Requirements for the Utilization of VR Hardware and Software in the Classroom

A Research Report for the DSCI 60998 Capstone Project in Digital Sciences Course

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Abstract

Virtual Reality is a technology which has the potential to teach new skills through interactive simulations, and to enhance a student's creative thinking abilities by reducing the fear normally associated with failure. This study explores the implementation requirements to utilize the Oculus Rift VR headset in a classroom environment. Hardware, software, space/design requirements, and Costs were all explored and analyzed, and the practicality of such an implementation was also discussed. The potential benefits students will gain from the use of VR for training purposes is immense, and the only potential downside is a high upfront cost to purchase all required hardware/equipment. This study also explored the actual classroom layout, and network infrastructure requirements, to fully realize the integration of VR in the classroom. All in all, Virtual Reality has the potential to change the way society learns as a whole, and improve the overall comprehension and mastery of a variety of aptitudes.

Keywords: virtual reality, classroom design, vr hardware, training simulations, education

Introduction

Purpose of the Study/Statement of the Problem

The primary focus of this study is the exploration of what a Virtual Reality (VR) enabled classroom could look like. This includes the creation of a conceptual design which outlines the technical requirements (size, equipment, hardware/software, etc.) of a room which would be equipped to facilitate this type of learning. VR can allow students to learn numerous topics, and get "hands on" experience, without ever leaving the classroom. Training costs and/or instructor resources can be overwhelmingly high depending on the subject matter being taught. While there may be a higher upfront cost to installing and setting up a VR enabled classroom, the long term cost savings can be well worth the investment.

Justification/Significance

Virtual Reality is really starting to take off in 2016 with the release of products such as the Oculus Rift, Samsung Gear VR, and PlayStation VR. What was once only open to a select few is now becoming more mainstream. Thoroughly examining the use of VR as a learning tool will allow educators and administrators to consider the pros & cons of this type of learning. It will also provide guidelines for anyone who may want to create a classroom equipped for education using VR by including an analysis of all related hardware and software. This will be accomplished through an examination of the various VR headsets which exist today, and what is needed to implement this type of technology into a learning environment. Existing research may explain VR as a concept, but never delves into the finer points of utilization and setup relating to student learning and immersion. This study will help explain this aspect of VR, and what it would take to turn it into a useful tool for instruction.

The Research Objectives

This is mostly an explorative study. In other words, it involves research and design without any actual implementation. The objectives below will be used to guide the research and provide a high level overview of all the items which will be explored in this study.

- Research and Evaluate Virtual Reality as a platform for education.
- Research Hardware requirements for the use of VR in the classroom.
- Research Software requirements for the use of VR in the classroom.
- Experiment with the Oculus Rift to determine possible use case scenarios.
- Determine space requirements for a VR equipped classroom
- Calculate final costs associated with all required hardware.
- Determine final proposed setup.

The knowledge gained from this research will assist educators for years to come, and will provide a comprehensive overview of everything needed to augment their classrooms with VR technologies. When looking towards the future it isn't hard to imagine a world where students learn primarily through Virtual Reality, or even Augmented Reality. Why bother purchasing tons of equipment for students to practice their skills when VR can be used to create anything the mind can dream up? That is one question (of many) which will get answered throughout the course of this study.

Various Digital Science related topics such as Instructional Design, Simulation Games in Education, & Networking Basics for Educators will all be explored in this research paper. The creation of a VR environment such as this requires some knowledge relating to how educational lessons are designed and created. The use of games in education must also be considered since much of VR learning may come in the form of games and/or interactive content. Various

networking skills will also be utilized to make sure the proposed classroom environment can function as part of the schools' larger IT infrastructure. Additionally, Virtual Reality as a concept will be explored, and the finer points of how VR can be utilized in a learning environment will also be analyzed. This will all culminate by actually designing and detailing a classroom which will be equipped to utilize VR for student learning.

Definitions of Terms and Concepts

- Virtual Reality (VR) – Creates simulated environments through the use of a VR headset which goes over the users eyes to provide a completely immersive experience. The user may also be equipped with headphones and hand controls to extend the level of interactivity and feedback.
- Augmented Reality (AR) – Similar to VR; however, AR allows the user to see the real world around them and simply overlays virtual items on top of their surroundings.

Literature Review

VR for Behavioral Learning

Ramachandiran, Jomhari, Thiyagaraja, and Maria (2015) conducted a study in which a virtual reality training prototype was developed to help autistic children learn specific aptitudes in a VR environment. The main purpose of this experiment was to help children who have autism develop various social skills which would otherwise be difficult for them to master. This study was conducted in four phases. First, parents and their autistic children were all interviewed to help better understand what a VR simulation such as this should include. The second phase utilized the Picture Exchange Communication System (PECS) database to select the icons and avatars which would be included in the virtual environment. Phase three was the actual design of the prototype, utilizing all of the data gathered in the first two phases. Lastly, the prototype was

reviewed by all those interviewed in phase one. The roles of any virtual agents were also finalized in this last stage (Ramachandiran, Jomhari, Thiyagaraja, & Maria, 2015).

After analyzing all of the research, a toilet virtual environment was selected as the case study for the prototype design. The appearance of the virtual agent, as well as the simulation imagery contained within the prototype, was selected based on the interview results from earlier in the study. In the end, a proposed virtual environment was created to help autistic children learn the skills necessary to use the toilet. While this research study rose some interesting questions, and came up with some thought-provoking results, it only begins to scratch the surface of what VR is truly capable of when attempting to teach children simple life skills. The results also suggest that by using a larger sample size some of the limitations of this study can be overcome (Ramachandiran, Jomhari, Thiyagaraja, & Maria, 2015). This research study showcased the advantages VR has over traditional education, and demonstrated how helpful it can be, especially when dealing with those who have a learning disability.

VR in Higher Education

When analyzing the use of VR in a higher education setting, Miller (2014) examined its use in distance learning scenarios. Miller's paper was published before products such as the Oculus Rift were available on the market, but theorizes about the use of VR for distance learning based on early conceptual designs and prototypes. Miller goes on to state that student interactivity, motivation, comfort, and experimentation can all be augmented through the use of virtual reality headsets. The ability for students to experiment with new devices and technologies in a safe controlled environment is one of the biggest advantages offered by virtual reality. No longer would students need to be worried about hurting themselves or others, they will simply be able to take chances and make mistakes with no fear. One of the biggest hurdles many students

must overcome is their apprehension when learning a new topic. VR makes those fears a thing of the past, and helps students learn like never before (Miller, 2014).

The use of VR as a form of instructional technology is an interesting topic, and opens the door to numerous possibilities. All things considered, there may be a slight learning curve when implementing VR in the classroom, but that can be said about any emerging technology. Once both students and teachers have mastered the use of VR, the learning process will never be the same.

VR and Creative Thinking

Ridong, Yi-Yong, and Chich-Jen (2016) studied the effects of VR on students creative thinking abilities. Their research primarily focuses on the correlations between creative thinking, instruction, and the student's ability to actually think creatively through an analysis of sensitivity and fluency. The results of this study shows that students do gain the ability to think more creatively through the use of VR. This primarily stems from the fact that students are encouraged to interact with objects, experiment with different scenarios, and are forced to pay closer attention to the lesson material. VR is also a great form of expression for those who may not be great at other types of communication. (Ridong, Yi-Yong, & Chich-Jen, 2016).

Overall, virtual reality offers much in the realms of free expression and interactivity. If properly implemented, VR can assist students in numerous facets of education. The ability to develop a student's creative thinking skills is essential to the learning process, and through the use of VR these skills can be drastically increased and improved.

Discussion

How would one incorporate VR learning into a modern classroom? That is the basis of this study, and to properly understand this question an exploration of virtual reality learning was

undertaken. The Literature Review analyzed various sources which looked at virtual reality as a tool to be used for the education and betterment of others. This was necessary to properly understand VR not just as a technology, but as a platform for learning. Subsequently, this study aims to not only comprehend VR, but to design and analyze the hardware and software required to create a fully functional classroom equipped with VR technology. To accomplish this, first an understanding of the technological requirements for this type of endeavor must be achieved.

While multiple VR headsets were looked at, the Oculus Rift was chosen as the primary piece of equipment for this case study. The Oculus Rift was selected because it falls in-between the most expensive and the cheapest of all VR headsets on the market today. It also has the ability to work better within a classroom environment, with each student getting his or her own headset which will be hooked up to a computer at the student's workstation. The costs associated with such an endeavor are nothing short of exorbitant. This mostly stems from the fact that each workstation must be equipped with a PC capable of supporting the Oculus Rift. The steep hardware requirements are one of the weaknesses of this type of setup; however, the long term benefits far outweigh any upfront costs. That being said, the size of the classroom will be kept at around 20 workstations to make everything more manageable. Actual measurements, diagrams, and charts will be included later in this paper which outlines all of these requirements.

Various sources of information were used for this study. As seen in the literature review several scholarly resources were utilized to understand VR as a method for learning. Additionally, research was conducted on the various VR headsets on the market today, and the manufacturers websites were used to verify the minimum hardware requirements for each headset. As stated earlier, the Oculus Rift was chosen as the headset for my proposed VR setup. It offers a nice balance of form and function; it is also one of the more mid-range headsets in

terms of price. After reviewing the technical specifications of the Oculus Rift, the required PC hardware components were determined, and the space which will fit all of these VR workstations was also calculated.

After researching the hardware, space, and cost requirements for a VR enabled classroom, VR software was also investigated. The Oculus Rift comes with some interesting games and simulations to help get people acclimated to the use of VR. Nevertheless, to truly utilize this type of technology in a learning environment some custom applications will need to be created. The creation of such software is beyond the scope of this paper; however, examples will be included later which theorize what types of software could be utilized to engage and educate students in a VR enabled classroom. Additionally, concepts from the realm of Digital Sciences convey a heavy influence on this paper and the types of software which will be theorized. A proper understanding of instructional design must be utilized to not only craft a game/simulation which educates students, but also provides a learning experience which can be properly translated to a VR environment.

Below is a summary of the characteristics and items related to each objective discussed in this study (more detail relating to some of these items will be addressed in the "Findings" section of this paper).

1. Research and Evaluate Virtual Reality as a platform for education.
    - Behavioral Learning – VR can be used to change and or augment a student's behavior for the better.
    - Higher Education – VR can be used in higher education for distance learning and the enhancement of the curriculum.

- Creative Thinking – VR can improve a student's critical thinking skills through practice scenarios where fear of failure is reduced.

2. Research Hardware requirements for the use of VR in the classroom.
    - Oculus Rift
        - MSRP: $599.99
        - Items Included: Headset, Sensor, Xbox One Controller, Remote, Cables.
        - Minimum Hardware Requirements: NVIDIA GTX 970, Intel i5-4590, 8GB RAM, 3x USB 3.0 Ports, 1x USB 2.0 Port, Windows 7 SP1 or greater (Oculus, 2016).
        - A more detailed overview of the Oculus Rift will be outlined later in this paper.
    - VR Ready PC
        - Dell XPS 8900 Special Edition
            - 6th Generation Intel Core i7 Processor, Windows 10 Home, 16GB Memory, Price/Unit: $1,099.99 (Dell, 2016).
        - Full specs will be outlined later in this paper.
3. Research Software requirements for the use of VR in the classroom.
    - The Oculus Rift comes with numerous games/simulations to help get students acclimated to the use of VR; however, most of these software titles are games, so to properly utilize VR for learning some more education centered simulations will need to be created.
4. Experiment with the Oculus Rift to determine possible use case scenarios.

- After utilizing the Oculus Rift for several weeks, it has been determined that the possibilities are endless when considering the uses for VR in the classroom. Once fully realized, VR in the classroom offers an interactive experience which not only educates but engages.

5. Determine space requirements for a VR equipped classroom
    - The proposed VR enabled classroom outlined in the paper will consist of 20 workstations + 1 teacher station. Exact measurements, outlines, and diagrams will be provided in later sections of this report.
6. Calculate final costs associated with all required hardware/software.
    - Final costs will include the hardware and equipment needed to deploy the Oculus Rift in a classroom environment (for simplicity other general items will be excluded from these calculations).
7. Determine final proposed setup and create diagrams.
    - Final setup involves the creation of a Visio diagram which outlines the layout of the classroom in relation to each workstation, and the network infrastructure requirements to get everything working properly.

All in all, after a thorough analysis of all objectives, a complete picture of what is required in this type of study is starting to take shape, and the end result will produce a classroom which looks towards the future and utilizes modern technology to make a difference in the lives of students everywhere.

Findings

Description and Analysis of the Results of the Research

Throughout the research presented in this study there are four topic areas which are

addressed: Hardware, Software, Space/Design Requirements, and Cost. These areas each make up a piece of the overarching "puzzle" when discussing the utilization of VR in a classroom environment. The following sections describe these aspects of the VR "puzzle", and convey all relevant information and facts which were derived throughout the course of this study.

First, let's take a look at the hardware analysis, and what would be required to successfully setup a VR enabled classroom. Three VR headsets were examined when determining which would be best suited for a classroom implementation. *Table 1* in Appendix A outlines these headsets, and includes an overview of the pertinent facts used when making this decision.

When comparing these headsets lets first look at price. The Oculus Rift is the winner in this regard. The PlayStation VR headset actually costs less, but requires the purchase of a PS4 to function. The HTC Vive is by far the priciest of these three headsets, and may not be entirely practical for a classroom environment. One thing the HTC Vive offers that the others do not is room-wide motion tracking. This allows the user to actually walk around the room and the hardware will track your positon in a 3D space. While impressive, this feature doesn't really lend itself to the end goal. Additionally, all three headsets offer motion controllers (The Oculus Rift will release theirs later this year) which allows your hands to become part of the action. This can be useful when training students on how to complete activities which require the use of their hands. The resolution and display technologies of all three headsets are comparable; however, the Oculus Rift also has a built-in headset which decreases the need for extra audio cables, and also creates a nice self-contained unit for both audio and video. Additionally, the Oculus Rift and HTC Vive both allow software designers to create custom applications which take advantage of the hardware, while the PlayStation VR only works with PS4 games and software titles. The

Oculus Rift is clearly the winner in terms of price and functionality. It offers users an integrative experience with loads of features and doesn't break the bank in the process.

Now that the Oculus Rift has been chosen as the VR headset to be used in our virtual reality classroom, let's take a look at the hardware requirements needed by the PC's which will run this immersive piece of technology. *Table 2* in Appendix A outlines the minimum technical specifications for the Oculus Rift.

As shown in this table, the technical specifications for a system capable of running the Oculus Rift is rather steep; however, the PC chosen for this setup (see *Table 3* in Appendix A) is well suited for the task. It possesses specs which surpasses most of the minimum requirements, and has been certified by Oculus to run their product.

A few other pieces of hardware will also be required to make this a fully functional computer equipped classroom. For starters the room will need a projector which is attached to the teacher's workstation for instructional purposes. A dedicated air conditioning unit should also be installed to provide more cooling than a traditional classroom. This is required to compensate for all of the additional heat given off by these workstations (NY Dept. of Health, 2010). The installation and setup of these devices is beyond the scope of this paper, but it's still something to be aware of. Various forms of cabling will also be required, and each computer will need a standard monitor attached to it.

The room also needs to be equipped with Ethernet RJ-45 Voice/Data/Video ports at each workstation, and should be setup on its own dedicated switch and network segment to separate any extra data traffic from the rest of the school's production network. This will help reduce the impact these extra workstations may have on other computers in the building.

Now that the hardware has been defined and laid out, let's move on to the software component. All of this hardware means nothing unless software exists that can drive it. The actual creation of software for VR learning is beyond the scope of this paper, but let's take a look at some of the games/simulations available for the Oculus Rift, and based on this it will be possible to theorize what types of software could be created to compliment VR learning. The Oculus Rift comes with several titles which could prove useful when first getting students acclimated to the use of VR. One of the first experiences presented to new users, when putting on the Oculus Rift for the first time, is something called "Oculus Dreamdeck". This is a series of short interactive experiences which encourages the wearer to look around a 3D space and observe the environment. The wearer is transported to unique worlds and it can feel quite real after surrendering all senses to the simulation (Oculus, 2016). While none of these simulations are educational, they are the perfect first experience for anyone who hasn't used VR before.

Subsequently, a game called "Lucky's Tale" comes free with the Oculus Rift, and it is a very immersive experience which lets the wearer see exactly what types of games and/or simulations the Oculus Rift is capable of. Unlike "Oculus Dreamdeck", which is a first-person experience, "Lucky's Tale" is presented from a third-person perspective. As the player progresses through this world, it is possible to lean forward, and look around corners, to get a different point-of-view (Oculus, 2016). This type of experience takes some getting used to, but is just as unique and engaging as any other game offered on the Oculus Rift.

Now that the Oculus Rift's software offerings have been analyzed, how can this piece of hardware present students with an experience that not only engages but educates? As explored in the literature review section, VR has the capability to teach students new skills and increase their ability to solve complex problems, but what would a piece of software like that look like?

Someone would need to have a deep understanding of instructional design to truly understand that question; but for the sake of this paper, VR for surgical training will be used as an example of what VR software in a classroom environment could achieve. One fascinating distinction is the difference between education and training. “While these two terms are often used interchangeably, it is important to understand the distinction. Education usually refers to the communication or acquisition of knowledge or information, while training refers to the acquisition of skills (cognitive or psychomotor)” (Gallagher, Ritter, Champion, Higgins, Fried, Moses, Smith, & Satava, 2005). The use of VR lends itself to training more than simple education. There are a multitude of educational devices in the world for the mere transfer of knowledge, but VR adds a new level to the learning process; the acquisition of practical skills in a safe controlled environment. For example, Gallagher, Ritter, Champion, Higgins, Fried, Moses, Smith, & Satava (2005) analyze the use of VR for surgical training. In their analysis they theorize that error reduction is one of the most valuable aspects of VR simulations such as this. It is crucial to not make any mistakes when actually performing surgery, but in a VR simulation the student can make as many mistakes as necessary to learn the correct way to perform a task. This is one of the best aspects of VR learning, and reduces a student’s fear of making an incorrect choice.

When theorizing about the types of software to deploy in an educational setting it all depends on the class being taught, but one common thread is that the software should function as a simulation, and should also engage the student in such a way that they are not afraid to make mistakes. The simulation should also have quantifiable criteria to measure a student’s progress and current skill level (Gallagher, Ritter, Champion, Higgins, Fried, Moses, Smith, & Satava, 2005).

Now that both the hardware and software requirements for a VR equipped classroom have been explored, let's take a look at some space and design requirements. (This data was collected from a document created by the New York State Department of Health Bureau of Emergency Medical Services, and the Total Room Size was calculated based on the number of proposed workstations).

As shown in *Table 4* (Appendix A), the total classroom size was calculated at 2,700 feet. This should provide enough room to accommodate all 20 student workstation (and 1 instructor station) while at the same time not feeling overly crowded or cramped (See Appendix B). The network infrastructure of this room will also need to be setup in such a way as it does not interfere with the network traffic of other classrooms in the building. Each workstation will be setup with a network port on the floor with all of them converging at a new Cisco gigabit switch. That switch will then connect to the rest of the school's network and out to the internet. Bandwidth throttling techniques can be used on the switch to limit the impact of any extra network traffic on the school's data infrastructure. VLANs can also be used to further segment this new classroom (See Appendix C). Now that the final space/design requirements for a VR equipped classroom have been calculated, let's put it all together and calculate the final cost of this endeavor. (For simplicity this list only includes the hardware and equipment needed to get this classroom up and running. It does not include supplementary items such as desks/chairs, whiteboard, AC unit, carpet, curtains, network cabling/ports, or projector/screen).

As shown in *Table 5* (Appendix A), the estimated cost of all required hardware is $52,839.37. That is a substantial investment, and may be well beyond the budget of most educational institutions; however, it is possible to purchase some slightly cheaper workstations which would be capable of running the Oculus Rift. Additionally, a less expensive switch could

also be purchased which would still handle the necessary network traffic. This study approaches these items from a best case scenario where everything is state of the art. But that is not necessarily mandatory to implement this technology. Lastly, let's move on to the conclusions which can be ascertained from the information gathered throughout the course of this study.

Conclusions

Restatement of the Problem

The primary focus of this research was the exploration of what a VR enabled classroom would look like. This included the creation of a conceptual design which outlines the technical requirements (size, equipment, hardware/software, etc.) of a room which would be equipped to facilitate this type of learning. Thoroughly examining the use of VR as a learning tool will allow educators and administrators to consider the pros & cons of this type of learning. It also provides guidelines for anyone who may want to create a classroom equipped for education using VR by including an analysis of related hardware and software.

New Knowledge Discovered

The creation of a fully VR equipped classroom is something which has never been thoroughly researched or documented. This paper explored the requirements of such a classroom, and all of the hardware/software needed for this type of an endeavor. It began by comparing three VR headsets and determining which one was best suited for a VR enabled classroom. After determining that the Oculus Rift is the best headset for this type of learning the types of software which are available for this headset were briefly explored, and the types of learning applications which would be best suited for training scenarios were discussed. Lastly, both the size and cost requirements of such an implementation were analyzed. Diagrams were also produced which depict the layout of the classroom, and the network infrastructure setup.

Significance of the Findings

This study brings together various aspects from the realm of Digital Sciences such as Instructional Design, Simulation Games and Education/Virtual Reality, & Advanced Networking. The creation of a VR environment such as this requires some knowledge relating to how educational lessons are designed and created. The use of games in education must also be considered, as much of VR learning may come in the form of games and/or simulations. Various networking skills will also be utilized to make sure the proposed classroom environment can function as part of the schools' larger IT infrastructure. Overall, the implementation of VR as a learning tool has immense potential to change the way people learn and grow. The ability to take chances and make mistakes with no fear of failure takes our ability to learn and enhances it beyond measure. The finding contained within this research not only proves the validity of VR in education, but lays out and explains the primary components to make it a reality.

Limitations of the Study

The biggest limitation of this study is the sheer cost of the implementation. Some cost cutting measures can be taken which will reduce the overall impact, but it still requires a large investment. That being said, the long term cost savings for utilizing this type of training will eventually make up for the large initial cost.

Recommendations for Further Investigation

This paper only briefly touches on the types of software which would be required to utilize VR in an educational/training scenario. Further investigation should be made into this area of VR, and an actual software demo should be constructed which demonstrates the use of Virtual Reality as not only a tool for education, but as a device where its implementation is only limited by what people can dream up.

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Appendix A

Charts and Tables

Table 1

Virtual Reality Headset Comparison			
	Oculus Rift	**HTC Vive**	**Sony PlayStation VR**
Price	$599.99	$799.99	$399.99 + PS4 ($349.99)
Room-Wide Motion Tracking	No	Yes	No
Motion Controllers	Coming Soon	Yes	Yes
Platform	PC	PC	PS4
Open System	Yes	Yes	No
Built-In Headphones	Yes	No	No
Resolution (Display Type)	1200 x 1080 (OLED)	1200 x 1080 (OLED)	1080 x 960 (OLED)

Note. Data for Oculus Rift from Oculus (2016), Lamkin (2016), and Shanklin (2016). Data for HTC Vive from HTC (2016), Lamkin (2016), and Shanklin (2016). Data for Sony PlayStation VR from PlayStation (2016), Lamkin (2016), and Shanklin (2016).

Table 2

Oculus Rift Minimum System Requirements	
Video Card	NVIDIA GTX 970 / AMD R9 290 equivalent or greater
CPU	Intel i5-4590 equivalent or greater
Memory	8GB+ RAM
Video Output	Compatible HDMI 1.3 video output
USB Ports	3x USB 3.0 ports plus 1x USB 2.0 port
OS	Windows 7 SP1 64 bit or newer

Note. Data for Oculus Rift Minimum Requirements from Oculus (2016).

Table 3

Dell XPS 8900 Special Edition Specifications	
MSRP	$1,699.99
Video Card	NVIDIA GeForce GTX 970 4GB DDR5
CPU	6th Generation Intel Core i7 processor
Memory	16GB RAM
USB Ports	2 USB 3.0 Ports (Front), 4 USB 3.0 Ports (Rear), 2 USB 2.0 Ports (Front/Top), 2 USB 2.0 Ports (Rear).
OS	Windows 10 Home

Note. Data for Dell XPS 8900 Specifications from Dell (2016).

Table 4

Space/Design Requirements for a Computer Classroom	
Room Shape	Rectangle
Student Workstation Space	30-40 square feet (approx. 5ft x 6ft)
Anti-Static Carpet	Yes
Blackout Curtains	Yes
Total Number of Workstations	20 + 1 instructor station
Work Surface Height	26-29 inches
Projector & Screen	Yes
Whiteboard	Yes
Total Room Size	2,700 square feet (approx. 45ft x 60ft)

Note. Data for Space/Design Requirements from NY Dept. of Health (2010).

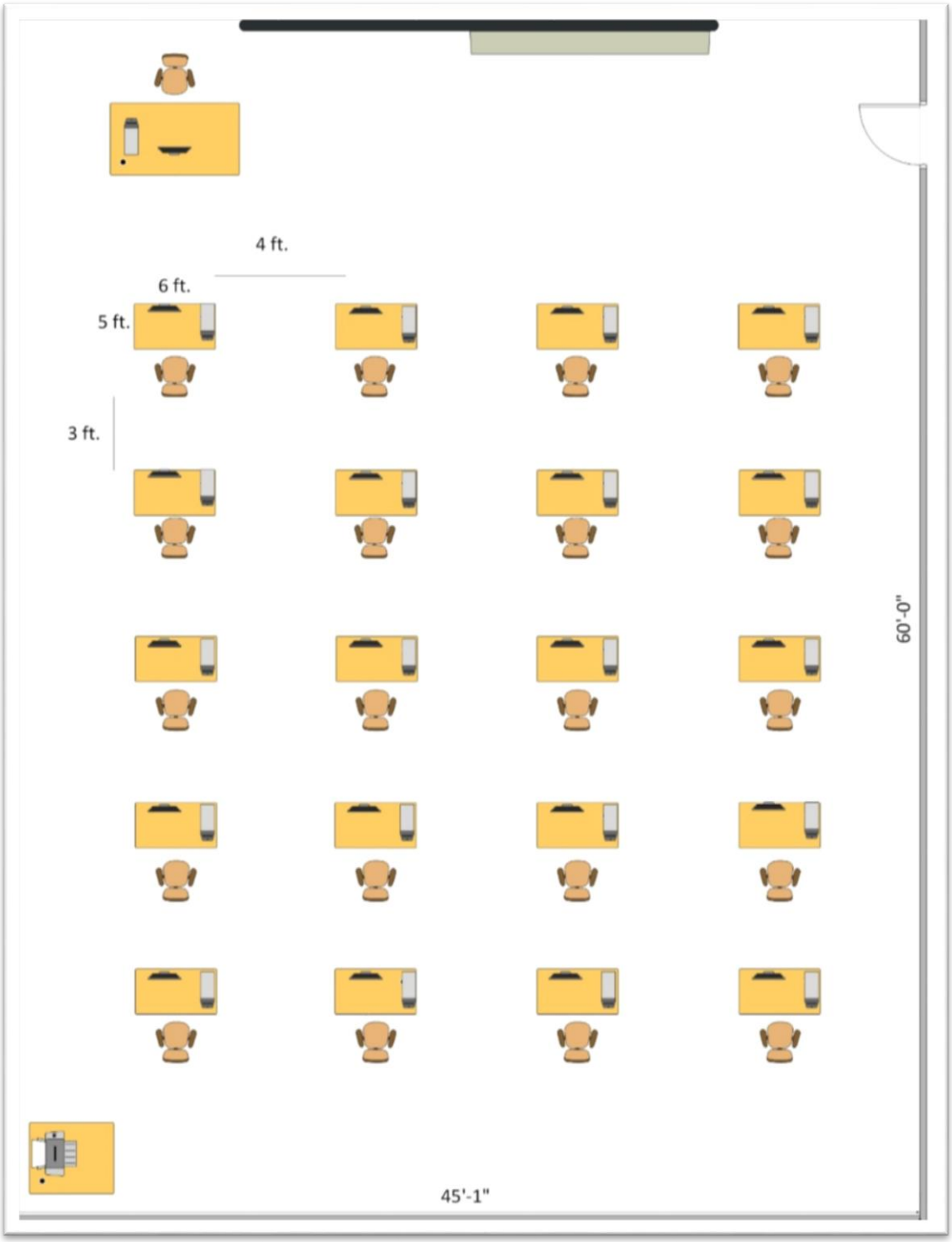
Table 5

Estimated Cost of VR Classroom Hardware			
Item	**Price/Unit**	**Quantity**	**Total**
Oculus Rift Headsets	$599.99	21	$12,599.79
Dell XPS 8900 Special Edition PCs	$1,699.99	21	$35,699.79
Cisco 3850 24-port Gigabit Switch	$1,600.00	1	$1,600.00
Dell 22” Monitors	$139.99	21	$2,939.79
Total			**$52,839.37**

Note. Data for Estimated Costs from Oculus (2016), Dell (2016), and Cisco (2016).

Appendix B

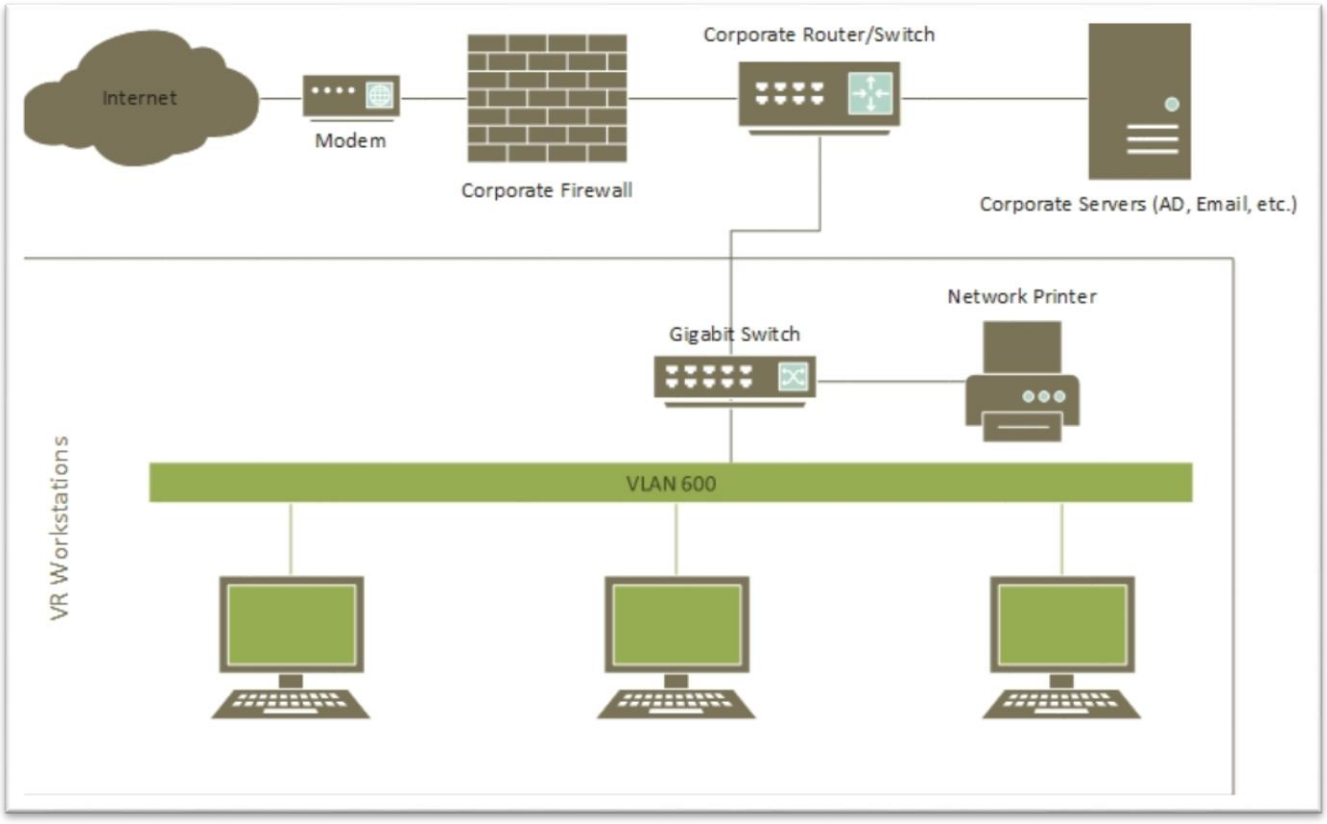
Room Layout and Dimensions



Note. Room layout diagram created by Jacob Adlon (2016).

Appendix C

Network Infrastructure Diagram



Note. Network diagram created by Jacob Adlon (2016).