Integrating Virtual Reality (VR) into the Classroom Experience

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Abstract

This project was developed to test the potential of integrating Virtual Reality (VR) into the introductory classroom experience. Integrating VR into the classroom will allow material learned in in-person training to be reviewed through practice, and would increase the number of available machines for student teams to use in the department machine shop. A storyboard was created that reflected the progression of challenges that would showcase common practice in the machine shop. A model of a Bridgeport Mill was uploaded to Unity and split into the main components, including the table feed handwheels for all three axes and the gear shift lever. The series of challenges were programmed within Unity, allowing user interaction with the Bridgeport Mill at each step. With each challenge, the user is prompted to do a task and given information as they make decisions. Due to extenuating circumstances, the project was not fully completed, nor did it reach a point of initial testing and feedback. This project will hopefully be continued in the future and be tested in an introductory Design and Manufacturing I class (MECHENG 250).

Background

Modern VR headset and goggles have ancestors that can be traced back to the technology of the panoramic picture. The introduction of the Headsight in 1961 kickstarted a boom of headset technology that could completely immerse the user in another world. By 1969, these headsets could be connected to computer programs that allowed the user to interact with the game around them. This technology was still too expensive for the general public, but research swiftly began using the technology to drive simulators that trained pilots and astronauts. In 1993, SEGA released a VR headset prototype that was intended for large-scale consumer distribution, but this headset never made it past the validation stage of design. Companies continued to develop games that incorporated VR headsets until 2012 when the Oculus Kickstarter showcased a new step in the modern VR gaming industry[1]. After the Oculus Kickstarter because wildly successful, games were developed specifically for the immersive environment delivered by the headsets. Eventually, developers began to innovate new ways to use the immersive experience, developing architecture and art programs that deliver a 3D canvas for creative expression. Now, VR is used

for many forms of entertainment, from gaming to traveling to creating. Most recently, the idea that VR can be used within education has swept across discussion boards as a new way to bring the material to life in the classroom.

The concept of integrating VR into coursework at the University of Michigan has been tested prior to this project, with the School of Nursing integrating VR into some of their courses as nursing simulators[2]. Since 2018, many different colleges at the university are looking into how Extended Reality (XR), which is comprised of VR and Augmented Reality (AR), can be used in the classroom, but these plans are still in early development[3]. The Mechanical Engineering Department in the College of Engineering includes several courses within the core curriculum that focus on topics that can benefit from the integration of XR, such as the Design and Manufacturing course series (MECHENG 250/350/450) and the Laboratory course series (MECHENG 395/495). For this project, the Design and Manufacturing I course, MECHENG 250, was selected as the ideal test course because it is the course in which students are introduced to the most material.

MECHENG 250 provides an overall introduction to how design and manufacturing work together and the best practices for producing a newly designed product. As part of the course, students complete some training in order to use several tools that reside in the machine shop and design lab in George G. Brown Laboratory (GGB). The tools covered in the machine shop training include the Bridgeport Mill, lathe, band saws, and drill press, and the training for the design lab covers safety procedures and good storage practices. Machine shop training is delivered in two parts: an oral walkthrough of the machine shop and a small project that requires the Bridgeport Mill and lathe. During the Fall 2020 academic semester, this training was converted into detailed documentation about each tool in the machine shop and the project was removed.

Upon analyzing the course structure of MECHENG 250, it was determined that several elements of the course included safety instructions and procedures. The list of safety procedures was sorted into two large situations of working in the class design lab and working in the machine shop. For each situation, an ideal XR experience was selected and an experience walkthrough was discussed. The two XR experiences covered safety and procedures for the main workspaces that students would use during the semester, but developing both of these experiences simultaneously would be a very complicated process that would require more time and team members. Due to the timeline, the use of the tools in the machine shop was selected as the priority project, as the proposed experience was more concrete and could be used in a greater capacity throughout the Mechanical Engineering design courses. To simplify the selection even further, it was decided that the first tool to be developed in a VR space would be the Bridgeport Mill since it is the most intimidating tool in the shop that students directly work with. The

machine shop experience was determined to be a VR experience due to the dangerous conditions of overlaying AR with the physical tool in the machine shop. Working on recreating a machine shop experience for students also held personal significance since my own machine shop training was not as seamless as I had anticipated. In high school, I worked in a machine shop, routinely using a mill and lathe for four years before entering college. The year-long break of my first year in college caused me to forget a lot about using the tools, and I became incredibly anxious about getting things right when the oral training ended and the machine shop was available for students to use. This personal experience provided additional motivation to develop a product that could serve students who face similar challenges with anxiety and nervousness over using the tools in the machine shop.

The user experience was a top priority because this product could be used as a supplemental training tool for new students. The VR experience would be used in conjunction with the oral training that is received in the early weeks of the semester. The option of practicing on a virtual machine will provide a resource for students who may be anxious about using large machines or students who feel that a little extra practice would be useful before engaging with the physical tool. In a study done by a Clemson University group in 2015, it was shown that VR training simulations increase cognitive function and psychomotor skills[4], indicating that this additional VR resource could assist students that struggle with anxiety in the machine shop and provide an opportunity for students to practice tool movements in a space that is not tied to a physical location with business hours and a limited number of machines. Providing a virtual machine would also give students the freedom to make mistakes, even going so far as to break the machine, without damaging expensive equipment or placing themselves and their peers in danger. Furthermore, the VR experience could be used as a refresher course for returning students (i.e. students enrolled in MECHENG 350/450) that would like to review basic knowledge before working in the machine shop.

Developing the Experience

As a baseline, the project needed to provide students with the same information that they would already receive as part of the course and machine shop training. This would ensure that the information received as part of the course would not differ with a student's decision to use the VR experience or not. In order to provide the same information, the Bridgeport Mill model within the VR experience needed to be visually similar to the physical Bridgeport Mill in the machine shop, including any visual assistance that had been attached to the tool after installation. The VR experience also needed to follow the same procedures that are followed in the physical machine shop, from general tool safety to shop-specific requests. In an effort to focus on the main procedures that most students would work through, the machine shop staff were asked to provide a list of critical components on the Bridgeport Mill that are called out during the oral

walkthrough portion of the machine shop training. These critical components would need to appear within the VR experience for students to familiarize themselves with the tool in the desired capacity. There were several ideas for how best to deliver important information about the critical components and procedures to students within the VR experience, and it was ultimately decided that a series of "quests" or "challenges" would serve as stepping stones for students to learn major tool movements while interacting with the critical components. This challenge setup resembled video games that follow a longer story arc with small individual quests, and the goal would be to have these VR challenges bring the student to a "boss" challenge that combined all the information they had learned from the smaller challenges. For each of the challenges, the challenge function was displayed in a storyboard that highlighted the user interactions with the VR space and the Bridgeport Mill model as well as the associated responses within the VR space. The storyboard also allowed the planned experience to be viewed from the user's perspective, as shown below in Figure 1.
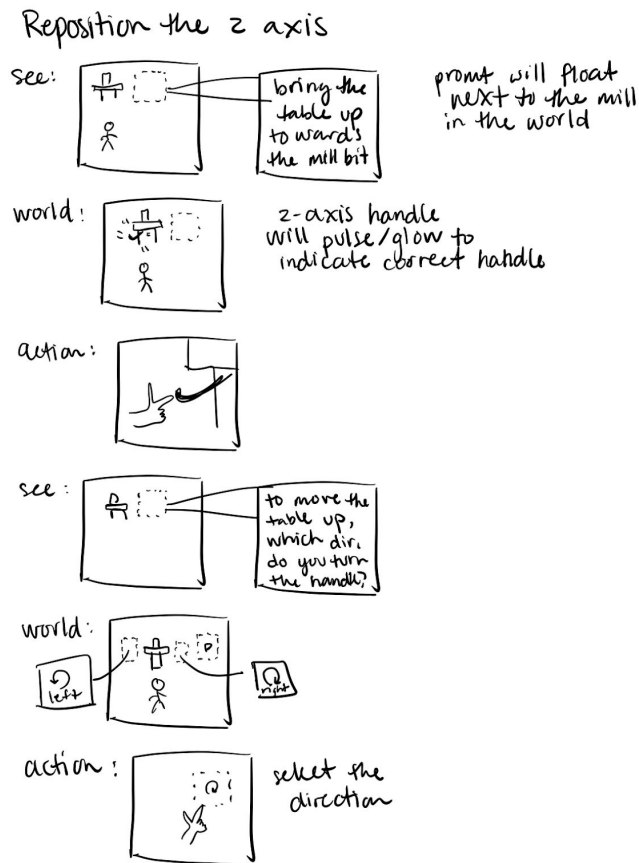

Figure 1. Example storyboard for the challenge of moving the Mill table upwards on the z-axis. At the top of the storyboard, the User Interface (UI) prompt is shown, and the user's associated

interactions with the world and model are
displayed in the scenes that follow.

Five main challenges were selected during the storyboarding process to further simplify the project within the timeline. These challenges were considered critical to the use of the Bridgeport Mill and include moving the mill table along all three axes (x, y, and z), moving the chuck up or down (small z adjustments), and changing gears (between low and high gear). For each challenge, the user would be given a prompt on the User Interface (UI) and must select the correct element to move on the Bridgeport Mill. Depending on the challenge, the user will be asked to determine how to manipulate the selected component (i.e. if the user selects the table feed handwheel that manipulates the x-axis, the prompt would ask which direction the user would like to turn it). If a wrong selection is made at any point, the UI instructs the user of the correct use of the selection and asks for a retry.

Building the Experience

Due to the semester-long timeline, the user experience was determined to be the top priority. A bare Bridgeport Mill model was downloaded from an open-source site for 3D models[5] and used to set up the VR scene in which the user would interact with the model. In later discussions, the bare model was deemed too simple and confusing for users who would be using the experience as a method for becoming familiar with the tool, as it directly opposed the original goal of providing a visually similar experience. A secondary Bridgeport Mill model[6] was found and could be loaded into the scene for use, and it features many buttons and levers that are not necessary for the challenges, but they provide a visual reference for the physical machines. A third option would be to create a full in-house model of the Bridgeport Mills in the machine shop for internal use. This option would require a significant amount of time but would provide the best long-term use for the model and VR experience. Figure 2 below showcases the differences between the Bridgeport Mill in the machine shop and the bare model that is currently used in Unity. Neither replacement model for Unity has been integrated into the original VR world scene.
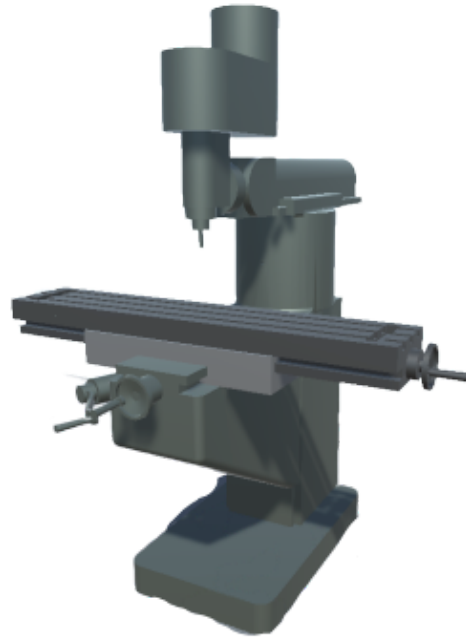
<center>A   B</center>

Figure 2. (A) Image of one Bridgeport Mill in the Mechanical Engineering machine shop. In total, the machine shop hosts six Bridgeport Mills. (B) Bare Bridgeport Mill model as seen in the Unity scene. Note that the upper half of the model is missing all the buttons and levers that students would see in the machine shop.

After the Bridgeport Mill model was uploaded to Unity, the storyboards were recreated in Unity through the use of C# scripts that connect the user with the Bridgeport Mill model. Each challenge is given a separate script so the instructor can rearrange and duplicate challenges to provide a meaningful experience for students. The rearranging of challenges is made easier with the use of a master script, so edits only need to be made in the master script before running the program. Figure 3 below provides an example of the user's view of the model and the prompt for a challenge.
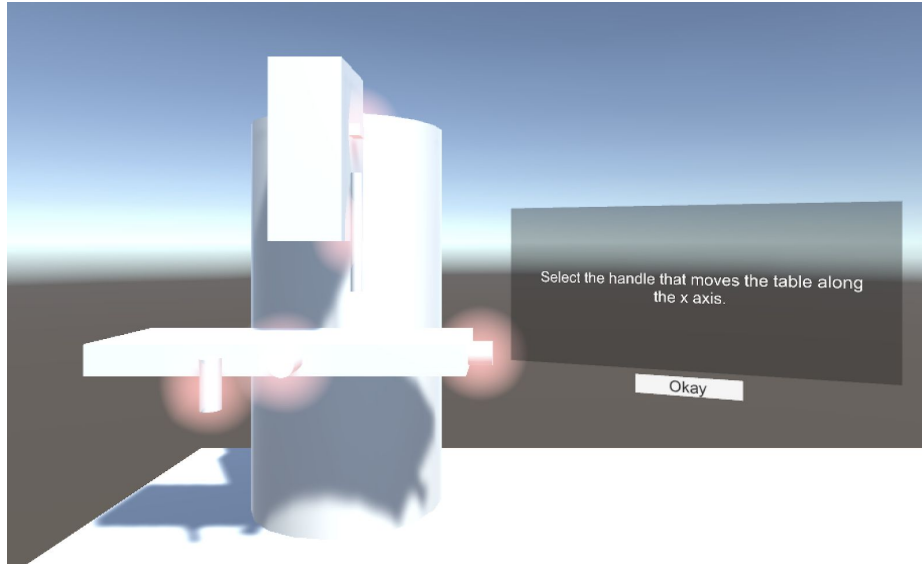
Figure 3. Screencapture of user visuals for the model. The red glow alerts the user that the component is interactive (i.e. can be selected as a response to the given prompt). The model shown is made of 3D shapes instead of the Bridgeport Mill model. Due to the events of COVID-19, the bare Bridgeport Mill model did not have all the required components and the second model has yet to be purchased.

While working on building the challenge scripts in Unity, the university made the executive decision to send students home due to the rising numbers of COVID-19 cases across the world. When the engineering campus shut down, the bare Bridgeport Mill model had not been fully corrected to use with the challenge scripts, so a generic geometric pile of shapes stood in as a mill while the challenge scripts continued being developed. The glowing interactive components on the geometric mill, as seen in Figure 3, would be replaced by the axial handles and levers seen on the Bridgeport Mill in Figure 1, p. 4.

Future Work & Discussion

Due to the ongoing COVID-19 pandemic, the project was unable to be completed. Within Unity, the challenge scripts were created and the VR experience can be played like a computer game using inputs from a mouse and keyboard. Further development of the UI needs to occur to create a seamless experience for the user, including the integration of the Oculus Rift headsets and handsets that students will use when working with this VR experience. It can also be noted that the Oculus Rift sets require a physical tethered connection, and technological advancements may deliver wireless headsets that can be used instead. Additionally, an updated Bridgeport Mill model with more features needs to be uploaded into the VR space to reflect the machines in the

machine shop. This model will also reside in a virtual environment that will ideally give the user a sense of standing in a room, which is important in order to avoid nauseating the users.

This project provides one example of how VR can be used in a classroom setting. Before developing the project further, it is recommended that students enrolled in MECHENG 250 test the experience and provide feedback. This feedback will be useful insight for developing this VR experience and could help instructors learn what platform works best for providing new or additional information. In the event that students find this project useful, it can be further developed to respond realistically (i.e. students can turn the feed handwheels in the appropriate direction), and the experience could transition to a virtual machining challenge. This process can be duplicated with other tools in the machine shop as well, like the lathe or the band saws. In the event that the students do not find any use for this specific VR experience (or presume to not need any further additions to the experience), it is recommended that a design lab safety AR or VR experience be created to fully test if any form of XR experience can be integrated into the classroom experience. This lab safety experience could include challenges such as cleaning up a spilled battery leak and finding the fire extinguisher, and it could be developed in AR so students could work through challenged in the physical lab space if desired.

Throughout the course of this project, from ideation during my junior year to COVID-19 indefinitely pausing work during my senior year, I learned a lot about the complexity of designing an all-inclusive experience for any kind of student experience. The largest hurdles I faced were during the generative process and scripting phase when all the storyboards were created, and I was very grateful for the tips I received from others who had backgrounds in video game design. Given the nature of the VR experience, it would have been a good idea to build the Bridgeport Mill model from scratch so that the department had an in-house model to use and update as time progressed. Beyond remote courses and a closed machine shop, I do hope that another motivated student picks up this project and continues to create a product that can be tested within MECHENG 250, as I think this experience would benefit a lot of students in the future.

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Acknowledgments