VRLearning: An Exploration into the use of VR in Education

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ABSTRACT

VR technologies and their use as a replacement for traditional 2D displays have become increasingly more common and accessible in the main stream in recent years. Similarly, more and more students are opting to attend classes remotely. However, this has sacrificed student engagement and interaction. A potential solution to this problem may be the use of VR as an alternative to traditional 2D displays for remote learning.

VR provides many advantages over traditional 2D displays, it's able to present information in a more engaging and immersive format which could produce a more memorable learning experience in which users are better able to memorize and recall information presented within a lecture.

In order to determine which of the two mediums, either a 3D VR display or a traditional 2D display, produced a more engaging and memorable learning experience, an experiment was designed in which participants would receive a lecture using one of the two mediums. Participants would then take a short multiple choice quiz on the information covered in the lecture. The scores from these quizes would be analyzed to determine if the lecture medium had significant effect on the participants' ability to remember the presented information.

Although our group was unable to perform our designed experiment, hopefully the reseach and development we have done can serve as a strong framework for future developers to build off of. Virtual Reality technologies are certainly going to become more commonplace in our lives. Further research and experimentation should be done into the viability of VR in education to uncover the specific advantages that it provides over alternative display technologies.

Author Keywords

virtual reality; remote learning; education; human-computer interaction

CCS Concepts

•Applied computing → Interactive learning environments; Distance learning; E-learning;

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INTRODUCTION

Background

In recent years, our lives have become more and more dependent on internet technologies. An example of this is the rise of remote learning, especially within higher education levels. Online college classes have become increasingly common, with nearly a third of college students enrolled in at least one online class. [7] Remote learning offers several advantages over the traditional classroom environment. Students can learn on their own schedule; some instructors opt to pre-record their classes so students can watch at any time. Remote learning is not bound by a physical classroom; students can participate in class from anywhere in the world. Convenience and accessibility are the cornerstones of remote learning, although, many question its effectiveness against the traditional classroom environment.

In their article titled, "Does Online Education Live Up to Its Promise? A Look at the Evidence and Implications for Federal Policy," Protopsaltis and Baum explored published literature to analyze student performance in an online learning environment. They found that student success is highly dependent on student-instructor and student-content interaction, and if this interactivity doesn't exist, student motivation, self-regulation, and organization must be present. [7] Traditionally online classes use 2D mediums to present their content, such as a Microsoft PowerPoint, or a recorded lecture video. Depending on instructor implementation, these mediums are not the most interactive for students. However, there are several emerging 3D technologies that might provide stronger student-content interaction for successful learning in a remote environment.

Virtual Reality (VR) is a 3D technology that has potential to remedy the lack of student-content interaction present in online classes. Allcoat and Mühlenen discuss the advantages that VR offers in their 2018 study into the viability of VR in education, that it "presents environments in 3D, it is interactive and it is able to give audio, visual, and even haptic feedback." [1] These advantages make VR headsets are a perfect medium for presenting information in an engaging and interactive format, and they could be used in place of a typical 2D computer display to develop more immersive lectures for remote students. This could help to replace the engagement and interaction that students would typically get from being physically in the classroom. In their study on the viability of VR for education, Radianti et al. discuss how "recent developments in immersive technologies – in terms of visualization and interactions – have made VR increasingly attractive to scholars." [9] When students are more engaged and connected with the content

they are learning, they are much more likely to retain the information presented. Because of this, lectures received in VR may lead to better student performance compared to lectures received on a traditional 2D display.

The novelty of VR is also notable. VR is an interesting and new technology, that is—objectively—fun. In her article titled, "The Neuroscience of Joyful Education," author and neuroscientist Judy Willis claims that having fun and learning are correlated. Learning in a fun and comfortable environment increases brain activity and storage in the brain. [11] The feeling of fun is triggered by the release of the neurotransmitter, dopamine, in the brain. Dopamine also stimulates the prefrontal cortex (a part of the brain that deals with memory), and triggers the release of another neurotransmitter, acetylcholinem, which aids in attention. [11] If students have fun learning in a VR environment, it may increase student success over the traditional online learning environment. Furthermore, studies have shown that emotion has an effect on learning and memory retention. Tyng et al. found that if an experience activates the amygdala (part of the brain that handles emotion), it enhances memory consolidation [10]. Positive emotions related to VR experiences can further boost learning and memory retention.

The current time we live in highlights why this research is so important. The COVID virus has put a halt to the face-to-face communication and so learning must be made remote. This is due to the pandemic but also a shift in people in general attitude towards preferable remote methods. VR research on this topic is vitally important to us today. VR can give people a learning experience that they would not be able to have while living isolated. This would be highly advantageous to expand VR research as this field will only become larger.

Due to the specific advantages that VR poses over a traditional 2D display, being more engaging and immersive, VR lectures may be better suited for specific areas of learning. In their paper, A systematic review of Virtual Reality in education, Kavanaugh et al. explore this question to find what areas of learning are best suited to be adapted to VR. Their study found that General Medicine, General Education, and Safety training were three areas which are best able to utilize the interactive and immersive learning environments that VR provides. [3].

VR has also been found to be highly beneficial in the medical industry. An article about VR's use for rehabilitation of upper limbs Levin presented a growing body of evidence that illustrates how enriched virtual environments may be used as a therapeutic training tool in which many principles of motor control and motor learning can be incorporated to provide a learning experience tailored to individual clients. [4]. Computers are an extremely flexible thing allowing them to be able to adapt to any kind of rehabilitation that people need. VR is able to provide meaningful feedback. Cognitive factors such as attention deficits and visual spatial neglect, executive dysfunction, and lack of awareness are major barriers to recovery for people needing physical rehabilitation. VR is able to combat all of these other problems that people face changing on the fly to apply to everyone ones specific needs.

With this in mind, our group needed to find a field of computer science which could similarly utilize the advantages that VR provides. We eventually decided on developing lectures covering the basic principles of digital logic. This was chosen due to the interactive and highly visualize-able nature of logic gates, and would allow for the development of interactive lecture features. Having a lecture with interactive and immersive features would allow us to get the most out of VR, and would aide in producing better conclusions on the viability of a lecture in VR compared to a lecture using a 2D display.

In order to answer the question of which of the two display mediums, either a VR Headset display or a traditional 2D display, produced a more engaging and memorable learning experience, and experiment was designed in which participants would take a lecture using one of the two display mediums, and then take a short quiz on the information covered in the lecture. The participants scores on the quizzes would then be analyzed to determine if the lecture medium had a significant effect on the number of questions answered correctly.

Our group hypothesizes that because of the advantages that a VR headset provides over a traditional 2D display, being more immersive and engaging, participants of a lecture using a VR headset will answer more quiz questions correctly than participants receiving a lecture using a 2D display.

Challenges

One hindrance to VR is that is relatively expensive to acquire the equipment. VR equipment can range from hundreds of dollars to thousands of dollars for different models. Along with the headset devices being cost prohibitive, people would also need high-powered computers to be able to effectively use them. In their study on the application of VR in Education, Kaminska et al. discuss potential solutions to the high-entry cost of VR, proposing alternative, phone-driven VR technologies including Samsung Gear VR, Google Daydream, or Google Cardboard to traditional VR headsets. These devices "are more accessible than the above mentioned high-end solutions (e.g., HTC Vive or Oculus), they do not require an additional computer, only a low-cost headset with a phone." [2] Although these phone-driven VR technologies offer less control over the virtual environment than traditional VR headsets, they may still be well suited for education on topics which do not require complex controls, especially in lower levels of education.

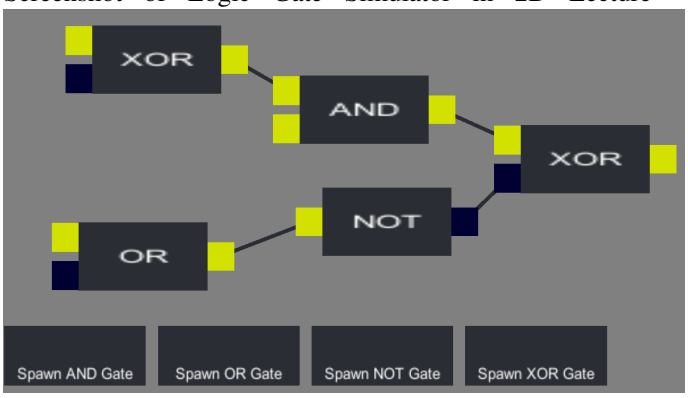
METHOD

In order to determine which of the two mediums, 2D or VR, produced a more engaging and memorable lecture, an experiment was designed in which participants would receive an interactive lecture in one of the two mediums, followed by a short multiple choice quiz on the content covered in the lecture. After participants completed the quiz, they would be asked to complete a short exit survey aimed at measuring how engaged the participant felt during the lecture.

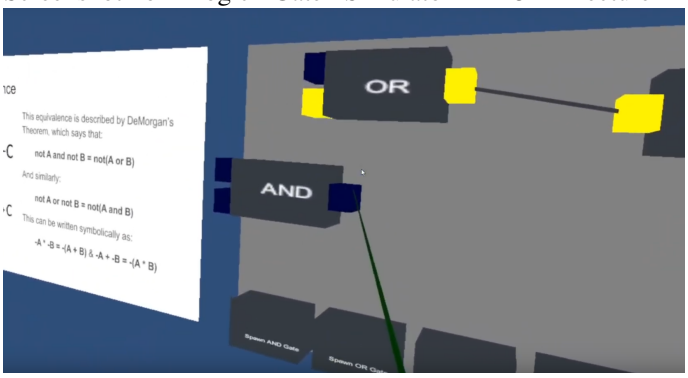
The two lectures were developed using Unity, and include an interactive logic gate simulator to take full advantage of the interactive nature of VR. Participants control the lectures by

moving from slide to slide using the arrow keys, and participants can interact with in-game objects via clicking and/or dragging the mouse/VR controller cursor.

Screenshot of Logic Gate Simulator in 2D Lecture

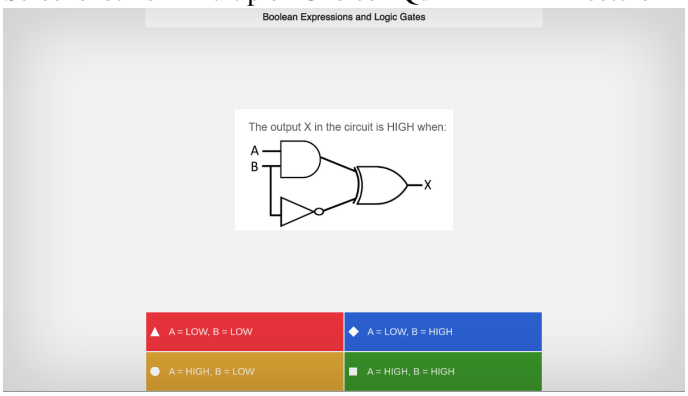


Screenshot of Logic Gate Simulator in 3D Lecture



After participants go through the lecture, they are presented with a short multiple choice quiz on the content of the lecture.

Screenshot of Multiple Choice Quiz in 2D Lecture



Participants

Participants were intended to be drawn from non-computer science college students. The lecture in the experiments serves as an introduction to digital logic principles, designed for people with little or no previous computer science education. Because the experiment divides participants between-subjects, a larger pool of participants would be needed. Around 20 participants would allow for 10 trials of each lecture, and would be sufficient.

Apparatus

Participants would receive a lecture on digital logic principles using either a traditional 2D digital display, or using a 3D VR Headset display. Both lectures were designed in Unity, and the content covered in the lectures is identical.

Procedure

Participants would be randomly assigned to receive a lecture in digital electronic principles using either a 2D display or a 3D VR Headset.

Prior to the lecture, participants would receive some short information on the content of the lecture, explaining that they will be presented with a short, interactive lecture on digital electronic principles, followed by a short multiple choice quiz on the topics covered in the lecture. Participants would also be informed on how to control the lecture, explaining that the left and right arrow keys can be used to move from slide to slide, and how the cursor can be clicked and/or held to interact with objects inside the lecture.

Participants are able to spend as much time as needed in the lecture portion before moving on to the quiz. There is also no time limit for the quiz, although once started, participants will be unable to revisit the lecture.

Multiple attempts are allowed for each of the quiz questions. Each question is worth a potential 100 points, with 25 points getting taken off for each incorrect answer submission. Scores for each question are automatically stored in text files for later analysis.

After completing the multiple choice quiz, participants would be presented with a short exit survey on paper aimed at gauging how engaging, memorable, and effective the lecture medium was in the eyes of the participant.

Exit Survey:

- On a scale of 1-10, how engaged did you feel in the lecture?
- On a scale of 1-10, how willing would you be to take full course using this display device?
- On a scale of 1-10, how easy was this display device to use?
- On a scale of 1-10, how fun would you rank the lecture?
- Do you have any other comments on the display medium or the lecture?

Design

Independent Variables:

- Lesson Medium - The type of display on which participants receive the lecture, 2 Levels (VR Display or 2D Display)

Dependent Variables:

- Information Retention - How well participants remember the information covered in the lecture. This is measured from participants quiz scores.
- Participant Engagement - How engaged or immersed the participants felt in the lecture medium which they receive. This is measured from post-quiz participant surveys.

Control Variables:

- Lecture content - The information covered across the two lectures and the interactive elements present within the lectures are consistent across both lectures, to remove any effect that covering different information might have on quiz scores.
- Participant Instructions - The instructions presented to participants for controlling the lecture should be consistent for all participants, to avoid any one participant having advantages over others.

Random Variables:

- Previous Lecture Content Knowledge - Some participants may be more knowledgeable on digital logic principles coming in to the experiment that may result in higher scores than other participants.
- Previous Experience with Lecture Medium - Some participants may come in to the experiment more familiar with the display medium they are using for the lecture, which may result in higher scores than other participants.

RESULTS AND DISCUSSION

Due to the unique nature of this semester, we were unable to carry out an actual experiment. However, if an experiment was eventually conducted we would analyze the participant quiz scores using a Mann-Whitney U test to detect a significant difference in participant quiz scores between the two lecture mediums. This type of test is used since the data is ordinal and the experiment divides participants between-subjects with two test conditions. Survey results would also be analyzed when making a final conclusion on the viability of the two lecture mediums.

Similar studies have been conducted that do draw conclusions on the benefits of VR learning. Radianit et al. explored virtual reality application in higher educations. They found that VR was able to create a immersive learning environment for participants, however application must include realistic surroundings and basic interaction elements. [8] If we were to carry out our own experiment in the future, possible improvements could be made to our lecture environment to provide a more realistic learning environment.

Allcoat and Muhlenen study found various benefits to VR learning versus the traditional 2D online environment **and** the traditional physical classroom environment. Participants in the VR and traditional classroom environment had improvements in knowledge acquisition and understanding over the traditional 2D online environment. [1] Their results also indicate a difference in emotional rating between learning environments. Participants had increased positive emotions and decreased negative emotion towards the VR learning environment, while both the traditional 2D/physical classroom environments had decreased positive emotions and and increased negative emotions. [1] Emotional experiences have been shown to be more memorable than less emotional experiences. However, the impact of emotion type on learning has not been explored by the current literature, therefore the lure for VR application in education may be increased if future studies investigate the impact of emotion type (positive emotions v. negative emotions) on learning.

Madden, J study that is very similar to ours has some interesting results dealing with differing learning environments from hands on, desktop computers and a VR environment. Participants' learning gains from pre-to post test were not significantly different, on average, between the VR, desktop, and hands-on conditions. Participants preformed similarly well on each question topic across the three conditions. They found no strong evidence that participants' retention differed between conditions after four months. Their hypothesis, that VR would improve learning by simplifying real-world complexities and providing an embodied learning experience, was not supported. Nonetheless, participants strongly favored learning in the VR activity. [5]

Ying Xie conducted a case study in which they used VR tools to teach Chinese language. They found students had and overall easier time learning their studies using the VR learning. Participants were found to be more interested in Chinese culture and were more motivated to learn more about it. However they found that even with the benefits described above. The teacher had a large part in the involvement in helping the participants maintain focus on learning tasks provided. [12]

In an experiment performed by Guido Makransky participants were asked to be part of two groups either the home or the supervised group. Their aim was to determine if learning in either environment were equivalent for learning with VR. The reason for their experiment is for companies are wanting to save costs by doing remote training. Learning if this is just as effective would be something vital to their training. Their main finding from the data was students learn as well from computer-based interactive science simulations when they are performed at home as when they are performed in class—was supported. Specifically, the students who were assigned the virtual biology laboratory simulation to independently complete at home in an informal environment performed equally well on the learning outcome test as the students who used the simulation in a formal classroom environment with teacher supervision. [6]

CONCLUSION

Because we were unable to perform the experiment, we are unable to come to a conclusion at the current time on which of the two lecture mediums produces a more engaging and memorable learning experience. However, our research has highlighted the numerous advantages that VR provides in an education context, that it's more engaging and immersive. VR Headsets are also able to provide learning experiences which would otherwise be too dangerous or too unrealistic to produce, an example being teaching a surgery procedure in VR. Because of these advantages, it is definitely worthwhile to perform further investigation on the use of VR in education.

Even if VR doesn't completely replace 2D displays for information communication, it's still highly likely that certain areas of education could not viably be taught remotely without the use of VR, and as VR becomes more accessible to the general

public we will almost certainly see its use as an alternative to traditional displays increase.

It's important that we understand the specific advantages that VR provides to us if VR technologies are to become a part of our every day lives. Further research and experimentation should be done to uncover these advantages, which will hopefully be aided by the framework that our experiment has developed.

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