cesar. "Experiencing Virtual Reality Together." *Proceedings of the 2018 ACM International Conference on Interactive Experiences for TV and Online Video* (2018).

The IDC reported that the market for VR and AR goods expanded by 92.1% in 2021; thus, it is worthwhile to investigate the efficacy of design patterns within present VR software and how we may create design models for future developers.[34] Despite this, the VR/AR software design concept is still relatively young in the context of the technological landscape. There are user experience (UX) models for people who build VR products; however, very little research has been conducted on user behavior patterns within the context of social VR. Designing the user experience of virtual reality (VR) applications poses a unique set of issues due to the application's fully immersive and virtual nature. Particularly challenging for educational VR applications is the incorporation of life-like and immersive elements to culminate in a practical experience.

Stages of Online Education

Glen M Farrell explains that the first generation of online education was mail correspondence education, wherein in the late 1800s, "land grant universities would deliver agricultural education to farmers in rural areas."[35] This mail correspondence culminated with the largest private for-profit Pennsylvania-based International Correspondence Schools that eventually grew to an enrollment of over 900,000 correspondence students. The second stage came from telecourse offerings of Sunrise Semester and Continental Classroom in the 1950s. It peaked in the 1990s with the Annenberg Learner project that broadly distributed educational video programs through the Corporation for Public Broadcasting. In 1989, the University of Phoenix became the first institution to offer fully online bachelors and masters degrees. The

[34] IDC. "AR/VR Headset Shipments Grew Dramatically in 2021, Thanks Largely to Meta's Strong Quest 2 Volumes, with Growth Forecast to Continue, According to IDC." IDC, 21 Mar. 2022. https://www.idc.com/getdoc.jsp?containerId=prUS48969722#:~:text=NEEDHAM%2C%20Mass.%2C%20March%2021,Quarterly%20AR%2FVR%20Headset%20Tracker.

[35] Glen M Farrell. "The Development of Virtual Education: A Global Perspective." (1999). 32.

utilization of the internet to deliver distance education markers the third age. Lastly, a fourth stage started with the deployment of entirely virtual programs of study. The fourth stage hit critical mass when colleges and universities started to offer online-only courses. These courses are facilitated by a central campus learning management system and deployed to students via the internet. In 2001, Professor James Taylor identified the fifth stage of distance learning. He hypothesized a fifth stage with the development of, "a customizable eInterface, a campus portal through which students, staff and other stakeholders can engage with the university in a highly interactive and compelling manner."[36] Farhad Saba argued that these stages of distance learning might be an oversimplification of what is transpiring within a classroom. Saba contends that, "this reductionist view of the field essentially precludes considering social aspects of learning from their practice."[37] The previously described stages do not account for the social interactions that enrich the learning experience.

Locationality

A problem with online learning is that students often feel disconnected from the educational institution. Joan B. Parris, Jana P. Beaver, David W. Nickels, and John D. Crabtree demonstrated, "There is sufficient evidence from these writers' hybrid class experiences to indicate that there is potentially a natural student 'disconnect' concerning student engagement in hybrid classes."[38] This disconnect can take many forms, including the overall connection of the

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[36] James C Taylor. "20TH ICDE WORLD CONFERENCE ON OPEN LEARNING AND DISTANCE EDUCATION The Future of Learning - Learning for the Future: Shaping the Transition." (2001).

[37] Farhad Saba. "Distance Education in the United States: Past, Present, Future." Educational Technology archive 51 (2011): 14.

[38] Joan B. Parris, Jana P. Beaver, David W. Nickels, and John D. Crabtree. "Is there a Student "Disconnect?" First-Year Hybrid Class Teachers' Observations and Recommendations for Improving Student Engagement in Information Systems Classes." *Information Systems Education Journal* 9, no. 3 (08, 2011): 50-8,

learner to the on-location experience that a traditional student has. Ruth N. Lopéz Turley suggested, “Many factors influence a student’s level of academic engagement; the single most important environmental factor identified in previous research is living on campus in a residence hall.”[39] However, virtual reality headsets can virtually place a learner in any environment. If a learner experiences a physiological response within an environment, one might claim that a virtual reality experience might offer much of the same benefits for a distance learner.

Mitigated Physiological Response

Research has demonstrated promising outcomes when utilizing virtual reality to treat phobias. Barbara Olasov Rothbaum, Larry Hodges, Benjamin A. Watson, G. Drew Kessler, and Dan Opdyke virtually exposed seventeen college students to examine if virtual exposure helped mitigate adverse reactions to phobias. The treatment group improved much more than the control group after seven weekly 35–45-minute virtual reality exposure sessions.[40] Cristina Botella, Rosa M. Baños, Helena Villa, Conxa Perpiñá, and Azucena García-Palacios investigated the efficacy of virtual reality exposure in treating claustrophobia. Four individuals with this fear were exposed to two distinct environments: a home and an elevator. Different situations were used in each location to elicit varying degrees of fear. There were significant reductions in all clinical parameters after eight individual sessions lasting 35-40 minutes each over a four-week period.

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http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fis-there-student-disconnect-first-year-hybrid%2Fdocview%2F1941335058%2Fse-2%3Faccountid%3D12085.

[39] Ruth N. López Turley and Geoffrey Wodtke. “College Residence and Academic Performance: Who Benefits from Living on Campus?” Urban Education 45, no. 4 (July 2010): 506–32. https://doi.org/10.1177/0042085910372351.

[40] Barbara Olasov Rothbaum, Larry Hodges, Benjamin A. Watson, G. Drew Kessler, and Dan Opdyke. “More Virtual Reality Exposure Therapy.” *PsycEXTRA Dataset* (1997).

Thus, it was determined that virtual reality exposure was beneficial for decreasing anxiety and avoidance in claustrophobic circumstances and improving self-efficacy.[41]

Jaye Wald researched virtual reality exposure's effectiveness in treating driving anxiety. Five female participants were exposed to six distinct typical routes through a virtual reality driving simulator. Each participant got eight weekly sessions lasting 50 to 60 minutes. Each person followed a set route along a road with varying weather and time conditions. According to the findings, symptoms related to the fear of driving were reduced in three of five individuals. Virtual reality exposure did not increase actual driving duration or frequency for any of the patients in this study. Thus, virtual reality exposure was moderately beneficial, even with brief exposure to the stimulus.[42] Rothbaum, Hodges, Watson, Kessler, and Opdyke performed a case study with a 42-year-old lady with a crippling phobia of flying and avoided traveling. During six weekly 35—45-minute sessions, the subject was virtually exposed to flying in a simulated aircraft. Her self-reported anxiety levels decreased, eventually leading her to fly in an actual aircraft.[43]

Gayle J. Beck, Sarah A. Palyo, Eliot H. Winer, Brad E. Schwagler, and Eu Jin Ang researched the benefits of virtual reality exposure therapy in the treatment of post-traumatic

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[41] Cristina Botella, Rosa M. Baños, Helena Villa, Conxa Perpiñá, and Azucena García-Palacios. "Virtual Reality in the Treatment of Claustrophobic Fear: A Controlled, Multiple-Baseline Design." *Behavior Therapy* 31, no. 3 (2000): 583–595.

[42] Jaye Wald. "Efficacy of Virtual Reality Exposure Therapy for Driving Phobia: A Multiple Baseline across-Subjects Design." *Behavior Therapy* 35, no. 3 (2004): 621–635.

[43] Barbara O. Rothbaum, Larry Hodges, Benjamin A. Watson, G, Drew Kessler, and Dan Opdyke. "Virtual Reality Exposure Therapy in the Treatment of Fear of Flying: A Case Report." *Behaviour Research and Therapy* 34, no. 5-6 (1996): 477–481.

stress disorder symptoms induced by severe motor vehicle accidents. Six participants underwent ten virtual reality sessions in which they were exposed to different real-time driving situations. Four kinds of sceneries were available: highway, urban, suburban, and country. The therapist was able to predict the amount of traffic, time of day, weather conditions, and particular driving incidents within each scenario type. Pre-to-post-treatment results showed that all individuals had substantial decreases in post-traumatic symptoms such as reexperiencing, avoidance, and emotional numbness. A virtual experience showed potential for the treatment of PTSD and driving-related anxiety.[44]

Page Anderson, Barbara O. Rothbaum, and Larry F. Hodges conducted two case studies with individuals who were afraid of public speaking. The participants were shown a virtual audience, which was a video of individuals in a virtual classroom setting. The completion of a behavioral avoidance test after therapy and reductions in self-reported measures of public speaking anxiety indicated that the treatment was effective.[45]

Music Performance Anxiety

A competent musician should be able to handle the mental and physical strain of performing in front of an audience and have good musical and technical abilities. Anxiety levels might rise during the process of preparing and giving a performance. This type of anxiety is known as Music Performance Anxiety (MPA), and occurs when the performer's response to

[44] Gayle J. Beck, Sarah A. Palyo, Eliot H. Winer, Brad E. Schwagler, and Eu Jin Ang. "Virtual Reality Exposure Therapy for PTSD Symptoms after a Road Accident: An Uncontrolled Case Series." *Behavior Therapy* 38, no. 1 (2007): 39–48.

[45] Page Anderson, Barbara O. Rothbaum, and Larry F. Hodges. "Virtual Reality Exposure in the Treatment of Social Anxiety." *Cognitive and Behavioral Practice* 10, no. 3 (2003): 240–247.

stress exceeds their typical arousal state. At low levels, MPA can benefit the performer, giving a heightened sense of awareness and motor faculty.[46] However, a high MPA can be detrimental to performance abilities.[47] Research from Wendy J. Cox and Justin Kenardy has shown that solo performances induce the most anxiety. [48] Charlene Ryan and Nicholle Andrew's research shows that solo performances cause more anxiety among vocal students.[49] Therefore, participants were asked to perform solo while being exposed to the audience situation. In addition, research has shown that musicians experience higher levels of stress when performing in front of a larger audience as opposed to when they are performing alone in a practice room or in front of a researcher.[50] Larger audiences have been shown to elicit a more significant amount of music performance anxiety.[51] Due to this fact, there were a minimum of twenty-five individuals in the audience.

Physiological Response for Virtual Performing Musicians

A study by Dr. Evelyn Orman took five men and three women who were saxophone majors and placed them in twelve 15-to-20-minute weekly practice sessions in which they were

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[46] Jamie A. Dyce and Brian P. O'Connor. "The Personalities of Popular Musicians." *Psychology of Music* 22, no. 2 (1994). 169.

[47] Margaret S. Osborne, and Dianna T. Kenny. "Development and Validation of a Music Performance Anxiety Inventory for Gifted Adolescent Musicians." *Journal of Anxiety Disorders* 19, no. 7 (2005): 725–751.

[48] Wendy J. Cox, and Justin Kenardy. "Performance Anxiety, Social Phobia, and Setting Effects in Instrumental Music Students." *Journal of Anxiety Disorders* 7, no. 1 (1993): 49–60.

[49] Charlene Ryan, and Nicholle Andrews. "An Investigation into the Choral Singer's Experience of Music Performance Anxiety." *Journal of Research in Music Education* 57, no. 2 (2009): 108–126.

[50] Donald L. Hamann. "An Assessment of Anxiety in Instrumental and Vocal Performances." *Journal of Research in Music Education* 30, no. 2 (1982): 77–90.

[51] M. Brotons. "Effects of Performing Conditions on Music Performance Anxiety and Performance Quality." *Journal of Music Therapy* 31, no. 1 (1994): 63–81.

immersed in one of four virtual environments with varying levels of anxiety elicitation potential. According to the findings, participants in the virtual worlds showed physiological and psychological signs of heightened anxiety.[52] A second study by Orman observed three upper division saxophonists performing in four immersive environments that gradually increased the expected anxiety level of the performer. Orman's finding corroborated previous research and found that virtual reality graded exposure did increase physiological and psychological anxiety.[53] Mackay investigated the efficacy of virtual reality exposure treatment for musicians with performance anxiety. Ten University of Queensland music students were randomly allocated to either a virtual or non-virtual exposure. Participants in the exposure condition had to perform in front of a virtual audience that they could manage with a pedal switch. In the non-virtual condition, the participants performed in front of an empty virtual performance hall. Following the exposure, all participants took part in a test session in which they played in front of a virtual audience. Subjective units of pain, a performance anxiety questionnaire, and heart rate beats per minute (BPM) were among the self-reported and physiological measurements used. There were no noteworthy findings in terms of treatment outcome. However, technological restrictions may have influenced the results' importance. For example, there were flaws in the graphical pictures,

[52] Evelyn K. Orman. "Effect of Virtual Reality Graded Exposure on Heart Rate and Self-Reported Anxiety Levels of Performing Saxophonists." Journal of Research in Music Education 51, no. 4 (2003): 302–15. https://doi.org/10.2307/3345657.

[53] Evelyn K. Orman. "Effect of Virtual Reality Graded Exposure on Anxiety Levels of Performing Musicians: A Case Study." Journal of Music Therapy 41, no. 1 (Spring, 2004): 70-8, http://ezproxy.baylor.edu/login?url=https://www.proquest.com/scholarly-journals/effect-virtual-reality-graded-exposure-on-anxiety/docview/223564157/se-2?accountid=7014.

which could have harmed the study's visual reality. As a result, this issue may have stopped participants from feeling present and immersed.[54]

Thyer conducted a study investigating virtual reality therapy as a viable treatment for music performance anxiety. A total of sixteen students took part in the research. The treatment group consisted of nine individuals who were obliged to perform a musical piece in front of a virtual audience. The VR group also had control over the size of the crowd via a pedal switch. Subjective units of discomfort and a performance anxiety assessment were used as psychological measurements. In addition, physiological parameters were taken, including heart rate. A waiting-list control group was formed with the remaining seven individuals. After the treatments, all participants performed in a session in front of a live audience to see if the virtual reality exposure effects could be transferred to a real performance environment. The study yielded no meaningful results, which could be due to the small sample size and limited statistical power.

A study by Josiane Bissonnette, Francis Dubé, Martin D. Provencher, and Maria T. Moreno Sala assessed the impact of virtual reality exposure training on students with music performance anxiety. The study found a significant decrease in performance anxiety for musicians with a high level of state-trait anxiety.[55] Additionally, the authors conclude, "between

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[54] Christina Mackay. "An Investigation into the Use of Virtual Reality Exposure Therapy for Music Performance Anxiety." Dissertation, Griffith University, 2003.

[55] Josiane Bissonnette, Francis Dubé, Martin D. Provencher, and Maria T. Moreno Sala. "Virtual Reality Exposure Training for Musicians: Its Effect on Performance Anxiety and Quality." *Medical Problems of Performing Artists* 30, no. 3 (09, 2015): np, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fvirtual-reality-exposure-training-musicians%2Fdocview%2F1737438299%2Fse-2%3Faccountid%3D12085.

the pre-and post-tests, we observed a significant increase in performance quality for the experimental group, but not for the control group."[56]

A similar study by Josiane Bissonnette, Francis Dube, Martin D. Provencher, and Maria Moreno Sala T considered the use of virtual reality as a treatment for anxiety problems. This pilot study looks at a virtual reality exposure training (VRET) program designed to help those nervous about performing in front of an audience or music performance anxiety (MPA). The goal is to gain first-hand experience with VRET in the realm of music. According to this study, during a session MPA, concentration and performance quality all change. Six 1-hour VRET sessions were held for three weeks, with nine music students participating. They were given four different virtual environments to experience, each representing a typical musician's audience. MPA decreased significantly between sessions, according to the data. The study also found a link between absorption ability and anxiety level before the start of the VRET, as well as a significant increase in performance quality within sessions. More research is needed to see if these findings can be applied in real-world settings.[57]

Christine Rahal studied to see if musicians' performance anxiety levels could be reduced by exposing them to a virtual reality audience. The study included sixteen music students. Live audiences were present at both the pre-and post-test concerts. Every individual was assigned to a VR group and a control group. The tension, heart rate, and cortisol levels of participants in the

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[56] Ibid, 23.

[57] Josiane Bissonnette, Francis Dube, Martin D. Provencher, and Maria Moreno Sala T. "Evolution of Music Performance Anxiety and Quality of Performance during Virtual Reality Exposure Training." *Virtual Reality* 20, no. 1 (03, 2016): 71-81, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fevolution-music-performance-anxiety-quality%2Fdocview%2F1793245482%2Fse-2%3Faccountid%3D12085.

VR program were measured. The environmental projection was used in this work to construct virtual reality surroundings. Christine Rahal Crawford noted, "We know that participants do experience some level of anxiety in the VR environment."[58]

Challenges for Online Learners

Socioeconomic inequalities in the utilization of online resources can cause digital inequality. In 2016 the United States Census Bureau noted inequality in access to technology, computers, and the internet based upon family incomes and geography. The study reported, "Differences in computer use and broadband Internet subscriptions by household income were pronounced. Of households with an income of $150,000 or higher, 99 percent had a computer, and 96 percent had a broadband Internet subscription. Among households with an income of less than $25,000, the proportions were 72 percent and 58 percent, respectively."[59] The lack of computer usage and internet availability for households with an income of $99,999 or below were "significantly more likely to use paper materials sent home for distance learning than households with income of $100,000 or more."[60] The lack of computing and internet usage among lower-income households presents a significant problem for the adoption of VR as an educational tool for students. If households are struggling to provide computers for their

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[58] Christine Rahal Crawford. "Effects of Exposure to Virtual Audience Environments on Performing Musicians." Order No. MR75937, McGill University (Canada), 2011. In PROQUESTMS ProQuest Dissertations & Theses Global, http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fdissertations-theses%2Feffects-exposure-virtual-audience-environments-on%2Fdocview%2F902192573%2Fse-2%3Faccountid%3D12085.

[59] Bureau, US Census. "Computer and Internet Use in the United States: 2016." *The United States Census Bureau*. Last modified October 28, 2019. Accessed October 8, 2021. https://www.census.gov/library/publications/2018/acs/acs-39.html.

[60] Bureau, U.S. Census. "Schooling during the COVID-19 Pandemic." *The United States Census Bureau*. Last modified August 26, 2020. Accessed October 8, 2021. https://www.census.gov/library/stories/2020/08/schooling-during-the-covid-19-pandemic.html.

children, it is safe to assume those same households will have difficulty procuring an emerging technology such as VR headsets.

Head Mounted Displays

The technological development of the Head Mounted Display or VR headset has only recently synergized the use of wireless technology, internet, high-quality graphics processing, and affordability. HMDs can now wirelessly connect to the internet. The lack of a tethered wire connection only strengthens the realism of the device. Internet speeds are now high enough to allow users from vast distances to interact within the same virtual environments. The latest consumer devices possess resolutions that exceed HD standards. High resolutions equate to increased realism of virtual objects. HMDs are now priced at an affordable consumer level when compared to previous iterations.

Spatial Audio Within Virtual Environments

Spatial audio allows users to experience the proximity of audio. This type of audio mimics one’s authentic experience through artificial replication of volume levels. When a sound source is spatialized using loudspeakers, it undergoes several modifications before reaching the listener. First, the source is modified by panning and other spatialization algorithms based on its locational properties in the virtual field. Next, the loudspeaker array projects the audio into the acoustic field, changing the source further. The virtual field, loudspeaker array, and acoustic field combine to generate the spatial audio field (SAF), which substantially affects how an audio composition is perceived. Johannes M. Arend, Tim Lübeck, and Pörschmann Christoph suggest, “Headphone-based binaural rendering of spatial sound fields is of great importance in the consumer sector for virtual reality and augmented reality applications."[61] Through spatial audio, users can navigate virtual environments and be given an accurate representation of an environment's unique audio characteristics.

Avatars and Characters

Modern VR systems that enable communication in VR, such as Meta Worlds, VRChat, and AltspaceVR, have a significant constraint in that users are often represented by comic-styled characters. This constraint may be advantageous for some children's games, but it may not be advantageous for many educational scenarios, such as business meetings or eliciting life-like responses in participants. Publications have examined the significance of avatar appearance in virtual reality (VR) and video games, as well as its significant impact on player performance. A 2016 study examined the effect of an avatar's appearance on training objectives. Based on their research of users in training simulations and video games, Irwin Hudson and Jonathan Hurter concluded that avatar appearance might be related to performance.[62] Similarly, it discovered that users performed better in team-based tasks when their avatar approximated their likeness.[63] Life-like avatars and characters bring an increased authenticity to virtual environments.

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[61] Johannes M. Arend, Tim Lübeck, and Pörschmann Christoph. "Efficient Binaural Rendering of Spherical Microphone Array Data by Linear Filtering." *EURASIP Journal on Audio, Speech, and Music Processing* 2021, no. 1 (12, 2021), http://ezproxy.baylor.edu/login?url=https://www.proquest.com/scholarly-journals/efficient-binaural-rendering-spherical-microphone/docview/2593954721/se-2.

[62] Hudson, Irwin, and Jonathan Hurter. "Avatar Types Matter: Review of Avatar Literature for Performance Purposes." *Lecture Notes in Computer Science* (2016): 14–21.

[63] Van der Land, Sarah F., Alexander P. Schouten, Frans Feldberg, Marleen Huysman, and Bart van den Hooff. "Does Avatar Appearance Matter? How Team Visual Similarity and Member-Avatar Similarity Influence Virtual Team Performance." *Human Communication Research* 41, no. 1 (2014): 128–153.

Virtual Environments

The design of realistic avatars can increase the realism and interaction of VR users. However, such realism may not be required for buildings and other structures. Daniel Paes and Javier Irizarry note, "In the design activity, the most relevant aspect of an efficient tool seems to be its ability to faithfully correspond to, reproduce, and communicate a designer's idea, not necessarily in a realistic format, when an idea is not realistic"[64] They argue that buildings may not have to include a comprehensive set of visual details or information to be effective.

Virtual environments are constructed within computer software applications. They can incorporate multiple media assets, including 3D objects, pictures, and videos. Such settings are nearly infinitely developable and are only limited in development by hardware requirements. One method for incorporating video within these environments includes overlaying a greenscreen video onto a virtual digital plane. This digital plane can chromakey a green screen video that leaves only the subject of the video placed within the virtual environment.

Cyber Sickness

Virtual reality experiences frequently induce motion-sickness-like discomforts, also known as cybersickness, which can result in general discomfort, headache, nausea, exhaustion, and other symptoms. Commonly, researchers employ pre- and post-immersive subjective questionnaires to quantify the intensity of Cybersickness. Recent research indicates that

[64] Paes, Daniel, and Javier Irizarry. "The Relevance of Visual Cues in Immersive Environments: Does Pictorial Realism Matter?" Computing in Civil Engineering 2019 (2019).

Cybersickness influences physiological signals such as heart rate, breathing rate, skin response, eye blinking rate, and electroencephalogram results.

Researchers have created numerous software-based approaches to alleviate pain during immersive encounters during the past several years. Some strategies involve altering user-presented pictures, such as modifying the user's field of view or obscuring the user's vision. Other solutions require the use of a companion item that follows the user during the simulation, such as rest frames that act as stationary reference frames or wire-frame boxes imitating CAVE automated virtual environments. Various mobility techniques, including teleportation, have also been used to alleviate the effects of cybersickness on users. Some methods to mitigate cybersickness prescribe changes in the virtual environment's realism and level of detail or design decisions addressing the geometry.

Metaverse

The author Neal Stephenson first used the term "metaverse" in his 1992 science fiction novel, Snow Crash. Stephenson alluded to the metaverse as an all-encompassing digital universe that runs in parallel with the physical world in his book. When computing and the internet originally came into existence, most interactions were conducted through text, including emails, messages, usernames, and email addresses. Then, over time, focus was gradually shifted toward media (photos, videos, live streams). The transition into three dimensions marks the next stage of development for user interfaces and experiences. Internet is the primary technology in the metaverse that drives people to replace reality with its representatives.[65] Within the metaverse,

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[65] James Trier. “Guy Debord's the Society of the Spectacle.” *Journal of Adolescent & Adult Literacy* 51, no. 1 (2007): 68–73.

digital life takes place in a realm that exists in parallel with the real one. The internet inserts the ability to enable multiplayer interactions within VR spaces. In their study on the Metaverse as an e-learning environment, Neama Dahan, Muna Al-Razgan, Ali Al-Laith, Muaadh Alsoufi, Mahfoudh Al-Asaly, and Taha Alfakih note that, "The virtual learning environment is the primary environment for future educational systems."[66] Emerging technologies come in a wide variety. Even though the metaverse may be complex and challenging to understand at first, it has the potential to alter people's lives. The metaverse represents the next logical progression of VR through integrating multiple users within the same virtual space. The ability to virtually gather individuals from various international locations for a synchronous experience holds tremendous potential for education.

Conclusion

Educational technology is undergoing a significant change through the use of XR. The next stage of online education may point towards immersive multiplayer virtual environments through the construction of virtual metaverses and metaversities. The understanding of shared effects between virtual and authentic experiences can help educators adopt and implement new pedagogies in this next stage. These pedagogies may offer exciting possibilities and new frontiers in music education research. Discovering the presence of MPA within virtual experiences holds value in its ability to be leveraged within music education. MPA is also an indicator of an elevated sense of virtual presence, which is a key element of a realistic

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[66] Neama A Dahan, Muna Al-Razgan, Ali Al-Laith, Muaadh A. Alsoufi, Mahfoudh Al-Asaly, and Taha Alfakih. "Metaverse Framework: A Case Study on E-Learning Environment (ELEM)." Electronics 11, no. 10 (2022): 1616, http://ezproxy.baylor.edu/login?url=https://www.proquest.com/scholarly-journals/metaverse-framework-case-study-on-e-learning/docview/2670126213/se-2.

experience. The ability to invoke MPA means that virtual environments can help students through MPA exposure, give them opportunities to overcome its effects, and ultimately work towards a significant experience that mirrors the complex emotions that an authentic performance experience yields.

This study investigated the impact of simulating a virtual audience on participants with self-reported anxiety levels, heart rates, and scores on a State-Trait Anxiety Inventory test. These measurements represent a guide for the understanding of MPA within a virtual auditorium. It was theorized that being in a virtual environment could lead to MPA. It is speculated that further research could lead to the mitigation of MPA through conditioning.

CHAPTER 3

METHODOLOGY

Introduction

Fourteen undergraduate voice and piano students from a university volunteered to participate in the study. The students that completed the study consisted of five males and nine females. All the students were taking applied music lessons. Ten were planning to pursue a college music degree. The instrumental categories included voice (10) and piano (4).

Measuring Performance Anxiety

The State-Trait Anxiety Inventory (STAI) was developed by Charles Spielberger, Richard L. Gorsuch, and Robert E. Lushene to be a self-reporting, four-point, 40-item measurement that ranges from 1 (not at all) to 4 (very much so). The test is used in clinical settings to diagnose anxiety and to distinguish it from depressive syndromes. The STAI has two subscales with twenty items each (see Appendix A). The first subscale is "state anxiety" or STAI-Y1, which represents an individual's anxiety level before a performance within a virtual environment. The second subscale is "trait anxiety" or STAI-Y2, wherein the subject's anxiety level is measured after a performance within a virtual environment. STAI has demonstrated a successful ability to discern between anxious and non-anxious individuals.[67] The following guidelines are recommended for the interpretation of scores: 0–9, normal or no anxiety; 10–18, mild to moderate anxiety; 19–29, moderate to severe anxiety; and 30–63, severe anxiety.[68] The

[67] Peter J. Bieling, Martin M. Antony, and Richard P. Swinson. "The State--Trait Anxiety Inventory, Trait Version: Structure and Content Re-Examined." *Behaviour Research and Therapy* 36, no. 7-8 (1998): 777–788.

[68] Laura J. Julian. (2011), Measures of anxiety: State-Trait Anxiety Inventory (STAI), Beck Anxiety Inventory (BAI), and Hospital Anxiety and Depression Scale-Anxiety (HADS-A). Arthritis Care Res, 63: S467-S472. https://doi.org/10.1002/acr.20561

test only requires a sixth-grade reading level, therefore minimizing reading confusion and can be used for various individuals.

Physiological Measurement

The subject's heart rate was measured with an Apple iWatch that recorded the participant's heart rate in beats per minute (bpm). The collection device used to record the heart-rate level was the Cardiogram application. Two measurement sets took place; the first was after a performance within an authentic practice room, the second was after a performance within a virtual auditorium. Correlating physiological arousal with heart rate shown in beats per minute has previously shown success in measuring music performance anxiety.[69]

A heartbeat produces an electrical impulse that travels through one's heart. The Apple Watch has been proven to record those electrical impulses accurately. In a study of comparison of the measurement accuracy between an Apple Watch and a standard 12-lead electrocardiogram (ECG), Nora Sprenger, Sepehri Shamloo Alireza, Jonathan Schäfer, Sarah Burkhardt, Konstantinos Mouratis, Gerhard Hindricks, Andreas Bollmann, and Arash Arya note, "A significant strong correlation could be observed between the Apple Watch and the standard ECG's measured variables."[70] An additional study by Matthew P Wallen., Sjaan R. Gomersall,

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[69] Albert LeBlanc, Young Chang Jin, Mary Obert, and Carolyn Siivola. "Effect of Audience on Music Performance Anxiety." *Journal of Research in Music Education* 45, no. 3 (1997): 480–496.

[70] Nora Sprenger, Sepehri Shamloo Alireza, Jonathan Schäfer, Sarah Burkhardt, Konstantinos Mouratis, Gerhard Hindricks, Andreas Bollmann, and Arash Arya. "Feasibility and Reliability of Smartwatch to Obtain Precordial Lead Electrocardiogram Recordings." Sensors 22, no. 3 (2022): 1217, http://ezproxy.baylor.edu/login?url=https://www.proquest.com/scholarly-journals/feasibility-reliability-smartwatch-obtain/docview/2627837526/se-2.

Shelley E. Keating, Ulrik Wisløff, and Jeff S. Coombes concluded that the Apple Watch accurately measures heart rate.[71] The Apple Watch 7 was used for this study.

Musical Performance Quality Rating Form

The National Association of Teachers of Singing Classical Adjudication Form is a rating form for voice performers that includes six categories with a thirty-point scale, which is used across North America in many vocal auditions (see Appendix B and C). The form has been in use with various revisions since 1952. The NATS audition rubric scores from 70 (lowest score possible) to 100 (highest score possible). The categories are (1) tone, (2) breathing/alignment, (3) language/diction, (4) musicianship/accuracy, (5) artistry/expression, and (6) ensemble. The first four categories from the form pertaining to individual performance without an authentic audience were used.

The Spokane Piano Competition adjudication form is a rating form for piano performers that includes four categories with a forty-point rating scale (see Appendix D). The form has been in use since 2013. The categories are (1) composer's intent, (2) rhythmic integrity, (3) technical mastery, and (4) musical artistry. Each participant's performance was recorded and blindly evaluated later by two licensed music adjudicators. The subject matter expert did not know which performance was in an authentic practice room and which was in a virtual concert hall.

[71] Matthew P Wallen., Sjaan R. Gomersall, Shelley E. Keating, Ulrik Wisløff, and Jeff S. Coombes. "Accuracy of Heart Rate Watches: Implications for Weight Management." *PLOS ONE* 11, no. 5 (2016).

Virtual Environment Construction

A virtual auditorium was constructed within Unity, a cross-platform game engine. The shell of the environment was made using Unity blocks. A flooring texture was added to the bottom block to replicate a hard vinyl floor. The two walls were given a light wood texture. A fabric texture was assigned to the ceiling. Small rectangles were added to the sides and ceiling and given a wooden surface to replicate acoustic wall treatment. Next, a curved stage was added and given a wooden texture. Auditorium chairs were assembled and evenly spaced. Theater curtains were added to the sides. Lastly, lighting generators were added to provide a theater-style look.

The audience was comprised of green screen video recordings of sitting individuals. The number of virtual concert attendees was chosen based on the number of attendees from a student recital observed at a local university. Due to constraints from the greenscreen stock footage, seating placement was not a replica for the same student recital. The greenscreen audience members elicited behaviors such as coughing, sneezing, and movement. The audience video footage was then overlaid within a virtual concert hall. This overlay resulted in an auditorium that resembled a life-like scenario wherein the performer was in front of an authentic audience (see Appendix E).

The VR software rig was positioned on stage. This rig represents the user's point of view and includes the headset's position and controllers across an XYZ spatial axis. The virtual voice environment consisted of a first-person standing point of view facing the audience. (see Appendix F). The virtual piano environment consisted of a first-person sitting point of view that faced the stage left side of the auditorium with a virtual piano positioned where the authentic piano was situated (see Appendix G). Both virtual environments allowed the participant to look around and visually experience the auditorium. The headset would adjust accordingly if the participant was sitting or standing.

Both virtual environments were managed to utilize a mobile device management (MDM) deployment software that enabled each participant to launch the appropriate environment quickly. The MDM managed the initial user experience of creating a guardian boundary and the initial experience launch. The MDM was set to kiosk mode to ensure that users triggered the correct virtual experience. The MDM homepage environment seemed to help users navigate a narrowed-down set of navigation options.

Hardware

The study specifically used Meta Quest 2 devices. The decision to employ Quest 2 devices was primarily motivated by the desire to design a realistic educational experience on a consumer-grade VR headset. The Meta Quest 2 is the most popular VR headset in terms of units sold as of 2021.[72] Additionally, Meta arguably provides the most feature-rich device for the lowest price, with a resolution of 1832 x 1920 pixels per eye, a high-speed Qualcomm Snapdragon XR2 processor, and 6GB of random-access memory (RAM). Additionally, the headset has built-in speakers that process cinematic 3D positional audio, allowing you to hear in all directions.

The Meta Quest 2 is an untethered VR device. It can be deployed in various situations without a separate host computer. It possesses the ability to scan the room and position itself accordingly. If a user moves within an authentic space, that movement is correlated with the virtual environment. Additionally, the device can track its controller locations. For this reason,

[72] IDC, “”AR/VR Headset Shipments Grew Dramatically in 2021, Thanks Largely to Meta’s Strong Quest 2 Volumes, with Growth Forecast to Continue, According to IDC.

once the experience was launched, the controllers were positioned behind the participant so they would be hidden from view. The controllers have ray casters that enable the user to point at 3D objects across an XYZ axis.

Soundscape

The virtual reality headset contained a stereophonic speaker system. Sneezes, coughs, and other unsettling sounds were individually recorded in a studio under carefully controlled conditions to create the soundscape. Additionally, audio ambient room noise captured unique room sounds for an auditorium. This ambient noise was later layered into the recorded crowd noises. The overall audio experience was mixed on a digital audio workstation (DAW) in an isolation booth that added reverb to the recorded sounds to give a sense of room presence. The Unity software then triggered this audio once participants entered the virtual auditorium.

Users were asked to adjust the volume of the ambient noise to a similar fashion that they would experience on stage. All participants chose between 32% and 87% overall volume range. The audio source was placed towards the center of the seating area. The headset tracked the participant's distance to the audio source and adjusted accordingly. Therefore, if students turned their heads, the focal point of the audience audio also turned in correlation to the headset's movement. This audio tracking helped provide a more realistic experience.

Procedure

Before the study, Citi training was required for the research. The Institution Review Board (IRB) approved the mixed-methods design, study procedures, and other required documents, including approval, consent, and recruitment letters (see Appendix H, I, and J). Students were recruited from the university's practice room constituency. Participants were reassured that participation had no bearing on their grades at the institution and were free to decline. Once participants expressed interest, they were given an oral overview of the study and the proper use of the virtual reality equipment. After the initial presentation, participants were asked to provide verbal consent. Lastly, each participant was asked to record their heart rate for sixty seconds to establish a baseline measurement and then fill out the STAI-Y1 form assessing their overall perception of self.

Testing commenced after the initial heart rate measurement and initial STAI form. Students were instructed on the use of the virtual reality headset. During the practice room authentic environment testing, all participants within the study performed a short, memorized music piece from their existing repertoire. All musical works were between two and four minutes in length. During the authentic environment performance, participants were asked to perform without stopping. As they performed, their performances were recorded with a digital audio recorder. Heart rate was recorded immediately after the authentic environment performance. A short 2-minute break was required to help students return to a normal physiological state. During the break, the participant’s heartbeat was monitored to ensure a return to a measurement that mirrored the pretest. All subjects required less than a 2-minute break to regain a normal heartbeat function.

Testing continued during the same session with student performances within a virtual reality recital hall. This portion of the testing commenced within a practice room on campus. Participants were asked to perform the same musical work previously performed during their authentic environment performance. During the VR performance, participants were asked to perform without stopping as if they were performing in their previous authentic environment. As they performed, their performances were recorded with a digital audio recorder. Heart rate was recorded immediately after the performance. Immediately after their VR performance, participants were asked to complete the STAI-Y2 to self-evaluate their anxiety level during the virtual experience.

CHAPTER 4

Results

The results focus on correlations from the STAI self-diagnostic test, the heart-rate measurement, and the music performance adjudication between the authentic and virtual environments. Comments from the testing group are included to give a sense of the subject's overall reaction and state of mind. Lastly, questionnaire results are presented.

State-Trait Anxiety Inventory Test

A one-way measured analysis of variance was administered to judge participants' anxiety levels. The first STAI-Y1 test examined the anxiety of performers within a broad context. The second STAI-Y2 test examined the anxiety of performers within a virtual environment. Table 1 and table 2 show the results of the STAI-Y1 and STAI-Y2 tests for each performer. A heightened anxiety variance was found for students that performed in the virtual auditorium with a p-value of 0.0499.

Table 1, table 2, and figure 1 represent statistical data gathered from the state-trait anxiety measurements. In table 1, the number (N) value is the number of participants. The mean equals the average of the scores. The standard deviation measures the dispersion of the dataset relative to its mean and is vital for one's understanding of how spread out the data is. The standard error is the statistical deviation of its sampling distribution. Standard error measures variability and allows one to estimate the sample's standard deviation.

In table 2, the Degrees of Freedom (DF) corresponds to the maximum number of independent values within a data sample. In regression analysis, the sum of squares (SS) is a statistical technique used to determine the dispersion of data points. The objective of regression analysis is to examine how well a data series can be fitted to a function that may help to understand how the data series was formed. Mean squares (MS) represent an estimate of the population variance. In regression, mean squares are used to determine whether terms in the model are significant. The F-statistic (F-stat) of overall significance indicates whether your linear regression model provides a better fit to the data than a model with no independent variables. When the F-statistic is higher than the p-value, it gives evidence to conclude that your model is significant. A p-value under .05 indicates that results can be replicated. Such a p-value suggests that the effect is substantial or that the conclusion has considerable theoretical, clinical, or practical significance.

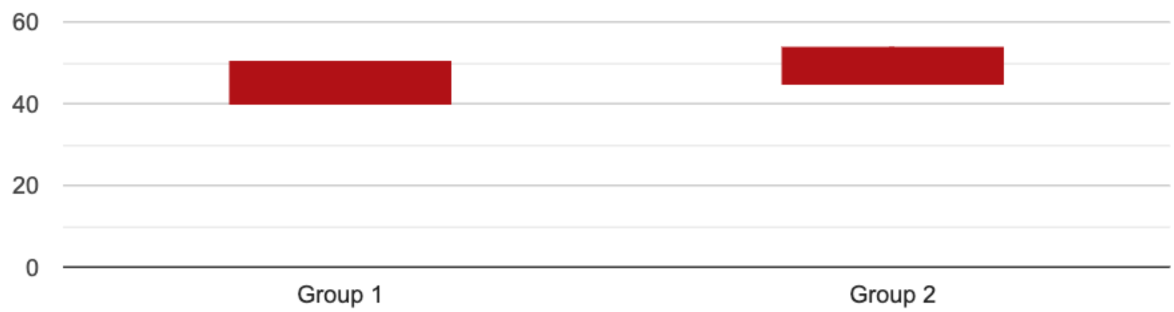
Table 1. Authentic practice room environment and virtual performance environment state-trait anxiety data summary

Groups	**N**	**Mean**	**Std. Dev.**	**Std. Error**
STAI-Y1	14	45.2143	5.4657	1.4608
STAI-Y2	14	49.2857	4.9989	1.336

Table 2. Authentic practice room environment and virtual performance environment state-trait summary

Source	DF	SS	MS	F-Stat	P-Value
Between Groups	1	116.0341	116.0341	4.23	0.0499
Within Groups	26	713.2174	27.4314		
Total:	27	829.2515			

Figure 1. Authentic practice room environment and virtual performance environment one-way ANOVA average ± standard deviation



Heart rate

A one-way repeated measured analysis of variance was conducted to examine the heart rate of an individual performing in authentic and virtual environments. Measurements were taken before and after each performance within each setting. The authentic environment analysis of the variance summary is shown in table 3, table 4, and figure 2. The virtual environment analysis of the variance summary is shown in table 5, table 6, and figure 3. A statistical significance was found in heart rates for individuals performing in virtual environments over authentic environments. No significant statistical difference was recorded between the pre-performance and post-performance measurements within an authentic environment with a p-value of 0.051. However, a significant statistical difference was recorded between the pre-performance and post-performance measurements within a virtual environment with a p-value of 0.0015.

Table 3. Pre and post-authentic practice room environment heart rate one-way analysis of variance

Groups	N	Mean	Std. Dev.	Std. Error
Before Performance	14	93	10.756	2.8747
After Performance	14	101.7143	11.7632	3.1439

Table 4. Pre and post-authentic practice room environment heart rate summary

Source	DF	SS	MS	F-Stat	P-Value
Between Groups	1	531.5732	531.5732	4.1846	0.051
Within Groups	26	3302.8373	127.0322		
Total:	27	3834.4105			

Figure 2. Authentic practice room environment One-way ANOVA average ± standard deviation

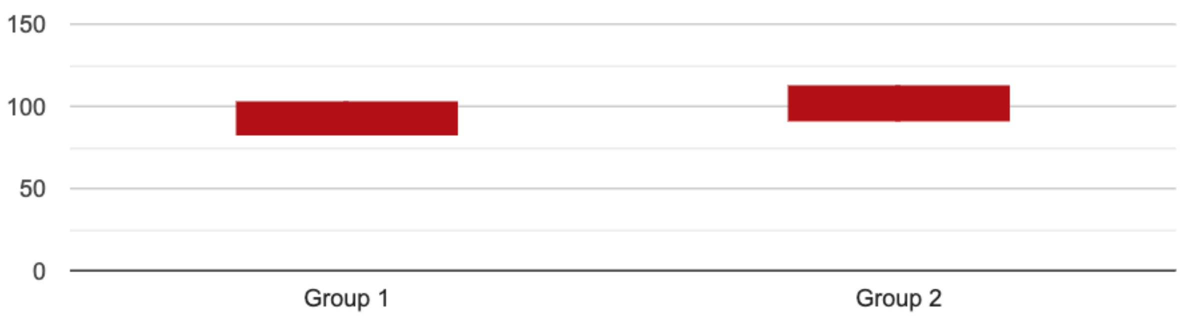


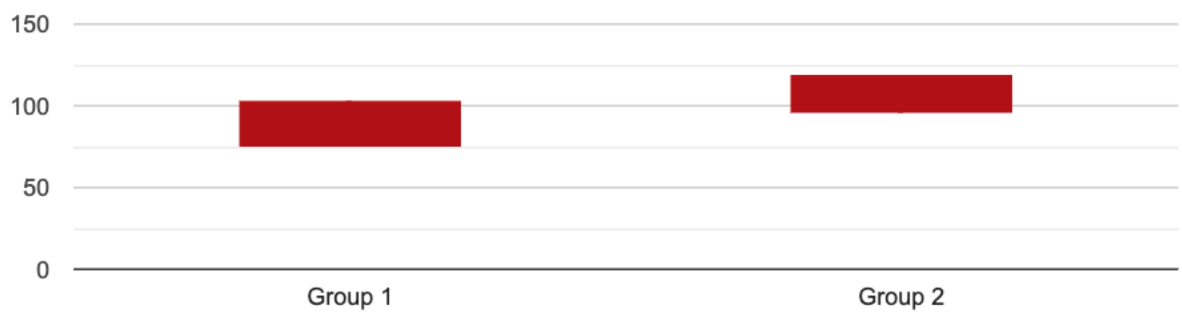
Table 5. Pre and post-virtual practice room environment heart rate one-way analysis of variance

Groups	**N**	**Mean**	**Std. Dev.**	**Std. Error**
Before Performance	14	89.0714	15.1732	4.0552
After Performance	14	107.6429	12.4444	3.3259

Table 6. Pre and post-virtual practice room environment heart rate summary

Source	DF	SS	MS	F-Stat	P-Value
Between Groups	1	2414.3043	2414.3043	12.5389	0.0015
Within Groups	26	5006.1582	192.5445		
Total:	27	7420.4625			

Figure 3. Virtual performance environment one-way ANOVA average ± standard deviation



Cross-Correlation

An analysis to explore any cross-correlation between authentic and virtual environments yielded no statistical correlation. A one-way measured analysis of variance was conducted to examine statistical correlations of pre-performance heart rate beats per minute across authentic and virtual environments. Table 7, table 8 and figure 4 show the pre-performance authentic practice room environment and virtual performance environment heart rate one-way analysis of variance. With a p-value of 0.7038, no significant correlations were found between the two groups. Additionally, a one-way measured analysis of variance was conducted to examine statistical correlations of post-performance heart rate beats per minute across authentic and virtual environments. Table 9, table 10, and figure 5 show the post-performance cross-correlation comparison. With a p-value of 0.0504, no significant correlations were found between the two groups.

Table 7. Pre-performance authentic practice room environment and virtual performance environment heart rate one-way analysis of variance

Groups	**N**	**Mean**	**Std. Dev.**	**Std. Error**
Before Performance	14	91.0714	12.1937	3.2589
After Performance	14	89.0714	15.1732	4.0552

Table 8. Pre-performance authentic practice room environment and virtual performance environment summary

Source	DF	SS	MS	F-Stat	P-Value
Between Groups	1	28	28	0.1478	0.7038
Within Groups	26	4925.8601	189.4562		
Total:	27	4953.8601			

Figure 4. Pre-performance authentic practice room environment and virtual performance environment one-way ANOVA average ± standard deviation

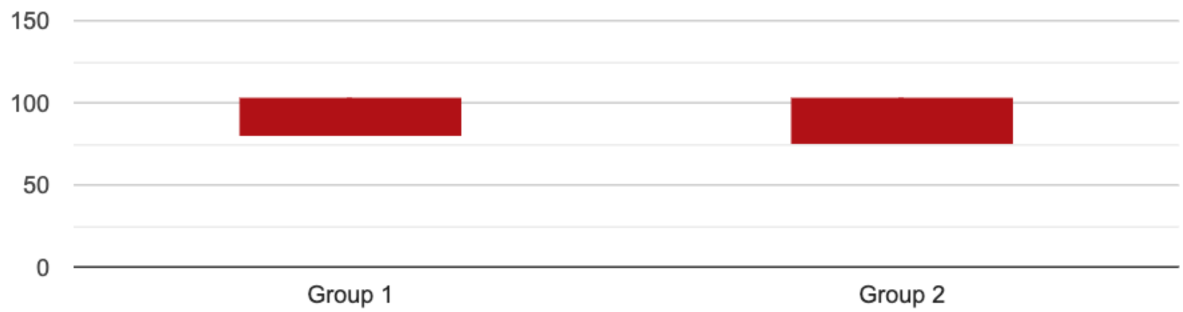


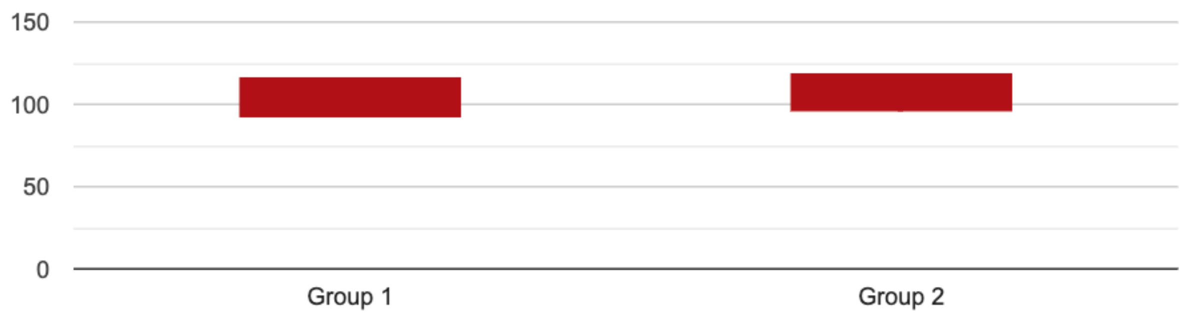
Table 9. Post-performance authentic practice room environment and virtual performance environment heart rate one-way analysis of variance

Groups	**N**	**Mean**	**Std. Dev.**	**Std. Error**
Before Performance	14	104.4286	12.6535	3.3818
After Performance	14	107.6429	12.4444	3.3259

Table 10. Post-performance authentic practice room environment and virtual performance environment summary

Source	DF	SS	MS	F-Stat	P-Value
Between Groups	1	72.3221	72.3221	0.4592	0.504
Within Groups	26	4094.664	157.4871		
Total:	27	4166.9861			

Figure 5. Post-performance authentic practice room environment and virtual performance environment one-way ANOVA average ± standard deviation



Music Performance

Two musically experienced judges blindly evaluated each performance. One-way mixed design analysis of variance was conducted on scores from the performances of the test subjects within the authentic and virtual environments. The adjudication examined the various performance categories for either voice or piano. Voice performances were scored across four categories, with a maximum score of 100. Piano performances were scored across four categories, with a maximum score of thirty. The analysis of the variance summary for vocal scores is shown in table 11 and table 12. No statistical difference was recorded for voice performances between authentic and virtual environments with a p-value of 0.6909. The analysis of the variance summary for piano scores is shown in table 13 and table 14. A statistical difference was recorded for piano performances between authentic and virtual classrooms with a p-value of 0.4948.

Table 11. Authentic practice room environment and virtual performance environment vocal adjudication scores one-way analysis of variance

Groups	**N**	**Mean**	**Std. Dev.**	**Std. Error**
Before Performance	10	88.7	11.5667	3.6577
After Performance	10	86.6	11.9276	3.7718

Table 12. Authentic practice room environment and virtual performance environment vocal adjudication summary

Source	DF	SS	MS	F-Stat	P-Value
Between Groups	1	22.05	22.05	0.1598	0.6941
Within Groups	18	2484.5057	138.0281		
Total:	19	2506.5557			

Table 13. Authentic practice room environment and virtual performance environment piano adjudication scores one-way analysis of variance

Groups	**N**	**Mean**	**Std. Dev.**	**Std. Error**
Authentic Performance	4	23.75	9.9791	4.9896
Virtual Performance	4	19	8.4459	4.223

Table 14. Authentic practice room environment and virtual performance environment piano adjudication summary

Source	DF	SS	MS	F-Stat	P-Value
Between Groups	1	45.125	45.125	0.528	0.4948
Within Groups	6	512.747	85.4578		
Total:	7	557.872			

Questionnaire

A research evaluation questionnaire was given to each participant of the study (see Appendix K). Participants were encouraged to add additional comments about their overall experience. This portion of the questionnaire allowed participants to freely express their ideas, concerns, and feedback. The comments are assembled within three categories.

This first category of comments pertains to the overall interest of the study. One participant noted, “This study is intriguing.” Another participant commented, “Interesting study. Should be studied more.” The second category of comments concerns the activity within the VR experience. One participant noted, “I could not perform well, because I could not see my hands.” Another participant wrote, “I couldn’t find my initial hand placement, but once I did – muscle memory kicked in, and I was able to perform.” Although the participant utilized previously acquired muscle memory, Evrim Eyikara and Zehra Baykara contend that muscle memory can be developed within virtual environments. When studying the role of simulation in nursing education, the two scholars note, “Simulation in nursing education replicates the clinical environment to provide nursing students an environment where they can practice technical skills, gain muscle memory and make errors safely while receiving feedback to improve their performance."[73]

The last category of comments involves the stress and anxiety of the virtual simulation. One participant commented, "I noticed a small difference in stress between the practice room environment and the virtual concert hall." In research concerning the measurement of stress within virtual spaceflight training, Tor Finseth, Michael Dorneich, Nir Keren, Warren Franke, and Stephen Vardeman conclude, "stressors present in an emergency procedure could be manipulated in VR and approximate the physiological and subjective responses expected during a stress response. Results from this experiment were mixed. The high and low stressor levels had distinguishable results, but the medium level was harder to distinguish."[74] Additional research is needed to explore the effectiveness concerning the effective measurement of stress across the gradient of stress response. However, the researchers conclude a high confidence level in the efficacy of measuring stress at high and low levels.

Another participant stated, "This could be a useful tool. I liked how I could look around the concert hall and practice singing in front of people." Although the effectiveness of a realistic environment's impact on user experience is still being studied, an investigation of the value of photo-realistic avatars provides insights into their value. Matthew Fysh, Iliyana Trifonova, John Allen, Cade McCall, Mike Burton, and Markus Bindemann report, "avatar faces of familiar people are recognized with high accuracy, replicate the familiarity advantage typically observed

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[73] Evrim Eyikara and Zehra Gocmen Baykara. "The Importance of Simulation in Nursing Education." *World Journal on Educational Technology: Current Issues* 9, no. 1 (2017): 02–07.

[74] Tor Finseth, Michael C. Dorneich, Nir Keren, Warren D. Franke, and Stephen B. Vardeman. "Manipulating Stress Responses during Spaceflight Training with Virtual Stressors." Applied Sciences 12, no. 5 (2022): 2289, http://ezproxy.baylor.edu/login?url=https://www.proquest.com/scholarly-journals/manipulating-stress-responses-during-spaceflight/docview/2637583137/se-2.

in real-world face matching, and show that these avatars produce a similarity-space that corresponds closely with real photographs of the same faces."[75] The presence of photo-realistic avatars in virtual environments may more closely mirror the experience of a performer within an authentic environment. The same study continues to state, "avatars that more closely capture real faces will not only improve the quality of the visual experience in VR but should improve the theoretical relevance of these experiments, by creating a closer correspondence between artificial laboratory settings and real life."[76]

Another participant stated, "I think I was nervous about using a VR headset. Some of the people in the audience didn't look realistic." Research by Norina Gasteiger, Veer Sabine, Paul Wilson, and Dawn Dowding conclude that "The extent to which a simulation is perceived as good or realistic also depends on a user's willingness to believe in it."[77] Within VR, users can still perceive environments as virtual or authentic. This difference requires users to employ a measure of suspension of disbelief when comparing the virtual against the authentic experience. In the future, however, it is speculated that the suspension of disbelief will no longer be needed. The CEO of Meta, the leading company of virtual reality headsets and virtual world creation, notes, "I think we're in the middle right now of a big step forward towards realism. I don't think

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[75] Matthew C Fysh, V. Trifonova Iliyana, John Allen, McCall Cade, Burton A. Mike, and Bindemann Markus. "Avatars with Faces of Real People: A Construction Method for Scientific Experiments in Virtual Reality." Behavior Research Methods (Online) 54, no. 3 (2022): 1461-75, http://ezproxy.baylor.edu/login?url=https://www.proquest.com/scholarly-journals/avatars-with-faces-real-people-construction/docview/2673615123/se-2.

[76] Ibid, 1462.

[77] Norina Gasteiger, der Veer Sabine N van, Paul Wilson, and Dawn Dowding. "How, for Whom, and in which Contexts Or Conditions Augmented and Virtual Reality Training Works in Upskilling Health Care Workers: Realist Synthesis." JMIR Serious Games 10, no. 1 (01, 2022), http://ezproxy.baylor.edu/login?url=https://www.proquest.com/scholarly-journals/how-whom-which-contexts-conditions-augmented/docview/2634264845/se-2.

it's going to be that long until we can create scenes with basically perfect fidelity."[78] One major hurdle to perfect fidelity is the creation of retina-class VR displays. Retina class displays possess resolution rates where users with 20/20 vision cannot visually distinguish the difference between virtual and authentically displayed environments. Once this hurdle is passed, the difference lies within the ability to replicate environments realistically. Recently, Meta announced the development of a lightweight, near-retina class resolution headset.[79]

A different participant noted, "I enjoyed experiencing a virtual practice environment. I could see where this type of technology could be used to help students get more comfortable with crowds. The concert hall looked quasi-realistic, but I enjoyed how audience members moved around."

Lastly, one participant's comment supports the notion of eliciting music performance anxiety in students through virtual reality. The comment reads, "The virtual reality experience helped me better define measurements for the anxiety I have on stage. Knowing this, I feel I can better prepare myself for future performances." Experiencing the physiological effects of MPA can be a logical initial step in mitigation.

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[78] "The Metaverse and How We'll Build It Together -- Connect 2021." *YouTube*. YouTube, October 28, 2021. Last modified October 28, 2021. Accessed July 22, 2022. https://www.youtube.com/watch?v=Uvufun6xer8.

[79] Ibid.

Results from the research evaluation questionnaire are as follows:

1. During the virtual performance, did you notice any physical symptoms of stress? (Fast heart rate, sweaty palms, etc.)

    A. 14% indicated no
    B. 28% indicated partially
    C. 43% indicated fairly
    D. 14% indicated considerable

2. In general, did you ever feel uncomfortable in front of the virtual audience environment?
    A. 14% indicated no
    B. 28% indicated partially
    C. 43% indicated fairly
    D. 14% indicated considerable

3. Do you think the concept of exposing musicians to a virtual audience should be developed and explored further?
    A. 28% indicated no
    B. 72% indicated yes

4. Was the virtual environment what you expected?
    A. 36% indicated yes
    B. 43% indicated no
    C. 21% indicated somewhat

5. How would you rate the instructions for this study?
    A. 57% indicated very clear
    B. 21% indicated moderately clear
    C. 14% indicated somewhat clear
    D. 7% indicated not clear

Conclusion

The research evaluation questionnaire showed a majority of participants noted anxiety during the experiment. The questionnaire served as a self-assessment for the presence of physical symptoms of stress and discomfort in front of a virtual audience. The comments provided further insights into how the participants responded within the experiment.

CHAPTER 5

Findings

The study's goal was to determine if virtual environments could induce physiological responses among vocalists and pianists compared to an authentic practice room. The results of this study suggest that virtual reality (VR) exposure did elicit a physiological response through symptoms commonly associated with music performance anxiety. State-Trait Anxiety tests revealed an increase in stress, with a statistical result inside the correlation threshold. Heart rate measured before and after performances showed considerable increases during a virtual environment performance. Adjudication scores for virtual environments yielded mixed results. Scores for vocalists showed no meaningful difference between authentic and virtual environments. However, scores for pianists in both environments yielded a statistical difference and suggested that pianists performed more poorly within a virtual environment. The cause of this difference between the two performance groups is speculated to exist because pianists needed to visually align the virtual piano with the authentic piano they could not see. It was unviable for the performers on the piano to perfectly align the piano resulting in an object that tactilely felt different than its visual representation. A majority of participants noted an increase in stress and discomfort within the virtual performance environment.

Lastly, participants noted that the concept of exposing performers to virtual performance environments should be further studied. They verbally suggested a few improvements to the overall experience that might have helped with the performance within the virtual environment. A piano participant verbally noted that reading music within the environment would have allowed her to perform at a higher level because the virtual experience made her nervous and subsequently forgot a portion of the musical work. Reading sheet music is a near-term possibility but does not yet exist in a feasible fashion. Reading sheet music requires either a retina-class VR resolution or a significantly, and subsequently unrealistic, enlarged piece of sheet music.

A vocal participant said he wished he could walk around the stage and perform more theatrically and that he desired to walk to the edge during the performance of the B-section of his musical work. This function is possible within current VR software and could easily be enabled to give performers the ability to practice, not only performing in front of individuals but also their stagecraft. VR's function within the development of stagecraft for theatre arts vocal students is an area of further study.

Lastly, a piano participant verbally noted a desire to perform in front of a full audience. Although the auditorium was populated based on the attendance from an authentic recital, the student wished to experience the emotional excitement of performing for a virtual crowd larger than anything they had experienced. The ability to populate auditoriums and even expand venue exposure is a strength of the virtual experience. It is possible to fill a virtual auditorium to the total capacity and it is even possible to change the venue, wherein students perform in the arena and stadium-sized venues. Alternatively, students could untether from replicated auditoriums and perform in exotic locations that might otherwise be difficult to experience or inaccessible to one's career. Students could perform music in diverse time-period settings to give a sense of geographical nuances for multicultural music.

Pre- and Post-Test

It was hypothesized that individuals within virtual performance environments would experience increased symptoms of music performance anxiety when compared to authentic practice room environments. This increase included a higher measurement of anxiety within the State-Trait Anxiety Inventory, an increase in heart rate BPM after the performance, a decrease in adjudication score within virtual performance environments, and an increase in stress and discomfort noted by the participants. The results indicate that the VR session influenced participants in symptoms of music performance anxiety.

Dr. Liz Kolb’s Triple E framework, which centered around engagement, enhancement, and extension, produced positive results concerning the technology's ability to create engagement opportunities. The virtual performance environment was constructed to help students focus on the performance goal of eliciting a physiological response by realistically mimicking an authentic performance environment and showed relevance for increased engagement. The virtual performance environment also helped motivate students’ learning, as correlated in the research evaluation questionnaire concerning the further development of this technology. The technology showed use for participants in a shift from passive to active social learners, albeit in a prescribed scenario-based way. The program used to create the virtual performance environment engaged students in a way that produced a physiological response; however, that interaction did not shift the behavior of students from passive to active social learners (co-use) because the computer program was designed to engage with only one participant at a time.

The virtual performance environment showed mixed results in the enhancement of learner outcomes. The technology tool may have aided students in developing a better understanding of music performance anxiety, as noted in the comments of the research evaluation questionnaire. The virtual performance environment scaffolded an experience wherein participants progressively experienced a physiological response to a performance environment but was not aimed to teach a particular concept. The virtual performance environment created paths for students to experience a performance environment that would otherwise be inaccessible.

The virtual performance environment excelled at the extension of learner outcomes. It was created for students to experience an auditorium outside their consistently utilized performing spaces. The technology was comparative to the learning of music and an artist's life experience of performing. Lastly, the virtual performance environment can serve to help students build skills that can be used while performing. Such performance skills are developed through exposure to experiences within otherwise inaccessible environments. Students could, in theory, repeat the experience and explore different interpretations of their performance in front of an audience without the limitations of time constraints.

Relation to Current Literature

Findings from this study parallel with the results of the two studies conducted by Orman. She found significant increases in heart rate and discomfort from baseline to performance in the VR condition, which indicated that VR elicited physiological responses due to increased anxiety. Additionally, Rahal's findings coincide with this study in that her research noted that performers experience some level of anxiety in the VR environment. Lastly, this study concurs with Bissonette's study that virtual environments can impact the quality of musical performance.

The ability to induce anxiety aligns across other fields of study, such as the phobia treatment study of Rothbaum, Hodges, and Kooper wherein subjects elicited a physiological response. Similar studies by Rothbaum, Hodges, Watson, Beck, Palyo, Winer, Schwagler, and Ang yielded similar conclusions by measuring increases in heart rates within virtual environments. The claustrophobia treatment study of Botella, Baños, Villa, Perpiña, and Garcia-Palacios also aligns. These findings are congruent with the present study's conclusions.

VR therapy may not be effective for all types of musicians. In this study, vocalists did not experience a reduced adjudication score in both environments. However, in the study by Anderson, Rothbaum, and Hodges, individuals with a phobia of public speaking found VR exposure beneficial. Similarities in speaking in front of an audience and singing in front of an audience seem comparable. Music performance anxiety may be more complicated because it deploys a more significant cognitive and motor interaction.

Limitations

Music performance adjudication results seemed to skew towards piano players experiencing a reduction in the score. In contrast, singers experienced no or slight decrease in score within the virtual performance environment. This difference in score reduction seemed to be caused by a lack of ability for piano players to see their hand placement on the piano. Hand and eye correlations are essential to performing on the piano keys. Several participants verbally noted that it was challenging to align the virtual piano with the authentic piano. Additionally, some piano-performing participants reported the difficulty on the research evaluation questionnaire.

A specific psychological vulnerability where-by anxiety comes to be associated with certain environmental stimuli through learning processes such as respondent or vicarious conditions. Barlow contends, "This particular psychological vulnerability, also a function of early learning experiences, becomes relevant for certain anxiety disorders where anxious apprehension is focused on potentially dangerous specific objects or events."[80] A preexisting trigger for anxiety may occur when wearing a headset that covers the face, possibly skewing the

[80] Barlow, Unraveling the Mysteries of Anxiety and its Disorders from the Perspective of Emotion Theory, 1256.

results. Individuals can have a similar virtual environment experience using CAVE environments. Such an environment would remove the need for a headset. Still, due to the need to project images on walls, it might induce other anxieties such as claustrophobia during the experience and nyctophobia before and after the experience. In addition, factors such as exhaustion, the quantity of sleep, effort, motivation, focus, preparation, and health can influence how an individual feels and performs during a concert. Although difficult to define, some of these variables probably affected the participants' state of anxiety and performance quality during the experiment. Identifying this category of psychological vulnerabilities might have been facilitated by including additional questions within the questionnaire concerning fear of affixation vision impairment. Non-MPA phobias within the virtual auditorium would be much harder to anticipate. A simple question asking participants if they experienced additional anxiety apart from MPA should be considered.

Cybersickness might have skewed the results of the heart-beat measurement. Certain individuals experience an increase in heart rate when exposed to high amounts of movement within virtual spaces. Research into low-movement cybersickness is still inconclusive and although the virtual environment was designed for low movement, simply looking around might have caused cybersickness.

Future Research

Although the number of participants was more extensive than in previous VR studies, further research would require a significantly larger sample size. In this investigation, the statistical power remained low because the sample size was small. Additionally, repeated exposures would have helped inform the research statistics of this study. Other research utilizing VR to treat non-music phobias used significantly more VR sessions than this study. The fear reaction toward a new technology could probably have impacted the current investigation. Therefore, future studies utilizing VR within music education should be expanded.

Numerous research studies utilizing virtual reality (VR) contain a presence questionnaire, which is used to quantify the presence felt in a VR environment. Various elements of the virtual environment can either enhance or diminish the sense of presence. Additionally, individual characteristics, traits, and abilities may increase or decrease the feeling of presence in a VR environment.[81] Future research with musicians should include a presence questionnaire, as it is essential to establish if VR exposure was effective.

This study used the latest consumer-level hardware with actual audience members inserted into a life-like auditorium. As the technology gets better and more realistic, VR can continue to cause authentic responses from virtual environments. Previous studies have used tethered headsets that did not track the participant's movements very well. Some previous studies utilized projectors that did not offer the same resolution as the VR headset. This study deployed the use of spatial audio, wherein participants could move their heads around to increase the audio volumes of various audience members. This auditory feature mirrors an authentic experience more closely through perceptual realism. Lastly, this is the first study to combine a virtual concert hall with green-screened authentic audience members.

The virtual environment within this VR study could have accommodated students with limited mobility; however, no participants had accessibility issues. Further study is needed to ensure accessibility is a priority within VR learning environments. In terms of mobility, VR

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[81] Simon Riches, Soha Elghany, Philippa Garety, Mar Rus-Calafell, and Lucia Valmaggia. "Factors Affecting Sense of Presence in a Virtual Reality Social Environment: A Qualitative Study." *Cyberpsychology, Behavior, and Social Networking* 22, no. 4 (2019): 288–92. https://doi.org/10.1089/cyber.2018.0128.

promises access to places that might otherwise be inaccessible. For example, a student with a mobility impairment might be able to experience the top of Mount Everest. However, solutions for other impairments, such as visual and auditory, have yet to become readily accessible. Kathrin Gerling and Katta Spiel note, “inherently ableist technology that assumes a ‘corporeal standard’ (i.e., an ‘ideal,’ non-disabled human body), and fails to accommodate disabled people adequately.”[82] VR technology relies heavily on the device’s ability to track a user’s kinesthetic movements for gameplay. To complicate matters, Camaryn Yokota predicts that in the future of music consumption, “VR games will check for ‘human-like’ movements and body reactions, implemented in the hopes of subverting the ‘unfair’ use of bots—and also to have users become more involved in advertisements.”[83] Users with disabilities may not reproduce such fluid body movements and might experience accessibility issues.

Future of Online Education

Only a few years ago, students and researchers were restricted to the libraries and museums at their university — or possibly in their city or region — since only a select few had the credentials to access materials from other institutions or the means to travel for research. The internet has altered such access, as much of human knowledge is quickly becoming accessible. Similar to how hypertext, digital publishing, and other digital media have revolutionized how we interact with documents and collections, VR technology may eventually transform how we teach, learn, interact with one another, and experience the world at large. In the not-too-distant future,

[82] Kathrin Gerling and Katta Spiel. “A Critical Examination of Virtual Reality Technology in the Context of the Minority Body.” *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (2021).

[83] Camaryn Yokota. "Music Consumption in 2070: Four Alternative Futures." Order No. 29169548, University of Hawai'i at Manoa, 2022. In PROQUESTMS ProQuest Dissertations & Theses Global, http://ezproxy.baylor.edu/login.

as VR technologies improve steadily and become ingrained in our lives, we may one day marvel at students who were once confined to a physical classroom, campus setting, location, or even time.

Virtual reality may be viewed as the logical extension of cyberspace. Since the 1950s, scientists and programmers have investigated the possibilities of VR. In 1962, Morton Heilig patented the Sensorama, the first VR machine that combined 3D video, vibrations, smell, and other atmospheric effects such as wind. His machine was a multi-sensory experience wherein a user inserted their head into a sizeable arcade-like device. Once inside, the user would be nearly surrounded by video screens and mirrors reflecting video screens. More recently, the free app Titans of Space allows users to explore the solar system. The immersive video documentary produced by The New York Times titled *The Displaced* lets users experience firsthand what it is like to be a young refugee displaced by war. One can now witness Roman gladiator combat with Colosseum VR or take 360-degree tour of world cities with StreetView VR and feel as if they are there.

Realizing the potential of VR entails overcoming technological and accessibility difficulties and financial considerations. Today, high-end HMDs with the most advanced GPUs and processors can generate incredibly lifelike worlds for students and instructors alike. VR can connect us to the world and one another in ways never imagined when paired with social media. Our classrooms, libraries, and shared academic spaces may one day feature physical grids or open sound stages engineered for virtual interaction, allowing student groups to take guided field trips to remote locations, connect with other cultures, or journey through time.

Emerging communication integrations mean that the instructor will also be present, guiding the discussion, highlighting key topics and features, and posing questions. Students with physical limitations or socioeconomic disadvantages may enjoy unprecedented access to locations and activities. Students may also be able to experience phenomena that can only be theorized, such as traveling through a strand of DNA, entering a black hole, or the molecular rotation of atoms.

Generation Z is comprised of today's standard college-aged students between the ages of eighteen and twenty-two. In 2015, this age group began college and their expectations for learning experiences that equip them with the required information, skills, and capacities to thrive in the future labor market increased. Generation Alpha, the age group directly behind Generation Z, are now entering college, having grown up with many of the same expectations for their educational experiences as Generation Z. Extended reality, which includes immersive technologies such as virtual reality and augmented reality, shows potential as a learning tool for Gen Z and beyond. VR enables a confluence of experience learning and engagement, considering Generation Z's well-documented affinity for gaming and need for higher education to equip them with problem-solving and practical abilities.[84]

XR technologies are not yet pervasive in higher education, and for many institutions, they may remain a niche addition to traditional teaching and working methods. Nevertheless, growth for XR in higher education is on the horizon as these technologies become more accessible, inexpensive, and pervasive in our social and cultural experiences.[85] As the usages for XR in higher education become more apparent, institutions will have more chances to align XR

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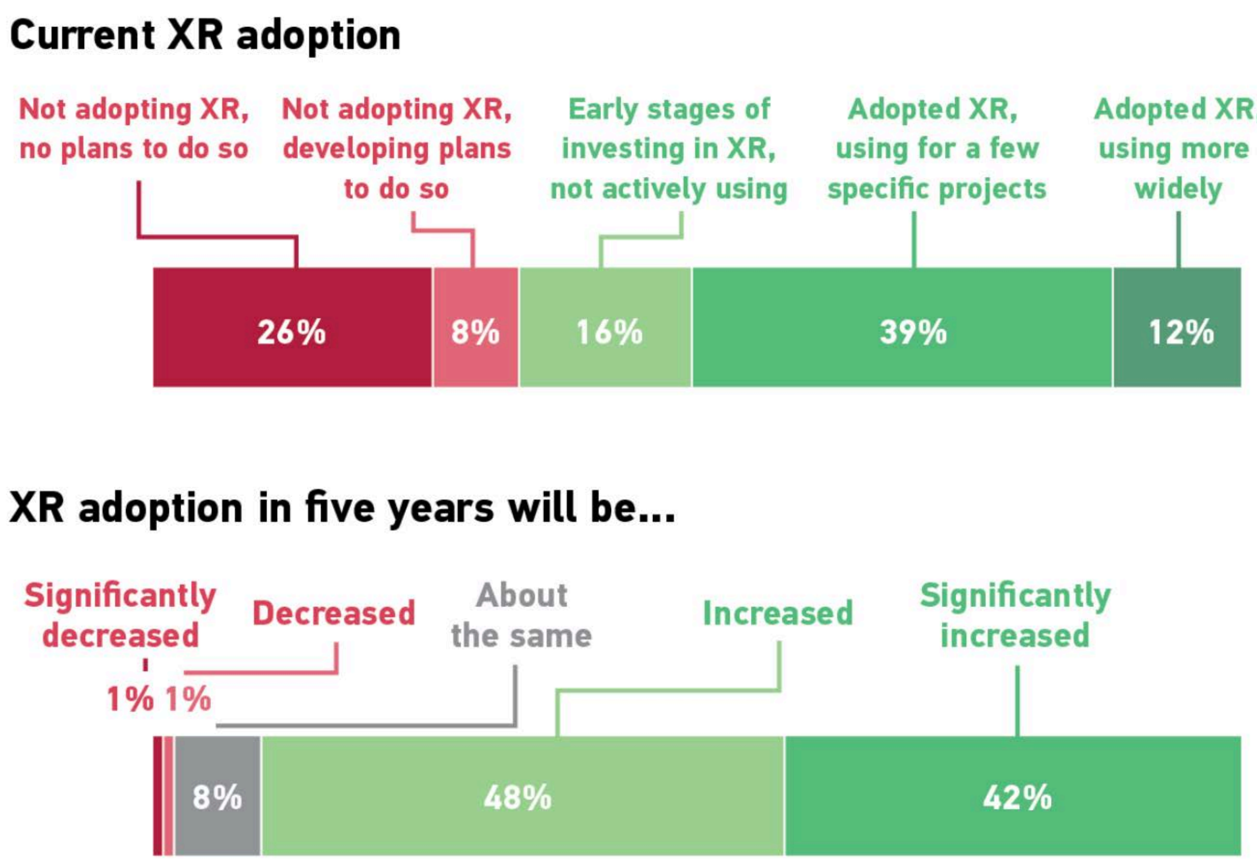
[84] Curtis Cain, Morgan Bryant Allison, Carlos D. Buskey, and Meyers Ferguson Yuvay. "Generation Z, Learning Preferences, and Technology: An Academic Technology Framework Based on Enterprise Architecture." *Journal of the Southern Association for Information Systems* 9, no. 1 (2022): 1-14,

[85] "Value Creation in the Metaverse." *McKinsey & Company*. Accessed July 1, 2022. https://www.mckinsey.com/business-functions/growth-marketing-and-sales/our-insights/value-creation-in-the-metaverse.

capabilities with their strategic priorities, as well as a more critical requirement for resource expenditures and faculty buy-in to support such alignment. An overwhelming majority of respondents in an Educause poll (90%) anticipate that adoption of XR technologies at their institution will somewhat or significantly increase over the next five years.[86]

Figure 4. Levels of XR Adoption, Currently and in Five Years.



[86] "Educause QuickPoll Results: XR Technology." *EDUCAUSE Review*. Accessed July 1, 2022. https://er.educause.edu/articles/2021/12/educause-quickpoll-results-xr-technology.

The increased adoption of XR technologies is already underway within higher education. In 2022, VR technology company Engage XR announced the launch of ten virtual universities, or "metaversities," across the United States. A metaversity often employs a digital twin or a virtual copy of an authentic university physical space to replicate perceptions of locationality. There, students can virtually walk around campus in an experience similar to an in-residence student. Students can enter classrooms that are unique to the authentic university's facilities. Managing an avatar within a virtual classroom might seem difficult, however, Eugy Han, Mark Roman Miller, Nilam Ram, Kristine Nowal, and Jeremy Bailenson conclude that, over time, managing an avatar within a virtual space gets easier for learners.[87] Once students are no longer uncomfortable with the novelty of new technology, they can experience the increased learning opportunities that VR provides.

Metaversities synergize VR educational spaces, synchronous multiplayer experiences, and perceptions of locationality. Currently, with the best conditions, musicians can perform together synchronously with no perceivable latency within five hundred miles.[88] Imagine if students could perform a symphony together using authentic audio signals and a virtual concert hall.

The synergy of the metaversity holds tremendous potential for music education; however, it recreates a high-stakes environment wherein multiple individuals assemble at a specific

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[87] Eugy Han and Mark Miller, Ram Nilam, Kristine Nowak, and Jeremy Bailenson. Understanding Group Behavior in Virtual Reality: A Large-Scale, Longitudinal Study in the Metaverse (May 14, 2022). 72nd Annual International Communication Association Conference, Paris, France., Available at SSRN: https://ssrn.com/abstract=4110154

[88] Nickolai Hammar and Colin Marshall. "Playing Music Together Online Is Not as Simple as It Seems." *NPR*. NPR, July 15, 2020. Last modified July 15, 2020. Accessed July 22, 2022. https://www.npr.org/2020/07/14/891091995/playing-music-together-online-is-not-as-simple-as-it-seems.

location. The multiplayer model was not used for this study because it is the purpose of this asset to allow students a concert hall experience on-demand. However, one might conclude that a metaversity music performance would fall somewhere in-between a virtual auditorium and an authentic auditorium experience.

Conclusion

The current study did establish that exposing vocal and piano performers to virtual audience environments is a valuable method for eliciting performance anxiety. Additionally, a majority of participants indicated that the study at least partially replicated the feeling of being in an authentic concert hall. Therefore, it is plausible to expect that, given the appropriate conditions and resources, this technology could be advantageous as a performance preparation approach for musicians that experience MPA and that students of a piano or vocal studio could expose themselves to MPA throughout the semester. The repeated exposure could produce two opportunities. First, repeated physiological exposure could produce a conditioned tolerance to the effects of MPA. Students could build up this conditioned tolerance to mitigate authentic environment MPA. Second, an increase in MPA exposure would allow students and educators additional opportunities to discuss MPA mitigation strategies. When VR is used in teaching music, students might be more attentive and engaged. This benefit is derived from the immersive nature of virtual reality, which conventional teaching methods cannot offer. In the virtual reality education process, students can have greater participation and better integration.[89] For subjects requiring a certain level of creativity, virtual reality technology can replicate settings that cannot

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[89] Alfalah, Salsabeel F., Jannat F. Falah, Tasneem Alfalah, Mutasem Elfalah, Nadia Muhaidat, and Orwa Falah. "A Comparative Study between a Virtual Reality Heart Anatomy System and Traditional Medical Teaching Modalities." *Virtual Reality* 23, no. 3 (2018): 229–234.

be achieved in a traditional classroom setting. VR spaces can deliver an immersive experience that enables situational learning. In education and instruction, virtual reality technology can actualize interactive teaching through human-computer interaction, which provides teachers and students convenience that could lead to the emergence of new teaching methods through the incorporation of XR technologies. Typical music instruction is conducted in a confined space, and teachers provide one-on-one coaching. Musical expression involves the uninhibited interaction between the performer and the audience. However, MPA serves to limit and constrict the interaction of the performer. The boundless extensibility of virtual reality education can make music education more engaging and seem more authentic. Moreover, giving students a "realistic" VR learning environment might allow them to explore various interpretations of artistic expressions within low-stake environments. It is intended that this study will contribute to the fields of virtual reality and education, and that the findings will motivate additional research into the development of additional music educational assets.

APPENDICES

Appendix A - State-Trait Anxiety Inventory Test

mind garden

www.mindgarden.com

To Whom It May Concern,

The above-named person has made a license purchase from Mind Garden, Inc. and has permission to administer the following copyrighted instrument up to that quantity purchased:

State-Trait Anxiety Inventory for Adults

The four sample items only from this instrument as specified below may be included in your thesis or dissertation. Any other use must receive prior written permission from Mind Garden. The entire instrument may not be included or reproduced at any time in any other published material. Please understand that disclosing more than we have authorized will compromise the integrity and value of the test.

Citation of the instrument must include the applicable copyright statement listed below.
Sample Items:

I feel at ease
I feel upset
I lack self-confidence
I am a steady person

Sincerely,

Robert Most
Mind Garden, Inc.
www.mindgarden.com

Appendix B – NATS Classical Categories Audition Rubric

National Student Auditions
National Association of Teachers of Singing

NATS Audition Rubric

CLASSICAL CATEGORIES

Each singer's performance is adjudicated in comparison to the following standards as applied to the category of entry.

STANDARD	DEVELOPING 70 – 79	ADVANCING 80 – 89	MASTERING 90 – 100
TONE • Resonance and timbre are appropriate to the style with balanced chiaroscuro and ring throughout range. • Transitions through passaggi are smooth and efficient. • Onsets and offsets are clean, clear, and balanced allowing for uniform vibrancy and clarity. • Dynamic flexibility is present. • The singer engages the ability to make subtle changes in timbre appropriate to the style and character of the selection.	The singer is beginning to develop vocal resonance and balanced chiaroscuro timbre. Onsets and offsets delay or press the tone and cause extra noise or air. Transitions through passaggi are difficult or uneven. Dynamic flexibility is missing in much of the performance. Vocal colors do not enhance the style and character of the selection.	The singer is advancing in resonance and balanced chiaroscuro through some of the range. Onsets and offsets are mostly immediate, but some pressing or breathiness is present. Passaggi transitions are inconsistent. Dynamic flexibility is evident much of the time. Vocal colors mostly enhance the style and character of the selection.	The singer is mastering resonance. A balanced chiaroscuro tone rings throughout range. Onsets and offsets are immediate and promote clarity. Passaggi transitions are smooth and efficient. Dynamic flexibility is consistently evident in the performance. Vocal colors consistently enhance the style and character of the selection.
BREATH & ALIGNMENT • Inhalation is easy, full, silent, and efficient. • Exhalation provides stability, support, vibrancy, buoyancy, loft, and vocal energy. • The alignment, coordination, and release of the head, neck, larynx, jaw, ribs, back, abdomen, legs, and feet assist a dynamic engagement of the vocal instrument.	The singer is developing appropriate respiration. Inhalation is often noisy or insufficient. During exhalation, the singer tenses or collapses requiring extra breaths to complete phrases. Buoyancy and loft are inconsistent. The lack of coordination and alignment of the body hinders a dynamic engagement of the vocal instrument.	The singer is advancing toward appropriate respiration. Inhalation is mostly easy and sufficient. Exhalation often provides stability, support, and vocal energy with some collapsing and tension. Buoyancy and loft are often present. The coordination and alignment of the body are mostly assisting a dynamic engagement of the vocal instrument.	The singer is mastering respiration. Inhalation is easy and sufficient. Exhalation provides support, balanced stability, and energy. Buoyancy and loft are consistently present. The coordination and alignment of the body consistently assists a dynamic engagement of the vocal instrument.
TEXT & DICTION • Languages are sung with accurate pronunciation and effective articulation with idiomatic inflection beyond basic phonetics. • The singer displays a thorough understanding in communicating the text. • Phrasing and flow respect the nuance of each language.	The singer is developing some language proficiency but is often inaccurate in pronunciation and articulation. Idiomatic characteristics of the language are not present. The meaning of the text is ambiguous and poorly communicated. Phrasing and flow do not respect the nuance of each language.	The singer is advancing in language proficiency with accurate pronunciation and articulation. Idiomatic characteristics of the language are inconsistently present. The singer often communicates the meaning of the text. Phrasing and flow respect the nuance of each language inconsistently.	The singer is mastering languages with accurate pronunciation and effective articulation. Idiomatic inflection beyond basic phonetics is consistently present. The singer understands and communicates the meaning of the text. Phrasing and flow consistently respect the nuance of each language.
MUSICIANSHIP • Pitches and rhythms are accurate. • Tuning is accurate throughout range. • The markings of the composer, editor, or arranger are observed and present in the performance. • Selections are accurately performed from memory.	The singer's musicianship is beginning to develop with many accurate pitches and rhythms. Some errors are present. Tuning is often problematic. The markings in the score are rarely observed or present in the performance. Memorization is incomplete.	The singer's musicianship is advancing with pitch and rhythmic accuracy most of the time. Tuning is mostly accurate and complete with some errors. Many of the markings in the score are observed and present in the performance. Memorization is mostly complete.	The singer's musicianship is refined. All pitches and rhythms are accurate. Tuning is consistently accurate. The markings in the score are observed and present in the performance. Memorization is accurate.
ARTISTRY • The performance synthesizes vocal and physical communication to embody and express the character and story/poetry. • The performance embodies clear musical intent and embraces the uniqueness of the singer. • The listeners are engaged in a believable and fulfilling aesthetic performance.	The singer's performance does not embody a thorough understanding of the text and music. Physical, musical, and vocal choices are not contributing to effective communication. The performance is self-conscious and insecure.	Physical, musical, and vocal choices coordinate to create believable moments. An authenticity that embraces the uniqueness of the singer is emerging. The singer is inconsistent in engaging the listeners in a fulfilling aesthetic performance.	Physical, musical, and vocal choices allow the singer to communicate effectively. An authentic performance embraces the uniqueness of the singer. The singer consistently engages the listeners in a believable and fulfilling aesthetic performance.
ENSEMBLE (comments only) The singer and pianist coordinate their efforts toward the same artistic goals in the performance.	The singer and pianist seem unsynchronized. The artistic goals of the performance were unclear.	The singer and pianist are often coordinated in their efforts toward the same artistic goals in the performance.	The singer and pianist are consistently coordinated in their efforts toward the same artistic goals in the entire performance.

Appendix C – NATS Audition Adjudication Form

National Association of Teachers of Singing
Student Auditions Adjudication Form
Add Chapter, District or Region Name here

Singer Name or #_________________________________**Category**____________________

☐**Check here if singing for comments only**

Using the NATS rubric and the criteria below as appropriate to the category of the singer, place an X in each of the standard headings below (Tone, etc.) that align with your overall score of 70--100. A numerical score should only appear in the score box at the bottom of the adjudication form. Comments should offer constructive criticism.

	developing	***accomplished***
Tone	--------------------/--------------------/--------------------	
Breathing/Alignment	--------------------/--------------------/--------------------	
Language / Diction	--------------------/--------------------/--------------------	
Musicianship / Accuracy	--------------------/--------------------/--------------------	
Artistry / Expression	--------------------/--------------------/--------------------	
Ensemble (comment only)	--------------------/--------------------/--------------------	

COMMENTS

Adjudicator ______________________________ **Date**____________ **Score**

Print Name____________________

☐

Appendix D – Spokane Piano Competition Adjudication Form

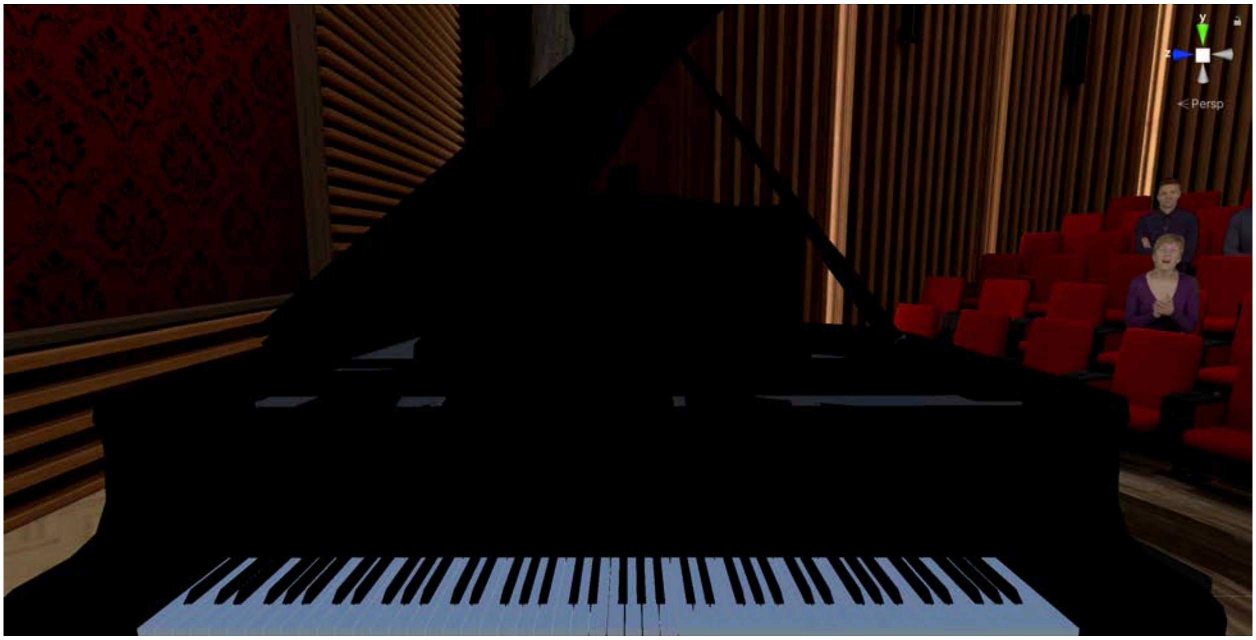
	0 1	2 3	4 5 6	7 8	9 10	
Composers Intent	0 1 Stylistic elements are incorrect throughout.	2 3 A mechanical or contrived performance; frequent stylistic inaccuracies; poor use of articulation, pedal or other nuances in respect to era or composer.	4 5 6 Good performance, with only some inconsistency in stylistic interpretation; occasional errors in demonstrating intent, but an overall solid approach to the composer.	7 8 An excellent understanding of era, composer and composition; commendable work in technical and musical elements necessary to project ideas and concepts to audience.	9 10 The composer's original intent regarding tempo and style is adhered to throughout. Nuance, articulation & interpretation are executed artistically with superb mastery.	SCORE ________
Rhythmic Integrity	0 1 Inconsistent pulse and rhythmic inaccuracies present throughout.	2 3 Rhythmic precision is lacking; basic pulse and metric inconsistencies appear throughout the performance; insufficient rhythm preparation is noticeable.	4 5 6 Good use of tempo, ritardando and rubato, resulting in rhythmic integrity; some rhythmic elements and nuance still remain inconsistent.	7 8 Excellent control of the pulse; few rhythmic inconsistencies; use of rhythmic nuance enhances the overall performance.	9 10 Rhythmic precision is nearly flawless; exemplary consistency of the pulse; use of rhythmic nuance is impeccable.	SCORE ________
Technical Mastery	0 1 Technical errors throughout performance; memory is unstable; technical requirements are beyond ability of performer.	2 3 Frequent notational and memory errors; sense of fluidity is inconsistent; sections of piece exhibit lack of technical control.	4 5 6 Good performance demonstrating fluidity, control and accuracy; technically challenging areas are performed smoothly with ease; sense of ability is conveyed to audience.	7 8 Excellent use of technique to project desired sound; demonstrates ability to adjust to the technical demands of the instrument, the room and music; performance displays ease, fluidity and proficiency.	9 10 Superb mastery of all technical aspects of the performance; control of sound, pedal, balance and tone production are exemplary; technically superior throughout the performance.	SCORE ________
Musical Artistry	0 1 Ineffective performance due to imbalance of emotional involvement, technical ability and preparation.	2 3 Somewhat unsuccessful performance due to lack of preparation & enthusiasm; insufficient projection of sound, balance and interpretation.	4 5 6 Good representation of musical elements and spirit of the music; performance shows involvement, grasp of style and consistency of musical thought and purpose.	7 8 Outstanding phrasing, with a clear understanding of musical structure and style; performance is musically involved and conveys the same spirit to the audience.	9 10 Stunning mastery of artistic elements of the music; all aspects of musical thought, projection, style, voicing, balance & nuance are perfectly coordinated for the performance.	SCORE ________

TOTAL SCORE:	%	

Appendix E – Greenscreen Video with Digital Auditorium

Appendix F – Voice Student VR Perspective

Appendix G – Piano Student VR Perspective



Appendix H: IRB Approval

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

March 25, 2022

Keith Pace
Lori Danielson

Re: IRB Exemption - IRB-FY21-22-781 Measuring Music Performance Anxiety with Music Students Through Virtual Reality

Dear Keith Pace, Lori Danielson,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under the following exemption category, which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:104(d):

Category 2.(iii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:
The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by §46.111(a)(7).

Your stamped consent form(s) and final versions of your study documents can be found under the Attachments tab within the Submission Details section of your study on Cayuse IRB. Your stamped consent form(s) should be copied and used to gain the consent of your research participants. If you plan to provide your consent information electronically, the contents of the attached consent document(s) should be made available without alteration.

Please note that this exemption only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued exemption status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this exemption or need assistance in determining whether possible modifications to your protocol would change your exemption status, please email us at irb@liberty.edu.

Sincerely,
G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office

Appendix I – Recruitment Letter

Hello Music Student,

As a graduate student in the School of Music at Liberty University, I am conducting research as part of the requirements for a Doctor of Music Education degree. The purpose of my research is to measure music performance anxiety with music students through virtual reality and if you meet my participant criteria and are interested, I would like to invite you to join my study.

Participants must be 18 years of age or older and be able to perform a musical instrument. Participants, if willing, will be asked to perform a piece of music from memory without a virtual reality headset, then perform a piece of music with a virtual reality headset. It should take approximately twenty minutes to complete the procedure listed. Participation will be completely anonymous, and no personal, identifying information will be collected.

Would you like to participate?
[Yes] Great, can we set up a time for a scenario wherein you will perform the same piece of music, first without a virtual reality headset, and then second with a virtual reality headset?
[No] I understand. Thank you for your time.

A consent document will be given to you at the time of the scenario. The consent document contains additional information about my research. Because participation is anonymous, you do not need to sign and return the consent document unless you would prefer to do so. Doing so will indicate that you have read the consent information and would like to take part in the study. Participants may receive a gift card.

Thank you for your time. Do you have any questions?

Appendix J – Research Consent Form

Consent

Title of the Project: Measuring Music Performance Anxiety with Music Students Through Virtual Reality
Principal Investigator: Keith Pace, Doctoral Candidate, Liberty University

You are invited to participate in a research study. To participate, you must be a music student at Baylor University. Taking part in this research project is voluntary.

Please take time to read this entire form and ask questions before deciding whether to take part in this research.

The purpose of the study is to measure the physiological response of music students when performing within a virtual reality concert hall. This response will inform intersections of virtual reality and fine arts for higher education.

If you agree to be in this study, I will ask you to do the following things:

1. Perform a 1–4 minute memorized piece of music that will be recorded via a separate audio recording device.
2. Perform the same 1–4 minute memorized piece of music that will be recorded via a separate audio recording device with a virtual reality headset on.
3. Fill out the short questionnaire regarding your experience.

Participants should not expect to receive a direct benefit from taking part in this study.

Benefits to society include the understanding of virtual reality's impact on music performance anxiety.

The risks involved in this study are minimal.

The records of this study will be kept private. Research records will be stored securely, and only the researcher will have access to the records. Participant responses will be anonymous. Data will be stored on a password-locked computer and may be used in future presentations. After three years, all electronic records will be deleted. Only the researcher will have access to these recordings.

Participants will be compensated for participating in this study. Participants will be paid $5 immediately after they complete the study. If participants fail to complete, they will not be compensated.

To participate in the research, there will be no cost to you.

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Liberty University or Baylor University. If you decide to participate, you are free to not answer any question or withdraw at any time prior to submitting the survey without affecting those relationships.

Appendix K – Research Evaluation Questionnaire

Questionnaire

6. During the virtual performance, did you notice any physical symptoms of stress? (Fast heart rate, sweaty palms, etc.)
   A. No
   B. Partially
   C. Fairly
   D. Considerable

7. In general, did you ever feel stressed or uncomfortable in front of the virtual audience environment?
   A. No
   B. Partially
   C. Fairly
   D. Considerable

8. Do you think the concept of exposing musicians to a virtual audience should be developed and explored further?
   A. No
   B. Yes

9. Was the virtual environment what you expected?
   A. Yes
   B. No
   C. Somewhat

10. How would you rate the instructions for this study?
    A. Very clear
    B. Moderately clear
    C. Somewhat clear
    D. Not clear

Additional Comments:

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