School of Mechanical and Manufacturing Engineering

Faculty of Engineering

The University of New South Wales Sydney

The Development of a Guided Knowledge Base to Effectively Teach Virtual Reality Programming

By

Kate O'Sullivan

Student zID: z5161671

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Supervisor: Dr Susann Beier (UNSW)

ORIGINALITY STATEMENT

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Abstract

The purpose of this thesis was to create a knowledge base that newcomers to virtual reality game development could use as an introductory guide to effectively reduce the learning curve and time spent upskilling on the Unity game engine. All accessible game development tutorial formats were investigated, with the most effective and relevant tutorials used as external resources in the knowledge base. The knowledge base was able to eliminate confusion, increase confidence and reduce uptake take for first-time virtual reality users. Future work should include maintaining and updating the knowledge base as required, thoroughly testing the efficacy of the complete guide, and adding interactive quizzes.

Acknowledgements

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Table of Contents

List of Figures

List of Tables

Nomenclature

2D	Two-Dimensional
3D	Three-Dimensional
AF	Atrial Fibrillation
AR	Augmented Reality
HMD	Head Mounted Display
KB	Knowledge Base
MR	Mixed Reality
VR	Virtual Reality
XR	Extended Reality

Chapter 1 – Introduction

1.1 Virtual Reality

1.1.1 Introduction to Virtual Reality

A visual representation of the three dominant technologies that encompass the extended realities (XR) is seen in Figure 1.

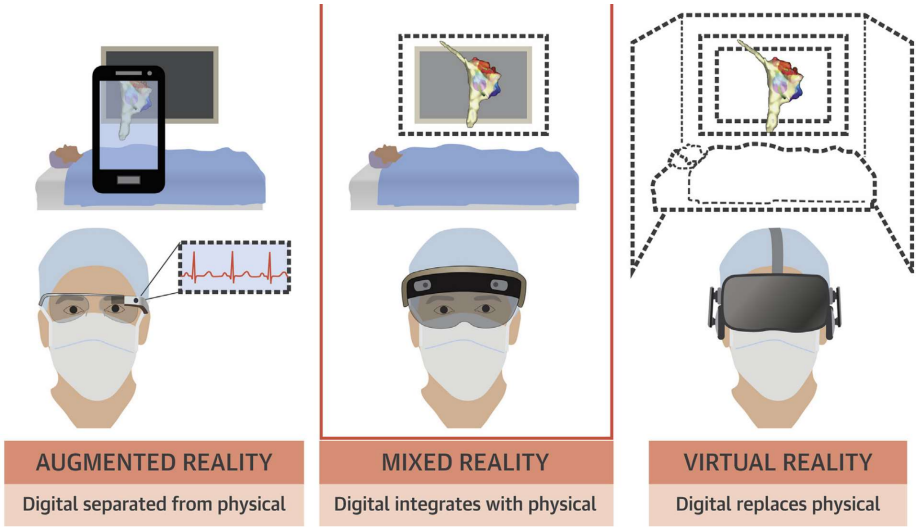

Figure 1: Visualisation of XR Technologies [1]

Virtual reality (VR) is a computer-generated simulation which digitally controls the wearer's visual and auditory experience. The user interacts in the digital environment with the possibility of some sense of touch [1]. VR simulations allow for interactive manipulations of models to aid in acquiring knowledge and practical skill in a safe environment that delivers a vivid and immersive experience [2].

VR has seen early acceptance and adoption from the video gaming community. The complete immersion works to enhance the game experience, making it more realistic and interactive. Headsets have become more commercially available and affordable as the technology has improved. Further, the uses of headsets and available applications have expanded, given the increased uptake of the devices.

In comparison to other XR technologies, VR provides an entirely immersive experience as users wear a head mounted display. VR also produces the widest field of view and has the highest quality image and colour representation [3].

UNSW currently owns several Oculus Quest 2 VR headsets [4], often rated the best VR headset on the market. The rating is a result of the native hand tracking feature. Therefore, they will likely be the headset used in this project. Oculus Rift, HTC Vive, and Valve Index are all popular VR headset models on the market. HP states that its 2020 Reverb VR Headset is the "new benchmark in Commercial VR" [5].

1.1.2 Virtual Reality in the Medical Field

In the medical realm, the use of VR technology dates back at least to the 1990s [6]. The tool is currently used for stroke rehabilitation, pain management, and exposure therapy [1]. VR has also been found to be highly useful in surgical education and planning. This is a consequence of the repeatability of the simulations to help build muscle memory, and the total immersion means that the simulations can occur anywhere and anytime.

Developing VR simulations is particularly helpful to train surgeons with complicated surgical techniques in a safe environment, leading to better outcomes for surgeons and patients. An example of such surgery is catheter and cryoballoon ablation used to treat atrial fibrillation (AF) patients. AF is the most common sustained heart arrhythmia, causing the heart to beat irregularly and chaotically [7, 8]. AF is a significant health challenge, particularly for developed nations, and its prevalence is on the rise. 6-12 million people are expected to develop AF by 2050 [9].

1.2 Learning Virtual Reality

Understanding game development is critical to advance VR use in all settings, including within the medical field. However, with no prior game development experience, it is time-consuming and confusing to learn. A simple Google search of "How to make Virtual Reality Games" gives rise to about 303 million results. Consequently, without a structured guide, it is almost impossible to know where to start, which may be off putting and prevent many people from discovering the possibilities of VR and game development. Game development is game construction, whether that be in 2D or 3D for virtual reality.

1.3 Thesis Aims

This thesis project aims to build a guided knowledge base (KB) for people wanting an introduction to VR and game development to reduce the confusion, initial learning curve, and any time-wasting activities that would arise when learning independently.

The KB will have additional resources for students working in the medical field, for example when working towards building ablation surgery simulations. In turn, users will spend less time upskilling and more time developing simulations for the virtual world, which will be particularly beneficial for students on projects with a set time frame.

Chapter 2 – Literature Review

2.1 Use of XR Technology in the Medical Profession

2.1.1 Surgical Training and Education

Simulation teaching has risen in necessity as the clinical duty hours of trainees and experts have been reduced to prevent fatigue [10]. Simulation teaching is defined as "a technique to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner" [11]. XR has become an established practice for medical students to gain and retain anatomical and surgical knowledge and skill. The use of XR for surgical training also eliminates ethical problems, such as the use of cadavers and improves patient safety. A 2021 French review of simulation teaching in cardiology highlighted that simulation training can aid in the transfer of learning and should be embraced to master complicated techniques and to gain experience in high-pressure crisis scenarios [10].

Many studies [1, 6, 12-15] have demonstrated the usefulness of simulation in healthcare education and training. These studies have proven that there is a significant correlation between surgical performance in simulations and operating rooms and the effectiveness of simulation in retaining knowledge and acquiring technical skills. Studies have also proven that trainees who use VR simulation in their curriculum are quicker to complete their learning tasks than peers who did not use VR [6, 10]. However, more research needs to be performed to validate the transfer of technical skills from simulation to open surgery and evaluate the impact on clinical outcomes [15].

A 2021 review of medical simulation techniques found that 78 per cent of simulations were custom-built and required custom hardware or props [16]. Though this means the simulations can be specifically tailored to the study's needs, the simulation is therefore not commercially available for medicine fellows to utilise. This review however, primarily focused on using AR or MR. By incorporating aspects of the real world into a digital space and utilising VR technology, the system can be simplified and eliminate the need for expensive specialised equipment.

One such study [17] used AR for the visualisation of tubular structures, in addition to physical stimulation, to reproduce realistic surgical scenarios, such as the interactions between surgical instruments and anatomy. This simulation aided medical students' practical skills and complements simulations that focus on students' knowledge of anatomy and medical procedures. For example, a VR experience was designed to improve students' learning in AF to educate patients effectively [8]. The simulation was a 320 second narrated overview of the AF ablation procedure, which consequently improved confidence and knowledge scores.

2.1.2 Preoperative Planning

Preoperative planning is an essential decision-making process for surgeons, as it requires consideration of the desired result and the surgical tactics and logistics to achieve it [18]. This can be made difficult when attempting to gain a complete perspective of complex procedures from traditional 2D screens. Therefore, XR technology has been advanced to view patient-specific information in a 3D interactive format. Consequently, surgeons can make better, safer, and more informed decisions for their patients.

For surgeons, visualising and manipulating personalised 3D models in VR enhances their understanding of the patient's condition, as in Figure 2. The IMHOTEP framework took patients CT and MRI scans and transformed them into 3D models, which were then available to view and interact within the VR space [19]. This advanced visualisation allowed surgeons to better consider the patient's anatomical situation before commencing the surgical operation, leading to greater precision and more informed decisions and better outcomes.

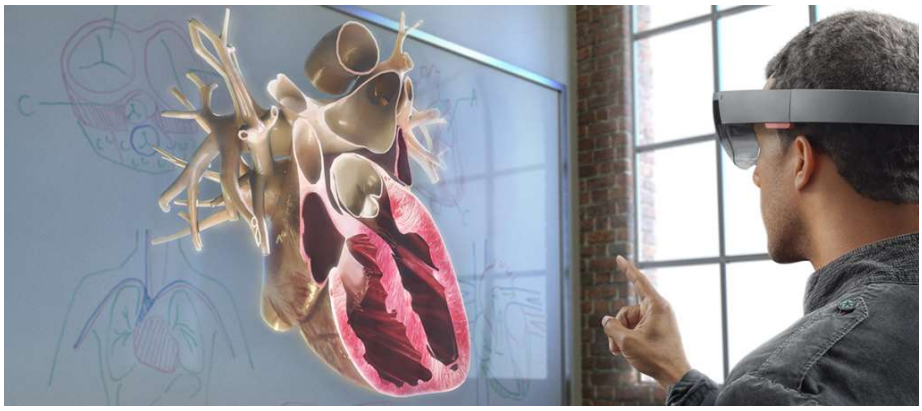

Figure 2: Explore Heart Anatomy using VR [20]

The FaMaS-VR user interface evolved from the IMHOTEP progress to enhance the interaction between the surgeons and the 3D VR models, specifically for the treatment of heart arrhythmias such as AF. The FaMaS-VR tool enabled surgeons to test various placement options for ablation lesions in real-time. This provided a safe and ethical method for surgeons to consider, plan and determine the most appropriate ablation strategy. The program was deemed intuitive by more than 95 per cent of tested students and researchers [8].

There have been several tools that have utilised patient images to create 3D VR images and assist surgeons in planning procedures. The MedicalVR platform utilised DICOM images specifically for cardiac surgeries. However, unlike most other studies, this technology was used successfully in clinical practices, aiding in the preoperative planning of cardiothoracic surgeries. The surgeons were particularly interested in the technology to view the patient's anatomical structures to determine the ideal location for surgical access [21, 22].

VR is the most appropriate technology for preoperative planning as it creates complete immersion and higher resolution of images in comparison to other XR technologies. This is important as the technology becomes used in clinical practice to provide greater precision and further assist surgical planning.

2.1.3 Open Surgery

AR and MR technology is more suitable and reliable than VR to implement intraoperatively, as users can communicate with their team and be aware of the physical environment. There are two dominant uses of XR in live surgeries that have been tested.

Firstly, AR technology uses 3D models generated before surgery, from CT or MRI scans, and superimposed on the surgeon's field of view. This provides surgeons with better spatial visualisation and improved safety for patients [23]. During pancreatic surgery, this has been used to identify lesions and make safer dissections to preserve adjacent vessels or organs [24]. However, further advancements in live organ tracking to overcome organ shift and deformation post-puncture issues are essential before this technology can become the norm in clinical practice [25].

The second use of XR technologies intraoperatively is to display 3D information in real-time, traditionally viewed on 2D monitors. Surgeons used MR headsets to view real-time 3D data obtained using Electroanatomic Mapping Systems and 3D transoesophageal echocardiography during live electrophysiology procedures and structural percutaneous cardiac interventions [3, 26].

AR and MR technology is the future of surgical procedures increasing precision, speed, and patient safety. However, this technology requires development to improve display quality, alignment errors, and ergonomics for more intuitive use.

2.1.4 Limitations in the use of VR and AR

Despite the recent exponential improvement in XR technologies and usage in the medical field, there are still limitations preventing the technology from surpassing current practises. These include initial setup costs, which was listed in a study of general surgical residents and experts as the primary barrier to its uptake [27]. Headsets can cost as much as $1399USD, and sufficiently powered computers can cost upwards of $2100USD [28]. Furthermore, multiples of equipment need to be purchased to allow for simultaneous users. Additional costs include accessories, such as hand controllers, the costs for the programs and necessary licensing to be loaded onto the devices, and the ongoing cost of repairs and upgrades [10].

In current commercially available technology, compromises are made between cost, usability, and quality [1]. Often inexpensive VR headsets lack the high quality, detailed display required for effective simulation. Tethered headsets restrict movability and often add to the headset's weight and size. Untethered headsets allow free movement but entail shorter usage times and have a reduced field of view. As technology improves, these compromises will be reduced. The current rapid rate of technology improvement in the extended realities however creates uncertainty when trying to justify substantial financial investments that could become outdated within a matter of years.

If an appropriate headset and necessary funding can be found, there can still be ergonomic problems in using these devices. In a study involving 170 participants using the Microsoft HoloLens, 26 students suffered headaches, and 17 felt nauseous and experienced eye fatigue or neck strain [29].

Implementing innovative technology introduces a learning curve for all, and considerable time may be required for teaching staff to learn how to use, assist, and assess students in the virtual world. Not only does this take time away from medical experts working in their field, but it may require further costs for training packs and user demonstrations. The success of the student's learning in the simulated environment is almost entirely dependent on the teacher's medical and technical expertise [10, 21].

Unfortunately, there are still limitations in the current technology, restricting the immersive nature and accuracy of the simulated environment. The lack of haptic feedback (the expected sense of touch) is one of the drawbacks when interacting with objects in the digital world [1, 10]. Haptic cues allow for greater immersion and a sense of presence in the virtual world [30]. This is emphasised by a study [31] which ascertained that surgical simulations require haptic feedback to provide a complete experience for trainees. Furthermore, the feel of using standard hand controllers, such as the Oculus Quest 2 hand controllers in Figure 3, compared to medical-grade tools, reduces the simulation's realism. A concern is that the transfer of skills from simulation to live surgery may diminish with the different hand positions with the controllers and the lack of tactile feedback [32].

Figure 3: Oculus Quest 2 Controllers [33]

Another option to create a more natural hand position would be to implement the use of VR haptic feedback gloves, such as the Haptx Gloves DK2 (AxonVR LLC, Seattle, United States) or the Dexmo Force Feedback Gloves (Dexta Robotics, Shenzhen, China), both seen in Figure 4. These gloves both feature an exoskeleton design that allows hand movement and can physically displace the users' hands as would an object. However, this would be an additional expense, requiring upkeep and upgrades. The most viable and accessible VR simulation should use as few accessories as possible, which will minimise cost, maintenance, and complexity, and reduce need for retraining.

Figure 4: Haptic Feedback Gloves - Haptx DK2 [34] (left) and Dexmo [35] (right)

Finally, tracking and alignment errors occur when attempting to place digital images in the real world. This is a critical issue that restricts the use of XR in live surgeries, as there are problems both in the alignment of an image onto the human body and the tracking of hands or controllers in the physical space [3]. Tracking of controller movement can be achieved to the necessary accuracy with instruments such as NDI's Aurora [36]. However, this comes at a high cost and requires supporting equipment. Live tracking of a patient's physical positioning is more challenging to achieve. A study [25] showed that accuracy could be achieved in the virtual world with a 2.5mm error. This translated to an error of 12 - 17mm in the physical world. Another study [17] reduced errors to a mean of 0.35mm, with a maximum error of 0.99mm. Both margins of error are deemed unacceptable in clinical application, but it is interesting to note that most of the error occurred in the z-axis. This suggests that errors occurred by the operator pushing down and deforming the target area. Live organ tracking could be implemented to negate the body's deformation; however, this area requires further development to be suitable for use [37].

AR provides the ability to stay present and communicate in the physical world and is far more suitable for open surgery. However, presently VR technology is surpassing AR and MR in terms of quality and detail of image produced. AR also restricts the users' field of view and does not provide the immersive and realistic experience of VR. Though the immersion into the digital world is unsuitable for operating room procedures, VR models are more accurate and reliable and prove highly useful for simulating surgery for training purposes.

2.2 Learning Virtual Reality

2.2.1 Learning Game Development for Virtual Reality

The issues limiting the use of XR technology in medicine are also preventing their use in schools and universities. Primarily this is the high setup costs for equipment, accessories, and upkeep [10, 27], as well as the rapid pace at which the headsets and accompanying software are updating.

Currently, options to learn game development in a structured course are very difficult to locate. Some institutions, such as SAE Creative Media Institute, offer formal courses on game development. This is not however an individual course to introduce game development, but a complete university level, multi-year, expensive program leading to degrees [38]. Therefore this is inaccessible to most who are not specifically aiming for a career in game development. Consequently, most students have not been taught game development.

In creating a university elective course on game design and development, trial and error were able to map a path to successfully teach game development without prior experience [39].

The first decision was which game engine should be used. A game development engine increases the efficiency and simplicity of game building "by handling complex computations such as object physics, 3D primitive shape creation, animation, sound, collision detection, and trigger events" [40]. When deciding which engine to use, a seven-step guide has been created [41]:

1. It must be easy to learn
2. It must be popular to attract student interest and prevalent in industry use cases
3. It must support programming languages with which students are familiar
4. It must allow development under both Windows and macOS
5. It must have a stable implementation
6. It must have sufficient documentation and a strong online community for support
7. It must be inexpensive to acquire and use

Table 1 nominates various game engines and compares their available languages, what computer system/s they work with, their approximate community size, and price.

Table 1: Various Game Development Engines and how they fit the criteria for use [40]

GE	Available Programming Languages	Dev OS	Help Community	Price
Blender	Python	macOS, Windows, Linux	Large	Free
CryEngine	C++, Flash, ActionScript, Lua	Windows	Medium	Subscription
Frostbite	C++	Windows	Medium	Proprietary
Lumberyard	C++, Lua	Windows	Small	Free
Source 2	C++	Windows	Medium	Free
Torque3D	C++, TorqueScript	macOS, Windows, Linux	Large	Free
Unity	C#, JavaScript, Boo	macOS, Windows	Large	Free
Unreal	C++, Blueprint	macOS, Windows, Linux	Large	Free

After analysing all available options and removing those without VR capabilities, Unity was selected as the game engine of choice. It most comfortably meets all the given criteria. It was noted to have the shallowest learning curve. It is free for educational purposes and accessible cross-platform [39]. More recently, Unity has pulled ahead as the go-to platform for game development. In fact, "as of September 2019, 52% of the top 1,000 mobile games were powered by Unity, as well as 60% of all AR/VR content" [42]. Furthermore, it supports all virtual reality headsets, which eliminates any issues if a headset manufacturer changes. Consequently, Unity skills and knowledge is valuable in the gaming industry, where the game engine has become prevalent.

Unity has published a comprehensive set of learning courses for all skill set levels, called Unity Learn [43] to help users learn the platform. Additionally, there is a thriving online community of Unity users which can be found on blogs offering support and answering questions.

Following the decision to use Unity as a game engine, there comes the decision of how to effectively and efficiently teach students how to use it, so they are able to spend more time on game development. In this instance [39], a textbook was followed, but once the course was implemented, the book was out-of-date, and therefore online sources were required to complement the resource. Each week, students would complete a chapter of the text and recreate the example built as a lab assessment. This forced students to continually make progress in learning Unity, and at the end of the course, all groups were able to build a playable game.

Though this method was successful, the paper was written in 2015. Even then, the most significant area of concern was "the rapid development of Unity and the effect this has on finding up-to-date materials to work with" [39]. Since then, Unity has grown exponentially and has outpaced authors. However, the method of continuous and gradual improvement through example recreation is still relevant and practical.

2.2.2 Effective Methods for Distance Digital Learning

A Knowledge Base (KB) collates resources and information about a topic, presented in a self-serve format [44]. This KB must assume users have no experience as is the case for most students without courses in schools or universities.

The self-serve format allows students the freedom to choose how and when they study. It has been proven an effective study method, but only when appropriate strategies are used. Students must choose to spend more time on complex problems. Significant issues however arise out of the accuracy of memory monitoring. Students may have biases and inaccuracies in their understanding and comprehension of the topic. For example, "poor students overestimate performance by up to an astonishing 30% of their actual test score" [45].

In addition, students tend to spend more time on areas they enjoy and may actively avoid topics they deem more difficult. Consequently, students can make counterproductive decisions regarding time spent on a subject [45]. Introducing recommended timeframes to spend on each step of the KB will help reduce students' biases and create better learning outcomes.

One problem that may arise from having a singular resource format is that it does not cater to a diversity of students and their varying study preferences, often divided into learning styles. Learning styles can be defined as preferences in the learning situation, or the approach students generally gravitate towards when acquiring a new skill or piece of information [46]. Though there is a myriad of learning categories, the three most used are pictured below in Figure 5 and can be defined as:

- Auditory Learners: These learners interpret information through auditory cues such as pitch, emphasis, and speed and learn through listening.
- Visual Learners: This is the most common of the presented learning types. These learners tend to think in images and learn best through pictures.
- Kinaesthetic Learner: These learners work best when interacting with the physical world, often through demonstration and replication of actions. '

Figure 5: Learning Styles [47]

A KB would need to incorporate all three learning styles to be accessible and effective for all students.

Finally, an effective KB designed for self-paced learning needs to look towards the lessons learnt during the COVID-19 pandemic in terms of distance learning. Distance learning occurs when students and teachers are separated by space and possibly time and utilises a broad spectrum of technologies [48].

Current students have now been exposed to at-home learning more than any other generation has before them and know how best they learn away from the classroom setting. Various pieces of literature [49, 50], include three suggestions to incorporate into distance learning to increase student engagement and success.

1. The source of information must be intuitive, user friendly, and well maintained. Students will become uninterested when the resource is too hard to use, as more time will be spent trying to understand the source rather than learning the content.
2. There needs to be some form of interaction with the material. Whether that be a follow-along tutorial where students can create something, a quiz, or group work. Without these elements, students tend to absorb information passively, and therefore nothing will be retained.
3. Students need someone they can comfortably talk to when they have questions. Many knowledge bases utilise a chatbot. However, a supervisor they can quickly communicate to is equally or more effective.

The key takeaway is that to create an effective learning tool that teaches VR game development, content needs to be designed explicitly for the environment in which it is taught. In this instance, the content will be presented as an asynchronous, distance learning program. To keep students engaged and interested in the topic, the tool must be intuitive, interactive, and accommodate diverse students' learning preferences and styles.

2.3 Future Direction of XR in Medicine

The role of the XR in medical practice will develop as the technology improves and becomes more accessible and ergonomic. With more access, more minds can consider newer and more incredible ways to utilise the technology as its performance and reliability improve.

Research needs to be performed to clarify and validate the ability of trainees to retain skills from VR training, as more authentic simulations and haptic capability are introduced. Simulations should be developed to address more complex cardiac procedures and promoted by establishing a training curriculum [10, 12].

Based on the current commercially accessible technology, it seems best to explore VR as it is more advanced, provides more detail, and creates the most realistic simulations. Introducing hand tracking to medical simulations has the potential to progress the virtual world experience further. The realism of the simulation may be further enhanced by adding basic props in the physical world that align with rendered objects in the digital world [21, 51]. This will provide haptic feedback to enhance the user's presence in the simulation.

To truly create realistic medical simulations, access to patient data would be required. Live positioning data could be used cohesively with VR technologies to enhance user experience with better visuals and real-world accuracy.

Students however need to learn how to develop games for VR applications. Without easily accessible game development courses, students will waste valuable project time on upskilling rather than building meaningful simulations. Therefore, it has been determined that a resource to teach VR game development is necessary. Future students will benefit from previous work by creating a resource that students can refer to and then update as they make their game development advancements. This will lead to faster progression of VR projects as they are handed off to new students in the long term.

Chapter 3 – Methodology

3.1 Overview

The primary objective is to build a guided KB to effectively learn VR game development to reduce the time it takes to upskill. Users of the KB could include novices to VR and game development. There is also a focus on students wanting to learn VR to develop simulations in the medical field. Therefore, the tool must explain the entire process of using the VR headset for the first time, connecting it to a computer, downloading relevant software, and using Unity for game development. Figure 6 illustrates a high-level overview of the process followed to create the KB, working from top to bottom.

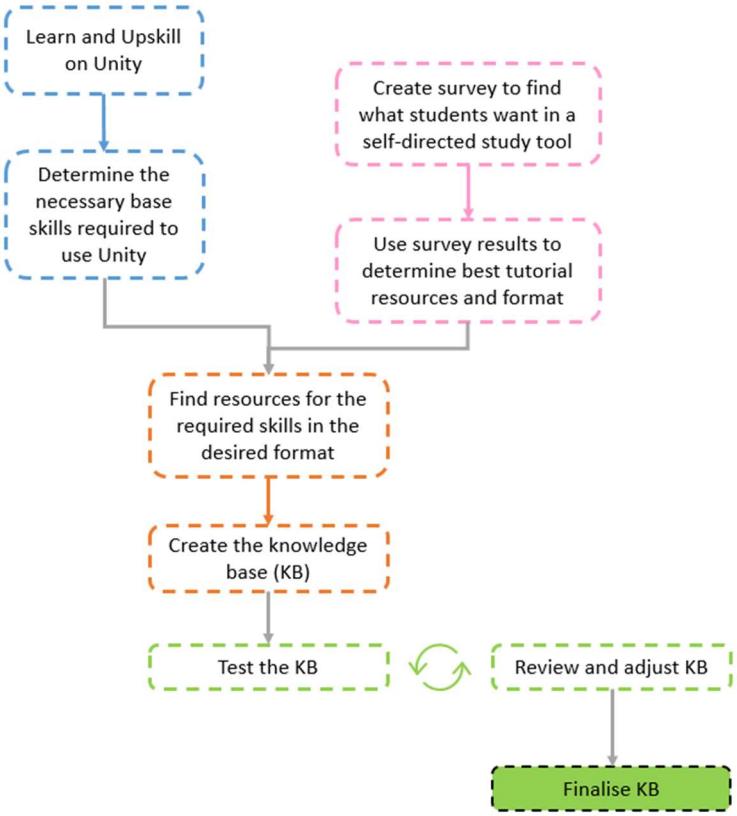

Figure 6: Methodology Overview Flowchart

3.2 Determine relevant Unity skills

3.2.1 Learn and Upskill on Unity

The first step was to learn how to use Unity and understand which tutorials effectively teach the game engine. Therefore, textbooks, online tutorials, blogs, and Unity Learn were all utilised and ranked in terms of efficacy in teaching.

To evaluate the effectiveness of each tutorial format, the tutorial should be replicated 24 to 48 hours after the initial learning without the tutorial in hand. This tested memory retention and the fundamental understanding of the Unity skill/s that should have been communicated in the tutorial learnt. For example, the steps may not have been completed in the perfect order. Still, if a decent replication of the original content were achieved, the tutorial would have effectively taught the skill.

3.2.2 Determining the required skills for the knowledge base

At this stage of the process, all skills required for basic game development should have been learnt. It was found that from upskilling, and experience from Joshua Dawson (another thesis student who also used the Unity game engine for the first time) the necessary skills to successfully develop games will be determined. It is essential to differentiate the steps relevant only to Joshua's thesis from critical steps for all game developers. Additionally, there should be content around setting up any required software and guide any use of hardware.

3.3 Survey for Knowledge Base Formatting

Though the personal experience was critical when determining what tutorials are most useful for VR game development, it was essential to eliminate biases. Therefore, a survey was created to discover what students who have experienced distance learning find the most useful for their education. The objective of this part of the survey would be to determine the best content type for the KB, whether that be a video tutorial, textbook, or something entirely different.

The secondary objective of the survey would be to find students' preferred format for the KB. That is, how the KB resource itself is presented. The options were either a PowerPoint presentation, Word Document, or a specially designed website.

The survey must be easy and quick to complete to ensure responders answer all questions appropriately.

3.4 Creating, Testing, and Finalising the Knowledge Base

3.4.1 Creating the first draft Knowledge Base

Following the survey and upskilling on Unity, the project's next stage is to build the KB. The learnings taken from the survey clarified that YouTube tutorials are a preferred mode of study and that the KB will be made on PowerPoint.

The first step in building the KB was to define all the steps. Each step was given one slide, with the ability to link additional material to other slides.

Once a general plan of all the steps was made, the content needed to be inserted. There was an attempt to find a video demonstration for most actions as this was the preferred learning method. Between the survey results, personal experience learning game development, and literature, tutorials used in the KB must meet the following criteria.

- ✓ Be a follow-along, step-by-step demonstration.
- ✓ Have at least a transcript or the steps written out.
- ✓ Have been created in 2021.
- ✓ Be able to stand on its own as a tutorial, i.e., it does not require watching previous tutorials.
- ✓ Have an engaging presenter with an understandable accent and who speaks at an easy cadence.
- ✓ Not exceed 35 minutes.
- ✓ Not double-up on content previously learnt.
- ✓ Be relevant and have a known purpose towards developing Unity skills.

Following that, each Unity tutorial needed to be revamped with the latest installation of Unity. Whilst completing the tutorials, timestamps were taken of any step that was not entirely obvious or may have slightly changed following an update, from the video demonstration or the accompanying narration. Next, a better and more explicit explanation of that step needs to be added to the tutorial slide with the timestamp.

For some of the setup process, there was no video demonstration. Therefore, straightforward steps with screenshots of relevant instructions were attached.

Anything additional to the core step, such as troubleshooting methods, was also linked to a separate slide in the presentation.

Finally, once all the content has been added, it is essential to ensure uniform and clean formatting. Users do not want to be distracted by many graphics and instead want to visualise the content easily. Additionally, a progress bar and "Mark Step as Complete" button should be added to match the Unity Learn tool. Any links, particularly external links to videos, should be obvious to use.

3.4.2 Testing the Knowledge Base

The knowledge base must then be tested on people with a range of Unity and VR skillsets. Users will be given the KB without instruction and report back on their experience using the KB.

Users without Unity experience should then be quizzed on how helpful the KB was. Some questions that could be posed include:

1. How intuitive was the KB to use?
2. How confident do you now feel in your skillset developing games in Unity?
3. If you were challenged to replicate the project/s made throughout the tutorials, would you be able to do it?

On the other hand, users with Unity experience should be asked a different set of questions.

1. How intuitive was the KB to use?
2. What method did you use to learn Unity game development?
3. Was using the KB easier than the method you used, and which method do you prefer?
4. Are there Unity game development skills you believe are necessary to learn that are not available in the KB?

The first section of the KB is dedicated to brand new users of VR headsets. This should guide users through the initial setup phase to correctly connect the headset to their computer. It should also guide users through their first experience in VR. Users of the KB should also additionally be asked:

1. Did the KB help you during your first use of the VR headset?
2. Is there additional information you feel should be provided to first time VR users?

3.4.3 Refining and Finalising the Knowledge Base

Feedback from testing will contribute towards refining the KB. The KB also needs to be maintained and monitored, as any update to Unity may result in slight changes to the user experience.

Following each update of the KB, it should be re-tested on a new set of users. Similar questions should be asked, and the process of refining should continue.

Once new users are entirely confident in the Unity skills following using the KB, and experienced Unity users feel that the tutorials are comprehensive enough as an introductory tool, the KB can be finalised and published.

If significant upgrades to the Unity package occurs, the KB may need to be adjusted to fit. Minor changes, such as bug fixes, should not cause too many headaches for users.

Chapter 4 – Results

4.1 Finalised Knowledge Base

The finalised KB is a 35 slide PowerPoint, shown in Appendix A – Completed Knowledge Base Slides. A summary of the slides is presented in Table 2. This KB eliminates confusion for students learning VR game development for the first time. It walks students through their first use of a VR headset, installing the necessary software, and taking the guesswork out of finding helpful, relevant, and up-to-date tutorials to demonstrate game development.

Table 2: Outline of KB Slides

Section Title: Title Slides			
#	**Slide title**	#	**Slide Title**
1	Title Slide (VR Knowledge Base)	2	Table of Contents
Section Title: 01. Set Up Headset			
3	Section Contents	4	Explore and Set Up your Headset
5	Set Up Oculus App	6	Using Oculus Link for Set Up
7	Using ADB Drivers for Set Up	8	Example Command Prompt (Windows)
9	Connect Headset to computer	10	OPTIONAL: Enable Wireless Connection
Section Title: 02. Unity Set Up			
11	Section Contents	12	Download Unity Hub
13	Install Unity Module		
Section Title: 03. Unity Basics			
14	Section Contents	15	Introduction to Unity and Navigation
16	OPTIONAL: In-depth Unity Tutorial	17	Create a Unity Scene
18	Apply Hand Controllers	19	VR Interactable Objects
Section Title: 04. Extra Unity Tutorials			
20	Section Contents	21	Calibration: Aligning the real and virtual world
22	Recreate an environment in VR	23	User Interaction
24	Hand Tracking	25	Completed!
Miscellaneous Slides Linked Throughout Previous Slides/Steps			
26	Troubleshooting Methods to Connect Headset with ADB Driver	27	Calibration Method
28	Calibration Code	29	Install android_winusb
30	Troubleshooting: Building and Running Unity Program through ADB	31	Troubleshooting: Test in VR with Oculus Link
32	Troubleshooting: Test Live with Laptop Device Simulation	33	Updates on Setup
34	Tips to Reduce Blurriness	35	Controller Explanation

Each section features a Section Contents page, as seen in Figure 7. The purpose of this slide is to establish the direction of the section. It allows students to have an idea of the content that is about to come up. Furthermore, each sub-title, such as "Apply Hand Controllers", is individually linked to the respective slide to allow students to skip to the desired tutorial quickly.

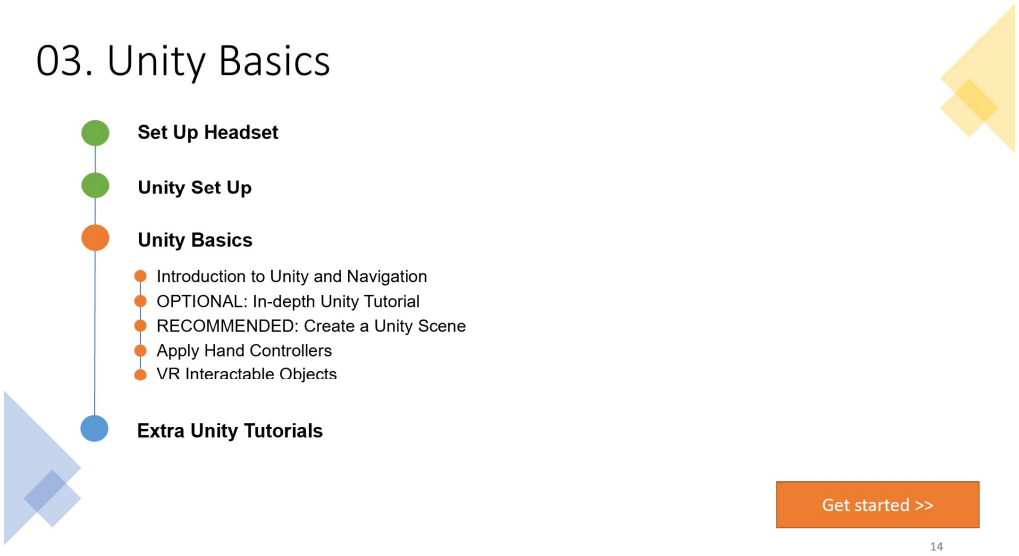

Figure 7: Section Contents Example Slide

Each tutorial slide page features a progress bar of the stage, as seen on the left of Figure 8. Once the user clicks the "Mark Step as Complete" button in green on the bottom right, the slide will move to the next stage of learning. The orange circle on the progress bar, which indicates the current step in the section, will then turn green. The blue circle marks the number of steps to come.

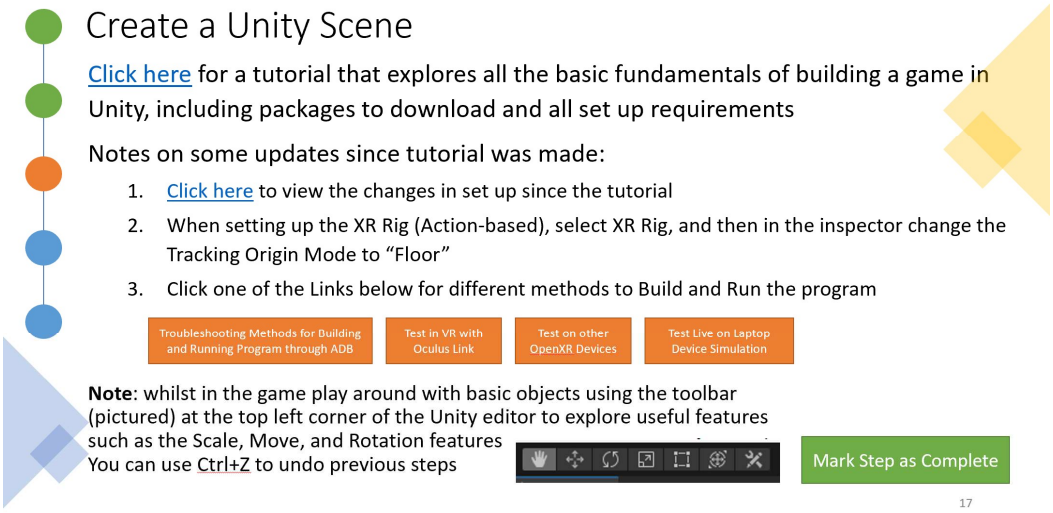

Figure 8: Tutorial Slide Example Page

There are two links in the slide featured in Figure 8 that users can click on to access. Using a blue, underlined font and the words "Click here" means users instantly know to click on the link.

The first link takes the user to the YouTube tutorial. The tutorial could have been inserted onto the slide; however, navigating outside the resource to the web page will allow the user to simultaneously have the tutorial and the PowerPoint ready to use and reference. Therefore, students can see the notes as they go through the tutorial. This necessity is more apparent in Figure 9, where the notes are presented with timestamps for reference throughout the tutorial.

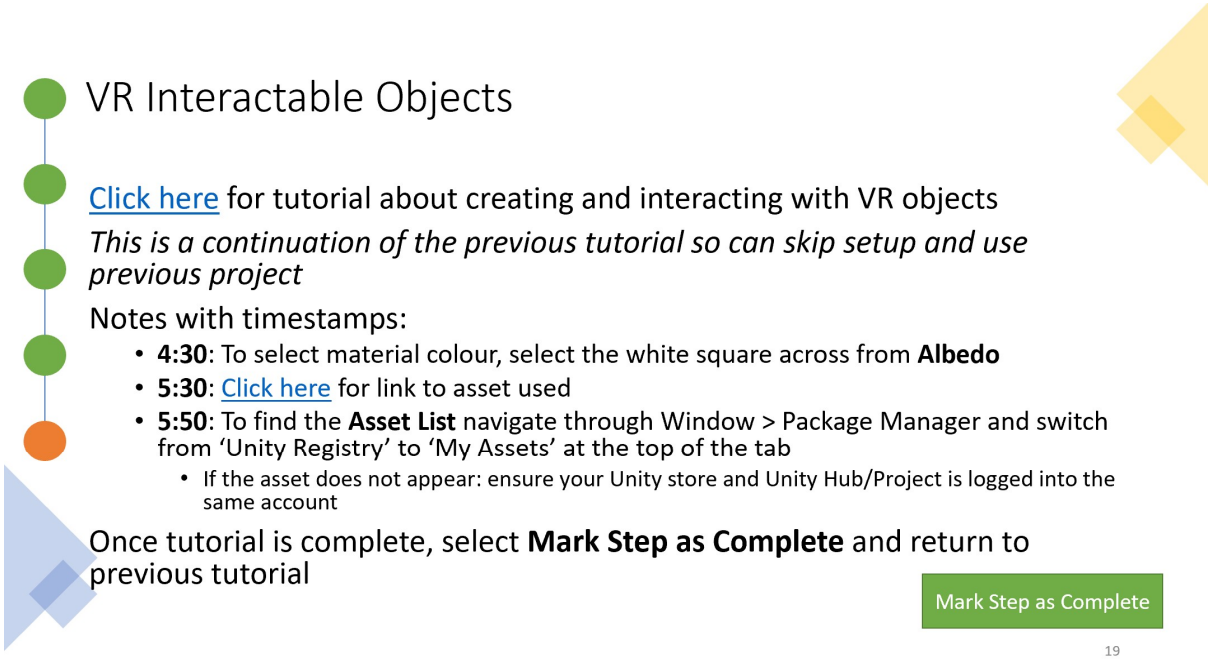

Figure 9: Example Tutorial Slide with Timestamped Notes

The second link on Figure 8 takes the user to the miscellaneous slide, "Updates on Set Up". This slide, shown in Figure 10, breaks down changes in the Unity setup since the tutorial was published. Though most of these changes may be intuitive, it was vital to eliminate all potential confusion.

Figure 10 differs from the tutorial slides as there is no progress bar, and the step completed button would return the user to the Unity Tutorial in Figure 8.

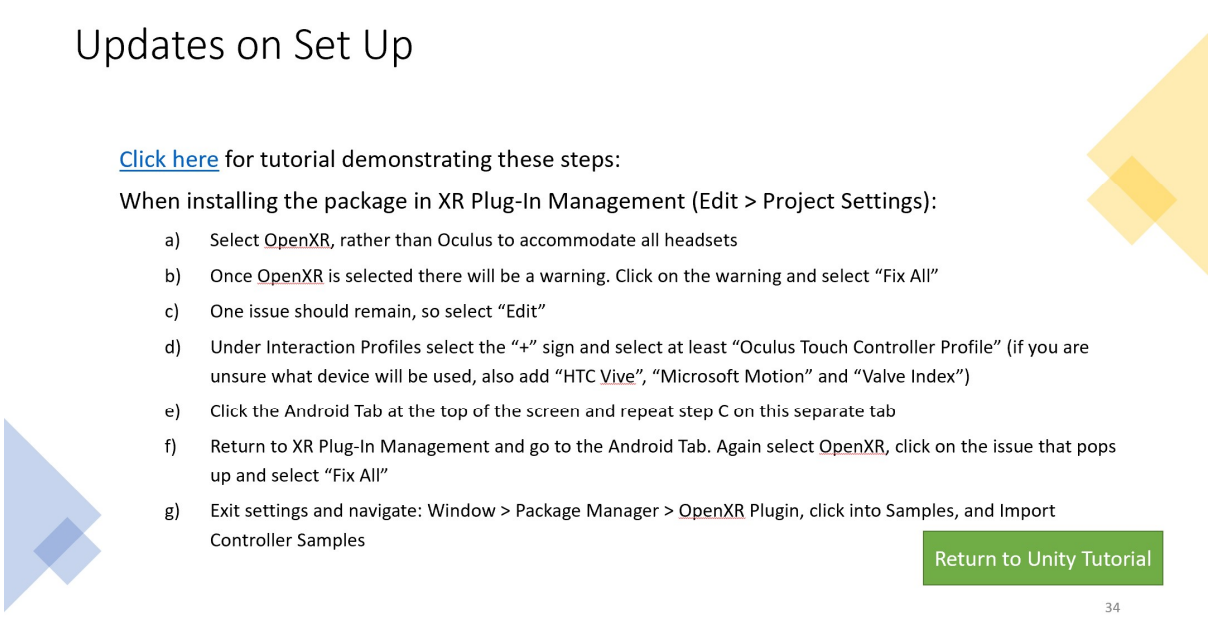

Figure 10: Example Miscellaneous Slide

Steps such as "Install Unity Module" shown in Figure 11 do not have an accompanying tutorial. Instead, a relevant image of the action has been inserted.

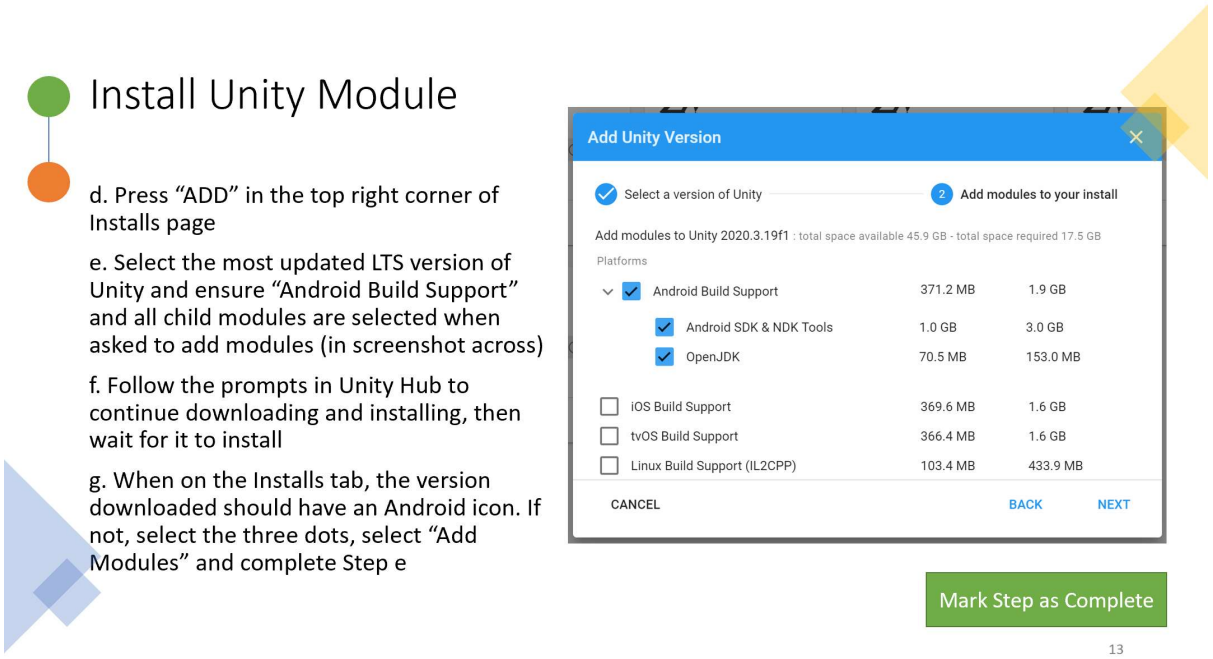

Figure 11: Tutorial Slide with Image

4.2 Testing the Knowledge Base

The KB's success will be determined by how significantly it reduces the learning curve for students new to VR, no matter their confidence in using new technologies. Unfortunately, the KB could not be entirely tested due to delayed completion and travel restrictions resulting from the COVID-19 pandemic. However, the first two sections of the KB, Set Up Headset and Unity Set Up, was tested on four family members, all with no experience of VR and varying confidence using new technology.

The four test subjects were divided into two groups.

1. Group one comprised people more confident using technology, and, as they were younger (aged 19 and 20), they had a better instinct utilising the headset.
2. Group two's members (aged 55 and 56) were significantly more hesitant to enter VR and experienced more difficulty using technology.

The primary objective of the first tutorial slide, shown in Figure 12, was to prepare users for their first experience using the VR headset. One member of each group was first encouraged to use the headsets without consulting the KB. These two users will be referred to as the control users. They were given the task of creating the guardian (the boundary a user can stay within when using the headset), changing the volume on the headset, connecting to WiFi, and playing the "First Steps" game. The same tasks were presented to the other group member, referred to as the experiment users. However, the experiment users were given the KB before using VR. The experience of the two group members was compared to understand the efficacy of the slide in Figure 12.

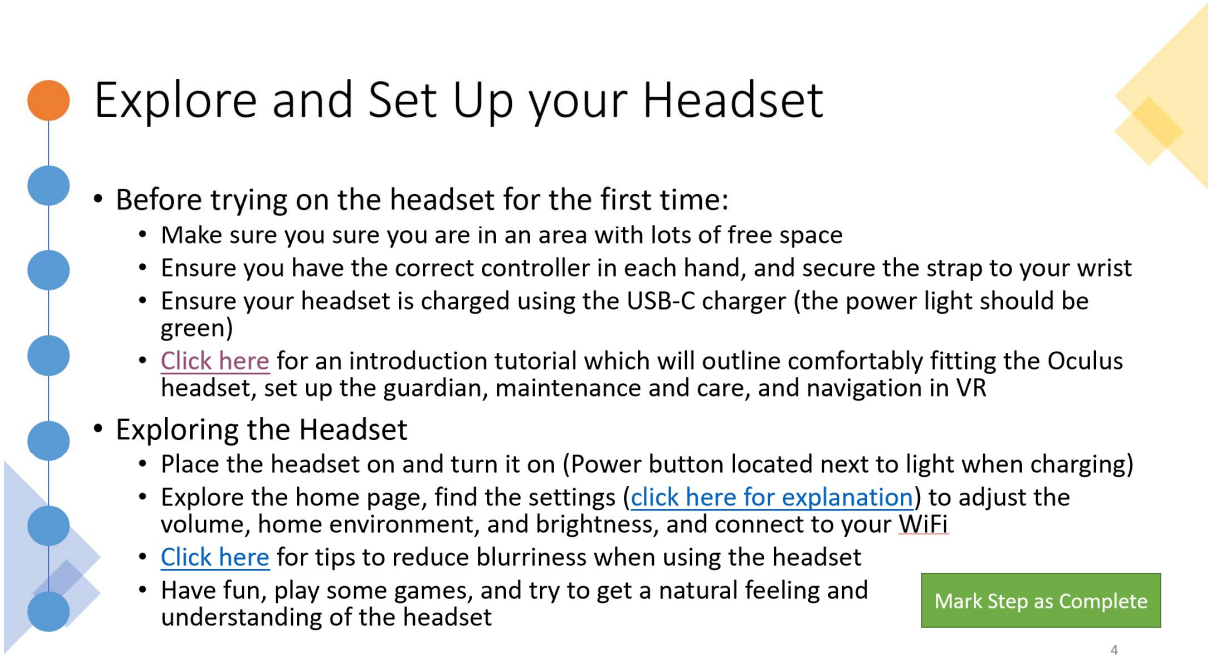

Figure 12: Knowledge Base Slide for First Time wearing VR Headset

Each member of the trial had a unique experience using VR for the first time. The group one control user was able to complete the tasks required. However, the user noted difficulty navigating to the settings menu and expressed that it was not intuitive. In contrast, exploring the app page was easy. Furthermore, once the settings were found, completing the tasks was quite simple. The user could set up the guardian, but this was met with some confusion and took a couple of attempts.

In contrast, the experiment member of group one had no difficulties using the headset. They successfully set up the guardian on the first attempt and quickly found the settings menu. They were able to complete the required tasks much quicker than the control group counterpart.

Therefore, it could be concluded that using the KB resource for this small sample group eliminated any initial confusion and hesitation. Thus, the learning curve was successfully decreased, as did the time it took to become familiar with the headset.

This experience differed significantly from that seen in group two. Group two members were much more visibly hesitant to put on the headset and expressed nervousness and uncertainty entering VR.

Group two's control member was surprisingly efficient at working through the guardian setup. In comparison to group one members, this user took more time to read all the instructions diligently. In contrast, group one members tended to go in headfirst and learn on the fly.

The control user in group two was also able to find the settings with relative ease. However, they faced a significant roadblock when attempting to navigate away from the settings into the apps. There were two obvious reasons why this user struggled to find the app library to play the First Step game. Firstly, when trying to select an option, they did not know what button to press. As a result, they tended to press all buttons at once. When a user presses all buttons, there is no consistency in how the headset responds, and the user becomes lost within the menus. This prompted the inclusion of a new slide, Figure 13, which visualises the Oculus buttons and describes the functionality of the two most used controls.

- The Oculus button: used to navigate in and out of apps and to pull up the universal menu
- The right-hand trigger button: used in the same manner as a left click on a computer. This button is used to select options on the screen.

Secondly, the user did not know how to find the app library, as there is no obvious path from the universal homepage. The user focused on trying the get out of the settings and then spent time on the explore page. There is an option to select Apps on the bottom pane of the menu; however, the user had difficulty finding this.

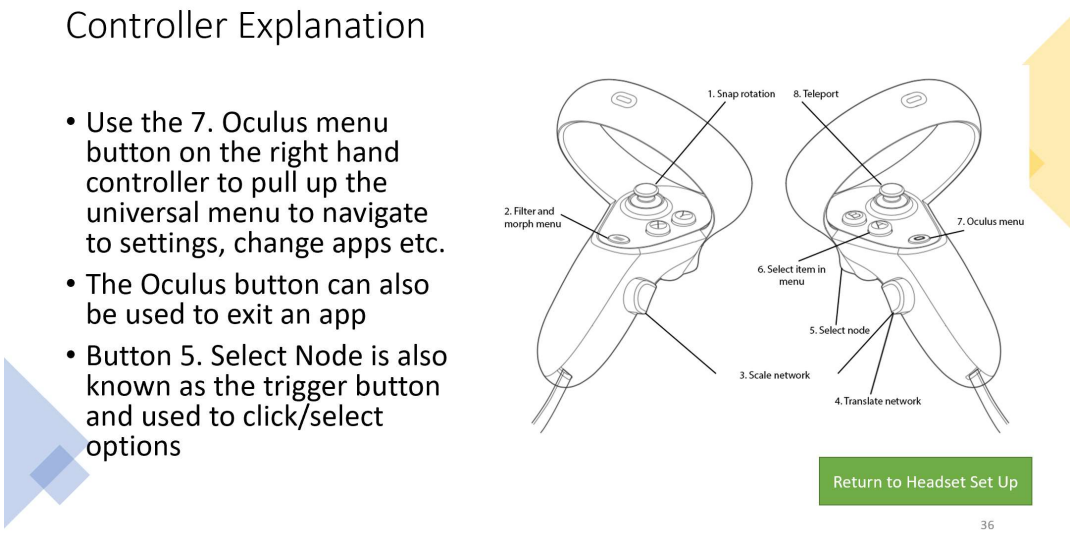

Figure 13: Knowledge Base Slide Highlighting Controller Function

Both issues were addressed in the tutorial linked in Figure 12. Therefore, it was interesting to observe the different experiences from the experiment member of group two. The user expressed that setting up the guardian seemed relatively easy, as they had seen the steps prior in the tutorial. They also knew to use the trigger button alone as the select button and use the Oculus button to navigate in and out of games. The tutorials also explained how to get into the Apps, so finding the App library was simplified.

One issue that group two members noted was blurriness. From that feedback, an additional slide was added to the miscellaneous section, seen in Figure 14.

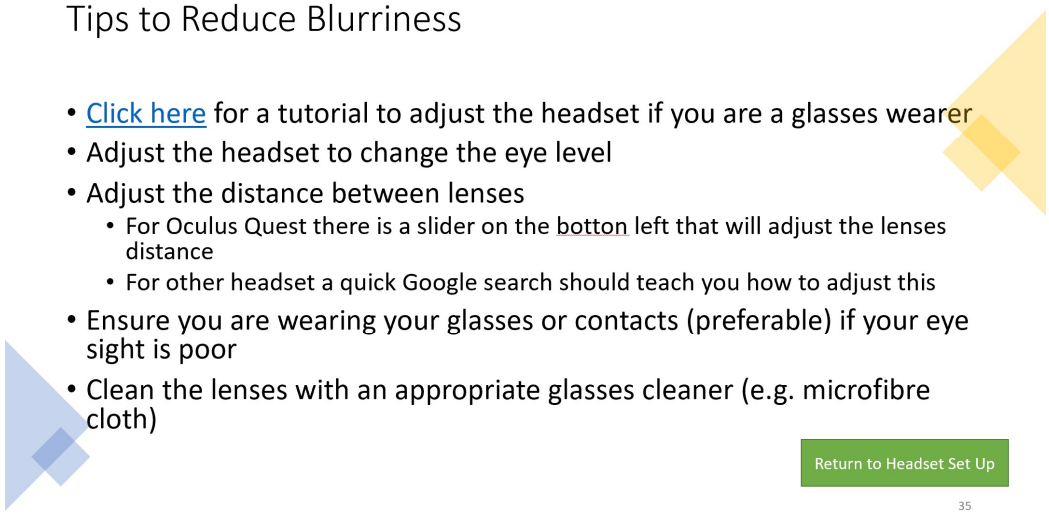

Figure 14: Knowledge Base Slide with Tips to Reduce Blurriness

All four users were then asked to complete the first two sections of the tutorial, which involved connecting the headset to a computer and downloading Unity. There was no control or experiment case, and instead all users followed the KB.

Group one members both efficiently completed the tutorial steps and stated that the steps were easy to follow. They both also expressed that navigation through the knowledge base was straightforward and enjoyed marking a step complete and seeing their progress throughout the section.

Both group two members noted some confusion on finding options on the screen. For example, 'press the settings icon' was not an understood term. Consequently, the slide was adjusted, and pictures were added with cues to aid the process, as in Figure 15. Firstly, the content was split across two slides so the font could still be legible, whilst the image was large enough to distinguish detail. Then the cues were updated. 'Press the settings icon' then became 'Press Settings (circled in blue)', which matched the accompanying screenshot of the Unity Hub homepage where the settings icon is circled with blue ink. The profile icon was circled in red for navigation, and the Installs link is highlighted in yellow. This adjustment particularly helped the group two members, as it removed the technical jargon that is not accessible to all people. Furthermore, it added a visual element to the instructions, which further helps comprehension for more students.

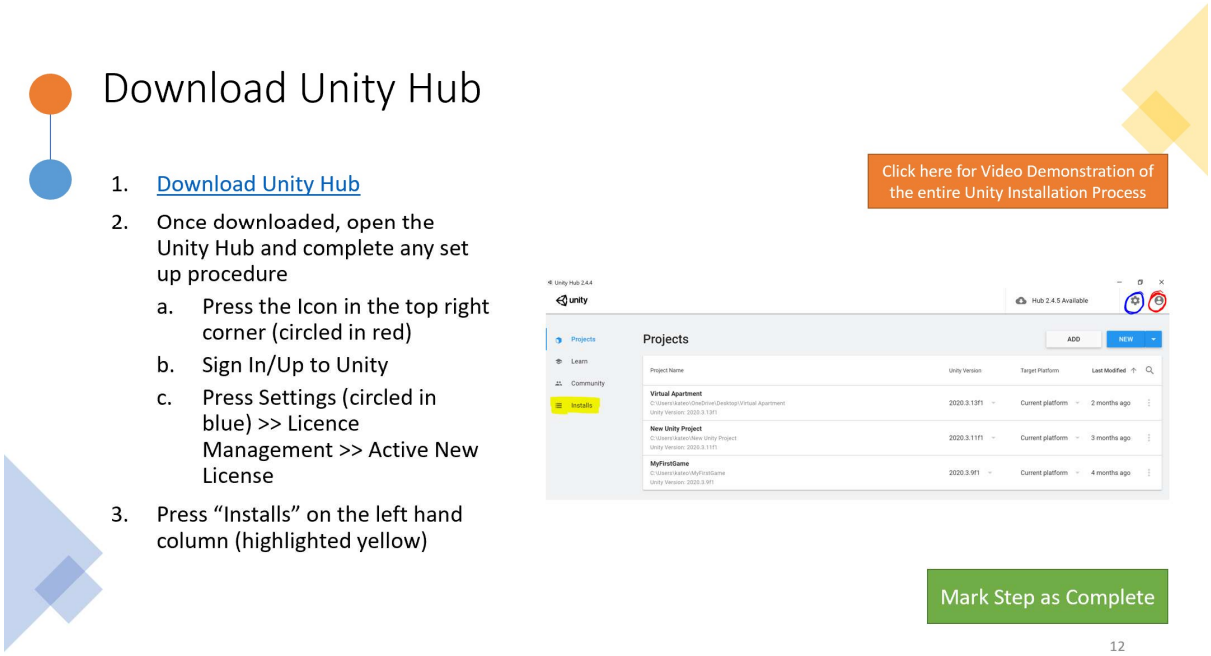

Figure 15: Knowledge Base Slide with Visual Guide

The KB was also given to the UNSW Immersive Technology team. They all described the KB as extensive and comprehensive. One interesting note they mentioned was to include a statement of 'why' to explain what the steps would achieve wherever possible. Though the 'why' statement is evident on the tutorial slides, it was not the case for other slides, particularly the setup slides. For example, in Figure 16, the first italicised paragraph was inserted to give users an understanding of the outcome of the step.

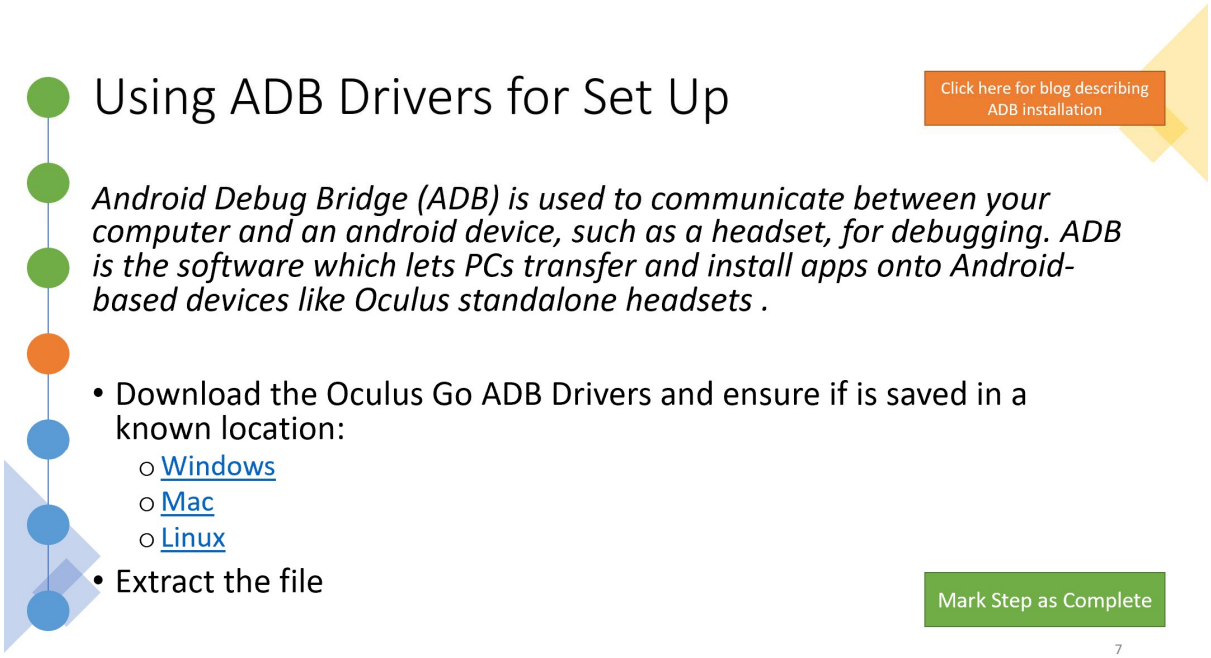

Figure 16: Knowledge Base Slide with 'why' statement

Chapter 5 – Discussion and Future Work

5.1 Knowledge Base Formatting Decision Process

Whilst learning the Unity game engine, a survey was created to eliminate biases that could have affected decision making regarding the types of tutorials and the format of the KB. There were 40 responders to the survey, 37 of which had experience with distance education.

The results of the three key questions are shown in Figure 17.

Firstly, responders' preferred format for distance education was PowerPoint. Alternate options considered was a specific website or a Word document. The question specified that users should select the best option for online learning and the easiest to use. This finalised the choice to use PowerPoint for the KB. PowerPoint is accessible on all computers and free for UNSW students. PowerPoint can also be distributed so that the file owner can continually update and maintain the content, but the user is unable to edit the file.

Two questions were asked to find students' preferred learning method, determining the tutorial type. Video tutorials with follow-along instructions were preferred, and therefore, YouTube tutorials were correctly chosen to be the dominant tutorial format.

The secondary preferred learning method was very close between step-by-step written and visual instructions. The video tutorials and slides such as Figure 11, Figure 13, and Figure 15 should satisfy those wanting visual education. Written instruction is present in the form of timestamps and the setup process. The YouTube tutorials all have transcripts that can be used for those that benefit from written instruction.

Another interesting question that was posed to responders is in Figure 18. Survey responders were asked whether they preferred PowerPoint presentations with more slides with less text on each or presentations with fewer slides with more text on each. Overwhelmingly responders preferred more slides with less text. This feedback was applied to the KB in instances such as Figure 8. The row of orange boxes is linked to separate slides in the PowerPoint pack. Therefore, reducing the word count on the individual slide but increasing the total number of slides.

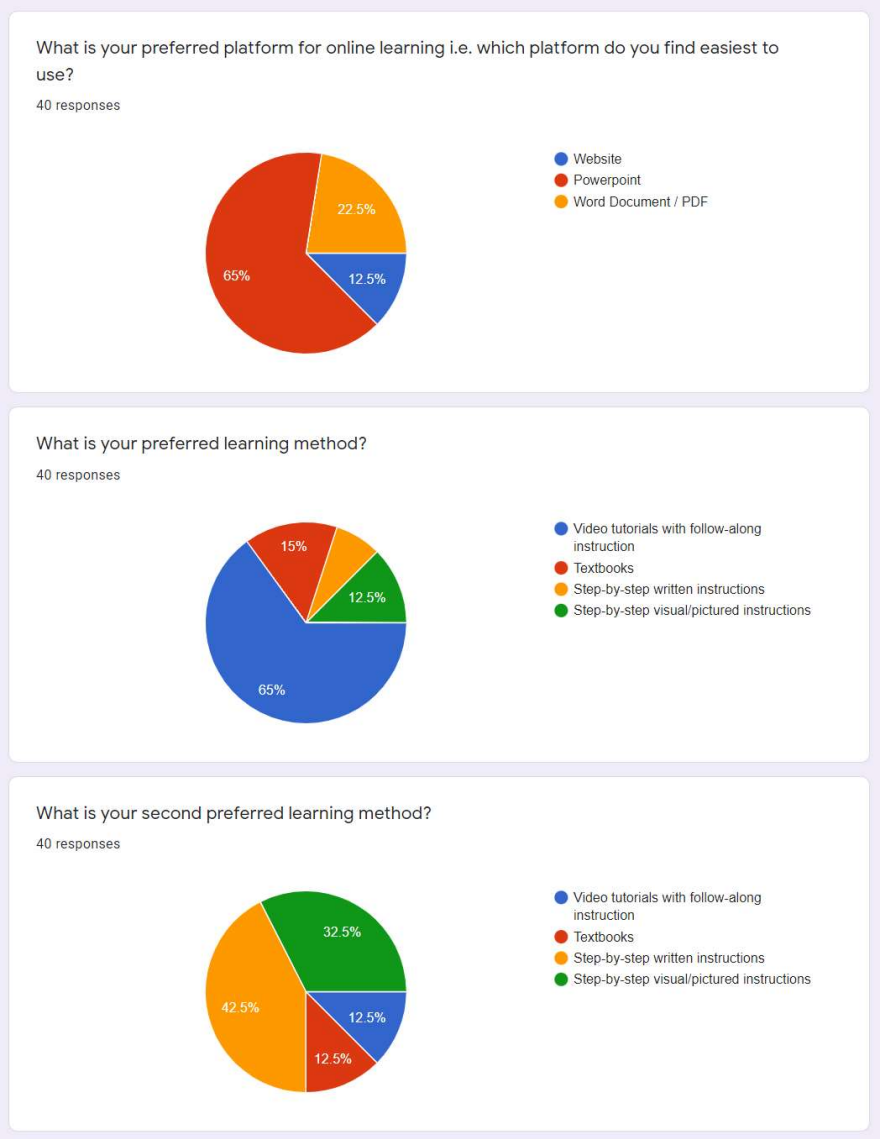

Figure 17: Survey Results

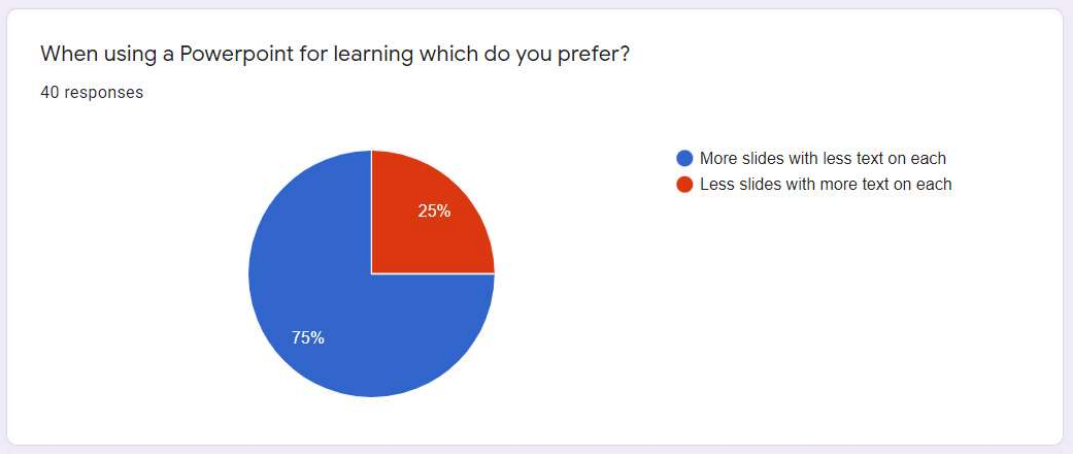

Figure 18: Preferred formatting on PowerPoint

The final question asked on the survey was: What makes an online learning platform effective and creates the most memory retention? This was an open-ended question where responders could insert their answers. All responses can be viewed in Appendix B. The most common theme of responses was:

- Examples and demonstration
- Clear content
- Enjoyment of subject
- Quizzes
- Engaging lecturer

Examples and demonstrations, clear content, and an engaging lecturer are all used in the careful selection of YouTube tutorials. Enjoyment of content can certainly be encouraged by providing purpose, rewarding progress, and including stimulating demonstrations. However, the enjoyment mostly comes from self-interest, something which students who want to learn VR should already have before starting the KB.

Quizzes are the only element not currently in the KB. Quick questions after each tutorial could be added to ensure memory retention. Asking students to replicate the tutorial content can also be a form of assessment. Either way, this is something that could be applied to future work.

5.2 Experience of Upskilling on Unity Learn

5.2.1 Overview

Unity Learn [43] is the official resource generated by Unity to learn game development. As it is the official learning tool and the first result on Google when "Unity Tutorial" is searched, it was the first tutorial format tested, as it would be for most first-time Unity users.

5.2.2 Drawbacks of the Unity Learn Tool

A significant roadblock preventing learning game development is the acceleration of Unity's software. This exponential improvement of the game engine has even outpaced Unity's learning tool. As of June 2021, when this step was being completed, the most up-to-date Unity Learn VR tutorial used the 2019 version of the game engine. Though the game engine version could still be used, it was not compatible with any of the current additional packages that needed to be applied. Furthermore, it missed out on Unity's developments and improvements over the last two years.

There was though still an attempt to use the 2019 tutorial with the latest version of the game engine. Unfortunately, this was unsuccessful. It seems that between 2019 and 2020, Unity dramatically changed the setup, layout, accessibility, and user interface of their game engine. Consequently, almost every step presented in the tutorial was redundant. It involved research through blogs such as Reddit, comments on the tutorial, and even YouTube tutorials to find the new 2021 process to achieve the same outcome. This process was highly time-consuming and massively decreased motivation. Despite attempting to push through, the Unity Learn tutorial could not be completed, as too many steps simply did not exist anymore, and therefore it was impossible to replicate.

In September 2021, a new updated version of the Unity Learn Introduction to VR tutorial was published [52]. Though this tutorial was more accessible to follow as the steps demonstrated were accurate to the game engine available, a few problems prevented Unity Learn from being the primary resource used in the KB.

Firstly, the entire tutorial was approximated at 30 hours to complete, assuming perfect conditions, such as a newer computer device with no latency, instant comprehension of each step, and some assumed Unity knowledge from a previous Unity Learn tutorial that took 12 hours to complete.

Secondly, the tutorial is defined as a series and runs like a waterfall, meaning that users cannot complete a step in isolation. For example, to complete step 5, users must have previously completed steps 1 to 4. This is an issue because the main objective of the KB is to teach the need-to-know fundamentals, and the Unity Learn tool went into significant and too much depth. Consequently, the KB could not just select the steps within the Unity Learn tool required for the KB, as all actions prior would have needed to be done.

5.2.3 Useful aspects of the Unity Learn Tool

Despite the difficulty of the Unity Learn tutorial, much was learnt, as if was found that the format of the tutorials was highly effective. The tutorials were successful as they provided:

1. An effective combination of video and written explanations
2. A comment tool that allowed users to ask questions that either Unity or other users could answer
3. Each section of the tutorial started by explaining the purpose and finished with a recap
4. Users could mark steps as complete and could visualise their progress as they worked their way through the tutorial
5. Each stage was broken up into smaller, quicker steps

Each step of the Unity Learn tutorial was presented as a video demonstration, with a presenter going through the steps on the screen. This is a highly effective tutorial method, as it incorporates desirable strategies for visual, kinaesthetic, and auditory learners. Additionally, for students who have English as a second language, it is often difficult to find translations for XR technology jargon as it is relatively new. Therefore, demonstration may be the only way to communicate and understand these processes effectively.

The video demonstration did have generated captions, but the written steps were more concise and simplified. Therefore, when there was difficulty understanding what the presenter did at a particular stage, you could read the transcript of the video and read the step written out.

Furthermore, each stage had a comment section that Unity did seem to respond to actively. If Unity themselves did not answer, other members of the large Unity community were quick to offer support. Having these discussions available to all public was highly beneficial and increased efficiency, as often users tend to have the same problems.

The other aspect of the Unity Learn tutorials that was helpful was that the tutorials were effectively bookended. This means that each section initially stated its purpose and the direction of work. The value of learning that step was also outlined. The last step of each section was a recap and summarised what had been discovered.

Knowing the end goal from the start helped create momentum and excitement to sustain interest. Additionally, by understanding the value of Unity and the possibilities that can come from learning the game engine, motivation was improved, and this further helped to encourage progress. A summary at the end of the stage acted as a reinforcement of what had been done to ensure memory retention.

The final element of the Unity tutorials was the progress checks and marking off each completed step. As seen in Figure 19, at the end of each tutorial step, an interactive button allowed the user to mark a completed action. This periodically provided a rush of dopamine, thus creating a sense of reward.

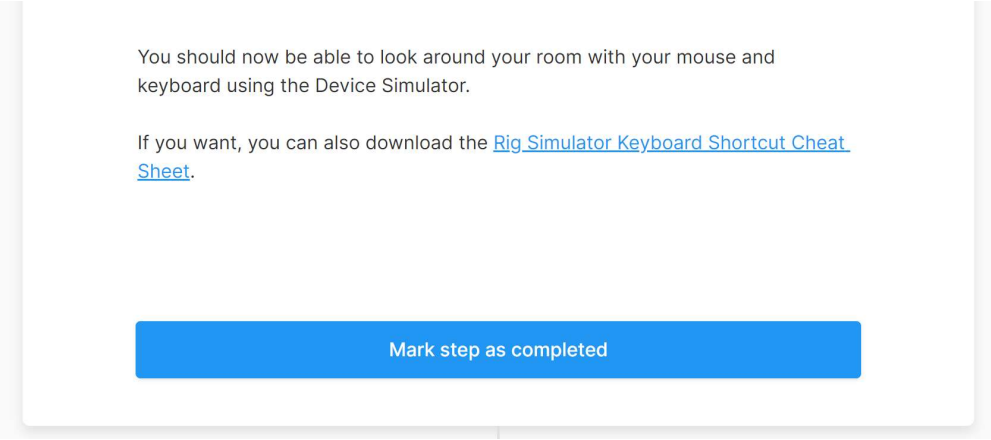

Figure 19: Unity Learn "Mark step as completed" function

Once a step was complete, it lit up as green on the progress bar on the page, seen in Figure 20. Even though this is particularly beneficial to visual learners, most learners benefit from having a sense of where they are within a tutorial. It helps pace yourself and again provides a dopamine hit as you work through the tutorial, lighting up more steps green. The progress bar and the associated colour scheme, green for completed work, were replicated in the KB.

As shown in Figure 20, the stage of learning is stage 1 – VR Basics. The stage is broken down into sub-step 1.1, where there are six steps and a recap. By breaking the steps down into smaller blocks, it becomes more manageable than one very long step. Furthermore, it creates momentum as there are more dopamine boosts from regularly completing steps. This breakdown of steps was also replicated in the KB.

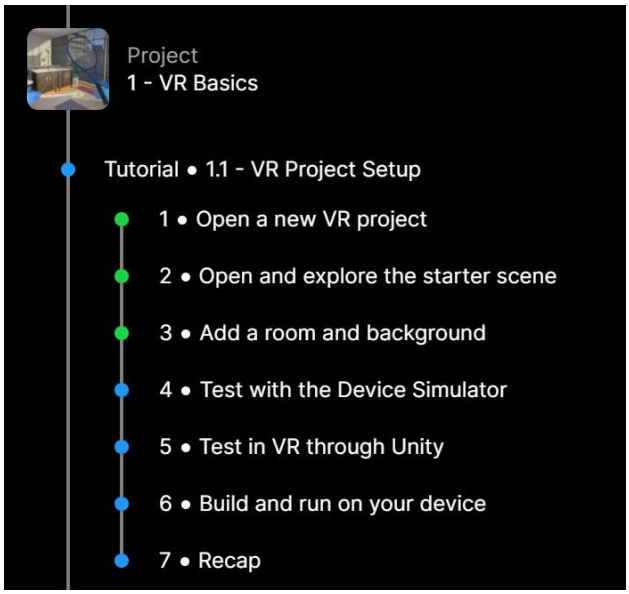

Figure 20: Progress Bar on Unity Learn Tool

Given how useful and complete the Unity Learn tutorial is, this will be offered in the KB. However, it is presented with warnings regarding the required time commitment. It will be recommended that users skip the Unity Learn tutorial for the quicker and more direct tutorials. Still, it is a highly effective learning tool that should be available for consideration.

The first few Unity Learn modules were also used in the KB. These were modules that demonstrated setup and testing methods, and therefore did not require completion of prior steps. The tutorials used are outlined in Table 3.

Table 3: Unity Learn Tutorials used in the Knowledge Base

Unity Tutorial	KB Slide
Introduction to the Unity Editor [53]	Introduction to Unity and Navigation
Test with the Device Simulator [54]	Troubleshooting: Test Live with Laptop Device Simulation
Test in VR through Unity [55]	Troubleshooting: Test in VR with Oculus Link
Build and run on your device [56]	Troubleshooting: Building and Running Unity Program through ADB

5.3 Experience of Upskilling using other tutorial formats

The following format of tutorial explored was textbooks, as this was an effective learning tool in literature. But again, problems of rapid development were faced. Having to Google most steps of a follow-along tutorial was demoralising and prevented any momentum.

Furthermore, unlike the Unity Learn tutorials, textbooks only presented the written steps, with images to highlight the result. Even if the steps were articulated perfectly, it was harder to absorb the information presented without the video presentation. Memory retention was much poorer, and it was easy to disengage. Furthermore, for students with English as a second language, translation issues may occur and prevent progress.

Next was an attempt to use blogs. Despite blogs being the most up to date of the resources, it was found that they are primarily used to answer community questions rather than to teach usage of the game engine.

One blog was used in the knowledge base to explain the installation of ADB Drivers [57]. This source was comprehensive and only used as an optional supplement to the tutorial if the user wanted additional detail. Furthermore, there is a note at the start of the knowledge base to take advantage of blogs if there is any confusion from the KB or a tutorial.

5.4 Experience of Upskilling using YouTube Tutorials

5.4.1 Overview of YouTube Content

Finally, YouTube tutorials were explored. In many ways, this was the closest match to the Unity Learn tutorials. Most video tutorials were designed as a step-by-step guided method to achieve an end goal. Most videos had at least English captions, and in the video's comments, questions can be posed, with a community of users responding.

The greatest downfall of using YouTube was that the quality and relevancy of the video varied greatly from one creator to another. In this context, a creator is someone who creates and uploads content to

YouTube. With over 6.7 million videos found when searching "Unity Tutorials", trying to find a good set of creators can feel like trying to find a needle in a haystack.

Unlike Unity Learn, filters could be applied to search results. For example, only videos made in 2021 were considered. Secondly, there was a preference to only use tutorials from creators who appeared on the first result page on YouTube and focused on creators with a high viewer count. When searching for information online, people rarely look beyond the first page of results. Consequently, tutorials on the first results page would be the most viewed, and therefore would have the largest community who could ask and respond to questions in the comments.

Most Unity tutorials tended to fall into one of two categories:

1. Over one-hour tutorials that attempt to introduce all functionalities of Unity
2. A series of videos

Videos over an hour-long are intimidating for new users who often want quick results to build confidence and momentum. As explained previously, series videos that work in a waterfall fashion are also a problem, as not all steps may be necessary.

5.4.2 YouTube Creator and Tutorials used in the KB

After significant searching, one key creator was identified: Justin P Barnett [58], shown in Figure 21. Though other tutorials supplemented his content, most of the KB is derived from his page.

Barnett's tutorials were selected as they fulfilled critical criteria that seemingly no other creator fulfilled.

Firstly, each tutorial was able to stand on its own and be used in isolation. Hence, relevant tutorials can be specifically selected for use in the KB. However, the tutorials can be completed within one project. As a result, users of the KB do not need to repeat the setup process, and computer memory is saved.

Each video is between 20 to 30 minutes long, which is an appropriate length to complete in one sitting to feel like progress has been made without burning out.

Furthermore, his content is engaging. Barnett speaks with clarity and at an appropriate cadence. His work is easy to follow, and he often responds to questions in his videos' comment section. He also bookends his videos with a purpose and summary similar to the Unity Learn content.

All his videos contain subtitles that supplement the video. Unfortunately, these are only in English, but the video can be slowed down for those who struggle with understanding on the first attempt.

Finally, the content is not only up to date, but he also updates his work as there are minor changes to the platform.

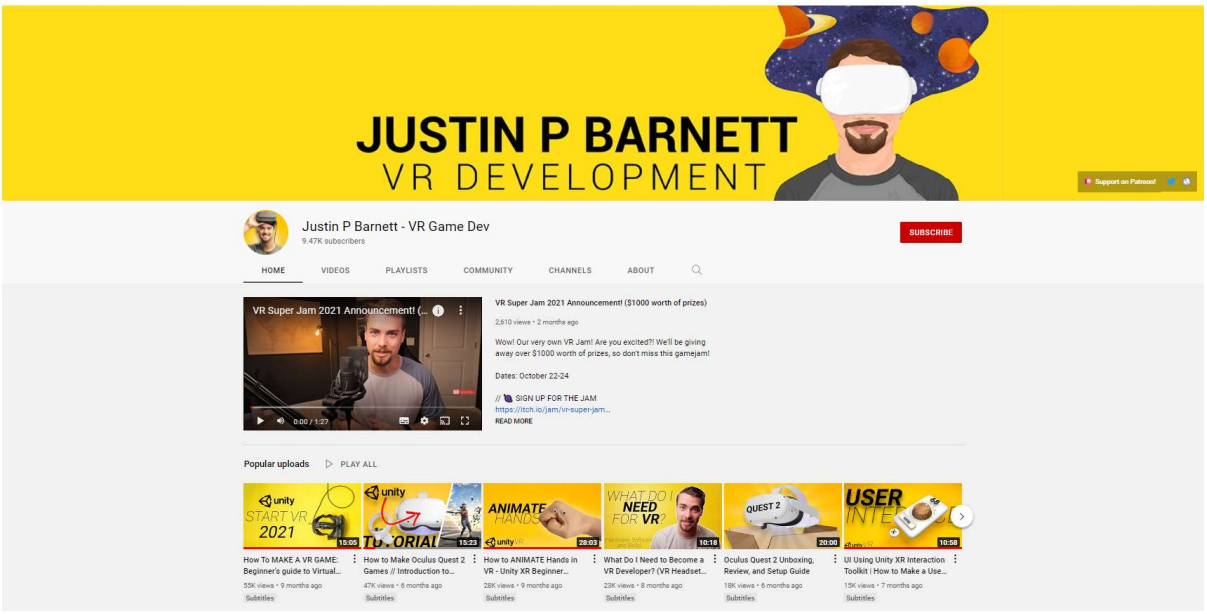

Figure 21: Justin P Barnett YouTube Home Page

His content was the most interesting and resulted in the most effective memory retention with all these factors combined. Therefore, it is the dominant source used in the KB. Additional content was pulled from other YouTube creators, as well as Unity Learn. An outline of all YouTube tutorials used within the knowledge base is highlighted in Table 4.

Table 4: YouTube Tutorials used in the Knowledge Base

YouTube Tutorial	Tutorial Creator	KB Slide
Oculus Quest 2 VR Headset Unboxing & Setup | Oculus [59]	Oculus	Explore and Set Up your Headset
Create Your Own Virtual Apartment in 1:1 Scale on Oculus Quest 1 & 2 (TUTORIAL) [60]	AltVR	1. Download Unity Hub 2. Recreate an environment in VR: Including models and textiles
How To MAKE A VR GAME: Beginner's guide to Virtual Reality & Unity XR Plugin [61]	Justin P Barnett	Create a Unity Scene
How to ANIMATE Hands in VR - Unity XR Beginner Tutorial (New Input System) [62]	Justin P Barnett	Apply hand controllers in Unity
All About VR Interactables [63]	Justin P Barnett	VR Interactable Objects
I turned my house into a VR Game [64]	Valem	Recreate an environment in VR: Including models and textiles
UI Using Unity XR Interaction Toolkit | How to Make a User Interface That Works in VR [65]	Justin P Barnett	User Interaction
Hand Tracking Updates and Resources | Oculus For Developers [66]	Oculus	Apply Hand Tracking
Unity Hand Tracking with Oculus Quest 2 and UI Canvas – Tutorial [67]	KatriSoft	Apply Hand Tracking
How to Start a VR Game using Unity 2021 [68]	Justin P Barnett	Updates on Set Up

5.5 Decision Process to Determine Required Tutorials

This step was completed in collaboration with Joshua Dawson, as throughout his thesis, he built a VR simulation specifically for atrial fibrillation surgical training. The objective of the KB is to be a generic tool for all people wanting to use VR.

Required skills were divided into two sub-categories. Firstly, "Unity Basics" encompassed the skills necessary for virtually all game developers. The decision for these tutorials was based on experiences upskilling on Unity.

All other helpful but optional tutorials were listed under "Additional Unity Tutorials". These additional tutorials also comprised tutorials specific to Joshua's project and in the medical field. For example, calibrating and aligning the physical and virtual worlds.

Two other sub-categories were implemented into the KB. These included "Set Up Headset", which incorporate the necessary steps for first-time users of a VR headset, such as tips for the first use of the headset and connecting the headset to a computer for game development testing. Additionally, there must be a "Unity Set Up" section describing installing Unity to a computer and downloading the correct package and modules.

5.6 Future Work

Looking towards the future, most of the KB's development will be focused on maintaining its relevancy. As VR technology advances and the Unity game engine releases upgrades to their platform to match, the KB will need to be regularly monitored and updated to keep relevance. Though only minor changes affected the platform in recent years, a significant upgrade as was seen between 2019 and 2020 may render a number of the external tutorials redundant.

Furthermore, proper testing will need to be performed on the entire KB to gain a complete perspective on its efficacy. Testing should be performed to compare game development learning speed and efficacy between students using the KB and students finding information independently. Examples of questions that could be asked during testing is provided in chapter 3.4.2. The goals of such testing should include discovering:

- ✓ How much faster users can come up to speed with game development on Unity with the KB in comparison to students learning VR independently without a guide
- ✓ Does the KB provide an excellent introduction to Unity for students to then move on to developing their virtual reality simulations
- ✓ Is there game development skills that should be added to the KB that are not currently included

As more students work on VR projects, particularly projects in the medical field, more skills should be added to the "Additional Tutorials' section of the KB. By providing easy access to tutorials, students will be able to catch up to previous students' work quickly, and therefore will have more time to make significant progressions. Furthermore, students create a Frequently Asked Questions section to the KB.

Finally, quizzes should be added throughout the KB to ensure memory retention, as this was one of the dominant responses from the survey when asked what makes online learning effective. Adding a quick quiz asking students about what they should have learnt during the tutorial at either the end of every tutorial or at the end of each section would be effective.

Chapter 6 – Conclusion

This thesis focuses on the use of Virtual Reality (VR) as a tool in industry and the role of game development in learning to use it effectively. The thesis aimed to create a repository of resources for new VR users to effectively guide them through the initial stages of learning Unity game development. Particular foci were the use of VR in the medical field and providing resources to help students on projects.

Various modes of learning were examined and considered in hopes of understanding how people best responded to them in a VR setting.

As a result, a 35-slide PowerPoint Knowledge Base (KB) was created. The KB uses up-to-date, reliable resources that introduce the fundamentals of game development. Consequently, this eliminates the confusion of entering the VR world and reduces the time spent finding relevant sources for upskilling. Therefore, students can dedicate more time to developing VR projects.

Preliminary testing demonstrated that the KB helped first time VR users feel more confident and comfortable using the VR headsets and reduced the time taken on basic tasks, such as adjusting settings and understanding the controller buttons' functions. The KB also successfully taught the initial setup required for Unity game development. The UNSW Immersive Technology Team also described the KB as 'comprehensive' and 'extensive'.

The use of VR in the medical field was considered and its application promises significant advancement in the mode of delivery of surgical training and procedures.

Future work must ensure the KB is regularly updated in line with Unity upgrades and VR technology advancements. Extensive testing also needs to be performed to determine the true efficacy of the complete KB. Students working on medical projects should also add their own VR learnings to the KB, perhaps through creating a frequently asked question page, so that future students can quickly come up to speed with current work and not reinvent the wheel. Finally, interactive elements, such as quizzes should be added to the KB to ensure memory retention.

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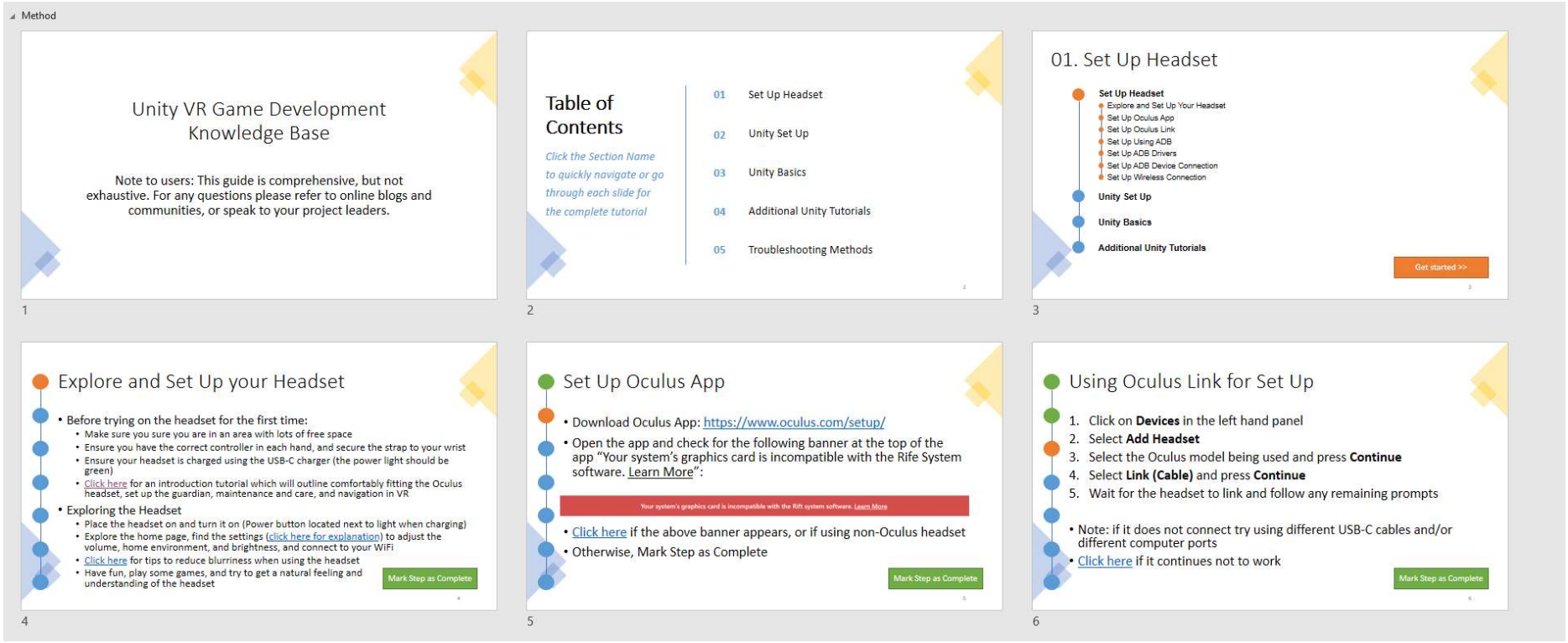
Appendix

Appendix A – Completed Knowledge Base Slides



Using ADB Drivers for Set Up

Click here for detailed blog describing ADB installation

Android Debug Bridge (ADB) is used to communicate between your computer and an android device, such as a headset, for debugging. ADB is the software which lets PCs transfer and install apps onto Android-based devices like Oculus standalone headsets .

- Download the Oculus Go ADB Drivers and ensure if is saved in a known location:
  - Windows
  - Mac
  - Linux
- Extract the file

Mark Step as Complete

7

Example Command Prompt (Windows)

- Open "Command Prompt" or Terminal or OS shell
- Navigate to platform-tools folder using "cd" to move forward
- Return to start using "cd \"
- Once in platform-tools type "adb", if a document appears as seen, then it has been installed correctly

Mark Step as Complete

8

Connect headset to computer

- Connect headset to computer using USB-C cord provided
- Ensure the headset is on, and press to "Allow" media access on the headset
- Run "adb devices" on the Command Prompt
- If the device does not appear go through to troubleshooting methods

Mark Step as Complete

9

OPTIONAL: Enable wireless connection

Enabling wireless connection, that is connecting the headset to the computer over WiFi and without a cable, is helpful as it means your game can be tested with free movement. However, when first building a project, it is often easier, quicker, and more reliable to keep the headset physically plugged into the computer.

1. Ensure your headset and adb host computer are connected to the same Wi-Fi
2. On your computer find the Wifi IP address (**Settings > Wi-Fi Settings > Advanced/Properties > IP Address**) e.g. *192.168.0.245*
3. Connect the headset to the computer and run adb as shown previously
4. In the command line type: **adb tcpip 5555**
5. In the command line, connect to the IP address from step 2, and type: **device_ip_address:5555**, for example *192.168.0.245:5555*
6. Disconnect the USB cable and check connection using: **adb devices**
7. Reconnect by executing in the command line: **adb connect**
8. Reset adb host by executing in the command line: **adb kill-server**

Mark Step as Complete

10

02. Unity Set Up

- **Set Up Headset**
- **Unity Set Up**
  - Download Unity Hub
  - Install Unity Module
- **Unity Basics**
- **Additional Unity Tutorials**

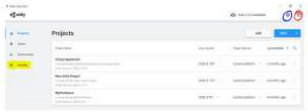
Get started >>

11

Download Unity Hub

1. Download Unity Hub
2. Once downloaded, open the Unity Hub and complete any set up procedure
   a. Press the Icon in the top right corner (circled in red)
   b. Sign In/Up to Unity
   c. Press Settings (circled in blue) >> Licence Management >> Active New License
3. Press "Installs" on the left hand column (highlighted yellow)

Click here for Video Demonstration of the entire Unity Installation Process



Mark Step as Complete

12

Install Unity Module

Adding build support is necessary for the project to be compatible with a headset, which is an android device.

d. Press "ADD" in the top right corner of Installs page

e. Select the most updated LTS version of Unity and ensure "Android Build Support" and all child modules are selected when asked to add modules (in screenshot across)

f. Follow the prompts in Unity Hub to continue downloading and installing, then wait for it to install

g. When on the Installs tab, the version downloaded should have an Android Icon. If not, select the three dots, select "Add Modules" and complete Step e

Mark Step as Complete

13

03. Unity Basics

- **Set Up Headset**
- **Unity Set Up**
- **Unity Basics**
  - Introduction to Unity and Navigation
  - OPTIONAL: In-depth Unity Tutorial
  - RECOMMENDED: Create a Unity Scene
  - Apply Hand Controllers
  - VR Interactable Objects
- **Extra Unity Tutorials**

Get started >>

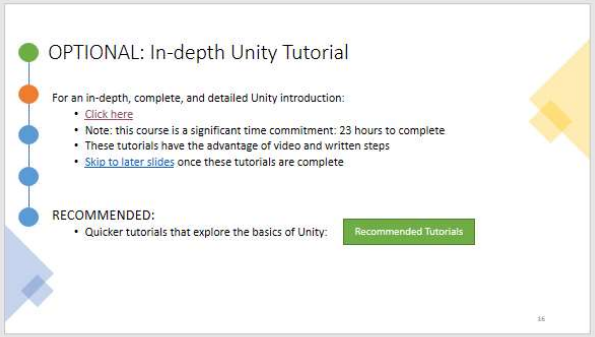
14

Introduction to Unity and Navigation

- Click here for an introduction to the Unity Editor
- Navigation in Unity (Click here for extra detail):
  - Pan: Select the Hand tool in the Toolbar, and click and drag in the Scene view to move your view
  - Zoom: Holding Alt (Windows) or Option (macOS), right-click and drag in the Scene view to zoom
  - Orbit: Holding Alt (Windows) or Option (macOS), left-click and drag to orbit around the current pivot point. Note: this option is not available in 2D mode
  - Focus (Frame Select): When a GameObject is selected, select F with your cursor in the Scene view to focus your view on that GameObject. Note: if your cursor is not in the Scene view, Frame Select will not work
- Flythrough Mode to navigate in scene view:
  - Click and hold the right mouse button.
  - Use WASD to move the view left/right/forward/backward.
  - Use Q and E to move the view up and down.
  - Select and hold Shift to move faster.

Mark Step as Complete

15



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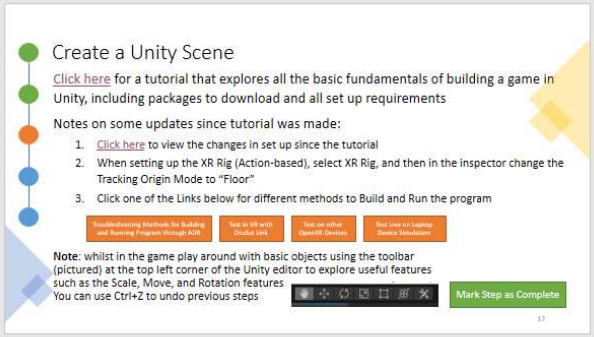

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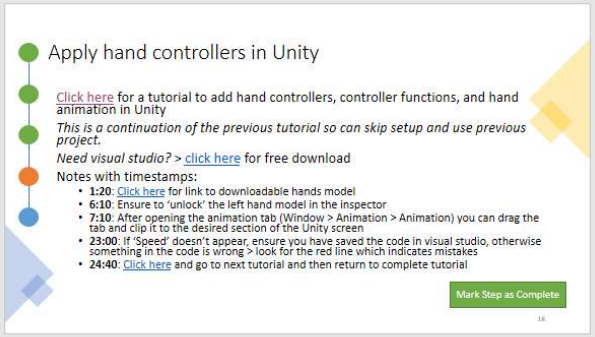

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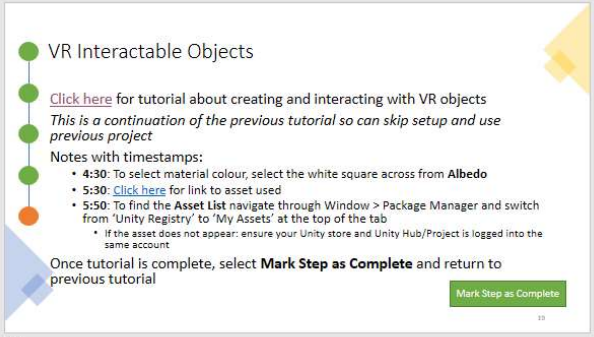

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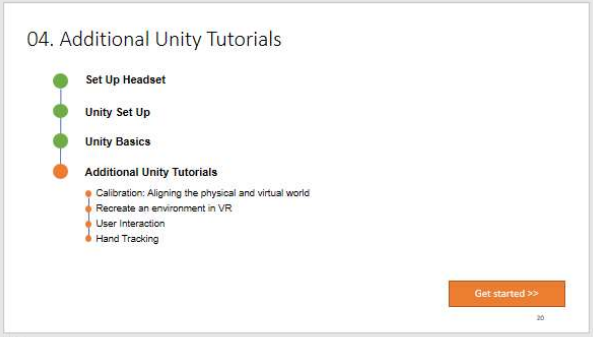

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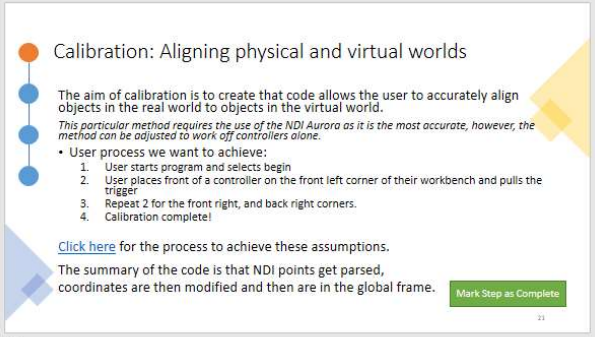

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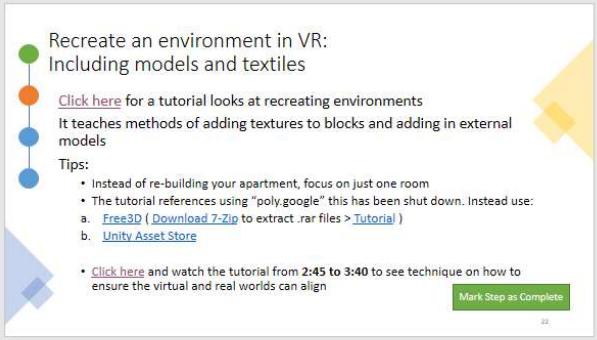

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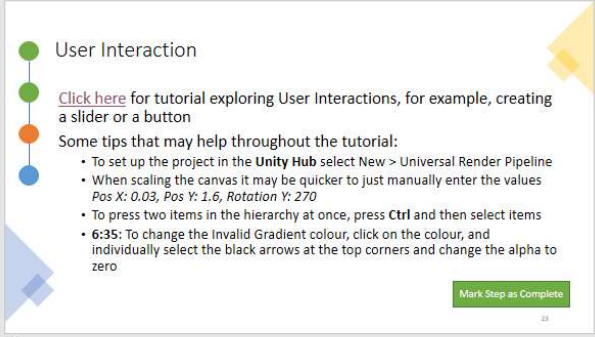

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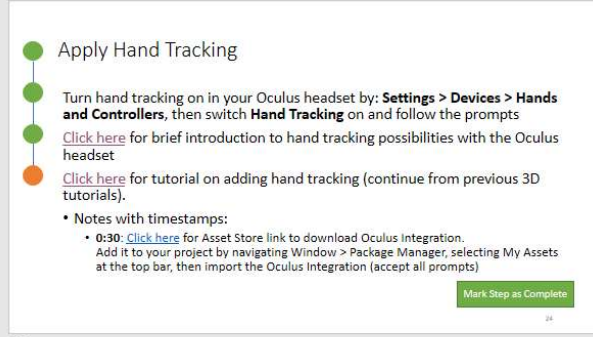


24

Completed!

- Set Up Headset
- Unity Set Up
- Unity Basics
- Additional Unity Tutorials

25

Troubleshooting Methods

Troubleshooting methods to connect headset with adb driver

- Download the Oculus ADB Driver
  - To install the driver, unzip the package and right-click on *android_winusb.inf* on press "Install" to install the file on your PC (screenshot of installation)
- Ensure you press "Allow" when access for access
  - If this pop up doesn't appear, in the headset navigate to Settings > Developer and ensure **USB Connection Dialogue** is switched on
- Try using a different USB cable or port
- Delete and re-install platform-tools
- Create Oculus profile and create a new organisation
- Last resort: speak to the UNSW Immersive Tech Team and / or your Project Managers and Team Academic Leads

Mark Step as Complete

26

Calibration Method

Set Up Assumptions (can be adjusted):

- A vector for the sensor origin is determined from the table corners determined by the user.
- It is assumed that the NDI field generator is placed in the middle of the tables back edge.
- Table height, depth and width are calculated based on the corner positions.

```
Vector3 sensorOrigin = new Vector3(testPinch.tableCorners[0].x + (tableWidth / 2),
        tableHeight + 0.1f, testPinch.tableCorners[0].z + tableDepth - 0.07f);
```

Click here for the Calibration Code

This code is part of the script attached the empty game object in the scene which handles the TCP Client.

Mark Step as Complete

27

Calibration Code

```
tempData.rotation.w = posData[0];
tempData.rotation.y = posData[1];
tempData.rotation.x = posData[2];
tempData.rotation.z = -posData[3];
tempData.position.y = -posData[4] + sensorOrigin.y;
tempData.position.x = -posData[5] + sensorOrigin.x;
tempData.position.z = sensorOrigin.z + posData[6];
```

Rotation: Only notable change is that `z = - NDI_z` as NDI use a left-handed coordinate system, whilst Unity uses a right-handed system.

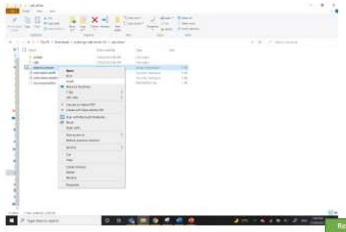
Position: x and y values are swapped, then offset.

```
X = -NDI_y + sensorOrigin.x
Y = -NDI_x + sensorOrigin.y
Z = NDI_z + sensorOrigin.z
```

Return to Calibration Method

28

Install android_winusb



Return to Troubleshooting Methods

29

Troubleshooting: Building and Running Unity Program through ADB

Click here for video demonstration and detailed steps

Running the program for the first time?:

1. Navigate through Edit > Project Settings > XR Plugin Management
2. Select the **Android** tab and then select **Oculus**
3. Navigate through File > Build Settings
4. Click **Add Open Scenes** and add the scene
5. Ensure the Oculus is turned-on and plugged in
6. Click **Refresh** next to the **Run Device** (your Oculus should appear)
7. Click **Build and Run**, then save the project in a new "Builds" Folder

Following that press **Ctrl+B** to automatically build the project

Return to Unity Tutorial

30

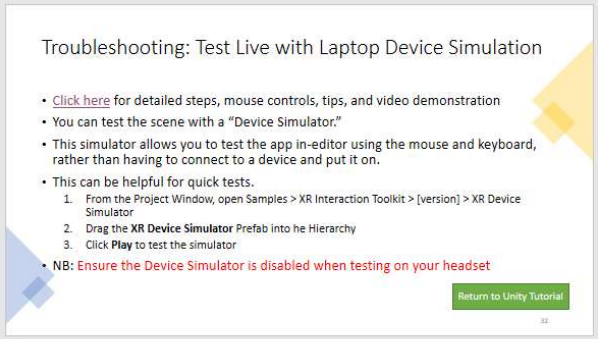
Troubleshooting: Test in VR with Oculus Link

Click here for video demonstration and detailed steps

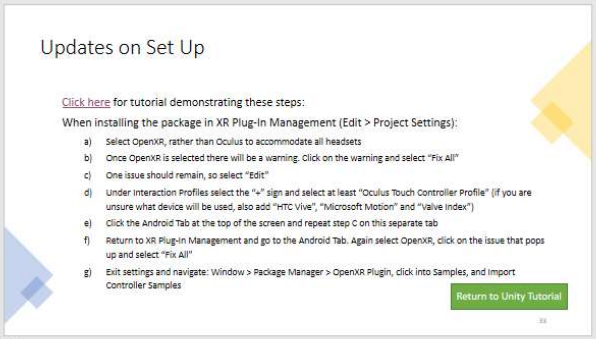
1. Navigate through Edit > Project Settings > XR Plugin Management
2. In the **PC** tab select **Oculus**
3. Connect your device through Oculus Link
4. Press **Play** at the centre of the top task bar

Return to Unity Tutorial

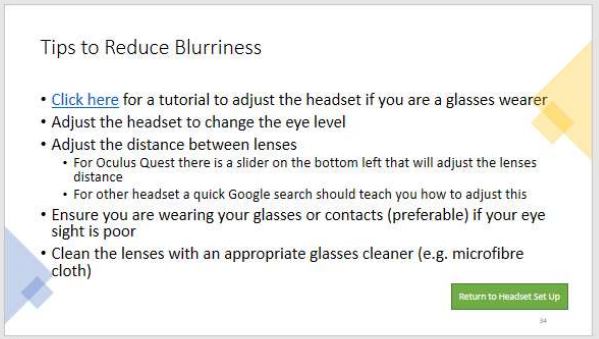
31


Troubleshooting: Test Live with Laptop Device Simulation
Click here for detailed steps, mouse controls, tips, and video demonstration
You can test the scene with a "Device Simulator."
This simulator allows you to test the app in-editor using the mouse and keyboard, rather than having to connect to a device and put it on.
This can be helpful for quick tests.
1. From the Project Window, open Samples > XR Interaction Toolkit > [version] > XR Device Simulator
2. Drag the XR Device Simulator Prefab into he Hierarchy
3. Click Play to test the simulator
NB: Ensure the Device Simulator is disabled when testing on your headset
Return to Unity Tutorial

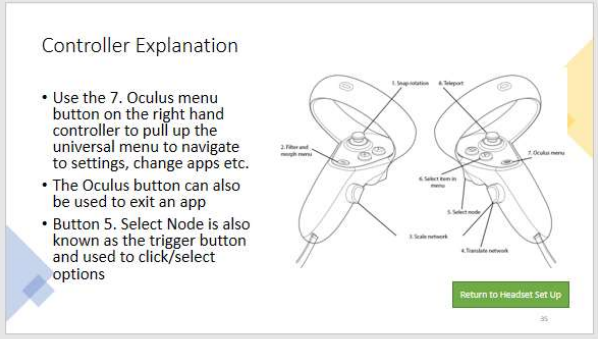
32


Updates on Set Up
Click here for tutorial demonstrating these steps:
When installing the package in XR Plug-In Management (Edit > Project Settings):
a) Select OpenXR, rather than Oculus to accommodate all headsets
b) Once OpenXR is selected there will be a warning. Click on the warning and select "Fix All"
c) One issue should remain, so select "Edit"
d) Under Interaction Profiles select the "+" sign and select at least "Oculus Touch Controller Profile" (if you are unsure what device will be used, also add "HTC Vive", "Microsoft Motion" and "Valve Index")
e) Click the Android Tab at the top of the screen and repeat step C on this separate tab
f) Return to XR Plug-In Management and go to the Android Tab. Again select OpenXR, click on the issue that pops up and select "Fix All"
g) Exit settings and navigate: Window > Package Manager > OpenXR Plugin, click into Samples, and import Controller Samples
Return to Unity Tutorial

33


Tips to Reduce Blurriness
Click here for a tutorial to adjust the headset if you are a glasses wearer
Adjust the headset to change the eye level
Adjust the distance between lenses
For Oculus Quest there is a slider on the bottom left that will adjust the lenses distance
For other headset a quick Google search should teach you how to adjust this
Ensure you are wearing your glasses or contacts (preferable) if your eye sight is poor
Clean the lenses with an appropriate glasses cleaner (e.g. microfibre cloth)
Return to Headset Set Up

34


Controller Explanation
Use the 7. Oculus menu button on the right hand controller to pull up the universal menu to navigate to settings, change apps etc.
The Oculus button can also be used to exit an app
Button 5. Select Node is also known as the trigger button and used to click/select options
Return to Headset Set Up

35

Appendix B – Survey Responses

Have you had experience learning from home (university or school level)?	What is your preferred platform for online learning i.e. which platform do you find easiest to use?	What is your preferred learning method?	What is your second preferred learning method?	When using a Powerpoint for learning which do you prefer?	What makes an online learning platform effective and creates the most memory retention (e.g. quizzes, demonstration of examples, an engaging lecturer, repetition, enjoyment/interest in content)?
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step written instructions	More slides with less text on each	engaging lecturer
Yes	Powerpoint	Textbooks	Step-by-step written instructions	Less slides with more text on each	quizzes/opportunity to participate, and making sure it's not too dry (maybe fun or relevant examples)
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	Less slides with more text on each	Engaging text, visuals, and welcoming vibe
Yes	Powerpoint	Video tutorials with follow-along instruction	Textbooks	More slides with less text on each	Focus on the big picture/the context in which the information is relevant. Appropriate explanation of information and how it links to material. Test questions. Engagement and contact with a lecturer/tutor
No	Website	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	More slides with less text on each	Kahoot
Yes	Powerpoint	Step-by-step visual/pictured instructions	Step-by-step written instructions	More slides with less text on each	Memes
Yes	Powerpoint	Textbooks	Video tutorials with follow-along instruction	More slides with less text on each	Quizzes and open discussions
Yes	Word Document / PDF	Textbooks	Step-by-step written instructions	More slides with less text on each	Engaging lecturer with clear content of the subject

Yes	Word Document / PDF	Textbooks	Step-by-step written instructions	More slides with less text on each	Engaging lecturer with clear concise course content
Yes	Powerpoint	Step-by-step visual/pictured instructions	Video tutorials with follow-along instruction	More slides with less text on each	engaging content
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	Less slides with more text on each	Quizzes, lots of examples, step by step
Yes	Powerpoint	Video tutorials with follow-along instruction	Textbooks	More slides with less text on each	Engaging lecturer, examples
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step written instructions	More slides with less text on each	Quizzes
Yes	Powerpoint	Video tutorials with follow-along instruction	Textbooks	More slides with less text on each	interesting content
Yes	Powerpoint	Step-by-step written instructions	Video tutorials with follow-along instruction	Less slides with more text on each	demonstration
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	More slides with less text on each	Gamification
Yes	Website	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	More slides with less text on each	Examples of application of the theory being covered
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	Less slides with more text on each	Engaging lecturer, demonstration of examples
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	More slides with less text on each	Engaging lecturer, quizzes to be scheduled AFTER tutorial examples, more preparation and structure to tutorials

Yes	Website	Video tutorials with follow-along instruction	Step-by-step written instructions	More slides with less text on each	An engaging lecturer who makes classes more interactive, Enjoyment or unit
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	More slides with less text on each	interactivity and demonstration of examples
Yes	Word Document / PDF	Video tutorials with follow-along instruction	Step-by-step written instructions	More slides with less text on each	Interactive opportunities to reiterate content and apply knowledge to questions/scenarios
Yes	Powerpoint	Step-by-step visual/pictured instructions	Video tutorials with follow-along instruction	More slides with less text on each	Demos and exercises, clear explanation with diagrams
No	Word Document / PDF	Video tutorials with follow-along instruction	Textbooks	Less slides with more text on each	Demonstration of examples and practice
Yes	Website	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	More slides with less text on each	
Yes	Word Document / PDF	Video tutorials with follow-along instruction	Step-by-step written instructions	More slides with less text on each	Interesting content, real life examples, quiz questions
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step written instructions	Less slides with more text on each	Engaging lecturer and interest in content
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	More slides with less text on each	Quizzes, interactive content where you practice the concepts
Yes	Powerpoint	Step-by-step visual/pictured instructions	Step-by-step written instructions	More slides with less text on each	Interactive modules because they are fun and stimulate the brain whilst learning content

Yes	Word Document / PDF	Step-by-step visual/pictured instructions	Step-by-step written instructions	Less slides with more text on each	Short engaging videos, pictures, colour
No	Word Document / PDF	Video tutorials with follow-along instruction	Textbooks	More slides with less text on each	Quizzes
Yes	Powerpoint	Textbooks	Step-by-step written instructions	More slides with less text on each	enjoyment/interest in content, engaging lecturer
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step written instructions	More slides with less text on each	continuous rewards for progress
Yes	Powerpoint	Step-by-step written instructions	Video tutorials with follow-along instruction	Less slides with more text on each	follow-along demonstration
Yes	Word Document / PDF	Step-by-step written instructions	Step-by-step visual/pictured instructions	More slides with less text on each	engaging lecturer that generates interest in the topic
Yes	Word Document / PDF	Textbooks	Step-by-step written instructions	More slides with less text on each	assessment
Yes	Website	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	Less slides with more text on each	examples
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step visual/pictured instructions	More slides with less text on each	examples
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step written instructions	More slides with less text on each	enjoyment of content
Yes	Powerpoint	Video tutorials with follow-along instruction	Step-by-step written instructions	More slides with less text on each	quizzes