HCI Project Final Paper - PC Builder in VR

A detailed overview of our semester project

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***Abstract*—This article describes the group project in CS464: Introduction to Human-Computer Interaction at Colorado State University. This project focuses on a custom made virtual reality computer building simulator designed to teach individuals how to build a computer and the importance of each component. An experiment for testing the effectiveness of our program was designed, but not carried out due to unforeseen circumstances.**

***Index Terms*—**

- **VR: Virtual Reality**
- **VRLE: Virtual Reality Learning Environment**
- **PC: Personal Computer**
- **HCI: Human Computer Interaction**

I. Introduction

A. Purpose

The goal of the experiment is to see if the VR computer-building tutorial is more effective than an alternative to teach people how to assemble a computer. If participants who completed the VR tutorial can retain more information than participants who complete an alternative learning method, then the program would be deemed superior.

B. COVID-19 Circumstances

Due to unforeseen circumstances from the COVID-19 pandemic, aspects of this project had to be altered in the middle of the semester. Changes included cancelling the experiment and choosing to put more effort in the system design and implementation, as well as increased background research.

II. Related Research

A. Context

This project uses peer reviewed articles in order to understand the previous research completed in regards to VR in an educational context. We have investigated the strengths and weaknesses of VR in educational tasks, and the future for VR in this field.

B. Benefits of VR in Education

VR provides a unique experience to those who use it in an educational manner. There are many strengths that VR has as an educational tool, which many previous studies have observed in detail. It should be noted that VR would be better described as a learning environment rather than an educational tool [8], but since the program designed in this paper is for a specific educational purpose, the terms ”learning environment” and ”educational tool” are used interchangeably for VR.

One advantage that VR has as an educational tool is the way it allows the user to focus all of their attention on the task at hand. This can be called immersion, and it has many benefits [12]. Immersion is unique to VR, because unlike other technologies, VR has control of the user’s entire visual, and often audio, input. Another term that describes this is multi-sensory input [3]. Since VR has full control of the entire visual field and audio input, it gives a lot of space for designers to experiment in educational programs that would not be possible with previous technologies. The program proposed in this paper is an example of a educational program that utilizes having full control of the users visual field.

Another way that VR is set apart from other technologies in the realm of education is its ability to integrate tasks and information, which leads to increased memory [9]. Within VR, there are a lot of capabilities for users to interact with virtual objects in 3D. That by itself may seem simple enough, but things become more interesting when one aligns actions done in 3D with information or instruction. When this is performed, it becomes clear that this increases the process of memory elaboration for the user, which leads to increased retention for the task [9]. In other words, when one is able to take information and perform related actions at the same time, they are able to remember the information better.

Yet another benefit that VR offers to users is the ability to simplify abstract concepts [2]. Since VR offers full visual control, it allows for the user to see 3D objects more clearly and understand how they interact with the virtual 3D surroundings. How this applies to learning a 3D concept is that it skips the typical intermediary step of learning words or terms for the 3D idea. An example of this could be a lesson in chemistry. A typical lesson in chemistry would be to describe the chemical bonds or reactions in words since humans cannot see at an atomic level with the naked eye. A VR educational program could visualize these exact ideas but at a scale where a person could see it, like having atoms be hand-sized spheres or reactions as a transfer of these spheres. In this VR scenario, the user would be able to understand the same concept, but without the cognitive load of attaching terms to the phenomena. They would be able to simply see and understand the concept instead of imagining it and attaching complex terms to things.

Another idea that aligns with the ability that VR simplifies abstract concepts is the idea of constructivism. Constructivism is the idea that when a student is learning a new concept, they are affected by their previous experience and lessons [6]. Aspects of constructivism should be considered when designing for VR. Understanding what previous assumptions, knowledge, even gestures should be considered, as they will impact how the user will interact with the program.

Lastly, it should be noted that not all of the benefits for VR in education are learning performance related, there are some observed emotional and motivational benefits as well. It has been observed that VR is an entertaining and stimulating format for educational material [10]. Users often find it captivating to be able to be fully immersed in a new environment. Since VR has the capability to support an endless number of possible virtual environments, users find it compelling to experience these new places, even if the purpose is to be educational.

C. Drawbacks of VR in Education

VR has many well documented benefits as a learning tool, but previous research has also uncovered some of it's drawbacks. VR is no doubt a positive addition to educational technologies, but it is not without its flaws. Not only does VR possess flaws, but the full extent of these flaws are not yet fully known, so this area requires more research.

One flaw that VR programs possess are their lack of catering towards individuals with various disabilities, cognitive or physical. It has been speculated that interacting with VR can be incredibly challenging for people with cognitive disabilities, especially those diagnosed with Down syndrome [4]. This is an area that would benefit from additional research, as the full extent of this problem is not yet know. It is also not yet know how VR affects children under the age of 10, since there has not yet been extensive research in this area.

Another flaw the technology world currently has to deal with in regards to VR is its price and development challenges. It is well argued that VR offers many benefits to users who are using it in an educational setting, but the technology itself is not cheap enough to, for example, deploy within the public school system. Computers themselves are still growing to their full potential within schools, where some schools have just 2 or 3 computers per classroom [1]. It will likely be several years, or even a few decades, before VR hardware will be cheap enough and readily available at a level for schools to use them easily.

D. Future of VR in Education

The technology and educational worlds are currently in the middle of the VR expansion, where VR itself has only recently become available for the general public. Many studies have been performed on VR in an educational setting, but this is still the early stages of the technology, so there are many speculations about where VR will go in the future.

There has been some studies that test whether VR can be directly applied to typical curriculum. One study applied a simple science lab into VR [7], and found that it was very effective at teaching participants various concepts. Participants reported enjoying the program and stated that they found it very compelling. This is a glimpse of how VR could be implemented in the area of public education.

It is likely not practical to use VR for everything in the future; It's important to understand when it's effective to and when it is not. One study mapped out when it would be effective to use VR to fulfill an educational goal, and how to develop the VR material [11]. Even though VR cannot be applied to all educational material, there is still an enormous amount of education lessons and topics that could benefit from the implementation of VR [5]. There are countless lessons and ideas that are taught within the public school system that could be more effectively taught through VR. The program proposed in this paper is an example of what such material could look like. Even though the purposes of this program is not to be implemented within a public educational system, it can be seen that programs like this one could be used to drastically improve the public education realm.

III. System Design

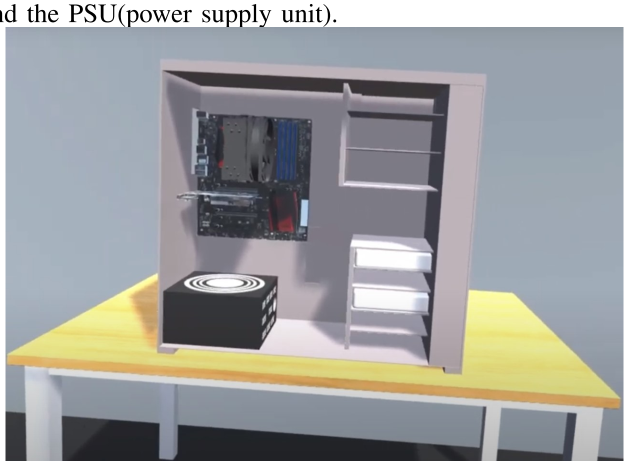
A. Softwares and Materials

We created the Virtual Reality Learning Environment using the Unity 3D engine. The Unity 3D engine is a popular engine written primarily in C#, and used to make 3D games and virtual reality environments, such as this one. Unity 3D supports scripting in C and UnityScript, but offers many high-level packages in order to implement objects, interactions, and scene changes that allow you to design the virtual reality environment.

In conjunction with Unity 3D, we used the Oculus Rift as our VR hardware. Unity has compatibility features for Oculus devices built in, so using the Oculus in conjunction with Unity worked effectively. The Oculus Rift includes the headset, which is the basis for immersing the user in the VR environment; two controllers, which are the basis for interacting with objects within that environment; and sensors, which track your body's movement to be translated into movement inside the VR environment.

In order to design the computer components that were placed in the VR environment, we used two 3D modeling software platforms: Microsoft 3D builder and Blender. We downloaded several of the components from open-source 3D modeling websites and designed the remaining components from scratch. For the open-source models we found online, we made adjustments to the dimensions, and then applied textures and materials to them using the 3D modeling platforms. In this way, we created virtual computer components that were realistic enough to easily recognize in the VRLE and to distinguish them from other components.

The 8 different computer components our system incorporated included: the PC case, the CPU(central processing unit), the CPU cooler, the graphics card, the RAM(Random Access Memory) stick, the motherboard, the HDD(hard disk drive), and the PSU(power supply unit).



The figure above is a screenshot of the program. The computer case can be seen resting on top of a table, with several components attached inside of the computer case.

B. Tutorial

The tutorial section of the system was the main purpose of this experiment. It is a step-by-step program that teaches the user how to build a PC.

We designed the tutorial by creating a new scene for each step of the PC building process. The user advances from one scene to the next by walking through a doorway labeled "continue". Each scene, or step of the tutorial, includes just one additional computer component that needs to be added to what has been put together up to that point. Everything that has been put together so far is treated as one object in each scene, so that previously assembled parts don't become disassembled. In this manner, we distilled the process of building a PC into simple, individual steps.

At each step of the tutorial, the user is presented with information on the computer components, teaching the user both their function and details on the assembly of the parts. A picture is also shown of the assembly for the given parts, to help the user see what they need to emulate. With this instruction, the user can attempt to put together the two components, and if he/she places one component on the other in the correct location, the components snap together.

By supplying text information, a visual example, and a virtual hands-on model in the tutorial, the user is learning the process of building the PC from three different instructional mediums, making the user learn most effectively.

C. Free-play

The free-play mode was designed to give the user freedom to interact with any of the computer components they desire. It would be used as a way to measure how well the user remembered how to assemble the computer after completing the tutorial, because they are not given any instructions in free-play mode. In this manner, the user could first be tested on their PC building knowledge inside virtual reality, before being tested outside of virtual reality. This way we could analyze the effectiveness of the virtual reality tutorial within the virtual reality paradigm, before testing the degree to which the virtual reality tutorial helped the user learn the real-world process of building a PC.

We designed the free-play mode by creating 8 stations, each with a certain subset of the entirety of the computer components. The first station started with just the first two computer components, and each station afterwards had one more computer component; so, station 7 had all 8 computer components available. This allows the user to break down the parts with which he/she wants to experiment with to a more manageable amount. At each of these stations, the computer components will snap together when placed in the right location, as they did in the tutorial; the difference is that nothing starts out put together, and no instruction is given.

D. Challenges

One of the challenges we faced was applying textures to the computer parts to make them look realistic. We had difficulties learning how to create textures and material files in the 3D modeling programs, and then how to use those in Unity. We ended up being able to create and use textures for all the objects except the HDD, which had problems rendering the texture when within Virtual Reality, and the computer case, which we deemed didn't need one.

Another challenge we faced was how to notify the user that they had correctly placed the components together. Our first way of thinking was to have the pieces stick together as one big component when placed correctly, but not everyone will immediately know that the pieces are stuck together. Based on our readings from our sources, we concluded that instant feedback would best support the user in their self-paced learning. Using this information, we implemented the check mark system. After consulting with our peers, we received positive feedback that this was an effective solution.

The final noteworthy challenge that we faced was deciding the amount of information that the user received during the tutorial. If we included too much information, we knew it would overwhelm the user and they would not absorb all the important information. If we included too little information, then they would possibly not know where to put the component, the component's importance, or if the program could even translate to a real life scenario. We figured that having different sections with clear headings would help support their learning, allowing them to know what each section is about and determine for themselves what they want to know more about. We tried to condense the knowledge as much as possible in less technical terms in order to best transfer our message and make it easier to read. One of the main components added to the information was the addition of pictures showing the pieces in place in a real life example. This would help the user discern where to place the computer component, but not blatantly tell them, like with a large arrow for example.

E. Next Steps

As much progress as was put into this project, there is still more to improve upon. Our main goal was to create a system to teach users about a complex topic (i.e. building a computer). We included all main components in a computer system, but some minor components were omitted. In the future, we would focus even more effort on the smaller details that are important in building a computer. This would include creating a latch for the CPU, applying thermal paste, using standoffs for the Motherboard, attaching the power cables between the PSU and other components, etc. We felt we should omit these items because they are the more nuanced aspects of building a computer.

Another additional step that we would perform is the completion of the designed experiment. Because of COVID-19 pandemic, we were not able to complete our experiment, as stated before. Completion of our study would allow for a full understanding of the performance of our program. After we have results, we could even extrapolate further and design additional studies. We would conjecture possible questions for study, but that would not be right and hold bias due to the absence of data.

IV. Experiment Design

A. Note

It should be noted that this experiment was not performed. Due to the unforeseen circumstances of COVID-19, the experimental design had to be cancelled. The following is the complete design for the experiment, as we would execute if we were able to do so.

B. Experiment Overview

The purpose of our program is to teach computer desktop assembly to individuals who have no such experience. In order to observe if it effectively teaches this, we need to compare our learning method with a different learning method. We chose to compare our program's performance with what we perceived to be the best current method of learning how to build a desktop computer, which is through online tutorial videos. Our hypothesis is that our program will more effectively teach computer assembly than online tutorials. We believe our program will exhibit better performance because a user has more sensory input by actually building a virtual computer, rather than just watching steps on how to do the task.

C. Participants

The participants for this experiment will consist of 30 college students whose ages range from 20-25. Participants from this background will be used simply because the research pool for that population is very large. Participants will be screened beforehand to determine if they have little to no experience with computer hardware assembly. These will be the individuals that will be selected to continue in the study since the goal of this software is to teach computer hardware assembly effectively, at a beginner level.

D. Methods

With 30 college students, there will be 15 individuals in each of the two treatment groups for a between subjects experimental design. The 2 treatment groups will be exposed to our tutorial VR program for building a computer desktop and exposure to a short video series on the same topic.

The experiment will include three phases: a pre-treatment survey, the treatment condition, and a post-treatment survey. The pre-treatment and post treatment surveys will be the same between individuals in both treatment groups, although the two surveys will have slight variations compared to each other. They will test the same information, but they will be worded slightly different so that they do not seem identical. These tests will assess the participants' knowledge of the functions of computer hardware components (like the GPU, RAM, etc.) and the order that one would have to assemble a desktop computer.

The two treatment groups will be using our proposed VR computer hardware assembly tutorial and watching a short video series on computer hardware assembly. The participants in the VR tutorial group will complete the "Tutorial" feature of our proposed program, or until they have been using the feature for 15 minutes, whichever comes first. The other treatment group will watch 15 minutes of a beginner computer hardware assembly video series. Both treatment groups will complete the post treatment surveys immediately after they complete their treatment condition.

E. Data Collection

The data for this experiment will come from the pre-treatment and post-treatment surveys. We are interested in how each individual will improve based on which treatment group they were in. The pre-treatment and post-treatment test scores will be compared and analyzed for how much each participant progressed.

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