CSE 412 FP: Effectiveness of Virtual Reality (VR) in Educational Applications

==

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1. Introduction

1.1 About Virtual Reality

Virtual Reality (VR) stands as a frontier in technological innovation, reshaping how we engage with digital environments. Since the debut of the Oculus Rift in 2012, which marked a significant milestone in VR development, the technology has predominantly found its footing in the gaming industry. However, its potential extends far beyond entertainment. As VR technology matures, its application across various sectors, including healthcare, automotive, and aerospace, showcases its adaptability and transformative capabilities.

In the educational domain, VR presents an unprecedented opportunity to enhance learning experiences. By immersing students in three-dimensional interactive environments, VR offers a dynamic platform for simulating real-world scenarios, thus transcending traditional learning methodologies. This immersive approach not only engages learners more effectively but also facilitates a deeper understanding of complex subjects.

Despite its promising attributes, the integration of VR in educational settings is not without challenges. The technology's infancy in the educational market means that its full potential and limitations are still being explored. This exploration includes understanding the practicality of VR in classrooms and vocational training, evaluating its accessibility, and addressing any potential drawbacks that may hinder its widespread adoption.

As we look to the future, the evolution of VR in education and other sectors will depend on a nuanced understanding of its strengths and limitations. This journey involves continuous innovation and adaptation to ensure that VR technology can meet the diverse needs of learners and professionals alike, ultimately leading to its successful integration across various domains.

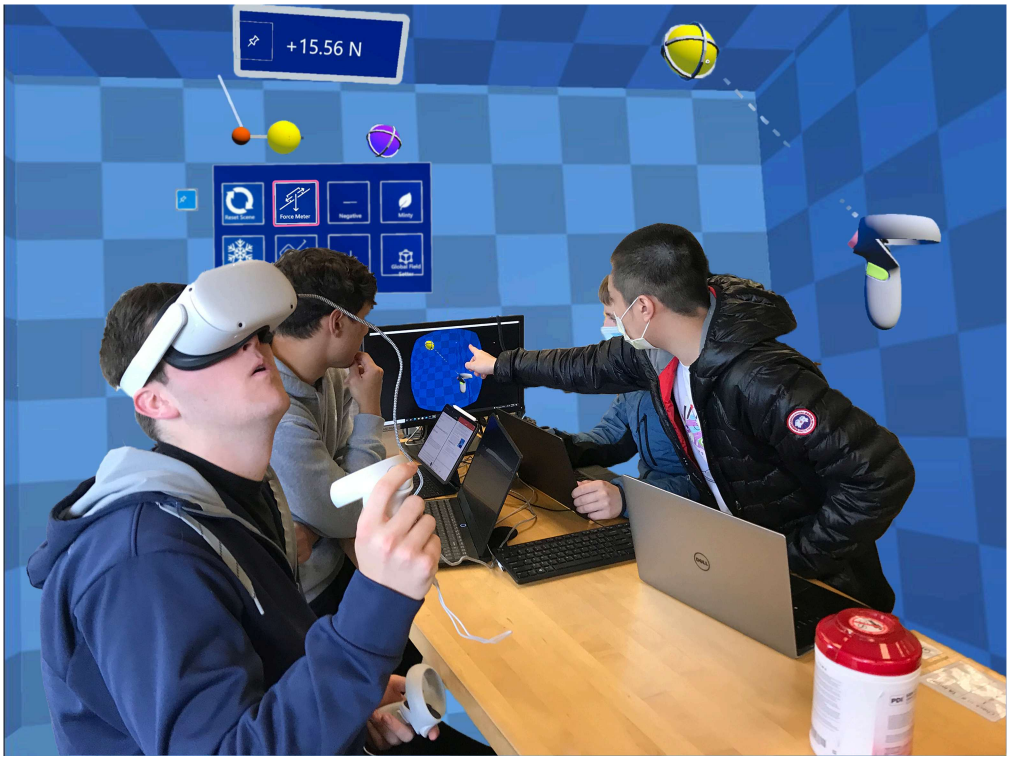
1.2 Current Research Study (NOMR)

Regarding education, the most obvious area of impact would be the classroom. However, the means of implementing VR into an educational setting has yet to be thought of, executed, and examined. That is, until Ph.D. candidate Jared Canright conducted the research himself.

Jared graduated from the University of Washington in 2023 with a Doctor of Philosophy in Physics. His research surrounded the implementation of Novel Observations in Mixed Reality, or NOMR, in the undergraduate introductory physics curriculum across multiple academic terms. The core of his idea was this: can VR, independent of its initial novelty, have its strengths as an immersive technology be leveraged to create unique learning experiences?

The NOMR software is a virtual environment with particles and measuring tools the user can interact with. During labs, students would be given the task of examining the behavior of different particles as they move around the screen, interact with each other, and respond to different tools given to the user. The students would then be tasked with measuring different properties, recording data, and coming to conclusions on how the particle behaves. The big catch is this: the particles themselves do not follow the natural laws of physics and are completely fictitious.

In the case of NOMR, the virtual, immersive environment of VR was leveraged to enhance the idea that the universe of NOMR is completely different from our real world. To this degree, students would not be influenced by any preconceived notions of how the particles *should* behave, and would instead focus on investigating the behavior themselves. In other words, students in labs would better mimic the act of experimental physicists discovering natural phenomena for the first time.



1.3 Additional Research Studies

In addition to this research study at the University of Washington, there are of course additional data sources that can help provide us additional insight into our exploration target.

Our second data source is research data from James Cook University (JCU) conducted in 2019 in Singapore. In this study, researchers aimed to investigate the level of immersion and directed attention in VR environments using objective and subjective measures. The specifics of their model won't be heavily disclosed in our paper, however what is most important to note is that the data involves evaluations of user attentiveness, presence factors like spatial presence, involvement, and realness, and intrinsic immersion tendencies, such as emotional involvement and absorption. From this data source, we hope to provide additonal insight into user engagement with the medium, and examine what type of applications would be more appropriate for VR versus something more traditional.

Finally, we have a data set from Kaggle that provides information on user experience. This data is more limited, but it is notable in that it is a study targeted around immersion and motion sickness that has a wide range of participant age, gender, and time in the headset. From this data set, more information can be drawn about the reception to current VR technology by specific demographics, and how that may impact its usability in certain sectors.

1.4 Paper Explanation

In this paper, we will be examining the potential for VR in educational settings through two lenses: one, the research study conducted by Jared Canright, and two, through additional data sources that provide additional insight into the use of the technology, such as demographic, and problems with the technology that remains to be addressed. Through exploration, we hope to create a clearer picture of what the future may hold regarding the potential of this technology, as well as share insight to its exciting potentional.

The subsequent sections of this notebook are organized as follows: Section 2 outlines the methodology for data collection and the structure of the acquired data. Section 3 showcases the visualization of the data. Section 3 encapsulates a summary of the efforts invested in this visualization task along with the learning outcomes. Finally, an acknowledgment section is dedicated to those who contributed to the data collection and provision.

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2. Data Source

2.1 Efficacy of the Approach

For the NOMR study, to research how this curriculum impacted the classroom, surveys were conducted at the start of the term and weekly at the conclusion of each lab activity. There were 3 main categories of surveys:

- Lab Epistemology Survey (LES):
  - Student attitudes and beliefs about the nature and role of experimentation in physics
- Physics Identity Survey (PhIS):
  - Degree of students' self-identification as a physicist, interest in physics, and belief in their ability to practice and succeed at physics
- Flow Survey (FS):
  - Degree and nature of students' engagement with the week's lab activity

From these 3 data sets, the original paper showcases different visual models to highlight the impacts on student learning. To highlight points made from the data set, we created different visualizations.

2.2 About NOMR Data Set

In educational settings, particularly within scientific disciplines, laboratory sessions are integral for bridging theoretical knowledge and practical application. Recognizing the importance of optimizing these sessions for maximal educational impact, the lab conducted a survey to gather detailed feedback from students post-laboratory sessions.

The collected data encompassed various aspects of the lab experience, including:

"Time": The date and time when the response was submitted.

"InstructorAssistanceNeeded": A measure of the extent to which the student needed help from the instructor.

"TaskGoalClarity": The student's understanding of the task's goal.

"TaskProcedureUnderstanding": The student's understanding of the procedures or steps needed to complete the lab task.

"PerformanceAwareness": The student's awareness of how well they are doing in the task.

"LabChallengeLevel": The student's perception of the lab's difficulty.

"KnowledgeAndSkill": The extent to which the student felt knowledgeable and skillful during the lab.

"LabEnjoyment": The student's level of enjoyment and interest in the lab.

"LabIdentifier": An identifier for the lab session.

This data collection is pivotal for several reasons. It allows educators to pinpoint and address specific challenges faced by students, thereby enhancing the effectiveness of lab sessions. Furthermore, it aids in identifying elements that contribute to student engagement and satisfaction, which are key to fostering a conducive learning environment. By systematically analyzing this feedback, educational institutions can refine their lab curricula, ensuring they are both challenging and supportive, thereby enhancing the overall quality of scientific education.

2.3 Supplementary VR Data Sources from the Internet

2.3.1 Immersion level of VR environments (ICU Dataset)

2.3.1 Immersion level of VR environments (JCU Dataset)
https://research.jcu.edu.au/data/published/cab48b30f6c611ecbf5941610fa1e0e4/

This study surveyed the participants' level of immersion in VR experiences over many trials using a 27 question survey. Questions included how the relationship between a participants physical body and virtual spaces felt, the level of engagement in the VR experience, and the level of realism of the VR experience.

The dataset includes the participant responses to these survey questions, including:

"IPQ1": Corresponds to responses to the question: "In the computer generated world I had a sense of "being there" - Not at all(1):Very much(7) "

"IPQ14": Corresponds to responses to the question: "The virtual world seemed more realistic than the real world - Fully disagree(1):Fully agree(7) "

"VRN2": Corresponds to responses to the question: "Spending time there gave me a good break from my day-to-day routine - Not at all(1):A great deal(9) "

2.3.2 User experience in VR environments (Kaggle Dataset)
https://www.kaggle.com/datasets/aakashjoshi123/virtual-reality-experiences

The goal of this dataset is to facilitate research aimed at enhancing VR technology through a detailed analysis of user preferences. It includes:

"UserID": A unique identifier assigned to each participant in the study.

"Age": The age of the participant. Age can be an important factor in VR experiences as it may influence how users perceive and interact with VR environments, as well as their susceptibility to motion sickness or their technological familiarity.

"Gender": The gender of the participant. Including gender allows researchers to analyze if and how VR experiences may differ across genders, which could be relevant for designing more inclusive VR systems.

"VRHeadset": The type or model of VR headset used by the participant during the experience.

"Duration": The length of time the participant spent in the VR environment during the session.

"MotionSickness": This refers to whether the participant experienced any symptoms of motion sickness during or after the VR session.

"ImmersionLevel": This could be a subjective rating provided by the participant indicating how immersed they felt in the VR environment.

2.4 Data Source Integrity

Our data source from NOMR was provided to us directly from the author of the study. Student names were kept undisclosed for confidentiality. In terms of motivation by participants, students were given minor points in extra credit upon completion of surveys, and showed clear trends upon multiple lab groups across multiple quarters. The data source itself is also the basis for the PhD study authored by Jared Canright, and is publicly viewable online.. We can say that this source is reputable due to its stakes for the PhD candidate Jared, but also for the supporting faculty named on the paper as representatives of the University of Washington.

The research data from James Cook University is similar in that this is a research paper published from the university itself, and is accessible via their website directly. There is no evidence to imply any interests from third parties in the credibility of this research.

Finally, we have our data from Kaggle. This is the data source we understood we needed to be the most careful about, as it contains very limited information about its originating source, how the study was conducted, how its sample size was chosen, and further details of its testing. However, we felt that the limit in information was appropriate to its limited scope in what the data implies. The spread of demographics across motion sickness was something we felt was an important contribution to the overall picture, and we had supporting data on immersion level in our other data sources, meaning we were not relying solely on this data set. The data source is also publically viewable online, which allows for scrutinization from multiple parties. We cannot guarantee the full credibility of this data source, but believe it adds contributing context on demographic data that is less present in our other data sources.

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3. Data Visualization

Part 1: Data from NOMR

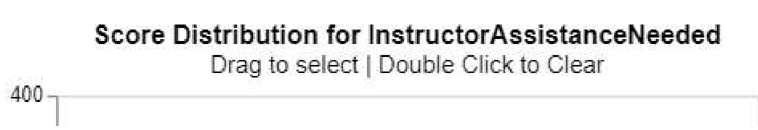
(1) Data Visualization 1

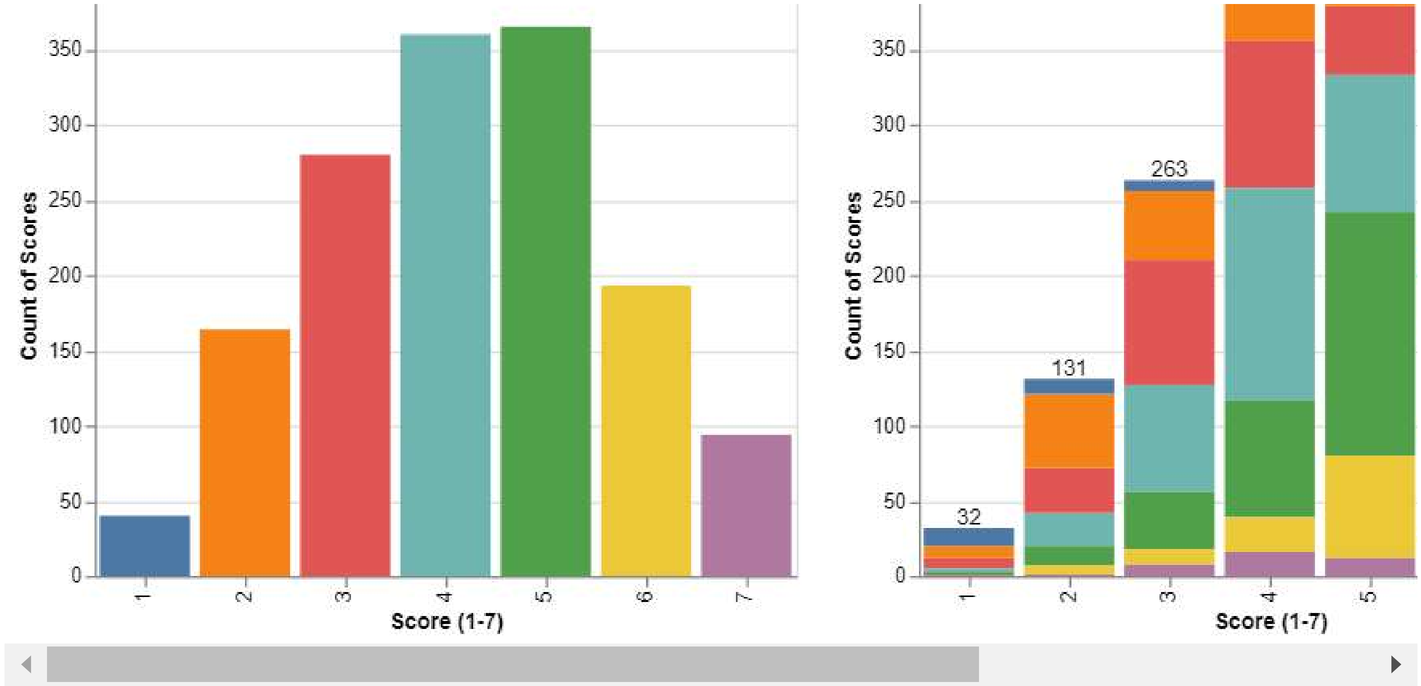
Question 1 Selection:

InstructorAssistanceNeeded

Question 2 Selection:

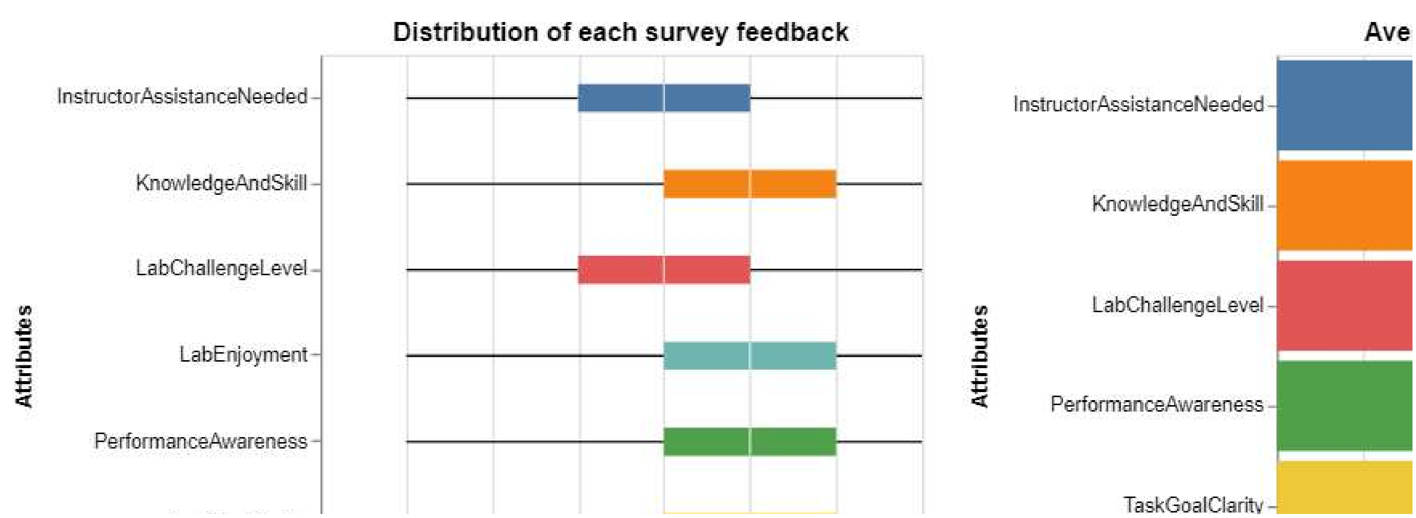
LabChallengeLevel

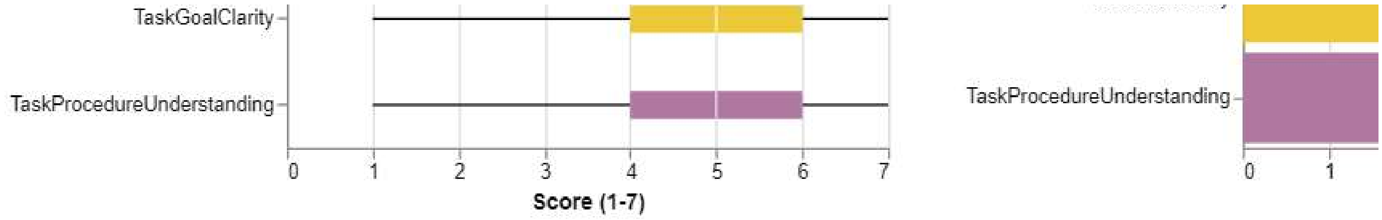




- Histograms of score distributions arranged horizontally with parameter selections above
- The left histogram (question 1) allows the user to select a range of responses along the x axis
- The right histogram (question 2) responds to this selection, filtering the score distribution to only include selected participants
- For example, by default, selecting participants who gave high scores for "InstructorAssistanceNeeded" would allow us to see how those participants scored "LabChallengeLevel"
- The user is free to select different questions for both the left and right histograms using the parameter selections

(2) Data Visualization 2

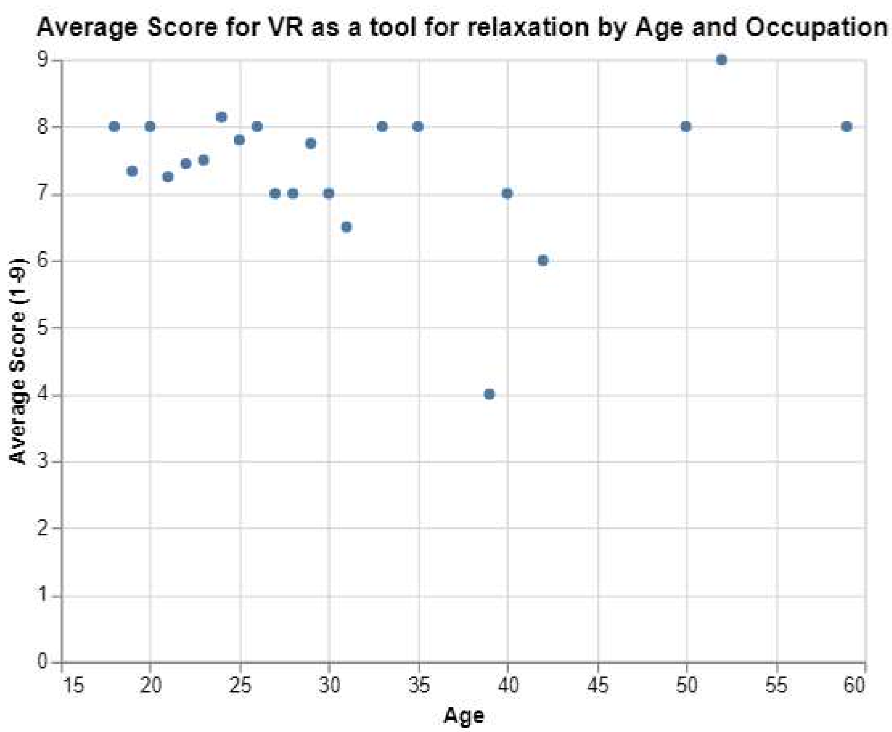




- Boxplot of each question on the survey
- The middle of the boxes indicate the median score of each question while the size of the boxes tells you the scores of 50% of where students scored their survey questions
- The edges of the whiskers tell you the mins and max of each question
- To the right of the box plot is a bar chart that shows the average scores of each question

Part 2: Supplementary Data

(3) Data Visualization 3 (JCU Dataset)

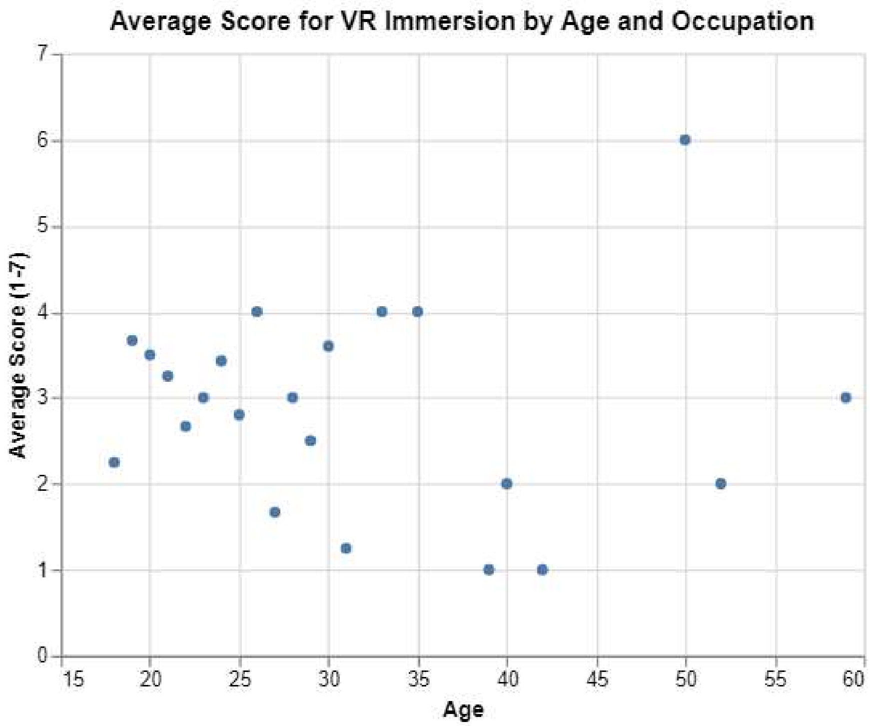


Participant Occupation: Student

- After using VR, survey participants were asked the following question: **"Spending time there gave me a good break from my day-to-day routine - Not at all (1) : A great deal (9)"**
- This is a scatterplot of the responses to the above question; Users can filter the data by participant occupation (student or working)

by participant occupation (student or working)

(4) Data Visualization 4 (JCU Dataset)



Participant Occupation: Student

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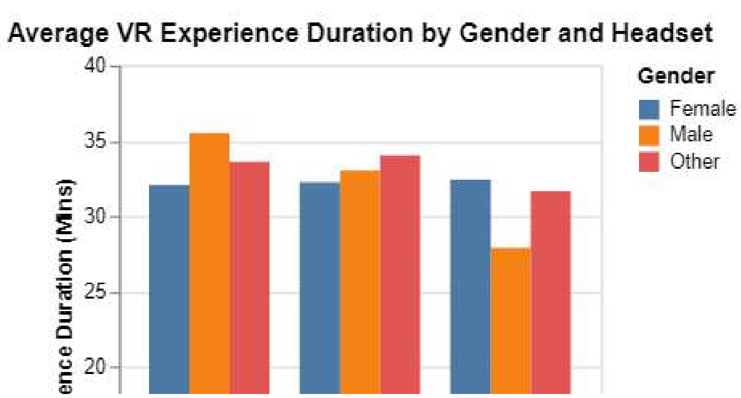
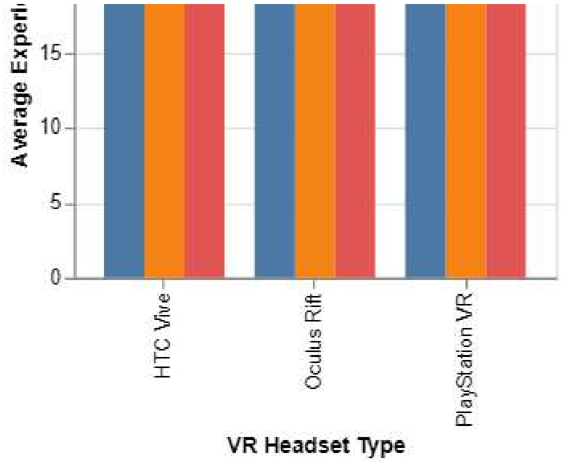
- After using VR, survey participants were asked the following question: **"The virtual world seemed more realistic than the real world - Fully disagree (1) : Fully agree (7)"**
- This is a scatterplot of the responses to the above question; Users can filter the data by participant occupation (student or working)

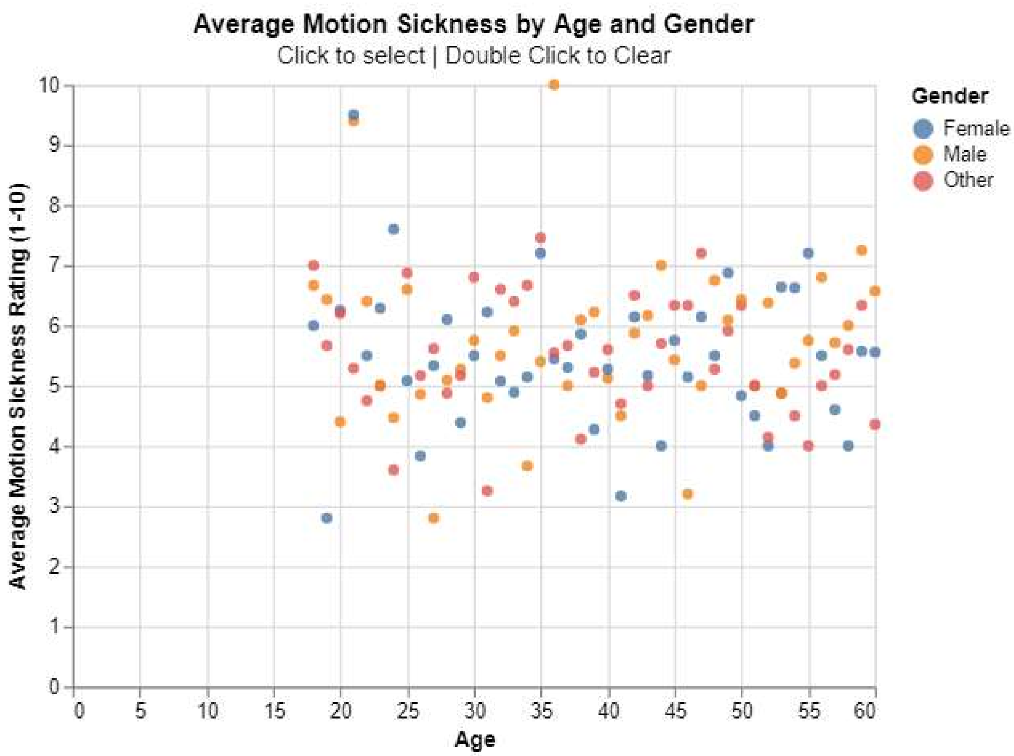
(5) Data Visualization 5 (Kaggle Dataset)





- Bar chart of average VR experience duration by VR headset type, with each bar divided by 3 gender classifications

(6) Data Visualization 6 (Kaggle Dataset)



- Scatterplot of Average motion sickness level by age, divided into 3 gender classifications
- Users can select a point to filter the gender classification

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4. Conclusion

4.1 Challenges

When exploring this project topic, VR's applicability in educational settings, we encountered several difficulties. The two most prominent among these were the challenges of (1) data analysis and information synthesis from multiple sources to produce a coherent narrative and (2) making assumptions to support our conclusions.

4.2 Findings

Our findings emphasize the important role of immersion and interactivity in enriching educational experiences through VR. The data suggests that engagement and interaction are key benefits of VR; however, the impact of factors such as the quality of visuals, user comfort, and the authenticity of the virtual environments is significant in determining the effectiveness of VR in education. These elements highlight the necessity for continuous technological advancements in VR to leverage its capabilities for educational purposes fully.

Additionally, our study brings to light the issue of the digital divide. The question of access and equity is foregrounded, as not every student has an equal opportunity to use VR technologies. This gap underscores the challenges in making VR a universally adopted educational tool, calling for efforts from both developers and educators to ensure VR learning tools are affordable and accessible to all.

4.3 Group Reflection

Our group collaboration was exceptionally productive, with every member actively contributing their expertise to the project. We kept up consistent dialogue regarding our thoughts and developments to make sure all people were well-informed and aligned. A special acknowledgment goes to Jonas for his extensive efforts in liaising with the research lab to obtain the necessary data.

For a group project to succeed, it's important to leverage each individual's strengths. So, we assigned roles and responsibilities right from the start:

- Coordination: Ori, Jonas
- Data Processing: Jonas, Coby, Cody
- Notebook Design: Ori, Jonas
- Visualization: Coby, Cody
- Video Editing: Jonas
- Slide Preparation: All Team Members

The successful completion of this project would not have been possible without the contributions of everyone. Once more, we extend our gratitude to all our team members.

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5. Work Environment Configuration

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```
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import {vl} from "@vega/vega-lite-api-v5"

import {printTableTypes} from "@jonfroehlich/data-utilities"

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import {uniqueValid} from "@uwdata/data-utilities"

import {printTable} from "@jonfroehlich/data-utilities"

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JCU = ▸ Array(120) [Object, Object, Object, Object, Object, Object, Object, Object,

userExp = ▸ Array(1000) [Object, Object, Object, Object, Object, Object, Object, Obje

NOMR = ▸ Array(1496) [Object, Object, Object, Object, Object, Object, Object, Object,

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