IMPLEMENTING VR/AR SYSTEMS FOR INSIGHT INTO WATER DESALINATION PLANT

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Implementing AR/VR Systems for Insight into Water Desalination Plant

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This paper/research is to identify the effectiveness of using Mixed Reality (MR) tool as a teaching method for students. The goal of this project is to show that MR can be incorporated as a significant form of learning for students. In addition to traditional data collection, we have placed emphasis on digital data collection; for example, the students' headset interactivity willbe videotaped and observed. This project showcases MR headsets as an effective tool for teaching that makes use of visual and sensory stimuli. It allows students to analyze, evaluate and create structures that allows for a well-rounded learning experience. In this case, users will be assigned to work with and understand the complex processes of a water desalination plant. The features explored in this paper are the methods required to build a successful MR application. The impact of our teaching method is not to eliminate classroom learning but to provide activity that can assist classroom learning for students. It will also be useful in the industry-level as it allows professionals to perform certain procedures as many times as they want in a safe way to acquire the necessary skills in real world systems.

ACKNOWLEDGEMENTS

We would like to thank our academic advisor, Dr. Konstantinos Kakosimos, for introducing us to this research program. We also would like to thank our family members and staff at TAMUQ and coordinators of Undergraduate Research Scholars program for assisting us in this research.

NOMENCLATURE

VR	Virtual Reality
AR	Augmented Reality
MR	Mixed Reality
TAMUQ	Texas A&M University at Qatar
MSF	Multi-stage Flashing
RO	Reverse Osmosis
PV	Photovoltaic

CHAPTER I

INTRODUCTION

1.1 Introduction to Mixed Reality

In the past, there were limitations to human-digital interaction due to the constraints within the hardware system: PC, Keyboard, and Screen. However, in the recent years, the digital interaction has expanded to 3-D spatial surroundings including MR. From work to play, MR has its applications. MR allows users to interact with digital objects in the physical environment. MR is at the forefront of many emerging technologies and it benefits the engineering field in many ways. Students can gain access to valuable knowledge of how real-world facilities and plants work without the need to be physically present at a factory or a facility. MR system ties virtual reality with the physical world and serves as an excellent testbed for building, inspection, and renovation. (Feiner, Webster, & MacIntyre, 1999)

1.2 Uses of Mixed Reality

With the rapid development of Mixed Reality, the integration of MR into disciplinary teaching and training has emerged. Many Industries, including Automobile Industry uses MR to train employees in emergency situations. It allows the employees to have hands-on training while having an immersive VR and AR experience. This will allow high risk events to be replicated on a virtual environment which will train the employees to adapt in an consequence event while having less related injuries. MR applications can also be used for monitoring and maintaining equipment; engineers can keep sensor-based equipment that can present data of the running machine without needing to be present onsite and provide faster, more accurate diagnosis. Monitoring these units physically will require heavy loads of machinery that will cause performance lags and is costly. In addition; Mixed Reality (MR) can be used for future student learning; Since MR can imitate on-field situations and put the student right in the middle of it, it offers companies looking to arm their new student workers with the best training possible which will allow the students to engage and be prepared if a real occurrence. For instance, in the medical Industry, MR is used for surgeons to practice their surgical skills in a virtual environment. (Hamacher, Kim, Cho, Pardeshi, 2016). The Texas A&M University at Qatar had done projects related to VR and AR for petroleum students to witness the offshore oil rigs where the students were allowed to navigate and explore the offshore oil rigs. (TAMUQ Research Computing, 2016). We plan to use their knowledge of applying interactive learning tools into our MR project.

1.3 Integrating MR in Desalination

The project is mainly designed for University students who want to get an educational background about the components and process of a functional Virtual Desalination plant. By using HoloLens, users will be able to interact with a 3D desalination plant by dragging, sizing and gazing of the 3D models present in the Mixed Reality application.

The reason we chose to work on Desalination plants is because of its operation worldwide; operated over 120 countries, and the Middle East has a high concentration of desalination plants (IDA, 2013). And since most of these Industrial plants require government patent, which can be a tedious process for an Educational Institution. This process makes it hard for people to learn about water desalination plants effectively and prompts for alternative ways to learn. Our futuristic 3D desalination plant include Turbine systems and RO based filtration system. Renewable sources of energy such as solar and wind are going to be utilized to meet the suitable energy demands of the plant. The price of fossil fuels tends to be characterized by high variability, and fossil fuels pollute the environment. (Shouman, MH, & Abulnour AG, 2015). Just as how we require clean water on a daily basis for good health, our environment requires a minimal amount of pollution to provide us with the best natural resources. We will incorporate MR headsets to guide users to build the desalination facility from provided parts while the users learn fundamental concepts of filtration systems such as Reverse Osmosis (RO) process. Of the various filtration processes that presently exist, and the most impressive were RO, thermal desalination and MSF (Multi-stage flashing) methods to desalinate brackish water. (Krishna. 2004) Currently, Qatar is actively shifting more towards RO process as it has immense potential to become more efficient and environment friendly. This is the reason why we were more inclined to working with it and will use this plant type as our subject.

1.4 Objectives and Goals

The objective here is to investigate and utilize the potential of MR to improve student learning mainly in first and second-year students in the engineering field. The baseline to determine the learning assessment tool is going to compare the user performance with traditional lecture slides with the user performance under MR immersion, from the data gathered, we will analyze the learning experience and the performance of students. We will use MR headset which is the HoloLens integrated a game format to educate students about water desalination plants to achieve our objective. This headset allows us to educate the users about a desalination plant in a interactive way by making a game where the headsets will provide a simulation of a desalination plant. This simulation will indirectly help users interact and assemble a virtual, smaller and non-functional version of water desalination plant. It will also provide comprehensive information on what each component of a water desalination system does. The tasks required to reach our goal are: Reviewing available Mixed Reality technologies; Conceptualizing a MR system for a selected industrial process, i.e., water desalination plant; Selecting the evaluation criteria, baseline and design of the study; Implementing the educational tool; Deploying, assessing and analyzing the impact on understanding for freshman and sophomore students.

1.5 Project Description

The purpose of this project is to identify whether the MR tools can be used as a technique to enhance student learning. The project will allow students to have hands-on and immersive experience resembling components to give a Desalination plant. In the education field; MR techniques is new. However; in Industry, MR tools are used to provide virtual field maps before implementing the project in the physical world. This project will help to evaluate whether students will benefit from using MR tools in learning engineering concepts.

The focus of this project is to integrate student learning with the use of MR technology. Our project required 3D visualization objects which will be achieved by developing 3D models using Unity. And making them interact using Playmaker. There are two stages in our project: The development stage and the deployment stage. The development stage involves building the MR project. To develop the MR ready model of the Desalination plant in Unity and Visual Studio (Playmaker). This will be accomplished by December. The second stage; the deployment stage, will start early January. This stage of our project is to test the effectiveness of our application and the MR tool; this will be achieved by having participants group go through the traditional lecture method and the MR method to check which learning tool is beneficial. The MR will provide an environment for students to learn and help build a miniature, functional water desalination plant, and thus engage student learning. The impact of our teaching method is not to eliminate classroom learning but to provide alternative learning-solutions for students. It will also be useful in the industry-level as it allows professionals to perform certain procedures as many times as they want in a safe way to acquire the necessary skills in real world system.

CHAPTER II

METHODS

2.1 Study Design

The study was conducted to assess the effectiveness of Mixed Reality tools as a learning simulation method. Quantitative research approach was used as a technique to support the hypothesis that mixed reality is a effective learning assessment tool. The study was conducted on fellow Texas A&M University at Qatar students after receiving the institutional reviewal board (IRB) approval. The participants record was anonymous and informed consent was obtained prior the inclusion.

2.2 Sample Evaluation

Sophomore and Junior engineering students participated in this Mixed Reality training method. Each Student participant were analysed on their ability to locate and transfer virtual equipment models to complete a Virtual Desalination plant. After the task/demonstration, students completed a Questionnaire to demonstrate their learning/competence in the Basics of Virtual Desalination plant. To prepare the students for their task, a small introduction was given on the overview of the navigation of the HoloLens device. We repeated the procedure using a different learning assessment tool, the traditional teaching method; which was conducted by research team. We analysed questionnaire responses of the two learning method groups and did a compartitative analysis to determine which learning tool was effective.

2.3 Design of Virtual Model

Initially we started researching on the scope of virtual training and simulation as a learning assessment tool. We had to decide on the type of model we are going to build. We started our literature review on types of Industrial plants that can be easily replicated into a Mixed Reality environment. Based on the literature review, we decided to replicate a virtual Desalination plant. We devised a game story development plan, decided the necessary game layout and the required interactions that can simulate the user and give the in-game experience. The game layout comprises of in depth about the functionality of the desalination plant by making the user learn to solve a puzzle game. This puzzle layout game mainly involves the user shifting the desalination blocks from the inventory to the facility section using the hints and guidance given to the user. The user plays the game through the MR headset and can interact with the virtual components using hand gestures.

To bring this game into mixed reality, we will be using 3D software applications such as Unity to design the 3D desalination components and add interactions to enhance the dynamics of the gameplay. To make our plant components, we will use SolidWorks since it is user friendly and has wide functionality. Autodesk 3DS Max and online resources will also be used to add 3D versions of the components of the water desalination plant. These virtual components will be transported to unity and animations will be added to enhance the gameplay in the MR headsets. Unity 2017 will play the major role in animation and designing the game and this game will be transported to the MR headsets through Visual Studio 2017.

Other library resources included video cameras, test subjects, online sources, documents, online 3D templates for water desalination plant models. For in personal assistance, we seeked assistance with our supervisor and Computer Research Institute of TAMU-Q on calibration of the device and also coding relate) d issues.

2.4 Inventory Description

Most of the 3D models of the desalination plant components were recreated, taking inspiration from the TAMPA bay water desalination plant system (as shown in figure 1), by using 3D software tools such as SolidWorks to make the 3D water desalination components. We used this layout model because it served a good overview starting point to build the components. It gave a good outline of how the desalination plant model should be organized. An initial issue that was faced was on the position of the plant components and the process diagram of Desalination plant on TAMPA bay helped us with that process. This model is easy to understand and has descriptions attached. This is the model we aim to design in our gameplay.

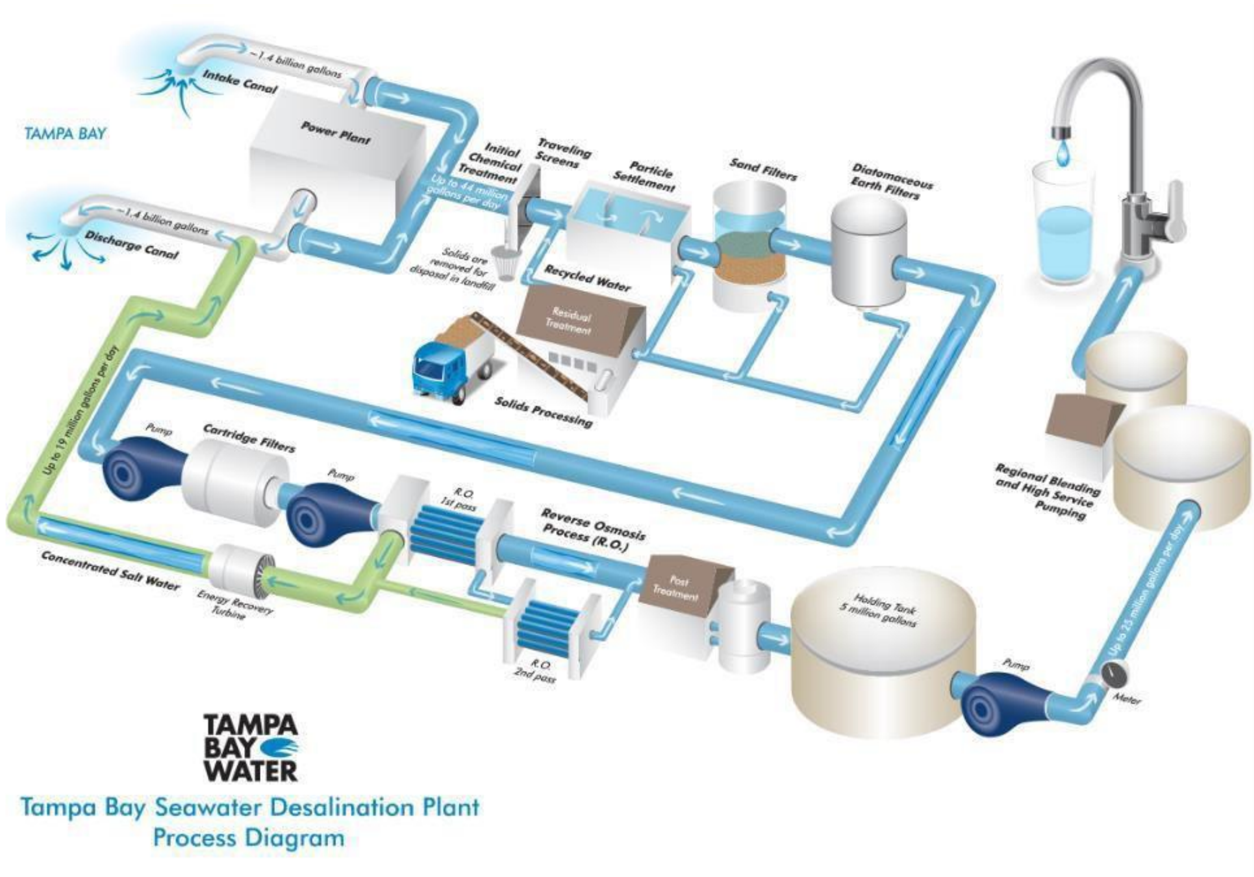


Figure 1: A water desalination plant layout: Tampa bay water

The below figures (Figures 2-11) below represent the main components of Desalination components that is used for the separation process of salts and soils from sea water. Each system of the Desalination component was recreated in 3D version as portrayed below:

1. Water intake system

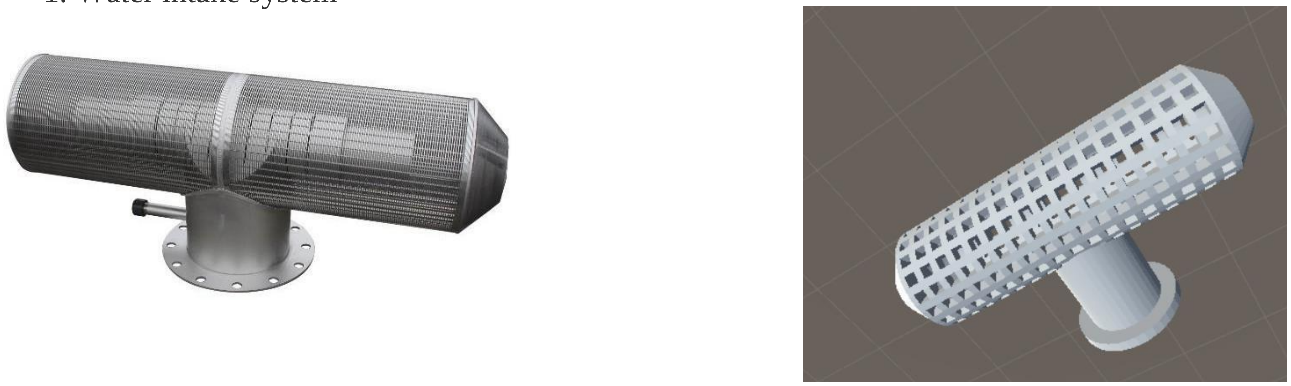


Figure 2: Water intake system (Aqseptance, 2017) presently in use in desalination plants and the recreated 3D model from SolidWorks

2. Travelling screens

Figure 3: On the left is a clear picture of a travelling screen (GoFlo, 2017) that is used to remove debris and on the right is the travelling screens recreated on SolidWorks

3. Coagulation

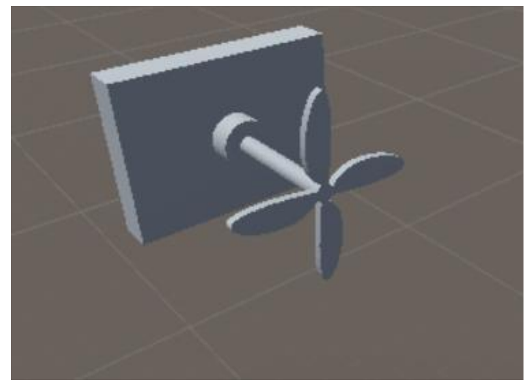


Figure 4: On the left is the process coagulates a considerable amount of dirt and causes them to settle at the bottom, and on the right is the coagulation recreated on SolidWorks

4. Disinfectant stage

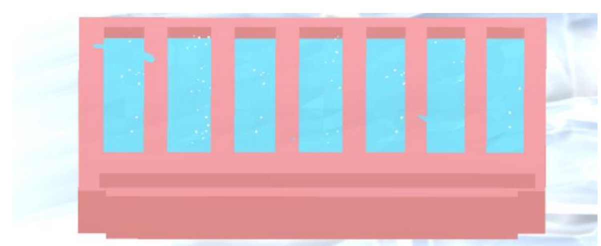


Figure 5: On the left is a disinfectant stage where the water gets disinfected, and on the right is the Disinfection recreated on SolidWorks

5. Filtration: Sand filtration

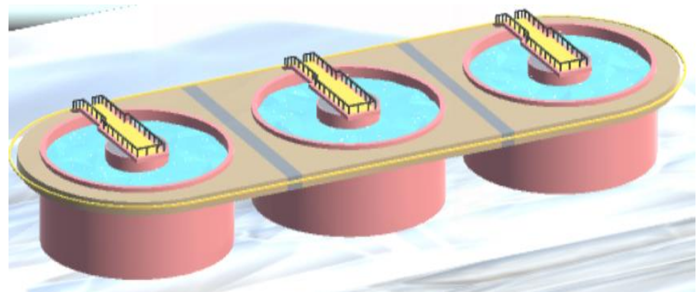
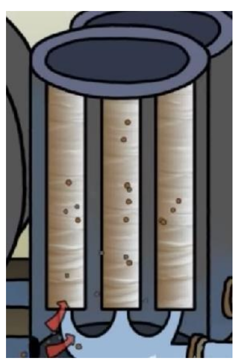


Figure 6: On the left is the Sand filtration (FEECO, 2019) in a water desalination plant, on the right is the 3D model of the sand filtration system.

6. The cartilage filters



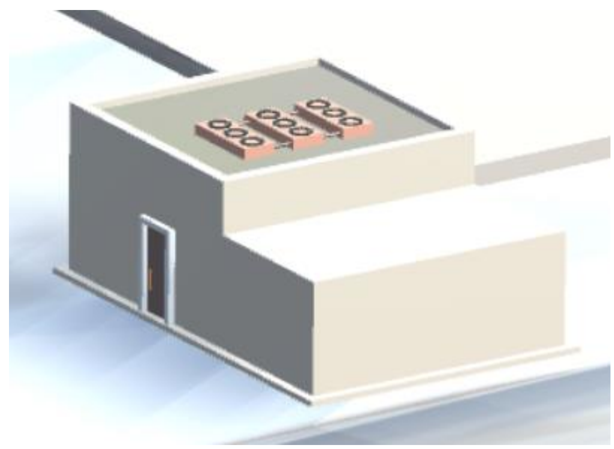


Figure 7: On the left are the cartilage filters (Dmenggco, 2017) that pulls out microscopic impurities, and on the right is a 3D Industrial building that contains the cartilage filters

7. Reverse osmosis tube

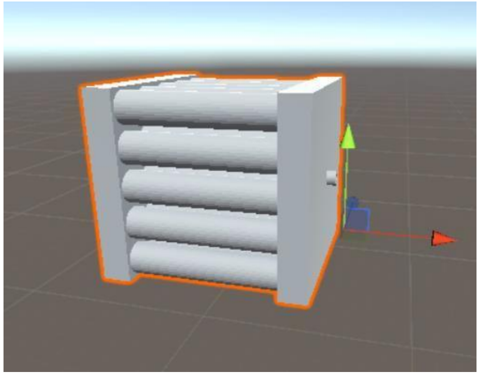
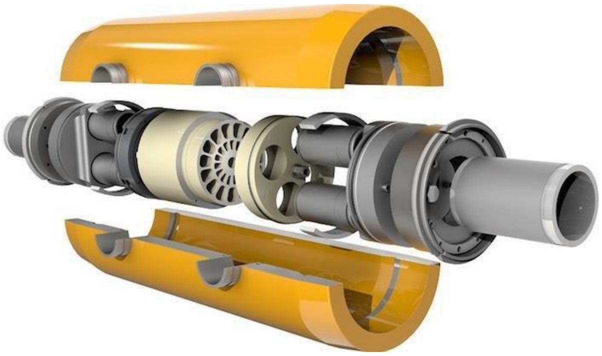


Figure 8: On the left, is the Reverse Osmosis Membrane (AMTEC, 2017) that desalinates the water using the process of reverse osmosis, and on the right is the recreated 3D model in SolidWorks

8. The energy restoration stage:



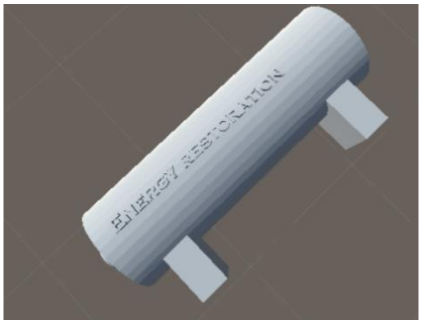


Figure 9: On the left, is a energy recycler (energy, 2019) that uses high pressure from Reverse osmosis process, and on the right is the recreated 3D model of the Energy restoration in SolidWorks

9. Pressure Pumps.

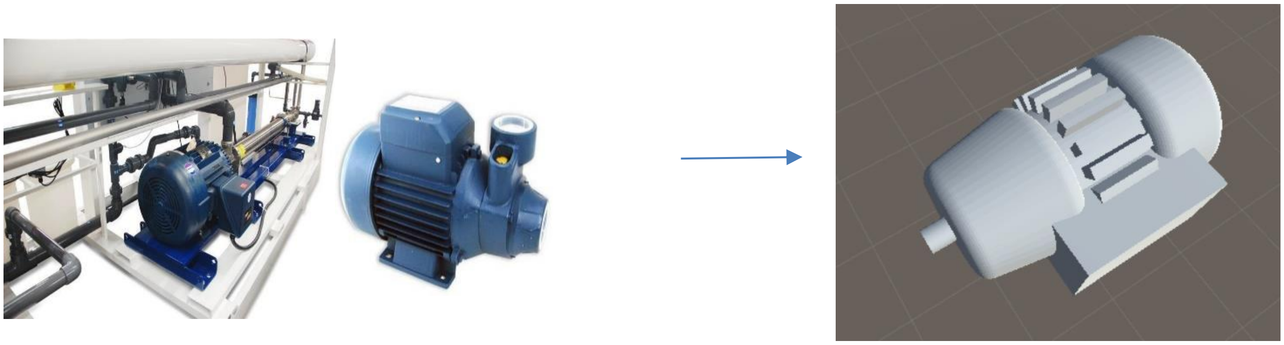


Figure 10: On the left, are the Pumps that provide the high pressure required for water flow across the plant, and on the right is the pressure pump recreated using SolidWorks

10. Remineralization process

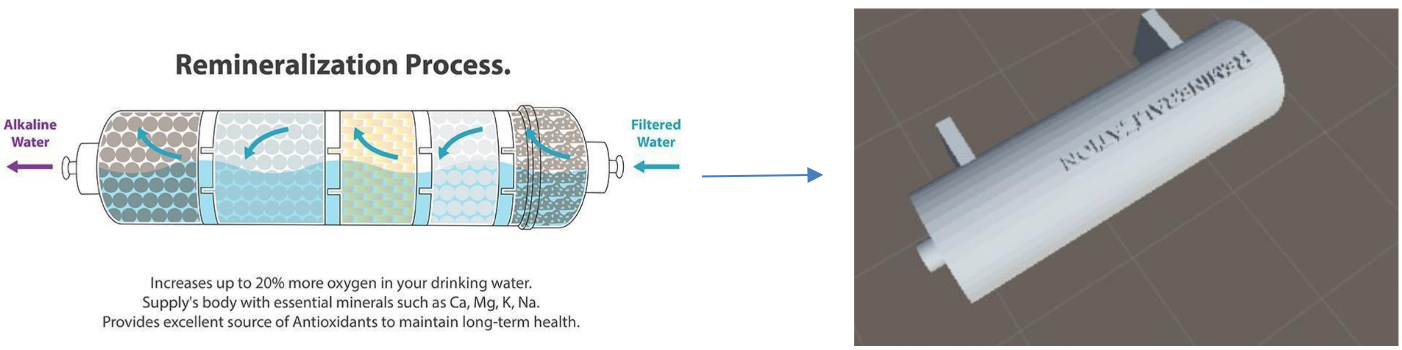


Figure 11: On the left, is the remineralization process that adds useful minerals back into the purified water, and on the right is the remineralization component recreated in SolidWorks.

11. Water storage unit

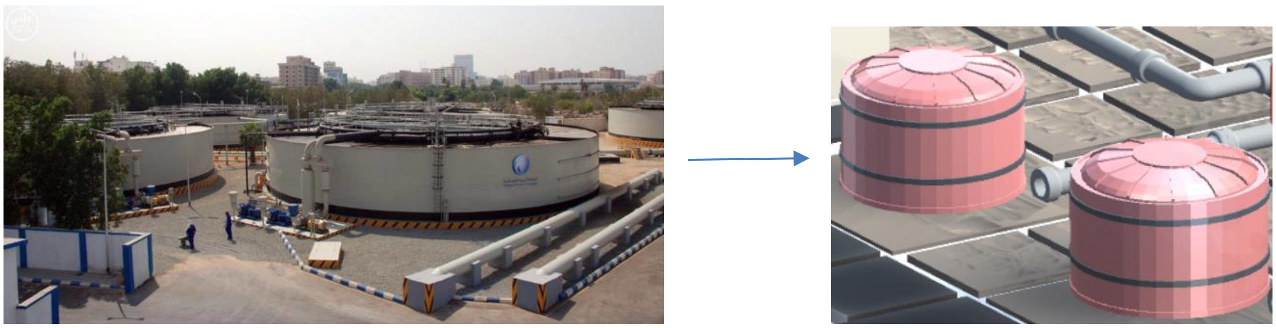


Figure 12: On the left are the storage tanks to store the purified water (SUSTG, 2018), and on the right is the 3D model of the storage tanks.

The figure 21 below, shows the main components of a desalination plant, without the detailed components and the overall buildings that was found online library CAD. Based on its simplicity; decided to use this layout as our desalination plant:

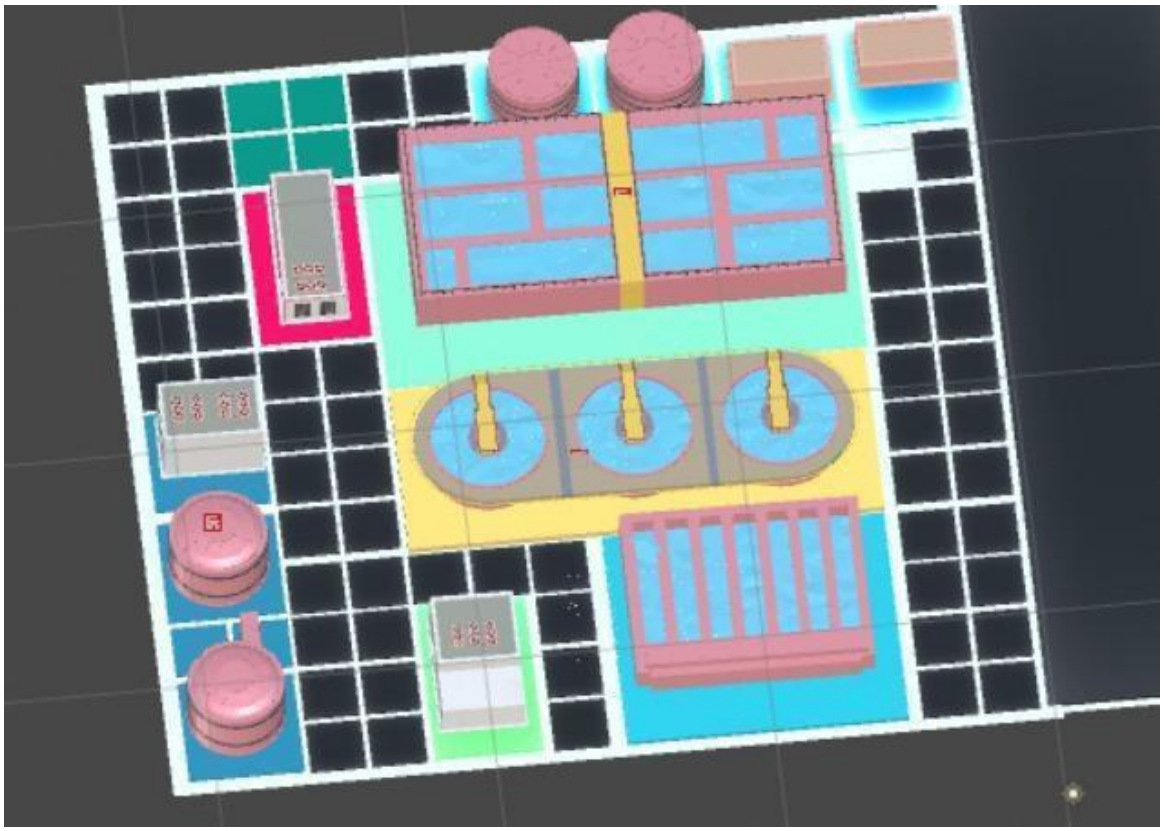


Figure 21: Desalination plant assembled

2.5 Making the Headset Application

Initially we decided to use the Tampa Bay Desalination plant as shown in figure 1 to represent our Desalination plant in our game layout. We decided to formulate the game like a virtual puzzle for the user, where the user can get a bird's eye view of the plant and can select the component and place it in the correct position according to the description attached to each component. They will have an inventory section on the right side of their view and a platform to place components on, on the right side of their view, as shown in Figure 22. Then we introduced the 3D models we made and found online into Unity 3D to make the user-MR interaction. To make the game more interactive and dynamic, we fixed the alignment, lighting, and audio systems. The environment of the game is placed on a green grassland, a cloudy day along with the sound of the birds; this was done to replicate a real-life situation. To achieve a scenic environment, we imported cloud and trees components from the asset store in Unity 2017. For the sound effects, we searched through a plethora of sounds on BBC audio database and imported the bird sound effect into Unity 2017. We placed it into the mixed reality camera component so the user can get a '3D' sound effect that can listened from anywhere around the game layout. The program primarily consists of grid systems that accept or reject the components based on whether they should be positioned there. This can be programmed through the use of playmaker software in Unity 2017. We wanted to make the game decide for itself whether the user is playing it according to the rules that the game sets. Playmaker was a good platform for achieving this since it is a visual scripting platform that can be used to add logic elements to the game without the need to write scripts of code. We also include the information on each of the water desalination components that will pop up when the user gazes at the object. Some additional animations for a moving particle representing water was made using scripts. Through these scripts certain targets were introduced (Figure 23) and the water particle followed these targets showing the path the water will take (Figure 24). The script enabled the particle to move only when user called for it.

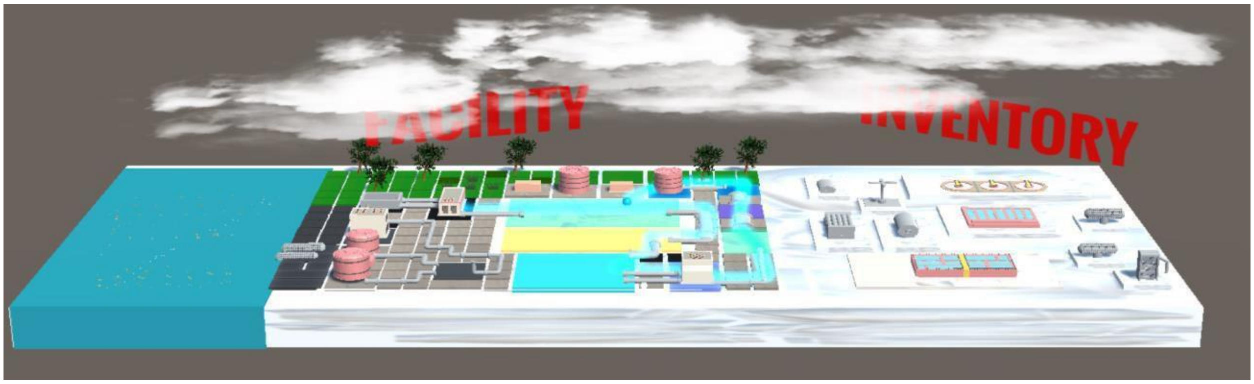


Figure 22: Desalination plant constructed with Unity software

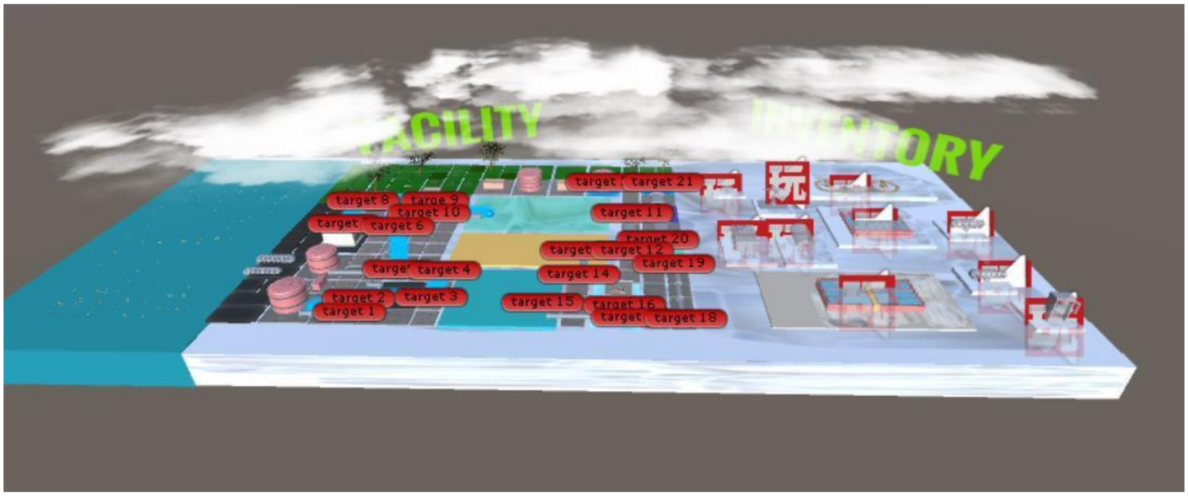


Figure 23: Targets introduced to the plant for the particle effect.

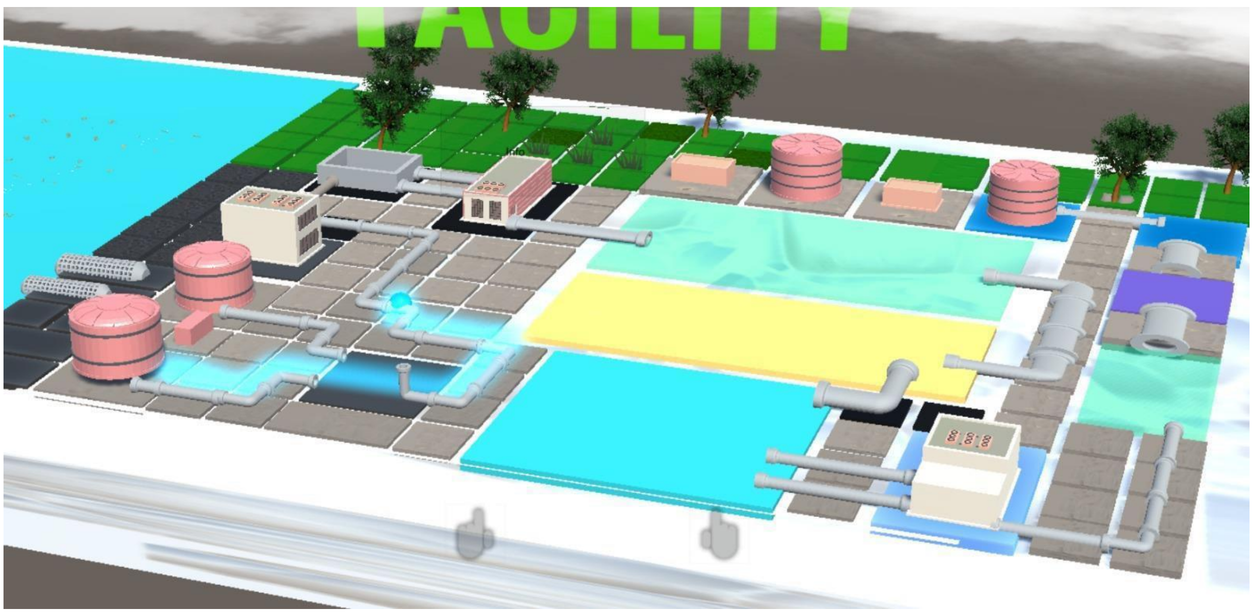


Figure 24: The water particle following the path.

2.6 Built Application on Headset

After making the application on unity, it was transferred via the building process using Visual Studio onto the HP Mixed Reality headset and the Microsoft HoloLens. There were still some issues in the placement problem and the dragging option. However, the MR gave a better experience since it provided a better view and allowed the user to be aware of his spatial surroundings, and it lagged much less than the MR headset. This phase was the debugging process that helped us to assess the 3D Desalination plant on a VR Headset and a Mixed Reality Headset. This process involved a lot of polishing; since there were technical errors when transferring from Unity to Headset. For Instance, the gaze and drag option was not calibrating on the headset. This allowed us to revisit our codes and interaction to check on the debugging errors. Table 1 provides further analysis of the pros and cons of each headset. And the imagery was better than the other headset. With the release of HoloLens 2 this will give us more opportunities to apply and refine our application to integrate with the HoloLens device.

Table 1: The major difference that accompanies each headset

		
Tasks	HoloLens	HP MR headset
Type	Mixed Reality	Virtual Reality
Ease of use	Users more aware of spatial surroundings	Users not aware of their surroundings
Compatibility	Can be used without USB connection. Portable device	Needs to be connected to PC when working

User Interactivity	Requires hand gestures to drag Desalination plant objects	Requires motion controllers

Figure 25 below gives a representation when viewed with the HoloLens device. This allows the used to be aware of his surroundings while immersed into the mixed reality environment. It was also the safer option to prevent from colliding with physical objects that would be more likely with a VR headset. Hence, this was one of the reasons the MR was the preferred headset compared to the HP Mixed Reality Headset.

Figure 25: The application with the HoloLens.

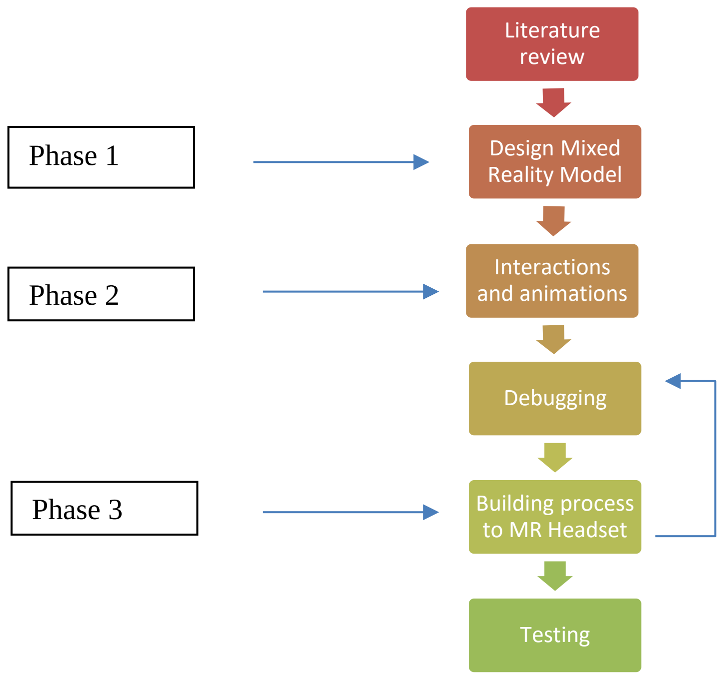


Figure 25: Flowchart representation of the storyline of the project development.

The above flowchart gives a representation of the project development to make the mixed reality application. Three phases were involved to make the final Mixed Reality application. Phase 1 was the designing phases: which was the building of the Virtual Desalination plant. Phase 2 was adding the interactivity and animations to the Desalination components; for this phase, mainly used playmaker and scripting and the third phase is the building and testing with the HoloLens device. Each of the phases contributed significantly to the making of the application.

CHAPTER III

DATA COLLECTION AND ASSESSMENT

3.1 Learning Assessment Tools

In order to test the hypothesis of Mixed Reality as a learning tool. Participants will be exposed to 2 methods of learning: Lecture and MR Game. Before and after each of the learning methods, the participants will take the quiz to demonstrate competence. In the classroom method, each of the student will take the lecture-delivery method (which give a lecture standard format over the basics of the process of a water desalination processes) together in a University classroom. The second learning method; MR headset teaching method will have the participants come at different time slots to assemble a miniature non-functioning water desalination plant components. As they use the equipment, they will be recorded and the HoloLens system and an external video camera. This recording will be used to deduce their hand gestures to test effectiveness of MR learning and to develop methods to improve MR learning experience. After this procedure, the participant will be given the same quiz and have a questionnaire that that asks them about their experience. After the results from the testing have been recorded. We will use it to deduce how much this tool had helped people learn by comparing the quiz before and after the teaching. We will also deduce whether or not the participants could even completely assemble the plant, What is the best approach to use this tool in a classroom, and how much did the participants think they had learned and whether or not they had enjoyed the experience.

3.2 Participant Interaction

To apply our learning assessment tool, study group will focus on TAMU-Q freshman and sophomore students, observe their interactions via video cameras and asses learning development. After receiving consent from participants, the focus group will be split into two batches and will be followed as shown below.

Batch 1 participants

1. The participant will be briefed about what the project entails including some instructions.
2. The participant will take the quiz concerning water desalination plants
3. Then the participant will be made to sit in a classroom format to understand the desalination process.
4. The same quiz will be taken again.
5. On another day, the student experiences our Mixed Reality application and gets a brief instruction on how to use it by us and through the MR headset itself.
6. The mixed reality application will contain the components of the desalination plant. It is a game-like format where the user's task is to make a desalination plant from scratch. The MR headset and other digital cameras will record the time and the interactions each student takes to build the virtual desalination plant.
7. The student should be able to interact and place the 3D components in different 3D spatial surroundings to make a desalination plant.
8. The MR headset application will give the participant a general description of each component before they place it. Hints will be given to the student by the research team if the user takes too long.
9. When the student builds the virtual desalination plant. The desalination plant will be put

into test. If pure water comes out the other end, the user is successful in building the virtual desalination plant.

10. The same quiz will be taken by them again but this time an interview will be taken about their experience will be included.

Batch 2 participants

1. The participant will be briefed about what the project entails, with other instructions.
2. The participant will take the quiz concerning water desalination plants.
3. Then the student experiences our Mixed Reality application and gets a brief instruction on how to use it by us and through the MR headset itself.
4. The mixed reality application will contain the components of the desalination plant. It is a game-like format where the user's task is to make a desalination plant from scratch. The MR headset and other digital cameras will record the time and the interactions each student takes to build the virtual desalination plant.
5. The student should be able to interact and place the 3D components in different 3D spatial surroundings to make a desalination plant.
6. The MR headset application will give the participant a general description of each component before they place it. Hints will be given to the student by the research team if the user takes too long.
7. When the student build the virtual desalination plant. The desalination plant will be put into test. If pure water comes out the other end, the user is successful in building the virtual desalination plant.
8. The same quiz will be taken again.

9. Then the participant will be made to sit in a classroom format to understand the desalination process.
10. The same quiz will be taken by them again but this time an interview will be taken about their experience will be included.
11. From the data we will be able to check if our teaching method is effective

3.3 Data Collection

When participant is using MR headset, we will track the user interaction and activity using video cameras while being present in the room. Use of Quantitative and Qualitative data assessment approach on the focus groups. The process involves; Quiz Pre, Immersive Headset Activity, Quiz Post. Based on the responses we will be able to evaluate on the effectiveness of the role of Mixed Reality on Education and learning development.

3.4 Quiz

Based on the literature review, enough information was obtained to develop standard Quiz based questions on water desalination plants, and a brief questionnaire that will be filled by the user relating the user experience of the MR headset. This process was done early to countereffect the long IRB approval process in order to ensure it will be ready for the testing phase in the Research timeline.

The quiz shown below in Table 2 will be shown to the participants at various stages of their testing phase in order to develop the learning growth and analyze each type of learning. The quiz includes the questions related to a water desalination plant. Before the MR gameplay, we will present the quiz to test if the users have knowledge of the concept. After the MR gameplay, the quiz and questionnaire will be provided to check whether this interactive method using MR headset will provide students an effective way to learn about water desalination plants, processes, and components. We will give a quiz to test if the students have knowledge of the relevant concept inventories. Both this and the questionnaire will allow us to analyze and assess the student's experience compared to a traditional lecture and compare the best of the 4 versions.

Table 2. The format of the quiz

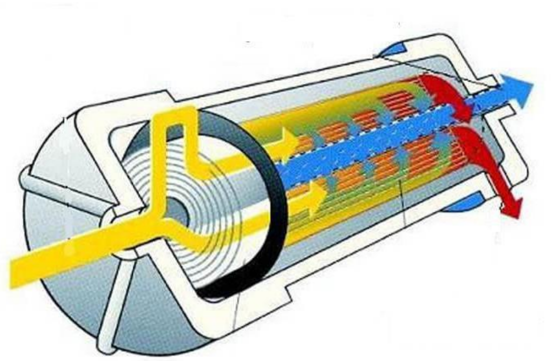
(please read carefully the instructions)

PRE or POST
ID…………….

Analysis, creative, where can we use reusable source of energy

Question/Statement
1. What is the purpose of doing the process of water desalination?
2. Where in the sea should sea water be taken from?
3. What does a travelling screen do in this process?

4. What is the purpose of reverse osmosis in a water desalination process?
5. Why do we give the water a pre-treatment before the reverse osmosis stage? Explain these stages.
6. After purifying the water, what is the last step required for it to be useable?
7. What is done to the leftover salty/waste water after the pure water is extracted?
8. Which step requires a lot of pressure, and why do we need to use it?
9. What precautions are taken to protect the ecosystem from the desalination process and vice versa?
10. List the basic steps below required to do the process?

11. Name the component and explain in what form the reverse osmosis takes place in this picture. 
12. Where can we add renewable sources of energy in the process.

3.5 Questionnaire

The Table 3 displays the questionnaire that the students will be given to get a gist of their experience.

Table 3. The Questionnaire

MAJOR……………………..ID…………………

Question/Statement
Do you find it easier to use a MR after this experience?

Do you think this AR tool facilitates learning about engineering concepts and systems when combined with traditional lectures? How?
When do you think using MR tool is better? Before or after?
Do you think you have learned and understood the concepts from this experience?
How does this AR software compare with other learning tools you have used, such as flash applications and 3D learning software, for which you use a mouse to interact with the computer? In what areas do you think AR is better than those tools?

3.6 Results and Discussion

Table 4 gives a representation of the performance analysis of the user in three different stages during the testing phase: Pre and post lecture and post MR application. Quiz 1 was taken before the subject had gotten a lecture and quiz 2 was taken right after. Quiz 3 was taken right after MR application.

Table 4. User Performance

User	Quiz 1	Quiz 2	Quiz 3
User 1	3.25	8	9
User 2	2.5	8.5	9

Table 5 shows the performance of the user 3 in three different stages. This subject was tested similar to the first two participants but used the MR application before the lecture-delivery method.

Table 5. Performance of user 3

User	Quiz 1	Quiz 2	Quiz 3
User 3	2	2.25	7.5

The questionnaire revealed that the two participant who took the lecture before using the MR were satisfied with their experience. After using the device in this research, they found themselves familiar with using the device and were inclined to thinking that the device facilitates learning. While the subject who used the MR before the lecture found it that they had a harder time to navigate using the MR application. Most of the participants believed the device would be better to use after the lecture. They all thought that it didn’t add to their learning experience as the app wasn’t developed enough.

Another opinion that they had was that the device could be used effectively only if the subject had prior experience with the device. Initial basic HoloLens training was provided using recorded video to demonstrate hand gestures and gaze features in order to navigate through the Mixed Reality gameplay. Each of the participant believed there was a learning curve and was a different experience compared to the traditional lecture method. The average time each participant to complete the objective in the MR gameplay was 25-30 minutes. Which is considerable based on their novel experience on the HoloLens device.

The subjects who took the lecture first came up with many uses on how the device could be used to help learn their major courses, while the MR first subject was apprehensive. The users believed the disadvantage of the MR is that it is time consuming, prior training is required and is expensive. They also pointed defects in the MR application and gave suggestions to improve the application. They recommended to update the application in order to prevent lagging, framing, gaze and improve component descriptions to enhance the gameplay experience.

Applying MR to the users traditional lecture method proved to be a challenging step for users. We noticed a learning curve during the testing stage of the project. The MR has a set of rules that needs to be followed in order for user to have a good learning outcome. There are some gestures that a user needs to perform such as an ‘Air Tap’ and ‘Bloom’. Users weren’t familiar with these gestures. In addition, users had to use gaze gestures and sometimes they couldn’t gaze properly at the object. Not having any lecture or experience with MR prior to using the MR app made the subject less confident with their knowledge and less satisfied with their experience.

We aim to refine the app because even though it was for us developers to use the MR, we made the wrong assumption that users will be able to grasp this idea. We initially recorded ourselves doing these gestures; however, users were still not able to apply these concepts that quickly. So we decided to make our MR game based on ‘levels’, where students first learn how to drag an object first from one place to another. After that level, student can then learn to gaze at an object and drag it to another position. The problem we encountered was that we sort of plunged the users into the main game itself and they literally had no information or cues to play the game smoothly. In the future, we aim to introduce mini tutorial-based levels that students should play to proceed to the next level.

Finally, we realized to avoid using MR before the lecture. This realization is due to many reasons: Firstly, it did not improve the users' imaginative skills because only one person solved the last question in the quiz correctly by the end of the testing session. Secondly, users could not figure out and were struggling with the controls of the MR and since they couldn't complete the game, they weren't satisfied with this method of teaching. Finally, the users were still anamateur when it came to using MR and the app was lagging that hindered their overall learning experience and imaginative skills. We still believe the game needs some refinements and does have the potential to be a game changer in the educational sector.

CHAPTER IV

CONCLUSION

The MR research project gave a good insight about the impact of using augmented/virtual reality device to enhance user's learning experience. It allowed to us to identify the niche in the Middle Eastern market pertaining to usage of these devices in the educational sector. Our team started off with this idea to make it easier for students to learn a technical content in an immersive, visual environment. We started off with literature research, learnt about various software used in making the MR game, and implemented many animations to bring the game to life. It was an amazing learning experience for us and our team surely benefitted from learning about the basics of gaming and learning from the perspective of the user's experience. Although our testing phase did not go as planned, we did receive a lot of good feedback and included some changes into our game. This includes implementing mini tutorials within the game and getting user familiar with the device. In addition, using the MR headset involved some serious performance and latency issues that we couldn't resolve and was something inherent in the device. We aim to resolve these issues into the future and hopefully introduce this as a potential device in the educational sector.

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