IMPROVING UNDERWATER WELDING SAFETY WITH VIRTUAL REALITY

THE PUBLIC'S PERCEPTION OF VR AND WHERE IT GOES FROM HERE

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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: Joshua Garrison Date:August 10, 2022

As technology has advanced, our society has started to switch more from the traditional video and text education that we have used the last several generations to a more interactive training, and in the case of some extreme or dangerous working environments such as health care or military even shifted to virtual reality training. Transitioning into these new forms of education transforms how people are trained, and by training in the most accurate virtual reality environments our society will be able to make actual work environments safer, and transitions into those environments easier (Blazauskas & Gudoniene, 2020, p. 82). Although the motive for fully trained and experienced health care employees or soldiers may be obvious, the field of underwater welding could also be improved with the use of virtual reality training simulators. Underwater diving can be very dangerous and the infrastructure that this occupation provides to all of society makes it an issue that everyone should all care about. The Underwater Construction Corporation (2022) illustrates in Figure 1, how "fifty years of harsh marine environmental impact required the rehabilitation of the bridge pier steel casings" exemplifying to the audience just one piece of infrastructure that almost all of us have used that needs to be maintained by underwater welding (*Marine Infrastructure Upgrades – Mid–Atlantic Region, USA*, para.1).

Figure 1: Restored Bridges. The top image illustrates the destructive effects of marine environment, and the bottom image depicts the restored deteriorated concrete with carbon fiber fabric (Adapted by Joshua Garrison (2022) from Underwater Construction Corporation 2022).

With all the infrastructure that exists underwater inclined to extra environmental degradation, it is easy to see why society needs underwater welders, so the only question that remains is why there needs to be a shift to virtual training in this field. Respected organization such as the Occupational Safety and Health Administration (OSHA) have stated that underwater welders experience high rates of tragedy with the chance of an accident occurring in the field being over 10% (Drtinova, 2022). A report from United States Department of Labor states "commercial divers are exposed not only to the possibility of drowning but also to a variety of occupational safety and health hazards such as respiratory and circulatory risks, hypothermia, low visibility, and physical injury from the operation of heavy equipment under water" demonstrating some of the risks that make the occupation so dangerous (Commercial Diving: Hazards and Solutions).

The need for underwater infrastructure and the dangers that the occupation comprises illustrates the need for these VR environments in this field to make actual work environments safer. The technical project and accompanied STS research projected in this prospectus addresses this issue, as well as the push for society to embrace virtual reality. NextGYN (2022) establishes the mixed perception our society has with virtual reality, with half of the population believing it to be "an over-hyped craze that might one day produce some cool video games" and the other half believing "it's a phenomenon that will one day alter our everyday lives" (*Societal Impact of Virtual Reality: Positives & Negatives*, para. 1). The loosely coupled STS research project will explore these social views and try to determine why public opinion is so split on the issue, and explore evidence about using VR in certain training fields such as medical. The focus here will be to see what advantages society receives from using VR to train our health care professionals,

if patients actually want to be operated or seen by new doctors and nurses who have done a large part of their training over VR instead of in the field as we are used to, and if there are real drawbacks to using VR training in these fields.

IMPROVING UNDERWATER WELDING SAFETY WITH VIRTUAL REALITY

Under the instruction of Electrical and Computer Engineering Professor Harry Powell, with additional help from Panagiotis Apostolellis, an Assistant Professor in CS and the previous UX Design Analyst at TLOS, I will examine the construction of virtual environments and how to adjust these environments to create safe, immersive, and accurate simulations that properly encapsulate the dangers that the occupation entails. As seen in Figure 2, with virtual reality design it is imperative to implement a design that focuses on four different aspects: believability, which is achieved by using the appropriate features such as images and sound that completely envelops the user in the 3D environment, interactivity, which involves making an intuitive design that would allow users to user tools and machines that they would in the actual environment, exportability, enabling users to move around freely and discover the environment, and level of immersion which is achieved by combining all of the above together in a way that really inserts the user in the experience (Interaction Design Foundation, 2022). In order to construct an environment that allows users to be fully immersed, we would have to focus on the audio-video headset that would allow us to

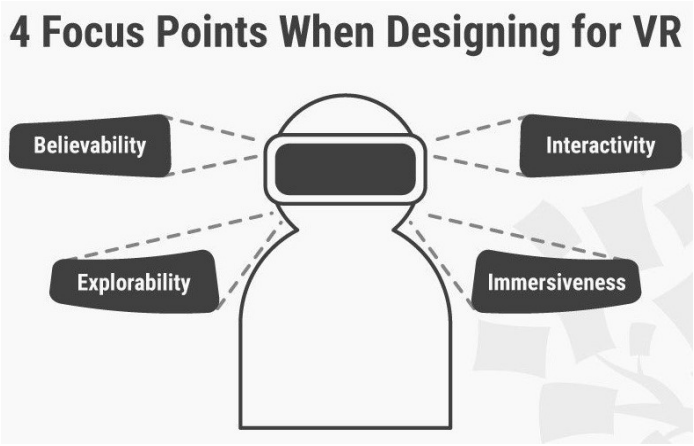


Figure 2: Virtual Reality Focus Points. Image showing the four different aspects of virtual reality (Interaction Design Foundation, 2022).

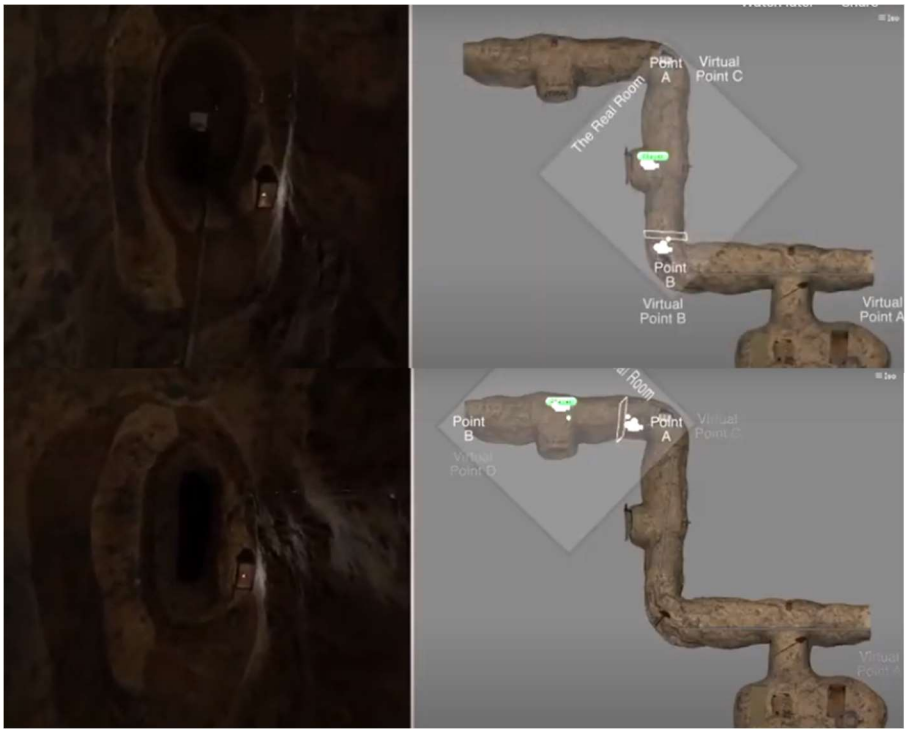
create the environment while simultaneously tricking the users mind to believe that they are in water and have their movements and actions reflected in that.

According to Water Welders (2022) a commercial diver uses six main tools: a diving helmet, underwater welding accessories, a diving suit, electrodes for sealing, a stinger, and a power supply (Dekker, para. 2). Although all of these pieces of equipment would need to be focused on to achieve a truly accurate and immersive environment for the user, that would go beyond the scope of a project this size, so the main focus would be designing a way to incorporate the virtual reality headsets audio and video features into a diving helmet, with heavy emphasis on software that would allow the helmet to simulate not only audio video features but also safely simulate, head movement underwater, low oxygen levels, and other possible hazards. Stephan Schutze and Anna Irwin-Shutze (2018) bring up an important note that in order to create the proper level of immersion "a VR headset should cover the eyes and prevent light from the real world from entering" and that "using closed-back headphones that completely cover the ears is the best way to isolate the audience from the world" (p. 83). By using a diving helmet, it will be easy to address both of these concerns and simultaneously create a more realistic feel for the user.

SETTING UP THE EXPERIMENT

Based on the initial goals of this experiment, the most important step is to identify how to use software in these simulations to trick the brain into believing that it is experiencing things such as tunnel vision when oxygen is low. To accomplish this goal, we will first look at research done by Doug Bowman, a professor of computer science and the director of the Center for Human-Computer Interaction at Virginia Tech who has led many research projects exploring virtual reality (3D Interaction Group, 2020). The navigational research done by Doug Bowman's

team (2018), truly highlights how software can be used in the virtual world to trick the brain when demonstrating users believing that they human have completed 90 degree turns while the user's actual body has turned almost 180 degrees can be seen in Figure 3 (3D Interaction Group). Using the same tricks in Bowman's research, this project aims to trick users into experiencing certain effects that they would in the field, such as utilizing software to make the graphics go up and down to imitate the effect of being underwater, and start to imitate real world effects like low peripheral vision accustomed to blacking out due to low oxygen.



Of course, this is just the environment of the simulation, it is also important to use embedded systems to make this simulation interactive. This project will require building a user monitoring system for receiving input from the user. "User monitoring is the real-time monitoring of the participant's actions in a VR experience" (Sherman, W, 2002, chap. 3, para. 5). The version of the simulation will use mostly spoken commands to receive user input as well as some commands on the keyboard to progress the simulation along that will be input by a third party after receiving verbal input from the user. This system is one of the easiest to implement while still being able to test that the user is reacting like they should.

This project will be documented in a technical report. The expected product resulting from this technical report is a VR headset implemented inside of a diving helmet with simple underwater simulations where users can train to identify certain things underwater, and appropriately react to these events.

THE PUBLIC'S PERCEPTION OF VR AND WHERE IT GOES FROM HERE

There is strong speculation around virtual reality ever being super popular in American society. Virtual reality has been around for quite a while and talk of virtual reality becoming revolutionary and sweeping through the nation has been around for a few decades, and yet thirty years have passed and even though virtual reality has become more popular than before it is still far from being a household item (Edwards, 2018). As shown in Figure 4, in 2018 there seemed to be a resurgence in VR technology as big tech companies invested in virtual environments but by 2020 those investments had fallen by almost 70% (Metinko, 2022).

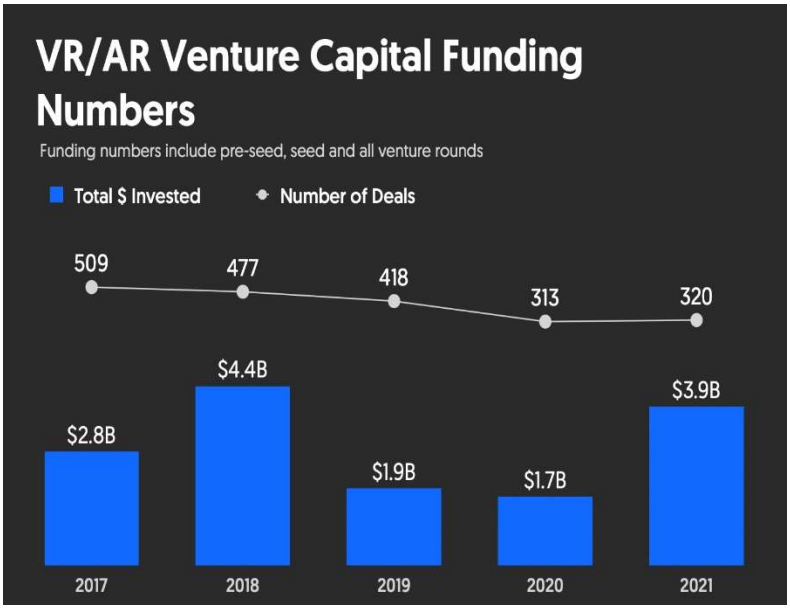


Figure 4: The rising and falling of investments in VR technology. An image showing the rise and fall of investments into VR startups. (Metinko, 2019).

Some of the struggles that have kept virtual reality from taking off include the lack of content, VR headset prices, and the time commitment to get truly involved and immersed into these virtual worlds (Metinko, 2022). With the pace our society expects us to move at it is hard to justify the time to go into a new world and explore it when it seems like we all have so much to

do in our own lives. With this evidence it does not seem like the world is ready to embrace VR technology, but that is not the entire story.

Blazauskas & Gudoniene (2020) discuss how education in training programs in schools and occupations using VR have become more popular over the years, as technology has become a little cheaper and the products have become more accessible (pp82-85). Although VR has not caught on commercially it is continuing to gain traction for training and education purposes by corporations and public services. *News India Times* (2021) even highlights how VR is being used in diversity training to let users "get as close as you can to experiencing the perspective of someone else" (p.18).

The biggest area of this expansion is the health care field, with VR being used to teach students various scenarios appropriate bed side manner, provider trauma care, and in some cases even some levels of surgery (Bowditch & Williams, 2021). Although this shift may be seen as a positive for the corporation and can be seen in some ways as a positive for the medical students, the question has to be asked if this is a positive for the patients, and is this something that patients want. Many patients want the best care there is to offer and would want those operating on them to have real world experience and expertise. A study done by department of Trauma & Orthopaedic Surgery conducted by experts Vaghela, Trockles, Lee, & Akhtar (2022) found when running a study to see if the VR FAST program could discriminate the differences between novice, intermediate, and expert surgeons that "six of eight VR FAST modules did not demonstrate construct validity" and when using them they "found no correlation between anthroscopic experience and ambidextrous performance" (para. 5). Although this test showed the VR FAST modules are ready to be used to test and train students it does bring some validity to

the argument that skeptics wonder if VR is really advanced enough to train surgeons on such a level of experience and precision for them to feel comfortable with real operations.

HOW THE RESEARCH WILL BE APPROACHED

The objective of this research will be achieved by studying the research that is done when testing VR training in these fields, and interview hospital staff to see how comfortable they are with the practice and if they think that it prepares them for the actual field. With instruction and permission from the IRB individual, and maybe patient interviews will be used to gather their thoughts on being treated by professionals who have had mostly VR exposure and what it would take for them to feel comfortable with those professionals. To best demonstrate this data, a Social Construction Of Technology (SCOT) framework will be used, a framework originally authored and illustrated by Trevor Pinch and Wiebe Bijker (Bijker & Pinch, 1984). As seen in Figure 5, the SCOT frameworks place the engineer in the center with all of the individual different represented groups on the outside. In my research model the engineer will need to take the role of receiving and exchanging

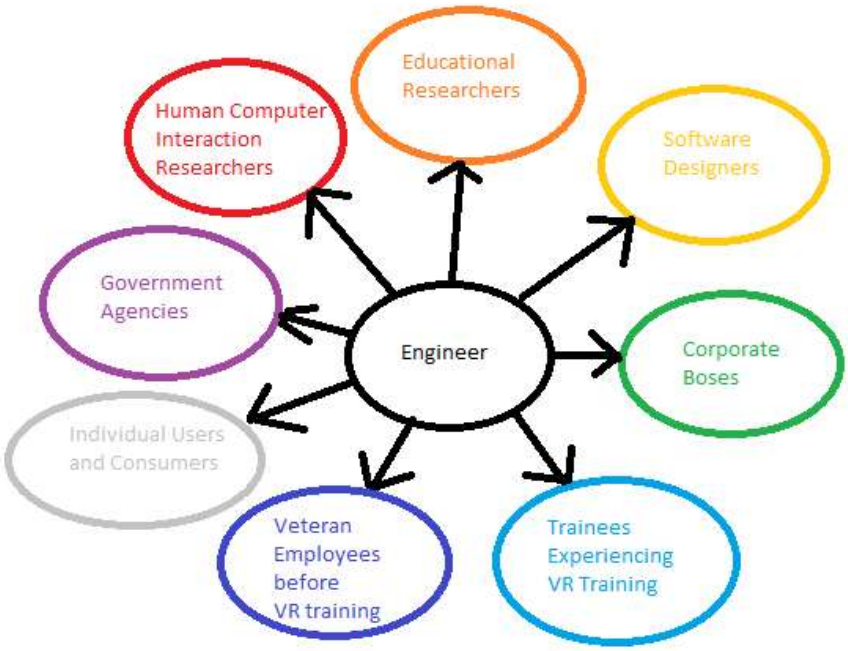


Figure 5: Virtual Reality SCOT model. The engineer negotiates between each social group to correctly incorporate and encapsule each group's values and goals in the design. (Adapted by Joshua Garrison (2022) from Carlson, 2009)

information between groups to best construct a design that works for all groups by addressing each groups concerns and making sure that the final product is able to reflect each groups expectations, and needs. This will allow for the creation of stable VR testing models that will be profitable and accessible to the corporations, useful and helpful for the staff, while being safe and trusted by the patient and other individual users.

This STS research project will be a scholarly article outlining the multiple relationships involved with using VR training in the medical field. Since this method of training is getting more popular, this research focuses on identifying these groups and establishing their concerns and goals, so that a proper and well trusted way to implement VR training where each social group comes out trusting the process and benefiting can be constructed. If it is possible to find a solution that works for all of these groups, then some level of VR can continue to grow in these situations and training and care improve across the board.

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