Chemistry VR

P2 – Project Preliminary Paper

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INTRODUCTION

The main goal of this project is to design a VR application to assist chemistry students in learning the redox titration experiment before heading to the lab. This is also meant to assist professors as this will lead to less chemical waste in the lab and more productive learning.

ABSTRACT

Our project is a VR chemistry station. When the application is first started, they will be in an entrance room where they must first login and then they can choose between different kinds of labs to do at a chemistry station. To start with, this chemistry station will be capable of completing the redox titration chemical reaction. The user of our VR app will have limited control of the chemistry station and will be mostly guided through the lab. If they make a certain number of mistakes, our system will give more and more descriptive hints until they complete the lab correctly. The user should get feedback when they make mistakes as well. There will also be a notepad to record data while completing the experiment. Finishing the lab correctly will present them with a congratulations message and the options to either reset the lab or to go back to the main menu to select a different lab to complete.

The purpose of this application is to introduce the experiment to the student before they go to complete the lab in person. Most students make mistakes when completing this lab. This VR prelab can help reduce chemical waste when they go to complete the lab in person. The student should be familiar with the experiment after using our application and will hopefully be less likely to make a mistake, or as many mistakes, when they complete it in person.

1 Literature Reviews

1.1 Elizabeth Dayton Review

"The JUST VR Tool: An Innovative Approach to Training Personnel for Emergency Situations Using Virtual Reality Techniques" [1]

VR tools are an incredibly effective tool at simulating real world situations. It can create a sense of really being in the situation at hand and test whether or not someone would be prepared if the simulation was real. The research paper I've chosen successfully demonstrated that a VR tool actually felt like a real-life situation and users really felt like they were there in a health emergency scenario. They used 20 participants and 2 different scenarios to test whether or not the VR simulation felt like real life and could be useful in training people for high intensity situations. Participants were then asked to complete a survey, developed and compared to similar surveys created by Slater, Usoh and Steed. This survey was meant to assess the participants feelings regarding their sense of presence and how close to reality the simulation felt. Comparing the results to the results of the similar surveys, they found that the participants felt very strongly that the VR simulation felt real and that they felt very present in the situation. This test was done in 2004 when VR technology was relatively new and since then many advancements have been made and VR is much more affordable (the cost of the system they created was estimated to be between $20,000 and $80,000).

I felt that this article was relevant because VR is a continuously growing technology and there are many uses for it apart from entertainment. This study showed that VR could help in an extreme scenario like a health emergency, and I think it shows that it can be largely beneficial for other scenarios that are not so high intensity. I think it shows that for our purpose, a

chemistry experiment VR experience, it could be very helpful for both students and teachers. It can help students learn and limit chemical waste. Also, now that VR headsets are much more affordable, students and teachers can make use of them for this learning purpose. It largely feels just like a real-life scenario and will benefit students who may be unfamiliar with chemistry equipment or with the experiment at hand. It will help students feel more confident and give teachers a good resource to aid their students learning.

1.2 Cole Beck Review

"Diagnosing changes in attitude in first-year college chemistry students with a shortened version of Bauer's semantic differential" [2]

Students of chemistry are often assessed based on their pre-existing understanding of the concepts of chemistry to evaluate and develop fitting instruction for the surveyed students. The research paper I have chosen suggests that assessment of a student's attitudes toward chemistry as a subject may be just as important as the student's prior knowledge of the subject when considering how best to develop a pedagogical approach. Naturally, one must have an effective diagnostic tool to measure such attitudes toward chemistry in order to effectively determine how impactful a student's attitude is on their learning outcomes. Unfortunately, these tools are sparse; however, the paper assesses the effectiveness of semantic differential test, ASCIv2, when measuring student attitudes toward chemistry. The tool asks students to choose one of two opposing adjectives to describe the subject of chemistry in a series of questions. For example, "chemistry is easy/hard." The study conducted found that the assessment tool was effective in measuring the attitudes of students toward chemistry as well as measuring statistically significant changes in student attitudes if assessed more than once.

The utility of this study and its findings should be of great assistance after completion of the ChemistryVR project. Without proper assessment, the ChemistryVR project could not be proven to effectively improve student attitudes toward chemistry. Ideally, the project will reduce student anxiety in the lab setting which will improve grades. Theoretically, these improvements would result in statistically significant improvements in student attitudes toward chemistry that could be confirmed by the ASCIv2 diagnostic tool. Additionally, the tool could be used to assess any added feature to determine if it requires improvement or even removal in the case that it decreases student scores on the ASCIv2 tool.

1.3 ByeongHyeon Choi Review

"How VR In Education Will Change How We Learn And Teach" [3]

As we evolved, education became key in our society, and right now education is more important than ever. We are pressured by society to produce solutions to many global problems such as global warming, trash, food, water, and economy. With all these problems to solve, and with rise in advance technology to our education we need to produce efficient way to make student learn about the topic instead of just memorizing it. However, many would agree that education system in U.S. has not been best and some would go further and say that U.S. education system has been deterring. According to the article, current education is still based on same old format which is fact retention, and sometime too much information will have negative impact on the students. However, with all these advancement in technology, there are many ways to improve education, and one of the best long-term cost-efficient solution is VR. This article I readied about talks about VR in education use, and how it will change the way we learn and teach. The argument that the article makes builds of these five key points: Immersive, easy to use, meaningful, adaptable, measurable.

When using a VR in an educational scenario, we are trying to create an illusion of real life. If the user drops something it should have physics, if glass falls it should shatter, if mixture is wrong then there should correct reaction, and so on. This way the user feels like this is what to expect in real life however all this challenging work making VR immersive is wasted without making the application easy to use. The user should not have tough time starting up the application as that well reduce the frequency of the visit to the application, and with ease of use it will increase the frequency therefore the application should be meaningful. In the article it talks about what it means to be meaningful: "Meaning is really important for students, you can't create a good VR learning experience without a good story" By this the author is trying to say that the lesson should have meaning or point that students are supposed to get because without it will just be another normal lesson that will just lead to memorization. The article is pushing the idea of learning rather than memorization which is what our current education is, so in addition to having meaningful experience there also should be adaptability. Assuming so far that students have immersive experience that is easy to use but also a meaningful impact, then it is safe to assume that the students have learned the material. Hence, the application should be able to adjust the level of difficulty when it comes to labs. Although this may seem unnecessary in our case since it is just tutorial of how to use lab equipment, we can adapt the difficulty as the user progress to further advance in their learning about lab equipment. Of course, this would mean nothing if developer and the educator cannot track measurable success and failure.

Having a VR as tool to teach in a education can and will bring benefits that will benefit the society as whole. In the article it talks about many different aspects of VR than the five key points, but I wanted to point those five key points as that is what we will be using in our development of Chemistry VR. Overall, the article I read give us good key points to focus as VR in education use. We can use the article to give us the same five key points to work off to build an effective VR Chemistry Lab.

1.4 Nick Arnold Review

"Effects of an immersive virtual reality-based classroom on students' learning performance in science lessons" [4]

Virtual reality is something that has been since the 1960s-70s. It was apparently first inventing in 1962, but it has gained a lot of traction over the past decade because it is now able to be easily acquired for the average household, if they have the money for the headset device. With this new interest in virtual reality and it becoming more common, there has also been an increase in the number of people that are trying to find new uses for it. Some of the common uses include gaming, training, and education. While there are people trying to use it for education, there are just as many people trying to verify and prove the validity of whether or not it is actually useful for students, or is it just a waste of time. In the scholarly article "Effects of an immersive virtual reality-based classroom on students' learning performance in science lessons", Ruixue Liu, Lei Wang, Jing Lei, Qiu Wang, and Youqun Ren set out to try to prove that the use of virtual reality does have some beneficial outcomes for the students involved in using it to learn.

First, they talk about what VR is. They describe VR as a technology that emphasizes the sense of presence in the computer-generated simulation of a three-dimensional image or environment. There have been many studies to look at how VR can help students learn various subjects including: ecosystems science, geography, geometry, and history. These studies have all yielded positive results. The writers dive into why this is. First, it is because using VR gives the students a sense of motivation that might not have been there before because they are being exposed to a new form of technology that is more interactive.

There have been a multitude of experiments that have to do with whether or not there are benefits in using VR to teach, but this study takes a look at trying to use VR as the main method of teaching for a common classroom. The VR that this study looks at is a form of immersive virtual reality (IVR) called a Head-Mounted Display (HMD), and how this form a VR can help the student of two 6th-grade classes better comprehend and learn the material that is being taught to them.

The classroom was set up so that there would be 10 HMD for students that are all connected to a teacher's mobile tablet. The mobile tablet would allow the teacher to control the lessons, make sure that the students were keeping on track, and help the students out if they need it. The VR system would then allow the students to go through four different lessons of various topics. Before they went to a topic, they would take a pre-test that would measure their prior knowledge of that topic. After they were done with a topic, they could complete it by going through a VR quiz/wrap-up test.

The two classes of 6th-graders were randomly divided into two groups with one learning with the VR system, and the other learning from traditional classroom methods. On the pre-test of the topics, the control group had a higher score with a mean of .56 while the experiment VR group had a mean score of .50. However, the results of the posttest show that the experimental VR group showed significantly better results with their mean score jumping to .713 while the control group only moved up to a .563. The experiment also tested the engagement of the students in different categories, but in all of the categories the experimental VR showed better results.

Overall, this study was set up to prove that there were benefits to having students learn different subjects using IVR as the method of teaching, and I think that it did exactly that. The results showed that the students who used the VR not only learned more, but also had a more enjoyable time while doing so.

1.5 Joshua Gatlin Review

"Virtual Reality and the Transformation of Medical Education" [5]

The field of medical education can be drastically shifted with the advent of VR technology. For several years now medical education has recognized that skilled medical practitioners have to be created through simulation of real-world conditions rather than simply through memorization and head knowledge. The thing is, most physical simulations can be extremely expensive and do not truly simulate real world conditions. This is where VR comes in. Multiple situations can be created inside a virtual environment that simulates the real world to a much higher degree. A virtual world can convey the stress and chaos of an emergency situation, and the results of individual actions can be shown without any real people being in danger. There are a few drawbacks, an example of which would be that VR does nothing to help a doctor break bad news to a real patient. VR being used for medical training has become popular with surgeons, though it is still catching on in other medical fields. Nevertheless, the future potential of VR cannot be underestimated, and even the way it is now it could be used to save a great deal of money in medical training.

This article relates to our Chemistry VR project because it lends context and provides an example of how and why students use VR in another field of learning. It shows that it simply makes sense for students to utilize VR to learn about a subject before trying something with greater risk or a greater price tag. In the case of the medical profession, VR replaces expensive training equipment and gives the student knowledge about what to do in a real medical situation without any of the risks involved. For chemistry, the reasons to use VR can be very similar. Practicing an experiment in a virtual space before trying it in the real-world may conserve money and increase safety. Chemicals are not free, and if used improperly during the experiment than they may need to be thrown out and replaced by new chemicals. Chemicals can also be dangerous. Having students practice handling them in VR may prevent injuries. Considering the relatively low price tag of VR, it just makes sense to be able to take the extra step to give students the extra practice they need before stepping into a laboratory.

1.6 Ben Dempsey Review

"10 Ways Virtual Reality Is Already Being Used In Education" [6]

Virtual reality is being used in educational settings with many different purposes. The immersive experience is a very helpful learning tool. For example, students studying foreign languages can use virtual reality to simulate visiting a foreign

country to practice the language. This creates an opportunity for students that might not be able to afford an international trip. Virtual reality can also be useful for topics like architecture and design. Being able to view building designs in an immersive three-dimensional plane is much more realistic than using schematics alone.

A chemistry virtual reality program would similarly allow students to become familiar with the tools that are common in a lab, and could allow students to remotely get a similar experience that would otherwise be in person. Many students may not be familiar with the tools in a common lab, and so being exposed to those for the first time may create anxiety for some. With a virtual reality lab test, students can get to know the lab environment without worrying about breaking glassware or any of the other possible things that could go wrong.

1.7 Jay Cieutat Review

"The Data-Driven Case for Virtual Reality Learning" [7]

Virtual reality programs are an effective way to deliver important information to students. Academic studies have shown that virtual reality is incredibly effective at making students absorb the information given. In fact, these studies also show that students utilizing high level virtual reality simulations in the classroom have an increased rates of learning retention. There are a few theories as to why this is the case. Perhaps the addition of multiple senses (sight, sound, etc.) increase the learning retention of these subjects. Another reason as to why this might be the case is that virtual reality is fun. In many situations a virtual reality simulation is more fun than a typical classroom experiment. These simulations may also be perceived as games, which are a great way to capture the full attention of students.

This article is relevant to our project because it gives us solid academic data to show that virtual reality is an improvement when it comes to information retention of students. While virtual reality labs are greatly utilized during the COVID pandemic lockdowns, it can also greatly benefit students outside of this situation. It is also worth mentioning from an accessibility standpoint that virtual reality labs might be more accessible to those with disabilities than traditional labs. This was touched on in the article, and as we have learned in this class accessibility is an important part of designing useful software. The idea that virtual reality labs could be more effective in teaching students than traditional labs gives the ChemistyVR project longevity.

1.8 Everett Clemons Review

"Reasons to Use Virtual Reality in Education and Training Courses and a Model to Determine When to Use Virtual Reality" [8]

Virtual reality can easily be seen as a fruition of the evolution of computers and technology. VR has been one of the most expected and anticipated technologies. It has been seen in numerous Sci-Fi movies as a technology seen hundreds of years in the future. This type of computer technology has always been integrated into education and VR is no different. This immersive VR tech can fully immerse students in an experience that "are specifically designed to help students learn material." This type of immersive experience cannot be obtained through traditional means of instruction. Immersive and hands on experiences have been shown to education better and faster than just formal instruction. Virtual Reality can and has been shown, to be able to create these hands-on experiences for students that formal instruction can't create. VR also gives new methods of "visualization" and helps students visualize the instruction they were given. This type of education can give the students a face to the material they are being taught. VR has also been shown to motivate students. This is an exciting new technology.

VR is a technology that motivates students to interact, not just passively learn. This is the most important part of VR in the classrooms. Instead of passively learning material, students can now be active in their learning and interact and collaborate with technology to be educated. Our project aims to show that this is true. VR can benefit millions of students and during these times of quarantine, many institutions are already relying on VR to provide distance learning to students. The benefits can already be seen. This project would give students an experience outside of the classroom that would allow them to get used to the chemistry lab environment, outside of the classroom, instead of a passive video. A VR experience would create a mental construction of the lab before students even step foot in the lab. This would allow students to practice safety procedures without being in danger. VR experiences would be very beneficial to students and our project aims to show that.

SPECIFICATION/REQUIREMENTS

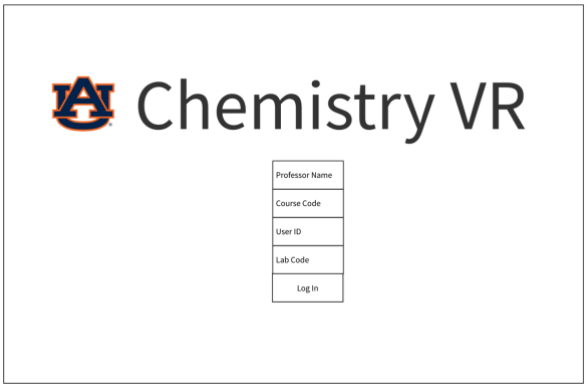

Figure 1: Wireframe showing the envisioned login/welcome screen of the application.

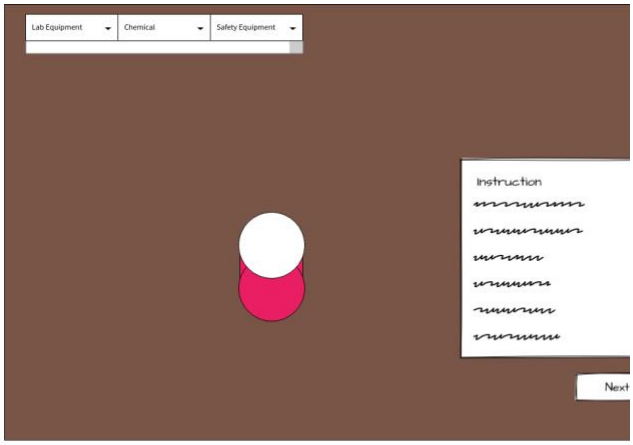

Figure 2: Wireframe showing the beginning setup of the redox titration experiment.

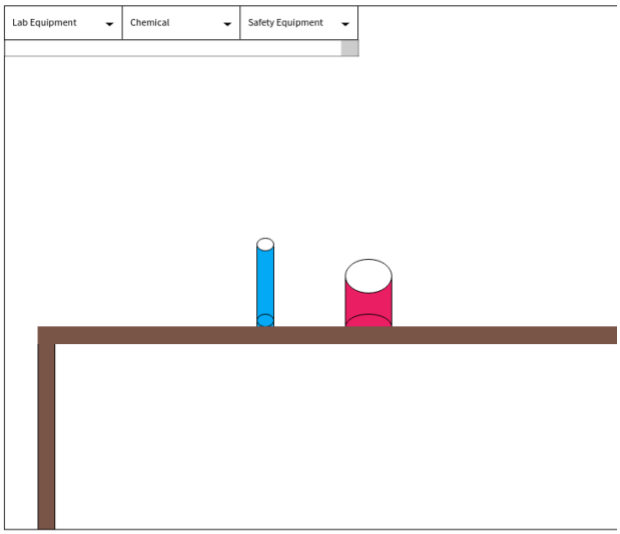

Figure 3: Wireframe showing another step of the redox titration experiment.

CONCEPTUAL MODEL

The functional requirements we have for our application to be successful are as follows:

- The system shall support a student in that they will feel comfortable with the redox titration experiment and be familiar with how to complete each of the steps.
- The system shall support a student using the Chemistry VR application in learning the redox titration experiment so that they may complete it with little to no errors in a real-world lab.
- The system shall support a student in that if they are struggling to understand or complete any of the steps, they will be met with helpful hints and suggestions until they can complete the step.

SOFTWARE REQUIREMENTS

The software requirements are as follows and are based on the VR technology that exists as of the completion of this paper:

Hardware (if it is a VR headset that requires a PC):

- Graphics card: GTX 1060/AMD RX 470/570 or greater
- CPU: Intel Core i5-4590/AMD Ryzen 5 1400 or greater
- Memory: 8GB but recommend 16GB
- AIO: HDMI 2.0, DisplayPort 1.2, USB 3.0, USB c,
- OS: Windows
- VR Headset: Valve Index, Oculus Rift, Oculus Quest, HTC, and more
- Controller: VR controller

Software:

- Chemistry VR application (that will be completed in Unity using C#)

SOFTWARE DEVELOPMENT PROCESS

The type of software development process that we will be using is the XP (EXTREME PROGRAMMING) methodology.

Using XP we will be able to manage our client's rapid introduction of ideas into the system.

XP is also the right choice in terms of development process because it allows the team to work closely together. This will be done through means such as pair programming. Since we have a limited timeframe to complete the project it would be wise to combine our efforts.

All of the advantages of XP, such as ability to continuously evaluate our specifications in regards to the demands of our client, will benefit our productivity greatly. The disadvantages of XP programming also will not affect us in this instance. Issues such as requiring a closely-knit team and geographic location will not be a problem for our development team.

LEXICON

The user will need to aware of jargon concerning the chemistry experiment itself. They will need to be familiar with chemistry lab equipment as well as the chemicals needed to complete the experiment. These include, but are not limited to, potassium permanganate solution, beaker, molarity, burette, KMnO4, Erlenmeyer flask, hydrogen peroxide, graduated cylinder, and meniscus.

Potassium permanganate solution, or KMnO4, is a chemical compound that combines manganese oxide ore with potassium hydroxide. It was originally used as a disinfectant and is still used to treat skin conditions like fungal infections.

A beaker is a lipped cylindrical glass container for laboratory use.

Molarity is the number of moles of solute per liter of solution, which can be calculated using the following equation: molarity = mol of solute / liters of solution. A mole is a standard scientific unit for measuring large quantities of very small entities such as atoms, molecules, or other specified particles.

A burette is a graduated glass tube with a tap at one end, for delivering known volumes of a liquid, especially in titrations.

An Erlenmeyer flask is a conical flat-bottomed laboratory flask with a narrow neck.

Hydrogen peroxide is a colorless, viscous, unstable liquid with strong oxidizing properties, commonly used in diluted form in disinfectants and bleaches.

A graduated cylinder, also known as measuring cylinder or mixing cylinder, is a common piece of laboratory equipment used to measure the volume of a liquid. It has a narrow cylindrical shape. Each marked line on the graduated cylinder represents the amount of liquid that has been measured.

A meniscus is the curved upper surface of a liquid in a tube.

EVALUATION/RESULTS

We will evaluate our project success and useability based on user testing of our application. This user testing will consist of us, the designers/developers, using the application and verifying that our functional requirements are met and that the application performs as expected. We will also use both Xin Wei and Qi Cui's feedback about our project to determine its success. We will receive their feedback periodically throughout the process and will make changes and adjustments accordingly. As the clients, their responses are ultimately what will determine our projects level of success.

DISCUSSION/CONCLUSIONS

We have spoken to Dr. Seals, Xin Wei, and Qi Cui about our project and received a lot of help and valuable information from them. Their vision is something we keep at the forefront of our minds while designing our project and will continue to be our main focus when we go into development. We anticipate that upon completion of this project, other developers in the future may take what we've done and add on other reactions and labs for students to complete.

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