ASSIGNMENT 1

Abstract— The medical industry has many opportunities and people who are interested in understanding whether they want to participate in it. What if there could be an easily accessible and educational option where they could understand how medical procedures are performed? There is a severe lack of these in the public sphere, especially for people who have not finished secondary school yet. A device coupled with a gamified simulation could introduce younger people to how medical operations are done in a professional manner with all realistic steps applied. This could give audiences a feel for whether they should become medical practitioners.

I. INTRODUCTION

Surgery, when done by hand, can significantly increase complication risks and pain in the patient and can significantly extend hospital stay. This contrasts to minimally invasive surgeries (MIS); however, the ability to gain the knowledge to use the equipment necessary to perform these surgeries is very difficult. Access to this type of training for people who want to become medical practitioners in developed, developing, and underdeveloped countries should become significantly more available. As designers, we looked at this issue and saw an opportunity to aid in this issue. Our objective is to develop a controller for a virtual simulation to help give doctors the necessary knowledge to use minimally invasive surgery tools. If we are to become successful, medical professionals will be able to learn this technology at a significantly increased rate due to the convenience and easy availability.

II. SCHOLAR RESEARCH

As we conducted the background research into our topic, we discovered many interesting articles. The following is the summary of our findings. The first keywords we used were “medical simulation training." We used these keywords since our device is meant to provide user-friendly training for laparoscopic surgeries. Many of the results have been left out due to the irrelevance to this specific study or the absence of quantitative analysis on student satisfaction. The study we decided to pick from the pool of results was *Students' perception towards medical-simulation training as a method for clinical teaching* by Marwa Ahmed El Naggar. The problem being addressed in this report is the lack of clinical skills with medical graduates in recent times. This is a result of a limited opportunity to practice their skills. The report states that the importance of simulation-based learning and practices for medical students is significant. This report uses a cross-sectional design with a validated questionnaire to get data on students' opinions regarding simulation-based training. It utilizes pre-clinical and clinical-placed students who participated in that style of learning. Their perspectives inform the researchers of their challenges and satisfaction. The study used actual simulation-based training with participants to get their views. Most of the students were satisfied with that method of learning. [1]

Moreover, while using the same keywords, we found another report that was of interest to our cause. The other report we found was called *How to Apply Simulation-Based Learning in Medical Education*. The report has multiple results revolving around using simulation-based training for medical students. The paper addresses the subject of lackluster clinical training as well as the moral implications of using real patients in medical educational facilities. Most people discussed were medical students and healthcare workers who were interested in enhancing their ways of teaching. It investigates various simulation techniques such as human-to-human roleplays in addition to non-human roleplays (mannequins, virtual simulators, etc.). Additionally, this report also looks at designing simulation courses. The purpose of those courses was to enhance lab experience, skills, and student preparation. The result deemed that simulation-based training is very effective in increasing the experience and capabilities of medical students and professionals. The most important takeaway from this report was that simulation-based learning can play a strong role in making it easier for medical students and professionals to become comfortable with working in real-world scenarios. [2]

Furthermore, as we moved on with our research, we used the new keywords “training on medical procedures." These findings were used to find resources that were mainly centered around the best strategies for medical training, alongside innovative solutions. The paper we chose was *The Role of 3D Printing in Planning Complex Medical Procedures and Training of Medical Professionals—Cross-Sectional Multispecialty Review.* In this paper, it provided us with a comprehensive overview of how 3D printing is transforming medical practice. It focuses on technology application in creating patient-specific anatomical models, which aid in pre-surgical planning, enhance the precision of complex procedures, and facilitate hands-on training. The report emphasized how 3D printing reduces risks, improves patient outcomes, and enables personalized treatment approaches across various medical specialties. Similarly, the report goes more in depth about patient-specific anatomical models, simulation, and training models in addition to rapid prototyping. All of these topics help us rapidly create innovative designs that can be created and tested to aid our cause. [3]

Alternatively, we found another paper using the same keywords. The paper was called *Using Enhanced Representations to Predict Medical Procedures from Clinician Notes* by Roberto Mostoles. This paper explores a method for predicting medical procedure codes from clinician notes using a novel feature representation. It combines diagnosis codes and clinical text annotations to enhance predictions, utilizing the hierarchical structure of the ICD coding system and leveraging embeddings from language models like BERT. The approach outperformed existing models in medical code prediction tasks using the MIMIC-III database. Additionally, this paper goes further in depth about the ICD Coding System, BERT, and the MIMIC-III Database. [4]

Also, while conducting our research, we used the keywords “virtual simulation in medicine." These keywords were used to discover information that was most relevant to our topic. We excluded some topics due to the nature of some of the articles and papers. Some of the information they provided was only discussing the problem and not solutions, hence why we excluded them. The paper we chose from these keywords was *Screen-Based Simulation and Virtual Reality for Pediatric Emergency Medicine*. This article addresses the intense focus on high reliability and safety in the medical field. As a result of this trend, simulation has become the standard for safe learning to improve quality and patient safety. It discusses methods like screen-based simulation and 3D VR. It also goes more in depth on those topics and gives high-quality explanations of the different types of SBS and 3D VR approaches. At the end of the article, they discuss the high front-end costs and development time of using SBS. Without completing all the design, development, piloting, and distribution, there is nothing to work with at all. More often or not, the high front-end costs are enough to dissuade many SBS and 3D VR-based projects. [5]

Additionally, we used the same keywords as above to find another article called *Using Virtual Reality Simulation Environments to Assess Competence for Emergency Medicine Learners*. This article examines the current use of VS in training and assessment. It includes the limitations and challenges in implementing VS into medical education curricula. They also discuss the need for determination of areas of focus for VS training and assessment, development and exploration of virtual platforms, automated feedback within such platforms, and the evaluation of the effectiveness and validity of VS education. Moreover, it discusses the logistic challenges of VS, including the large number of learners across healthcare systems. The current VS design approaches are not standardized or well described, which limits the ability to adapt training from one application to another. However, the rapid changing of VS technology is also presenting major challenges to establishing VS-based curricula. The need for healthcare communities to commit to using a specific platform is at an all-time high. Finally, like all other types of methods listed in our paper, the cost is also another major challenge that is holding back VS technology. VS can be good and useful; however, with all these logistical challenges, it is making it harder than ever to create a good VS program. We will need to overcome these challenges to succeed in this area. [6]

III. COMMERCIAL DEVICE RESEARCH

While conducting our research, we discovered three very intriguing commercial devices that will help us with our mission. The first keywords we used for our search were “Laparoscopy Commercial Device." We used these keywords to ensure we found something like what we are making that is being sold commercially. The tool we found is called a Laparo. This is a tool meant to create physical simulations of what it is like to perform a laparoscopy. It contains several components, such as dissection, grasping, scissors, needle holders, and clip appliers. It has 46 unique exercises designed to replicate real medical procedures involving minimally invasive surgeries. [7]

Furthermore, we used the same keywords to find another device. This laparoscopy product was produced by Stryker, and it uses high-quality technology for superior transmission and impressive detail recognition. [8] Additionally, we used these keywords (Robotic Surgery Arm Commercial Device) as we wanted to find more equipment that was like what we are making. The commercial device we found is called the Da Vinci Xi. This device is designed to provide flexibility for procedures performed across multiple specialties. It offers broader anatomical access, enhanced ease of use, and complete integration of advanced Da Vinci technology. [9]

IV. WEBSITE SOLUTIONS

Part of our research was discovering website solutions that could aid our findings and help us develop a better product. The first website solution we found was a video discussing a laparoscopy simulation that trains medical students. It is very effective in its ability to simulate and enhance the skills of people learning to become surgeons. The simulation allows students to practice procedures and protocols that can prepare them for real-world application. [10] Moreover, we found another video that describes the steps and resources that are needed to prepare for medical surgeries. From our findings, we discovered the equipment that you need in addition to a thorough explanation of how to clean your area before any medical procedure can take place. [11] Finally, we found a discussion form on Reddit discussing Quest 2 and how it can be used to aid in the learning of different types of surgeries. We found that many redditors discussed different simulations that you learn on the Quest 2 and how well it aided them in the learning process. [12]

V. RESULTS

The results of our project idea and current iteration were promising. The Tinkercad component simulation is working as planned (link to it here: https://youtu.be/MJpA_bagfdw). The switch between the green lights and red lights with the corresponding buzzer sounds functions as expected. The physical iteration is mostly working except for one of our potentiometers (link to the demonstration here: https://youtu.be/R6iXfJeA-FE). The virtual laparoscope can be rotated using two of the potentiometers. Operation sessions can start and stop according to the button push along with the corresponding flashing lights as well as the buzzer sounds on the Arduino setup. Our team plans on updating the hardware setup for the intended controller for the next iteration.

VI. CONCLUSION

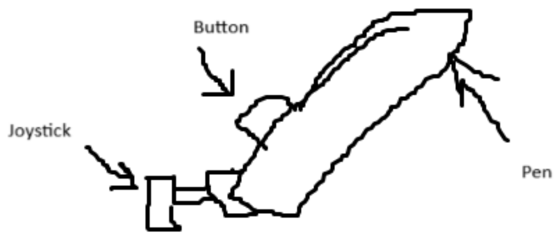
In conclusion, this device will be efficient, reasonably constructed, and effective. The current prototype functions mostly as planned within the Tinkercad simulation and with the physical component with the Arduino setup connected to Unity. Our team plans on iterating and updating the project. The controller pieces will be assembled to be as beneficial as possible.

APPENDICES

Task Analysis:

Our use case goes as follows: The player presses the button on the Arduino to signal the start of an operation with flashing green lights and an accompanying buzzer sound. If the laparoscopic device is positioned properly, the player will move the controller, which will manipulate the virtual laparoscope in Unity. Additionally, the player can press a button attached to the controller to perform a grabbing motion in the virtual environment. The code will be able to sense if the virtual laparoscope is colliding with another object, such as a virtual organ or foreign object piercing the body. When the object is in the grip of the virtual laparoscope, the object’s position will change to consistently follow the device to mimic a real carry movement. The player can then press the same button on the controller to release the object once it is in a location that is medically accurate to a standard procedure. When the procedure is done, the medical equipment will become inactive, and the player can push the button connected to the Arduino to signal the end of the procedure with flashing red lights and the accompanying buzzer sound.

System architecture:



The joystick will control the movement of our controller. [13] This will consist of moving the virtual laparoscope in and out. Additionally, the joystick will be connected to the Arduino. It has two potentiometers for X and Y analog signals for measuring rotation and tilt. Power and ground will have to be connected to the joystick as well. Furthermore, the pen will be connected to an IMU to capture the realistic movements of the pen controller, such as tilting and moving left to right. The IMU is connected to the ground, power, and the Arduino using i2C with SCL and SDA pins. The pen will have a button connected to control the grabbing movements. Moreover, the button is connected to the Arduino with a digital pin as well as a ground connection.

Design Thinking:

Planning: We wanted the model to help people understand the process of medical procedures and make it appear simple as well as logical to the users. Below we included our sketches and clay prototypes to understand how the controller should look so that anyone, young or old, can use it.

Sketch and Clay Prototypes:
https://drive.google.com/file/d/13EJuaA1HdXfhYwdvqMDi-eWSIeEh0rwx/view?usp=sharing

Feedback: We should make adjustable parts. More precision should be considered if VR is used (which we do not plan to). A secondary model of the patient can be used for the head for engagement reasons. Tracking should be kept in mind for the accuracy of the controller. Utilizing a test dummy will help with experimenting and iterating. Using Yield and Haul effect sensors can help with accuracy as well.

Link to our OBJ file of our basic controller model:
https://drive.google.com/file/d/1YuzcFcYKRA-M-094tZuJi5Bn4Fo--PWB/view

Tinkercad Schematic and Component List:
https://drive.google.com/file/d/1cLhhP6jm3mkvuOPz95RIUwMOq3ZAUU_p/view?usp=sharing

Code to run the current controller from Arduino:
https://drive.google.com/file/d/1XJJ9joBEHVXfy_KEZERVg64JYBjFFCZo/view?usp=sharing

SPECIAL NOTE

ChatGPT was utilized by Dilan Mian to understand what parts were needed for the physical component to build what we needed. Extra components were added, such as more lights, to create a more engaging experience for the user.

CONTRIBUTIONS APPENDIX

Dilan Mian worked on research for the background review, helped format the document, and then created and tested the Tinkercad along with the physical prototype.

Michael Wilson worked on research for the background review, detailed our work through the design thinking process, and set up the GitHub repository.

Dylan Jordan made the idea, worked on research for the background review, helped format and proofread the documentation, and created the 3D model using RealityScan.

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