

# THE FOREST TEMPLE

EXPLORING AN ILLUSTRATED NARRATIVE IN VR

BY

Nayaki Anandan

THESIS

Submitted in partial fulfillment of the requirements  
for the degree of Master of Fine Arts in Digital Arts  
awarded by DigiPen Institute of Technology

Redmond, Washington

United States of America

December

2018

Thesis Advisor: David Longo

Thesis Committee: Natalie Burke, Mark Henne.

© 2018, DigiPen Institute of Technology, All Rights Reserved.

The material presented within this document does not necessarily reflect the opinion of the Committee, the Graduate Study Program, or DigiPen Institute of Technology.

## ACKNOWLEDGEMENTS

The creation of this immense project is due to so many people other than myself and would not have been even conceivably possible without them. First, I would like to thank the prolific team of thesis advisors and professors at Digipen Institute of Technology, who helped me scope, program, design, and realize this project that was originally just one small idea swimming amongst many in an artist's mind.

I must specifically thank Professor James Borchers, for creating the beautiful sound that adds so much emotional quality and guidance throughout *The Forest Temple*.

That mind was forged through unimaginable support and life experiences thanks to my mother and father, who are always presenting me with new lenses to see the world through. Therefore, I must thank Pell and Padmanabhan, my loving parents, for their constant fostering of my curiosity, and for saturating my life with art and culture.

Thank you also to Shevek, the brother who introduced me to video games in the first place and to this world that has become my calling

Finally, thank you to my partner, Nick, who was there to keep me going through many a late night, and always knows just the thing to do, say, or cook. Your legendary breakfasts know no equal.

## ABSTRACT

This thesis presents a narrative experience in virtual reality titled “The Forest Temple” that aims to present an original artistic aesthetic that, in combination with narrative and compositional cues, drives the player forward through the plot. Using Virtual Reality platforms in conjunction with Illustrative tools creates a compelling and emotional player-driven narrative with the power to alter perception. The artistic aesthetic of the experience is a heavily researched and tested watercolor technique that shows evidence of the original medium and creation in the final product. “The Forest Temple” guides a player through the environment using sound, posing, composition, and the player’s innate curiosity. This storybook-like experience demonstrates a new way to present a narrative in virtual reality, without animation or complex interaction. This project shows potential for extended applications in therapy, entertainment, and problem solving, and gives artists and storytellers a new format in which to create.

## TABLE OF CONTENTS:

ABSTRACT.....	iv
LIST OF FIGURES .....	vi
INTRODUCTION .....	1
I. BUILDING A NARRATIVE .....	3
II. CHOOSING VR .....	12
III. CREATING A LOOK AND FEEL .....	22
IV. ILLUSTRATING A STILL EXPERIENCE .....	25
V. WATERCOLOR TEXTURING TECHNIQUE.....	43
VI. SOUND AND COLOR COMPOSITION .....	59
VII. OPTIMIZING FOR VR.....	64
VIII. GAME TESTING .....	74
IX. LOOKING FORWARD .....	77
X. CONCLUSION.....	81
BIBLIOGRAPHY.....	84

## LIST OF FIGURES

Figure I.1 Nayaki Anandan, Diagram of the Hero's Journey, December 1st, 2018. ....	3
Figure I.2 UsTwo Games, Land's End, Screenshot, Game Released October 30th, 2015. 4	
Figure I.3 Chris Van Allsburg, The Seven Chairs, "The Fifth one ended up in France.", 1984, Houghton Mifflin .....	5
Figure I.4 Nayaki Anandan, The Temple, 2018 .....	8
Figure I.5 Nayaki Anandan, Diagram of The Forest Temple Journey, 2018. ....	10
Figure II.1 Oculus Rift (Left) and HTC Vive (Right) headsets, courtesy of www.geek.com. ....	12
Figure II.2 Jim Naughten,"The Deer", Stereographic Image, 2017. From the Series "Mountains of Kong" .....	12
Figure II.3 Nayaki Anandan, Teleportation Mechanic, 2018. ....	15
Figure II.4 Nayaki Anandan, Blink Teleport Option, 2018.....	16
Figure II.5 Nayaki Anandan, Idol with Timestamp, 2018.....	17
Figure II.6 Nayaki Anandan, Blink Teleport Option, 2018.....	17
Figure II.7 Nayaki Anandan, Panorama Painting in Photoshop, 2018. ....	19
Figure II.8 Nayaki Anandan, Map of Camera Locations, 2018.....	20
Figure II.9 Nayaki Anandan, example of a blueprint, 2018 .....	21
Figure III.1 Nayaki Anandan, Charcoal Village, 2016.....	22
Figure III.2 Ready at Dawn, Okami HD, 2014, Screenshot. ....	22
Figure III.3 Ubisoft Entertainment, "Child of Light", 2018, Screenshot.....	23

Figure III.4 Illustration from 'Bland Tomtar Och Troll' (Among Gnomes and Trolls) art by John Bauer .....	24
Figure III.5 Andrew Wyeth, Night Hauling, 1944. Bowdoin College Museum of Art, Brunswick, ME. ....	25
Figure IV.1 Michelangelo di Lodovico Buonarroto Simoni, David, marble, 1501-1504. Galleria dell'Accademia .....	26
Figure IV.2 Michelangelo Merisi da Caravaggio, Salome Receives the Head of John the Baptiste, oil on canvas, 1571-1610. The National Gallery. ....	26
Figure IV.3 Nayaki Anandan, Baby Creature Posed, 2018. ....	27
Figure IV.4 Excited Puppy, Image courtesy of Stock Images, 2018. ....	27
Figure IV.5 Nayaki Anandan, Posing for final scene, 2018. ....	28
Figure IV.6 Nayaki Anandan, Parent Creature in Temple, 2018. ....	28
Figure IV.7 Nayaki Anandan, Posing in Zbrush, 2018. ....	29
Figure IV.8 Nayaki Anandan, Creature Silhouettes, 2017. ....	30
Figure IV.9 Nayaki Anandan, Final Creature, 2018. ....	31
Figure IV.10 Nayaki Anandan, Origami Alien Creature, 2018. ....	32
Figure IV.11 Nayaki Anandan. Environment Designs for The Forest Temple, Digital Painting, 2017. ....	33
Figure IV.12 Michael Nielsen, Giant's Causeway, June 9, 2001. ....	33
Figure IV.13 Nayaki Anandan, Rocks from the Forest Temple. 2018. ....	34
Figure IV.14 Nayaki Anandan, Tree, 2018. ....	34
Figure IV.15 Fred Hoogervorst, Photo #20978. ....	34
Figure IV.16 John Henley. The Great Dismal Swamp, Image #12. November 9, 2011. .	35

Figure IV.17 Storm_Front, Lichen on a Mesquite Tree, December 29, 2006. Courtesy of Flickr.....	35
Figure IV.18 Nayaki Anandan, Big Tree, 2018.....	35
Figure IV.19 Nayaki Anandan, Environment Textures, 2018.....	36
Figure IV.20 Nayaki Anandan, Color Script, 2018. ....	37
Figure IV.21 Nayaki Anandan, Using MASH in Maya, 2018.....	38
Figure IV.22 Nayaki Anandan, Retopoligizing a wall, 2018. ....	39
Figure IV.23 Nayaki Anandan, Finished Temple Wall, 2018.....	40
Figure IV.24 Nayaki Anandan, Tree Script Screenshot, 2017. ....	41
Figure IV.25 Nayaki Anandan, Temple Altar, 2018. ....	42
Figure V.1 Nintendo, Screenshot from The Legend of Zelda: Ocarina of Time, November 1998.....	44
Figure V.2 Bethesda Game Studios, The Elder Scrolls V: Skyrim, November 2011. ....	45
Figure V.3 Sergey Kolesov, Mermaid, 2014. Courtesy of Artstation.com .....	46
Figure V.4 Robert Lawson, Ferdinand The Bull, Munro Leaf, 1936. ....	46
Figure V.5 Tadahiro Uesugi, Courtesy of The Art of Animation.....	47
Figure V.6 Nayaki Anandan, UV map of Idol, 2018.....	48
Figure V.7 Nayaki Anandan, Temple Painting, 2018.....	50
Figure V.8 Nayaki Anandan, AO map of Idol, 2018.....	52
Figure V.9 Nayaki Anandan, AO plus UV map, 2018. ....	53
Figure V.10 Nayaki Anandan, Acetone Transfer Result, 2018.....	54
Figure V.11 Nayaki Anandan, Curvature Map of Columns, 2018. ....	55
Figure V.12 Nayaki Anandan, Column with Curvature Map, 2018.....	56



Figure VI.1 Nayaki Anandan, Diegetic sound integration, 2018. ....	59
Figure VI.2 Nayaki Anandan, Sound Attenuation Spheres, 2018. ....	61
Figure VI.3 Nayaki Anandan, Node structure for saturation, 2018. ....	62
Figure VI.4 Nayaki Anandan, Desaturation technique, 2018. ....	63
Figure VI.5 Nayaki Anandan, Snapshot with Desaturation level 0, 2018. ....	63
Figure VI.6 Nayaki Anandan, Snapshot with Desaturation level 0.8. ....	64
Figure VII.1 Nayaki Anandan, Parent Material, 2018. ....	66
Figure VII.2 Nayaki Anandan, Instanced Material, 2018. ....	67
Figure VII.3 Nayaki Anandan, Baby Creature with FULL SS, 2018. ....	68
Figure VII.4 Nayaki Anandan, Baby Creature with NO SS 2018. ....	68
Figure VII.5 Nayaki Anandan, Shader Complexity Viewer in Ue4, 2018. ....	70
Figure VII.6 Phosphor. "A Palm Branch before and after excess alpha space is removed". November 2, 2017. ....	71
Figure VII.7 Nayaki Anandan, LODs for Trees, 2018. ....	71
Figure VII.8 Nayaki Anandan, All levels visible, 2018. ....	72
Figure VII.9 Nayaki Anandan, Inside the Temple Level Streaming, 2018. ....	73
Figure VII.10 Nayaki Anandan, Level Streaming, 2018. ....	74
Figure VIII.1 Nayaki Anandan, Data from Tester Experience Survey, 2018. ....	76
Figure IX.1 Wesley Allsbrook, Dear Angelica, Oculus Story Studio, January 21, 2017. ....	79

## INTRODUCTION

From birth we are exposed to stories that tell us what is good, what is bad, and how to create those definitions for ourselves. We are given the opportunity to build our philosophies through knowledge, to understand the universe around us, to invest in belief, and to study. All this opportunity is given to us through information in the form of writing, speech, illustration, and data. The growth of technology offers new tools to help us understand this information, to curate it, and create it. One such technology is Virtual Reality.

Over the course of the next few chapters I explore how using Virtual Reality platforms in conjunction with Illustrative tools creates a compelling and emotional player-driven narrative with the power to alter perception. I do this through discussing the inspiration, creation, and final deployment of a video game experience titled *The Forest Temple*. This game is a representation of not only my own watercolor style and aesthetic, but how I have developed that style to fit within the context of a video game. It also explores a method of storytelling in Virtual Reality, a relatively new technology with opportunities and challenges in immersion.

The first few chapters of this paper will discuss the narrative direction and story development for *The Forest Temple*. They will detail the primary sources of inspiration in both video games and artworks in traditional media and give a brief summary of the journey the player takes in-game. After that, the artistic aesthetic and motivations are explored, and I introduce the watercolor texturing technique that defines the overall look for the experience.

In the later chapters I will outline the difficulties of working in the medium of Virtual Reality. This includes issues with nausea, performance, and movement in VR. I will then briefly discuss the testing of the game at a milestone, and the results and implementations of this testing. In the last two chapters I will explain the successes of the project and some future applications from this thesis. Lastly in the conclusion I discuss the successes and challenges faced in the project, and the final result.

## I. BUILDING A NARRATIVE

What is needed to create an effective narrative? Many narratives start simply with a hero, and follow the path of the hero's journey, written about famously by Joseph Campbell<sup>1</sup>, and roughly outlined by me below [Figure 1.1].

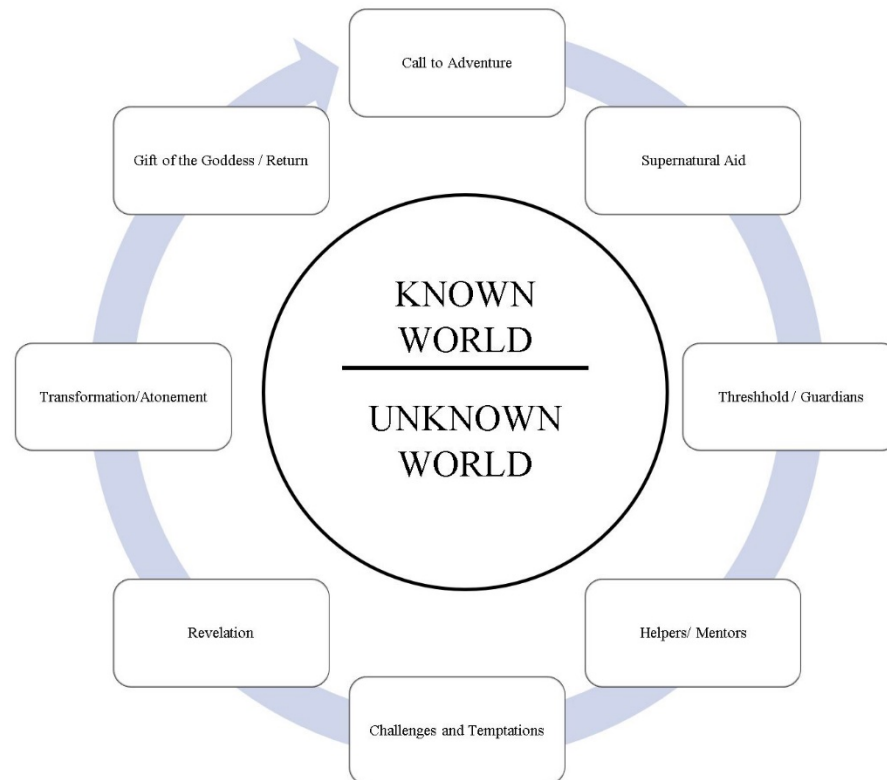


Figure 1.1 Nayaki Anandan, *Diagram of the Hero's Journey*, December 1st, 2018.

Many popular stories use this formula, including but not limited to: *The Lord of the Rings* Trilogy, *Star Wars*, *Harry Potter*, and *The Lion King* (and most Disney Movies). There are many ways to follow this path, and many ways to deviate from it, as is evident in the plethora of stories and myths passed down from generation to generation. There are also

<sup>1</sup> Joseph Campbell, *The Hero with a Thousand Faces*, 2008th ed., The Collected Works of Joseph Campbell, Book 17 (New World Library, 2008).

many ways to discover a narrative. These stories can be spoken, read, sang, painted, sculpted, and more recently, played in a video game. In the creation of *The Forest Temple* I have been inspired by many narratives in many different formats. My primary source of inspiration is the first VR game I ever played, titled “Land’s End” [Fig 1.2].

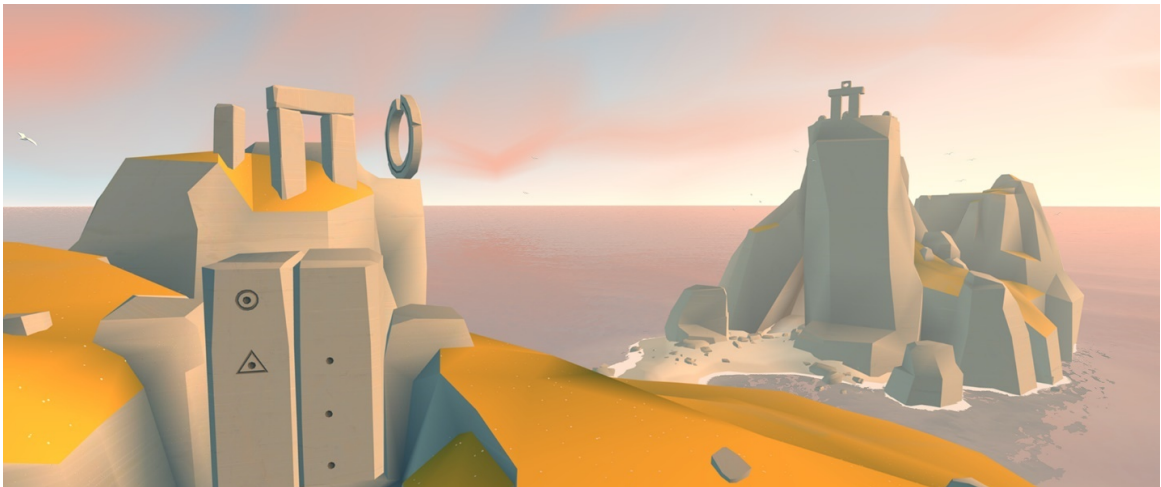


Figure 1.2 UsTwo Games, *Land's End*, Screenshot, Game Released October 30th, 2015.

In Land’s End, the player uses their gaze to travel through a world and solve puzzles that reveal clues to a subtle story. The artwork is simple, there is very little in the way of animation and sound, and the entire game takes less than an hour to play. What interests me, however, is the fact that the motivation to continue is entirely player generated. There is no reward aside from uncovering a narrative. There is no great hero’s journey, there is only the expansive beauty of the environment and the desire to explore. I was instantly captivated by the effective simplicity of this game, and the intuitiveness with how it used the format of VR. The use of gaze-based interaction to move the player not only helped keep them immersed in the environment, but it also allowed for a seated, comfortable experience that didn’t induce nausea. Nausea and movement style are common issues with VR games, and I was impressed at how these problems were tackled in this instance. Rather than having the player hold a controller, or use head tilts or other

gestures of the head to move, they must simply look at a specified location on screen (marked by a white dot), wait for it to indicate that you've been looking at it for the appropriate amount of time, and then be taken along a pre-defined track<sup>2</sup>. This required little to no explanation in the beginning of the game and cause me personally no discomfort while playing. This later influenced some of the technology implementations in *The Forest Temple*.

Books also played a role in the creation of *The Forest Temple*'s story. The book *The Mysteries of Harris Burdick* by Chris Van Allsburg features individual illustrations

with no more than a sentence or two next to them on each page. For example, in this page [Fig 1.3] taken from the book, one can see a seated nun floating in a tall cathedral hall, being stared at by two Cardinals. The title of the page is "The Seven Chairs", and the caption simply reads "The fifth one ended up in France." Giving so little information paired with an intriguing image adds to the interest of the illustration.

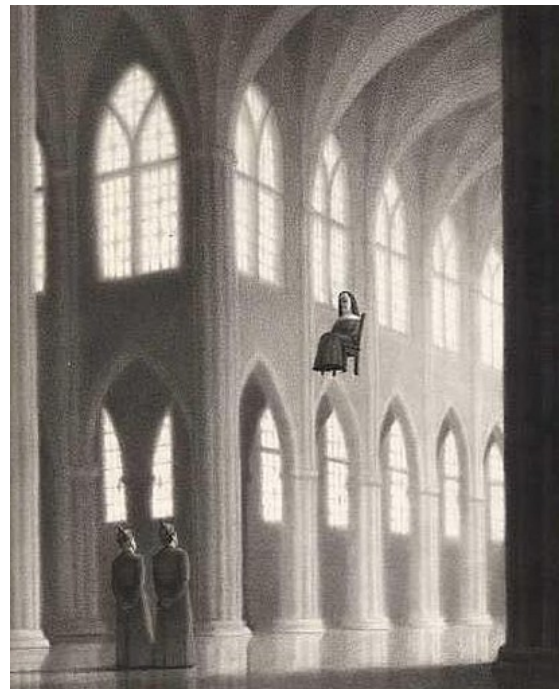


Figure 1.3 Chris Van Allsburg, *The Seven Chairs*, "The Fifth one ended up in France.", 1984, Houghton Mifflin

Despite the minimalism of this book, the

narrative possibilities it gives the reader are enormous, as it only gently implies a story, allowing the reader to fill in the blanks. I was interested in the way the reader was

---

<sup>2</sup> POP 2Review, *Land's End for Gear VR - A Stunning VR Adventure from the Creators of Monument Valley*, Youtube Video, 2016, <https://www.youtube.com/watch?v=Jlt5OasHOH0&t=379s>.

responsible for interpreting the small clues given by each image and sentence, all while being taken away by Van Allsburg's deep and luminous renderings in pencil. This book demonstrates the importance of a rich artistic style and attention to the appropriate details to help drive an interesting story. Later, this book played an important role in helping me to determine how to appropriately stylize my Virtual Reality experience.

Both *The Mysteries of Harris Burdick* and *Land's End* played a part in developing the narrative for *The Forest Temple*, which I wanted to be subtle and player-driven. Rather than guiding a character through a linear story, I wanted to reveal clues and opportunities to discover context that would eventually paint a picture for the player, supplemented by fantastic artwork in a specific style. I also wanted movement through the game to be fluid and woven into the gameplay in a way that is optimized for Virtual Reality. VR gives of the opportunity to fully engage the player and asks them to explore and decipher the narrative structure of *The Forest Temple*. I wanted the player to feel like an outsider who has stumbled across this recording of a series of events and must play detective to understand the progression and results of what has happened. Therefore, to give players the best close-up and engaging experience, VR was the best mode of delivery. Eventually, I constructed a narrative experience that played out somewhat like the trailer for a game, leaving the player wanting more to discover and explore.

The idea for *The Forest Temple* was initially inspired by a more complex world I had started formulating my senior year of undergraduate studies at the Rhode Island School of Design. The game idea was an open world experience, taking place on a planet that was divided into 4 distinct environments. In each of these environments walked a huge creature that supported the complex ecosystem of the planet. The player of the game

represented an explorer who had crash landed or been assigned to explore the planet. Tragically, an alien species which resembled in appearance folded paper like origami, had begun to 'infect' the native life of the planet, turning creatures violent and angry. As the foreign explorer, your task was to either find a way for the native life and the alien life to survive, or to allow one to die off while the other thrived. *The Forest Temple* acts as a trailer to this larger game, providing an emotional experience that urges the player to navigate each diorama carefully to discover what has happened, and will happen to the main characters.

In *the Forest Temple* the player follows two characters through a colorful watercolor alien world. There is no movement or animation because the player is experiencing this story as individual moments frozen in time. Instead, the player is invited to focus on the artwork and simple movement through the scenes to discover the story behind the experience. Each of these 'scenes' I reference are set up like small dioramas. Each one is a moment that has been stopped in time, featuring the necessary characters in poses that express their personalities or their actions. The choice to have no animation was based on three reasons; first: hardware optimization, second: to give the game a more storybook-like feel, and third: limited time. No more than one diorama can be seen from each viewpoint, aiding the continuation of the story. The player moves through the game by gazing at objects specified in the beginning of the experience; small trailside idols that somewhat resemble the main characters of the game. This idea for using gaze-based interaction was taken directly from Land's End. I chose this teleportation system because I felt that having the player hold a controller would detract from an otherwise meditative and naturally flowing experience. When a player has stared



at an Idol for long enough, they are moved on a predetermined path to the next Diorama to explore. In order to move back to the previous diorama, they need only look at the same idol that just teleported them. In this way, the player can experience the narrative in a non-linear, but cohesive and continuous fashion.

The main characters of *The Forest Temple* are two alien creatures that resemble dinosaurs, a design I chose while referencing animals one might find in a forest that have a primarily vegetarian diet. Deer were an inspiration, and the dinosaur Brachiosaurus, with its incredible proportions. I also researched giraffe anatomy to properly structure the legs of the creatures. These characters are a parent and child which is evident by the size of each creature, the posing in the individual dioramas, and the interaction between them. The player follows the pair of creatures through some dense forest, until they arrive at a temple [Fig 1.4].



Figure 1.4 Nayaki Anandan, *The Temple*, 2018

On entering the temple, the player is met by a mysterious, out of place looking creature. It has little to no color in stark contrast with the rest of the environment, and it resembles folded paper in its construction, like origami. Upon investigation, this

character in silhouette resembles the same species as the main characters in the game.

Also, inside the temple the player will find the parent looking down at another creature of its species, which has been half transformed into the same colorless, polygonal creature mentioned before. The player is given the opportunity to explore the temple from various angles, discovering other clues that give an idea of what might have transpired. Upon leaving the temple, the player finds themselves facing more dense forest, and some ominous music, on the other side of the temple. As they continue, they find the parent creature and the child running through the woods, some sort of polygonal, colorless infection spreading from a point on the parent's side. Moving forward, the player might notice that most colors have become less vibrant and tinged toward red, as they stumble upon the parent and baby in a clearing in the woods. The parent at this point has transformed almost completely into an origami-like form, and the child appears to be backing away in fear. The player can then move on to the last scene, which shows the baby standing on the beach, looking to the horizon, alone. There is a boat that has been pulled up onto the beach, and if the player continues onward, they will find a note left by an explorer. The note states that the explorer was instructed to come to this temple by the local intelligent life, who fear something that originates from it. The explorer then explains that they have gone to investigate but will record what they find. The implication is that this recording is what the player is currently experiencing. At this point the player can choose to keep going and circle back to the starting point of the

game, where they can revisit scenes looking for more clues.

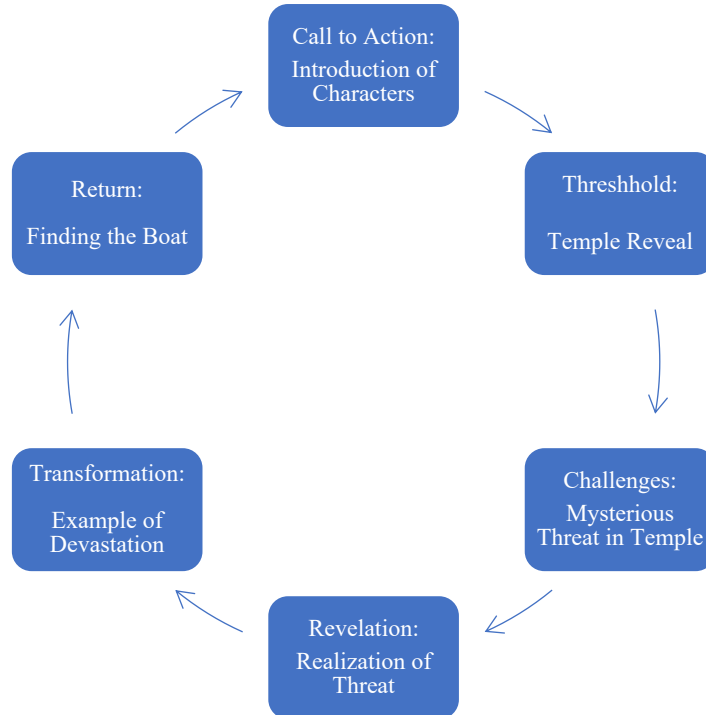


Figure 1.5 Nayaki Anandan, *Diagram of The Forest Temple Journey*, 2018.

At the beginning of this chapter, I outlined briefly Joseph Campbell's Hero's Journey. Despite my emphasis on player-driven narratives, it is important to discuss how the player in *The Forest Temple* experiences the hero's journey as well. In [Figure 1.4] I have outlined how *The Forest Temple's* story still correlates with the Hero's Journey, and where it departs from that formula. The story begins by asking the player to explore through introducing an unfamiliar environment with alienlike creatures, this is an abstract call to action. Then, after a scene that gives the characters another chance to express their personality, the player sees the temple, which represents the threshold to the unfamiliar world. Upon entering, it is apparent that something is happening, but it is difficult to understand what, other than that the parental creature seems eager to protect its child from the odd, origami-like figure in the scene. This scene challenges the player to try and

understand what is happening. The revelation comes when the player continues outside of the temple and realizes that there is a transformation taking place in the parent creature. The next scene shows an origami-like substance sprawling across the parent creature's body. This represents both transformation literally, and in the emotional context of the game. The careful posing of the characters in the final transformation scene implies the pain and terror of this process. Finally, the player can move onward to the beach, where they see the devastation the parent's transformation has caused on the baby. They also find the boat, which represents the return to the familiar world, because it gives context as to who the player is meant to be in the story.

Although much of this narrative is meant to be constructed by the person experiencing *The Forest Temple*, there is a basic path that I designed for them to follow. That path, despite often deviating from the Hero's Journey chart presented earlier, still follows the overall schematic in many ways. The medium of Virtual Reality allows the hero's journey to be experienced from the first person in a more impactful and emotional way.

## II. CHOOSING VR

My first experience with Virtual and Alternate Reality was in watching sci-fi TV shows like *Star Trek: The Next Generation*<sup>3</sup>, which specifically used the Holodeck to



Figure II.2 Jim Naughten, "The Deer", Stereographic Image, 2017. From the Series "Mountains of Kong"

transport characters from the series to the future, past, and other worlds entirely. It could be argued that the first example of VR

technology was the creation of stereoscopic photos and viewers. In short, these separated images into the right and left eye view (usually photos of the same scene taken at slightly different angles [Fig 2.1]) and recombined them using special lenses to make a 3D



Figure II.1 Oculus Rift (Left) and HTC Vive (Right) headsets, courtesy of [www.geek.com](http://www.geek.com).

<sup>3</sup> Gene Roddenberry, "Star Trek: The Next Generation" (Paramount Pictures, n.d.).

illusion for the viewer. This same simple technology is used in the newest Virtual Reality headsets such as the Oculus Rift and the HTC Vive [Fig 2.2]. Put simply, these devices use special sensors that track the location and movement of the player's head, and stereoscopic lenses to fuse 2 images together to give the illusion of 3D space. When playing a game on the Oculus Rift for example, the device is rendering 2 different perspectives of the scene on two monitors and fusing them together using the lenses to create a 3D experience. Thanks to the use of stereoscopic rendering and expanded capabilities in tracking and graphics, people can now experience Virtual Reality by using headset devices like the HTC Vive and the Oculus Rift. Better yet, some phones can run VR games with the purchase of a Samsung Gear Headset or even just a cardboard box with some inexpensive lenses. While we haven't quite reached Holodeck Levels of VR, one can now put on a VR headset and be immersed in a completely unique world that they can interact with from a first-person point of view.

Virtual Reality has offered an exciting new format for narratives, providing a level of immersion and believability that opens endless doors of opportunity. In order to harness this exciting tool, I wanted to see if I could boil down to the essentials of a VR narrative, that overcomes some of the struggles that this technology presents. In order to have a truly engaging experience, without disruption, I needed to tackle the issue of nausea. VR has been demonstrated to cause issues with nausea for a variety of personal, medical and technology related reasons. The main problems that cause issues with simulation sickness in VR are these:

1. Low framerate and/or high latency
2. Moving too fast

### 3. Teleportation Style <sup>4</sup>

I write ‘simulation sickness’ simply because there is a small difference between this and motion sickness. As put in a GDC vault talk by Ben Lewis-Evans, “In motion sickness you are moving, and there’s some kind of mismatch, in simulation sickness, you’re not moving but you’re perceiving you are moving, and that’s the mismatch,”<sup>5</sup>. Low framerate is the main culprit for nausea<sup>6</sup>, and the solution to this is simply to optimize your models, textures, and lighting for the given hardware. A good standard for framerate is 90 FPS or above, and the Oculus Rift hardware I used for my project is built for this. Much of my optimization of framerate can be read about further on in my discussion of the artistic creation process, but I also stuck to some standards for VR. These were: Use only static lighting, no transparency, and keep models as low poly as possible. The decision to not have animation or movement in my scene greatly aided optimization for VR as well.

Adjusting the movement style and speed in *The Forest Temple* was the next step. As previously stated, I used a spline-based teleport system, that was triggered by the player looking at a specific object (in this case, an idol) for a period before they would be automatically moved along a spline. A spline is a path generated by extrapolating a curve

---

<sup>4</sup> Patrick O’Luanaigh, *Travelling Without Moving - Controlling Movement in Virtual Reality*, Youtube Video, 2015, <https://www.youtube.com/watch?v=Zsg8L43k7QY>.

<sup>5</sup> Ben Lewis-Evans, *Designing To Minimize Simulation Sickness in VR Games*, 2015, <https://www.gdcvault.com/play/1022772/Designing-to-Minimize-Simulation-Sickness>.

<sup>6</sup> Becca Cady, “Vomit Reality: Why VR Makes Some of Us Feel Sick and How to Make It Stop,” *Wareable*, October 19, 2016, <https://www.wareable.com/vr/vr-headset-motion-sickness-solution-777>.

from several specifically placed points. Movement became challenging to refine, as the

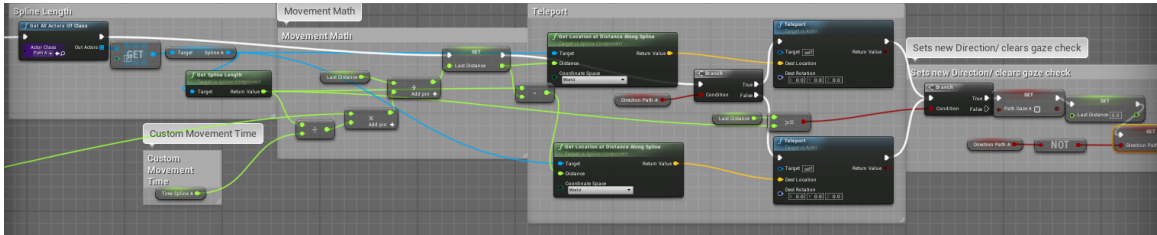


Figure II.3 Nayaki Anandan, *Teleportation Mechanic*, 2018.

player's speed in *The Forest Temple* is determined by a different value that must be individually edited for each spline.

This image [Fig 2.3] shows the logic behind the teleportation mechanic, which I was able to structure thanks to Professor Natalie Burke. Essentially, this formula divides a spline into values based on the 'Custom Movement Time' and uses that to move the player incrementally along the spline. Additionally, the formula changes a Boolean that determines what direction to move the player along the spline, allowing them to move from point A to B and back to A again smoothly. Put simply, it indicates whether the player is currently at point A or B when they start moving. Since the 'Custom Movement Time' is different for each spline, I had to copy and paste the same node structure over and over, reconnect all the appropriate nodes, and repeatedly adjust and test my spline movement. Something that is congruent with speed, however, is the need to ground the viewer so that they have something to visually reference for their balance<sup>7</sup>. As I tested my game, I found that people were still getting nauseous, and the main suggestions I received was to 'put the player in a boat', indicate the spline visually or, finally, scrap the movement altogether and implement blink teleport. Putting someone in a boat means to give the player something to ground them as they are moving such as a platform, so that

<sup>7</sup> Lewis-Evans, *Designing To Minimize Simulation Sickness in VR Games*.



they have a point of reference for their body. I decided to see if I could explore my other options first, as I didn't want to add too many distracting visual elements. I did end up

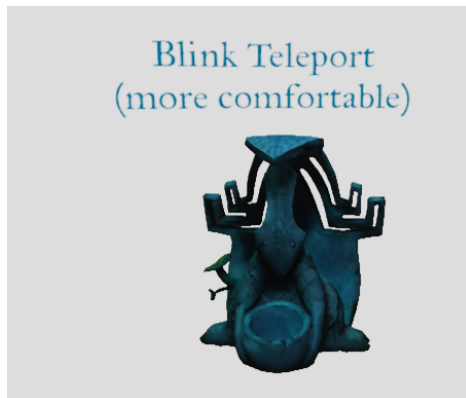


Figure II.4 Nayaki Anandan, *Blink Teleport Option*, 2018

indicating the spline visually, by making it glow before and during movement along the route.

Finally, I added the option for blink teleport [Fig 2.4] at the beginning of the game. A blink teleport, instead of having the player travel along a spline in real time, simply fades the screen to black, and fades back in at the next location. Adding this

option also gave me an opportunity to show the viewer *how* the teleportation mechanic worked by having them select one of the idols to choose teleportation style. After testing my game with these solutions in place, I found out that blurring or hiding the player's peripheral vision can also reduce nausea from one of my teachers<sup>8</sup>. I used a post processing material to add a vignette to the camera as the player is moving, blocking their peripheral vision. Post processing materials can be used to create effects that are added after the engine has rendered the scene, which saves time and memory. In this case, I

---

<sup>8</sup> Ajoy S. Fernandes and Steven K. Feiner, "Combating VR Sickness through Subtle Dynamic Field-Of-View Modification" (Columbia, March 19, 2016), <http://www.cs.columbia.edu/2016/combating-vr-sickness/images/combating-vr-sickness.pdf>.

called the vignette to be adjusted within the character blueprint [Fig 2.5]. In this section of the blueprint, it checks to see if the character is moving within the last 0.001 seconds,



Figure II.5 Nayaki Anandan, *Idol with Timestamp*, 2018

and if they are, it adjusts the vignette intensity to be at its strongest.

I also used a post processing material to have the screen fade out during the blink-teleport. After more testing, I found that those who used the blink teleport option did not

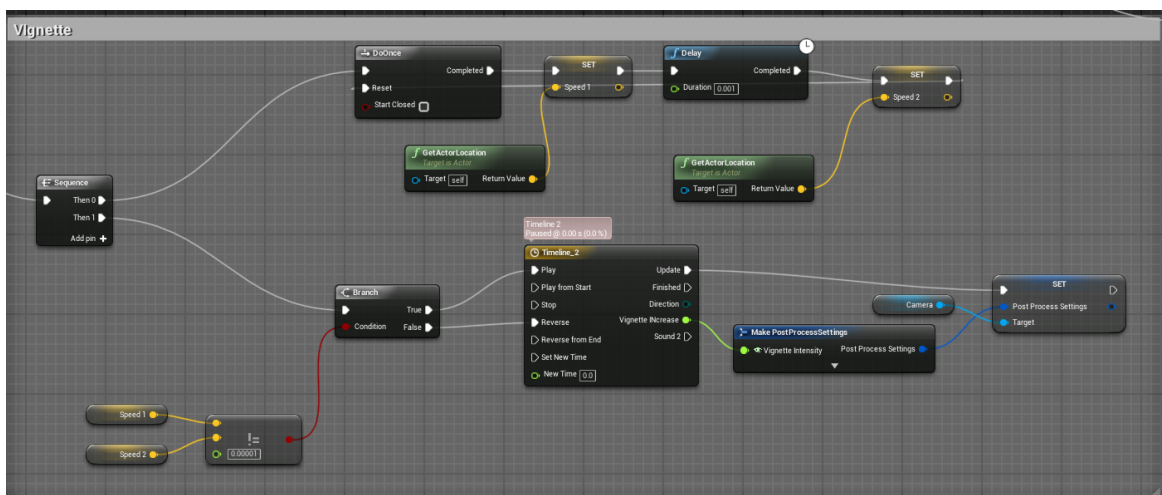


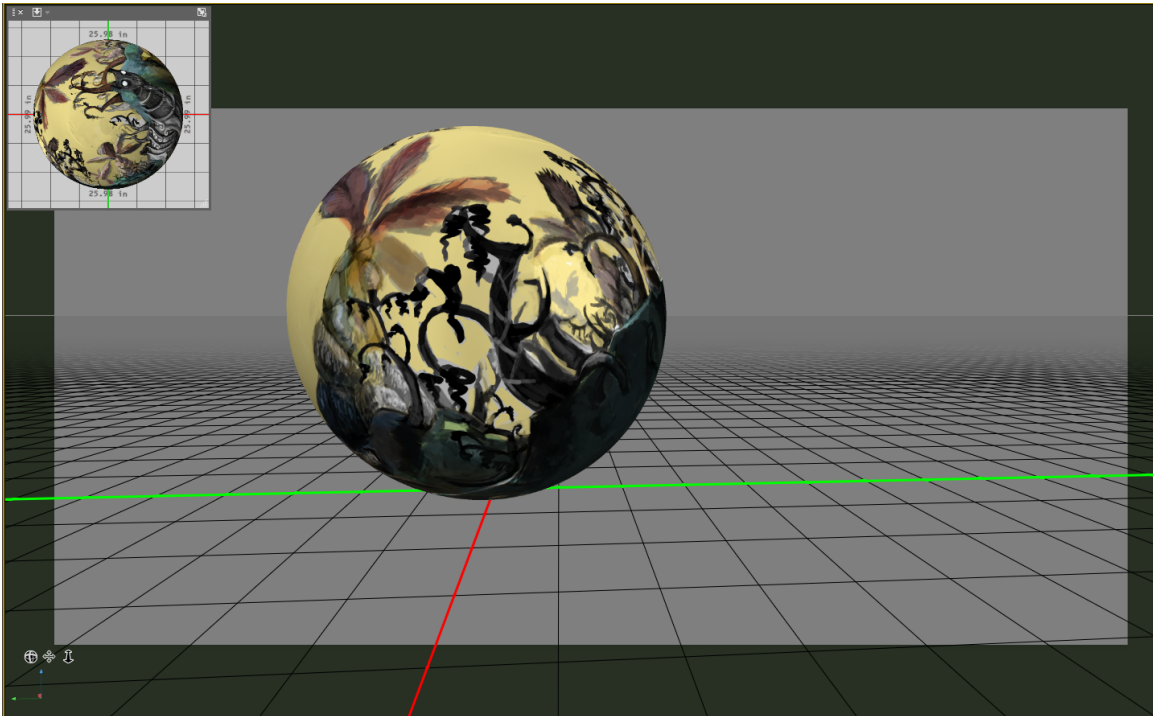
Figure II.6 Nayaki Anandan, *Blink Teleport Option*, 2018

experience nausea, but found the mechanic very disorienting, which dampened the ability to comprehend the narrative. In order to give blink-teleport users more context, I added

timestamps above each Idol which also help to push the narrative concept that the player is experiencing a recording [Fig 2.6].

Aside from the issues that cause nausea, Virtual Reality also presents problems when it comes to film techniques such as composition and framing. Camera framing is an important part of any video game or film, as it helps guide the viewer through the narrative. Designers can use a simple zoom to indicate an important object, or where the player should go next, and create striking compositions when they control the camera. This is especially crucial in film, as this is how directors will hide all the extra details that go into filmmaking; huge lights for a set, microphones, tripods, etc. In many video games the player is given free reign of the camera, but during cutscenes or important moments in the game the camera may be forcibly rotated or moved in a chosen direction by the creator. VR live-action filmmakers struggle with how to hide their hardware from the camera, and how to compose scenes in an attractive manner from all angles. In creating *The Forest Temple*, I didn't have to deal with hiding any hardware, but I did have the issue of how to compose my scenes. This was especially challenging because I only wanted the player to only be able to see one diorama per camera point, but I also had to allow them to move between the camera points by triggering an Idol that can be seen from both locations. Furthermore, the Oculus Rift hardware I chose does not allow the controlled rotation of the player camera. Therefore, in order to rotate the player, I'd actually have to rotate the entire scene around them, which would cause a plethora of software, lighting, and latency issues.

The first way I went about tackling the composition problem was to create a 360-degree concept painting in photoshop, using their 3D tools. These tools allowed me to paint on the inside of a sphere using several layers, just like a regular photoshop painting



*Figure II.7 Nayaki Anandan, Panorama Painting in Photoshop, 2018.*

[Fig 2.7]. This not only helped me develop the impact of the introduction scene but allowed me to understand better some of the issues I'd find once I started creating my game in engine. I also created a map of camera points for my storyboarding class [Fig 2.8], which helped me layout the environment in an intuitive way. I used this map to create an animatic for my game that helped structure the posing and sequence of each diorama. The camera points were perfected by constant iteration and playtesting (on my own and with others) to carefully hide and reveal story elements at the appropriate time. On building my game in engine, I used my animatic as a reference to decide where to

place the player and characters so that the story would flow no matter what direction the player chose to look.

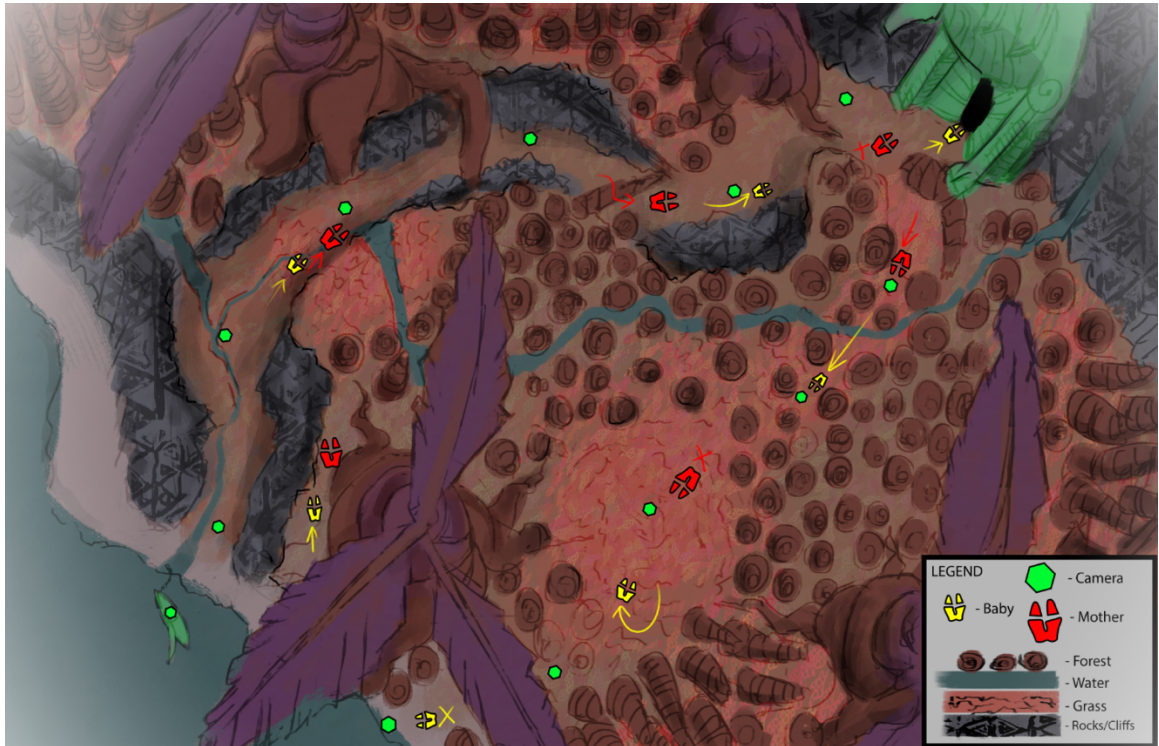


Figure II.8 Nayaki Anandan, *Map of Camera Locations*, 2018

One fundamental aspect of this project I should mention, was picking the correct game engine. This was an especially complex task since I came into DigiPen's MFA program with absolutely no experience using any sort of game engine. The two engines I was primarily introduced to in my studies at DigiPen were Unreal Engine and Unity Editor. Looking at the small projects I made using both programs, I decided that Unreal Engine was the easiest for me, as an artist, to comprehend. In particular, the node-based programming structure [Fig 2.9] I have previously and will continue to reference, is very easy to learn as an artist who has no background in coding. I also found that setting up my materials was easiest in Unreal, although Unity recently added a node-based material

network that I haven't tried yet. I also found that Unreal was incredibly easy to integrate with the Oculus Rift and required only a push of a button to play in headset.

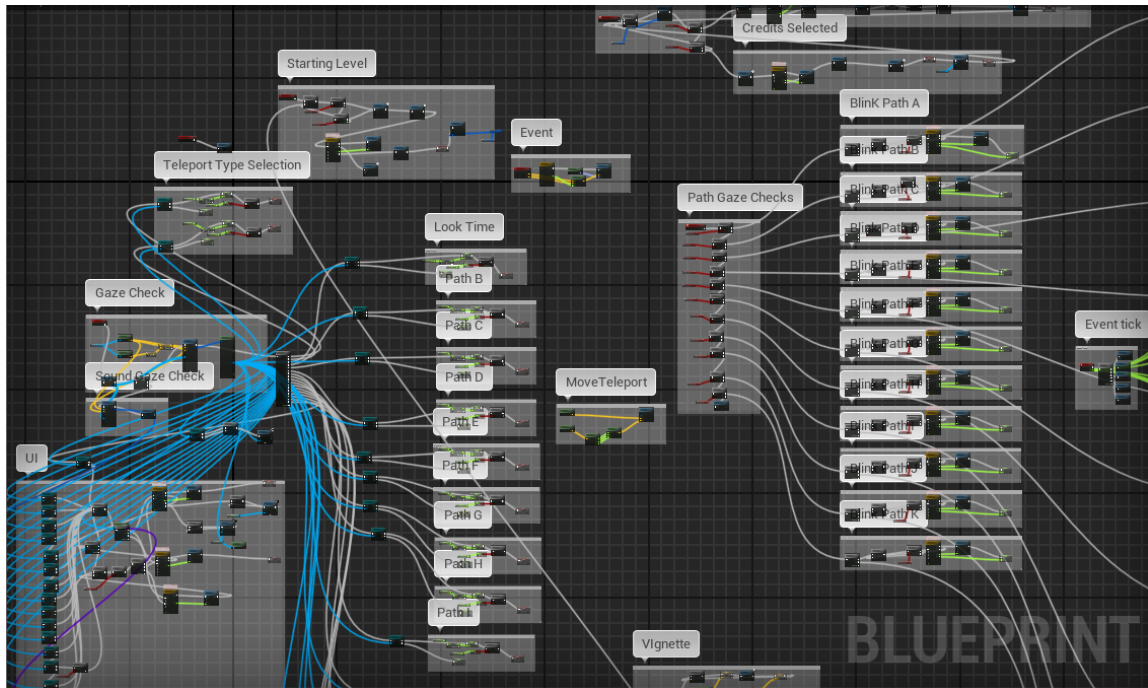


Figure II.9 Nayaki Anandan, example of a blueprint, 2018

No matter what engine is chosen, making a Virtual Reality game run smoothly requires optimization in every aspect of the game, and there are certain guidelines to follow that help a game run at its prime speed and quality. I want to discuss some of the challenges I faced in creating my game in respect to modeling, choosing what hardware to run it on, texturing, and how these influenced the final product. Many of these decisions were based on my own artistic aesthetic and influences from other games that present unique aesthetic traits.

### III. CREATING A LOOK AND FEEL

While I have already discussed much of the narrative influence of my project, I haven't yet written about the artistic side. I have always found that my artistic style was best expressed in my environment paintings, which I executed in every media from digital painting to rough



Figure III.1 Nayaki Anandan, *Charcoal Village*, 2016.

charcoal [Fig 3.1]. The first game that gave me the idea to do a uniquely hand drawn style was *Okami*, which is centered around a sumi ink theme [Fig 3.2]. The main



Figure III.2 *Ready at Dawn, Okami HD*, 2014, Screenshot.

character and all others in the game are painted with a thick black line no matter which direction you look at them from. Many of the menus in the game use a

scroll and brush to write out dialogue text. Taking things even further, the entire attack system of the game is based on symbols painted by the player using a thick sumi ink brush. When I tried to research how the makers of *Okami* achieved this effect, all I could find was one person's hypothesis which stated that they simply created a duplicate of each object, expanded it slightly, and flipped the normals. Even though the game has an

incredible and consistent visual style, it isn't one that I'm very familiar with, so I looked for an alternative source of inspiration, that still used traditional drawing and painting as a visual style. That's why when I played the game *Child of Light*, I was immediately struck by the vibrant watercolor style that literally bled into every aspect of the game [Fig 3.4]. Even the main character's hair had that identifying rippled edge, despite that they used a 3D model to achieve this look. The layers of landscape shifting as I ran through the many environments read so much like a storybook, as did the stylized watercolor and stained glass cutscenes. In reference to narrative, Patrick Plourde states that Ubisoft's



Figure III.3 Ubisoft Entertainment, "Child of Light", 2018, Screenshot.

goal was to create a "playable poem" with *Child of Light*, inspired by the Illustrations of John Bauer [Fig. 3.3] that feature fairies and creatures of the forest. At one point during the production, the team working on *Child of Light*

was told that they needed to find a style that was unique enough to be explained in one word<sup>9</sup>. The word they chose was 'Watercolor'. Through a process of going from concept

<sup>9</sup> Patrick Plourde, *The Art of Child of Light*, 2014, <https://www.gdcvault.com/play/1020561/The-Art-of-Child-of->



art, to level design, and then back to concept art, they created a game that vividly represented the characteristics of watercolors.

Both *Child of Light* and *Okami* made me look at what I really thought modern game narratives were missing. I realized that every time I played a game with an art style that made me think of just one word, be it “Sumi”, or “Watercolor”, I was really inspired and much more invested in the game emotionally. Realistic games still captivated me in a different way, but I loved the idea that in these more stylized games you could really *believe* in being transported to this other world,



Figure III.4 Illustration from 'Bland Tomtar Och Troll' (Among Gnomes and Trolls) art by John Bauer

instead of struggling with a potentially imperfect representation of realism I also loved that the brush strokes and evident drawing lines gave games a unique personality, and the artistic inspirations really shown through. When I looked at my own library of work, I found that despite recently learning many new skills in photoshop, my favorite and most consistent medium seemed to be watercolors. But while *Child of Light* had the characteristic vibrant, bleeding edge appearance, I found that my style was more detailed and realistic. I was inspired by artists like Andrew Wyeth, who despite rendering objects

so carefully and delicately still managed to let the medium speak through his paintings [Fig 3.5].



Figure III.5 Andrew Wyeth, *Night Hauling*, 1944. Bowdoin College Museum of Art, Brunswick, ME.

I wanted to take my unique way of painting and bring it to life with my 3D skills and my interest in VR.

#### IV. ILLUSTRATING A STILL EXPERIENCE

In video games without animation It can be particularly difficult to explain to the player the plot of a story, and even more so the direction they should be going in that story. This became a huge struggle with *The Forest Temple*, and my thesis hinges on the success of guiding the character through an emotional journey. A professor at DigiPen, Ryan Finnerty, gave me some very helpful advice to this effect. In short, he explained that any good piece of art that is trying to tell a story is either showing the moment after

something happens, or the moment before. For example, one of the most famous sculptures of all time, Michelangelo's David [Fig 4.1],

shows the moment just before David throws the stone at his enemy Goliath. His concentration is not only visible in his face but in the strength of his pose. In contrast to David, this painting [Fig 4.2] of Salome holding the head of John the Baptiste represents a moment in time *after* an event has occurred. This is made apparent by the man holding the sword and placing the head on the platter. It is not just the posing of the characters that tells the story, but also the colors, the materials, and the subject matter. The golden platter in the painting of Salome tells of her background,

and the worth of John the Baptiste's head to her. The sling in David's hand tells of what



Figure IV.1 Michelangelo di Lodovico Buonarroti Simoni, *David*, marble, 1501-1504. Galleria dell'Accademia



Figure IV.2 Michelangelo Merisi da Caravaggio, *Salome Receives the Head of John the Baptist*, oil on canvas, 1571-1610. The National Gallery.

he is about to do. These details in paintings and sculptures also translate to the storytelling details needed in a game. Construction, posing, color, material, composition, music, and shape language all give important context to the player of the game.

Although I previously discussed some of the posing of my characters, I'd like to delve more into the references used to create my poses, the posing process, and the final poses that are seen in *The Forest Temple*. In order to create dynamic poses for my characters, I referred to the animatic I had made for my storyboarding class. I selected the poses for each scene that were the most informative in directing the narrative and



Figure IV.4 Excited Puppy, Image courtesy of Stock Images, 2018.



Figure IV.3 Nayaki Anandan, Baby Creature Posed, 2018.

displaying the personalities of the characters. For example, the child creature at the beginning of *The Forest Temple* is excited, curious, and innocent. I likened several of this character's poses to a puppy [Fig 4.3, 4.4]. I also had the baby character staring directly at the player in the first scene, not only to give the player a sense that they play a role in this narrative, but also to amplify the small creature's personality. The parent creature is also lighthearted in the beginning but is more reserved and alert about their surroundings. The temple scene was by far the hardest to pose, because it is where the climax of the narrative occurs. Going back to what Ryan Finnerty said about choosing the moment just before or just after something happens, I decided to pose the characters in the moment just before the parent is infected by the strange origami creature. I posed the parent character to be looking down at another creature [Fig 4.5] that is half transformed and in

pain, while the baby is just about to touch the origami creature in front of it. Props like fruit bowls, some spilled, were placed around the baby to give the idea that it was running to the temple with the intention of receiving food offerings. The final couple of scenes involved the parent transforming, so her poses were influenced by this change. Although



*Figure IV.6 Nayaki Anandan, Parent Creature in Temple, 2018.*



*Figure IV.5 Nayaki Anandan, Posing for final scene, 2018.*

the change isn't yet apparent when the two creatures are running through the forest, it becomes obvious in the final scene. The parent's limbs in this part are contorted and it is

struggling to stand and get one more look at its child [Fig 4.6]. The child's body is shrunken and pulling away in fear, tail tucked, while its gaze remains focused on the parent. In the final scene only the baby remains, looking dejected but also focusing its gaze once again on the player. The poses of both parent and child in *The Forest Temple* help illustrate the overall story, and since there is no animation to inform the player, it is crucial that these poses sell the mood and action of each scene.

Rather than rigging my characters in the traditional way, I posed all my characters using Zbrush [Fig 4.7], A program developed by Pixologic. This choice was made mostly to save time, but also because rigging the characters was not necessary as they wouldn't



Figure IV.7 Nayaki Anandan, *Posing in Zbrush*, 2018.

be animated. Posing a character in Zbrush is incredibly simple and quick thanks to a tool called Transpose Master. This compresses all the layers of sculpture into one that can be deformed evenly. By masking off specific limbs and joints, you can use ZBrush's 3D Gizmo, or

Transpose tools to rotate and move them independently. This allowed me to move my characters into a variety of poses quickly, and then export them back into my engine efficiently.

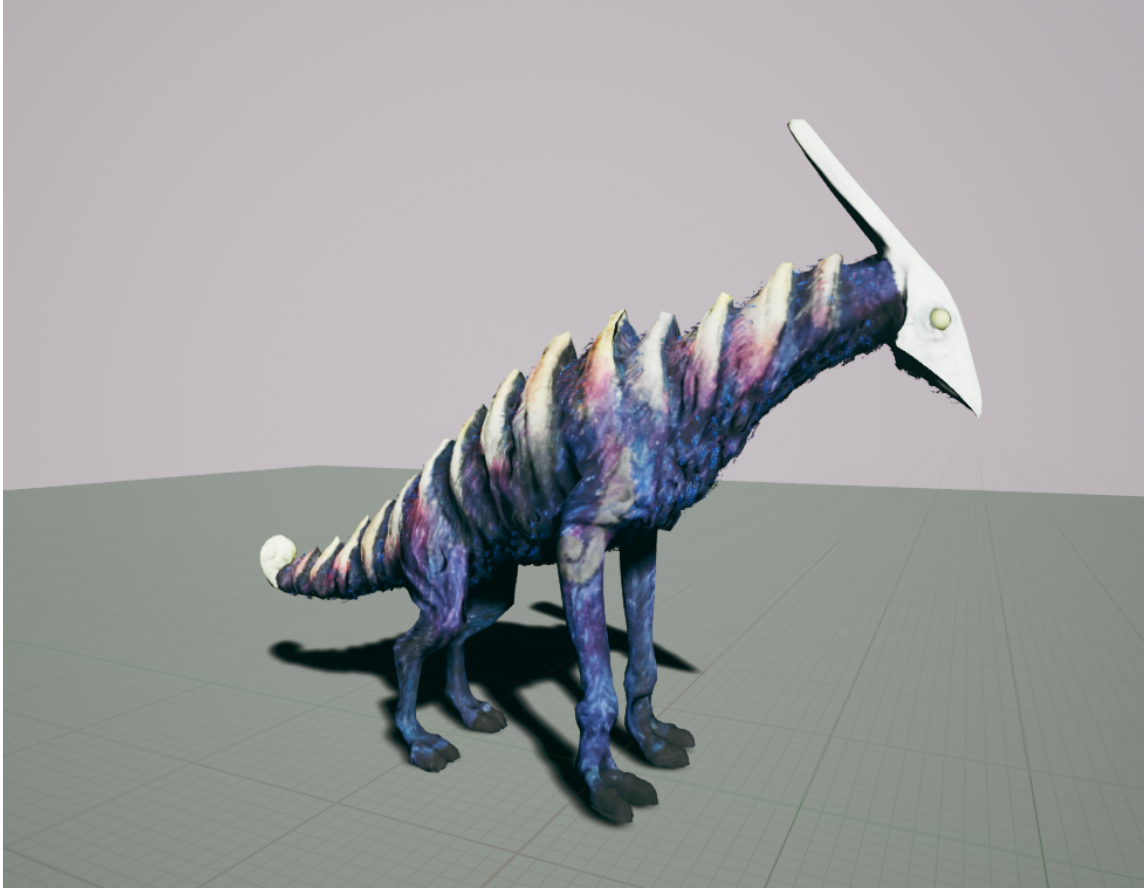
The design of the main characters in *The Forest Temple* was chosen to make them feel alien and mysterious, but not threatening. The creatures have a long neck like a

giraffe or brachiosaurus, with an accordion-like exoskeleton that emphasizes their gestures via expansion and contraction. Although all my designs originate from silhouettes [Fig 4.8] this design invoked ideas of herbivores that are built strong and sturdy. I also made the creatures eyes slightly forward on the face, to give them a sense of



intelligence. This and the long crown-like structure atop their heads make them feel like they might be something more than just local wildlife. This feeling is confirmed when the player sees the temple that has been crafted to look like the creatures. The final appearance of *The Forest Temple's* creatures looked like this:

Figure IV.8 Nayaki Anandan, *Creature Silhouettes*, 2017.

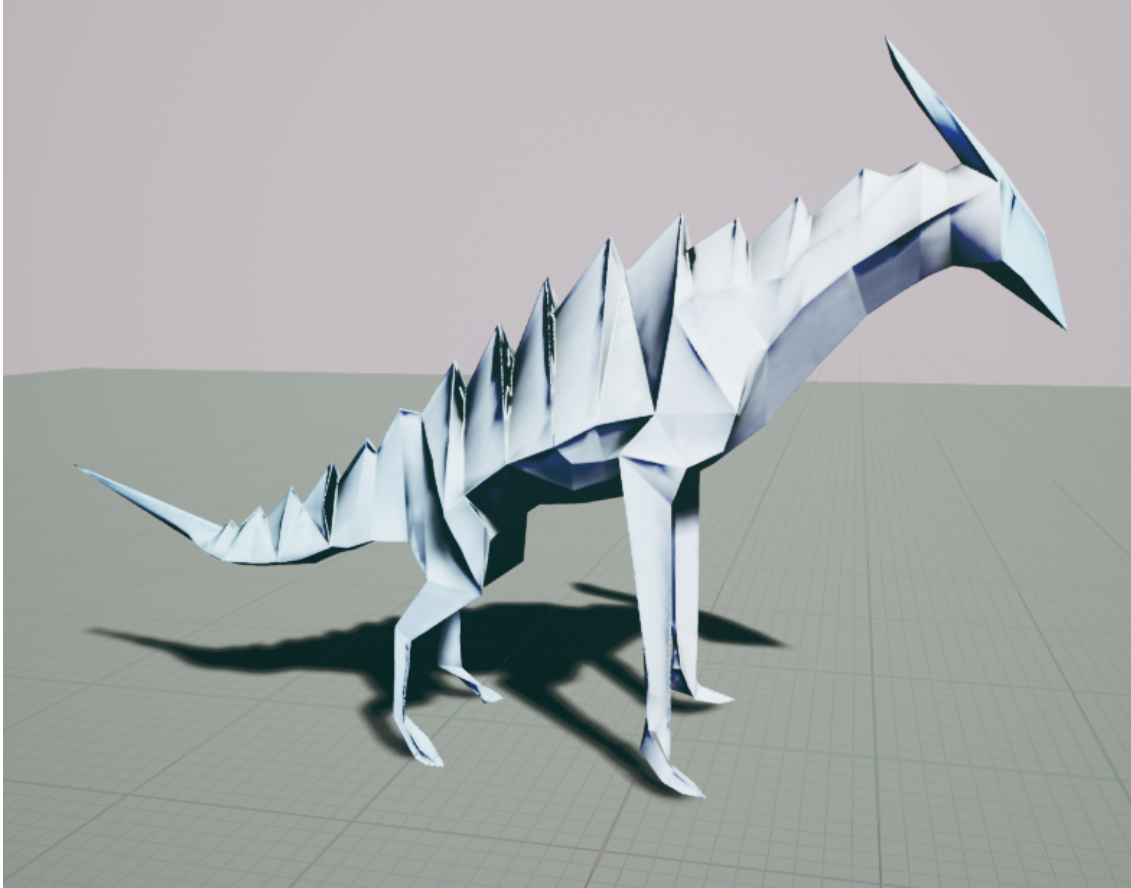


*Figure IV.9 Nayaki Anandan, Final Creature, 2018.*

[Fig 4.9]. One might also notice that they have very few sharp edges and are covered in fur. I wanted the characters to seem large and strong, but not fearsome, and the presence of fur and chunky, rounded forms indicates some friendliness. I colored these characters with vibrant purples and blues to help them stand out from the outside environment, and to give them some cohesion with the stones in the temple scene.

While the main characters are round and welcoming, the origami-like creature is the exact opposite. It was designed based on the same silhouette of the creatures to give the sense that it was, at one point, one of them. The creature has many sharp points and edges, and is comprised mainly of hard, flat, planes [Fig 4.10]. Triangular shapes and





*Figure IV.10 Nayaki Anandan, Origami Alien Creature, 2018*

sharp points are naturally symbols of danger to humans and animals alike, giving this creature a sense of danger. The planarity of it is meant to induce curiosity in the player and makes this creature stand out starkly from the rest of the game. This is also why the origami creature was given little to no color, in contrast to the vibrant colors that comprise the environment of *The Forest Temple*.

Posing and creature design aside, I still needed to create concepts for every single object in my environment, and I did this through a process of finding reference and doing

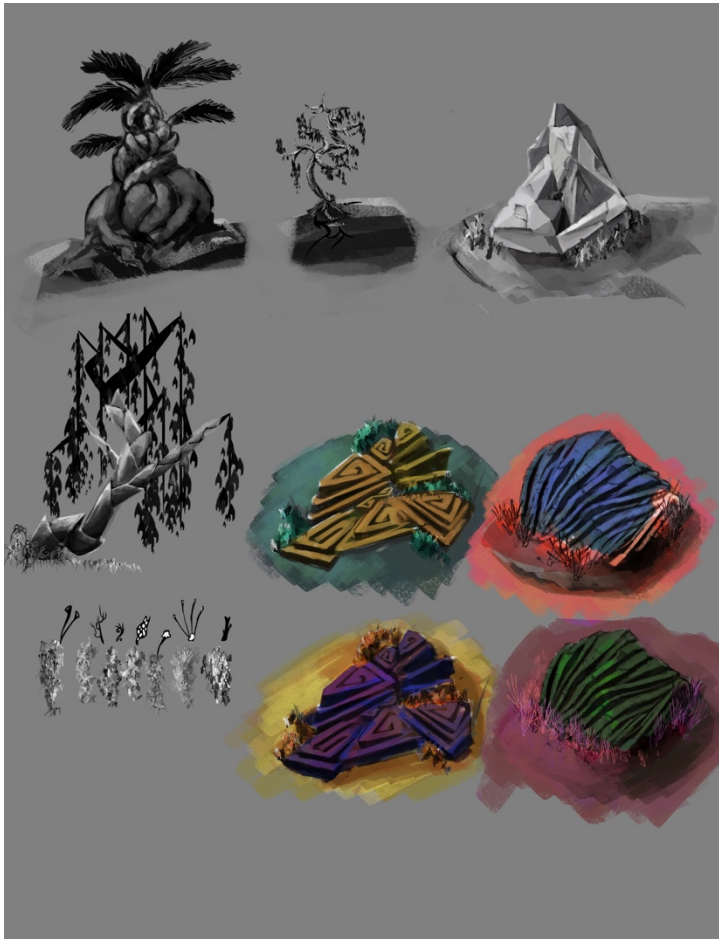


Figure IV.11 Nayaki Anandan. *Environment Designs for The Forest Temple*, Digital Painting, 2017.

rocks used in *The Forest Temple* [Fig 4.14]. I tested out different colorations for the rocks

briefly but found that a slightly desaturated cyan blue worked best with the rest of the environment. The Trees in my environment were inspired by a plant from South America called heliconia [Fig

4.13]. I was attracted to the way that one can

sketches [Fig 4.11]. In order to create an alien environment, I took references from strange rock and plant formations, went hiking for mosses and lichens, and altered what I found. The rocks in *The Forest Temple* were inspired by the Giant's Causeway

[Fig 4.12] which boasts marvelous hexagonal formations caused by ancient volcanic activity. This evolved

into the tessellating triangular



Figure IV.12 Michael Nielsen, *Giant's Causeway*, June 9, 2001.

see how the plant grows just from a picture. This eventually led to the creation of the trees in *The Forest Temple*, where I adapted the unusual leaf structure to be a part of the

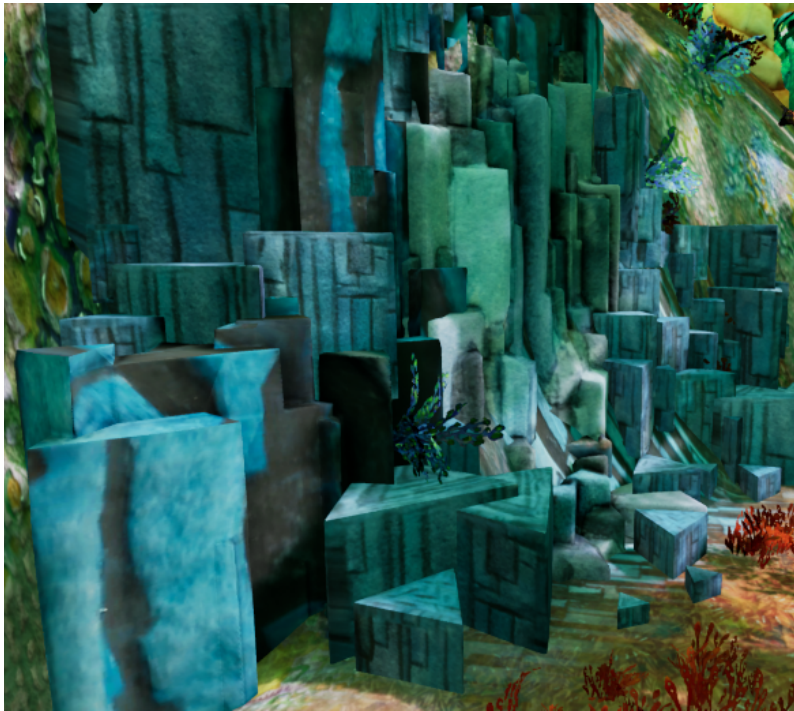


Figure IV.13 Nayaki Anandan, *Rocks from the Forest Temple*. 2018

trunk and continuing to the ends of the plant, which might contain a yellowish fruit. I also used the unusual coloring of the heliconia to inspire the coloring for my tree, [Fig 4.15] with a warm orange base that gradients to blueish green tips. The

huge trees in *The Forest*



Figure IV.15 Fred Hoogervorst, *Photo #20978*.



Figure IV.14 Nayaki Anandan, *Tree*, 2018.

*Temple* were inspired by Baobabs and ferns. These were important for breaking up the visual business of each scene, and for giving a sense of scale to the other environment objects. I was also inspired by unusual trees that looked knotted such as this one standing in a swamp [Fig 4.18].



Figure IV.18 Nayaki Anandan, *Big Tree*, 2018.



Figure IV.17 Storm Front, *Lichen on a Mesquite Tree*, December 29, 2006. Courtesy of Flickr

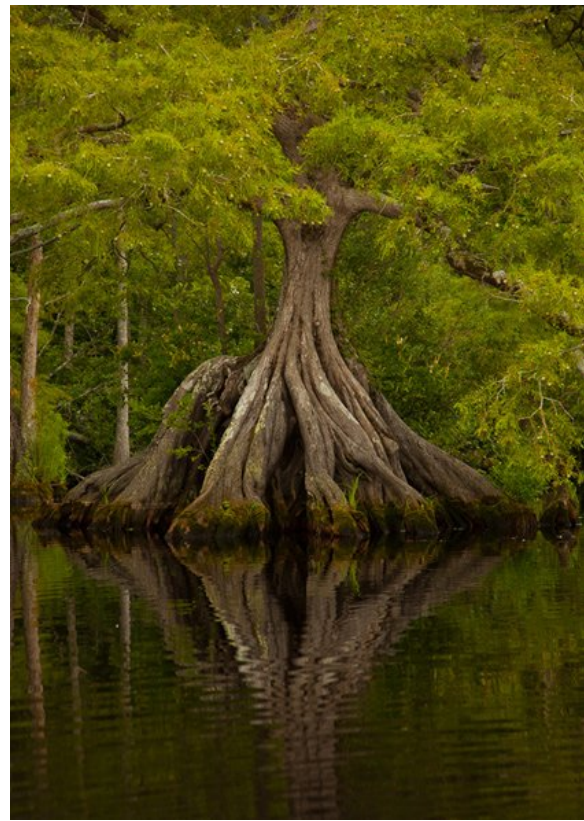


Figure IV.16 John Henley. *The Great Dismal Swamp*, Image #12. November 9, 2011.

Eventually, my trees developed a distinct shape with a deep, brown colored base and a few blue-green fronds sprouting out of the top [Fig 4.16]. The grass and bushes in *The*

*Forest Temple* took their color and shape inspiration from various lichens and mosses discovered in my research. This particular image gave me the idea to have the round cup-like points at the ends of the bushes, and the vibrant coloring that makes up so much of *The Forest Temple*'s landscape [Fig 4.17].

As for the actual landscape textures, I wanted to blend the environment with the rocks, trees, bushes, and grass. I chose a transitional moss-like texture to blend rocks with bushes, giving the sense that the bushes act as a lichen that grows on and near the rocks. I used a bright red texture with flowery markings to blend the grass with the ground, and then I created a deep brown soil texture that would bring everything together. A blue,



Figure IV.19 Navaki Anandan, *Environment Textures*, 2018.

rock-face texture was also created for some of the steep cliffs featured in my environment. All these textures created useful transitions that I could apply to my landscape to help create the impression of a dense and flourishing ecosystem [Fig 4.19].

In order to keep colors cohesive, it was suggested by Professor Mark Henne that I develop a color script for *The Forest Temple*. A color script is a resource typically used in films to determine overall color language. Color is important in influencing the mood of a scene, tying together compositions, and bringing focus to specific details. I created my color script using the animatic I developed for my storyboarding class at DigiPen. I

selected what I felt were the most important storytelling moments and took those frames out to be colored. I ended up with a color script that looked like this [Fig 4.20]:

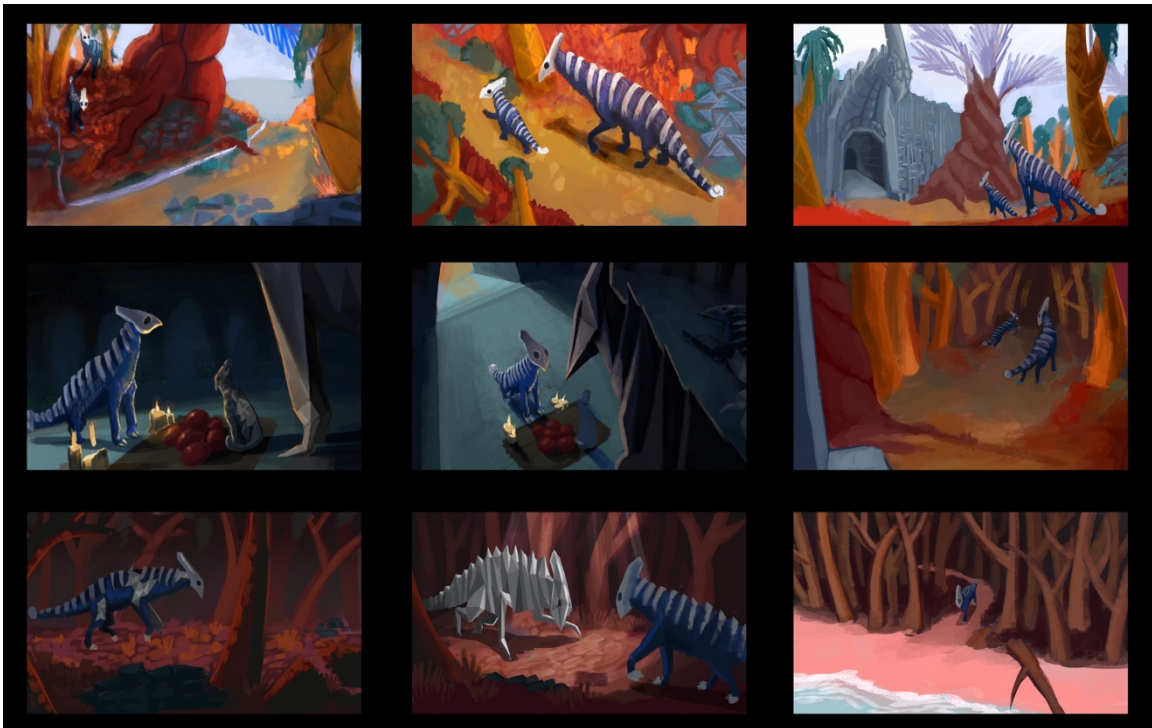
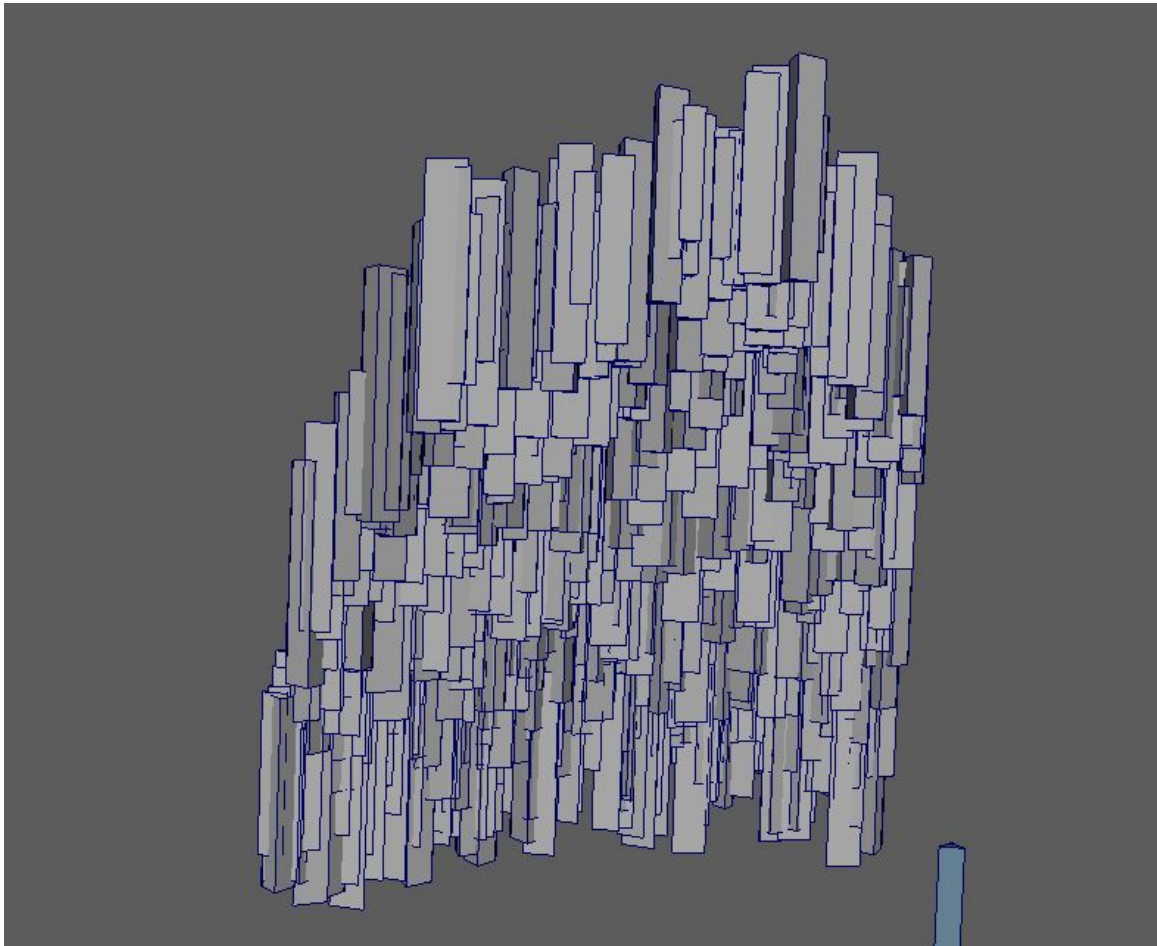


Figure IV.20 Nayaki Anandan, *Color Script*, 2018.

As can be seen in this script, *The Forest Temple* starts out vibrant and bright, but over time the blues and greens are reduced, and the scene becomes darker and more red. All these decisions were intentional with the purpose of increasing the sense of danger as one progresses through the experience. Altering the colors in game was made possible thanks to the use of Post Processing features, which will be touched on in the discussion of composition.

In creating my objects for *The Forest Temple*, I wanted things to match their handmade watercolor appearance. Therefore, I constructed my objects mainly using Autodesk Maya and Zbrush, and tried to avoid making things look too symmetrical or

realistically detailed. Maya was used to create almost all the base meshes for my objects and using Maya's tool called MASH I was able to create some interesting rock structures.



*Figure IV.21 Nayaki Anandan, Using MASH in Maya, 2018*

MASH is a tool that lets the user select a mesh and make duplicates of that mesh that can be controlled in every way possible. In the case of my temple walls, I used this to randomly generate a triangular rock mesh onto a plane, creating a jagged, layered rock wall. Taking this wall into Zbrush, I was able to project the details of it onto another plane, which I then cleaned up to the best of my ability [Fig 4.21] After cleaning it up

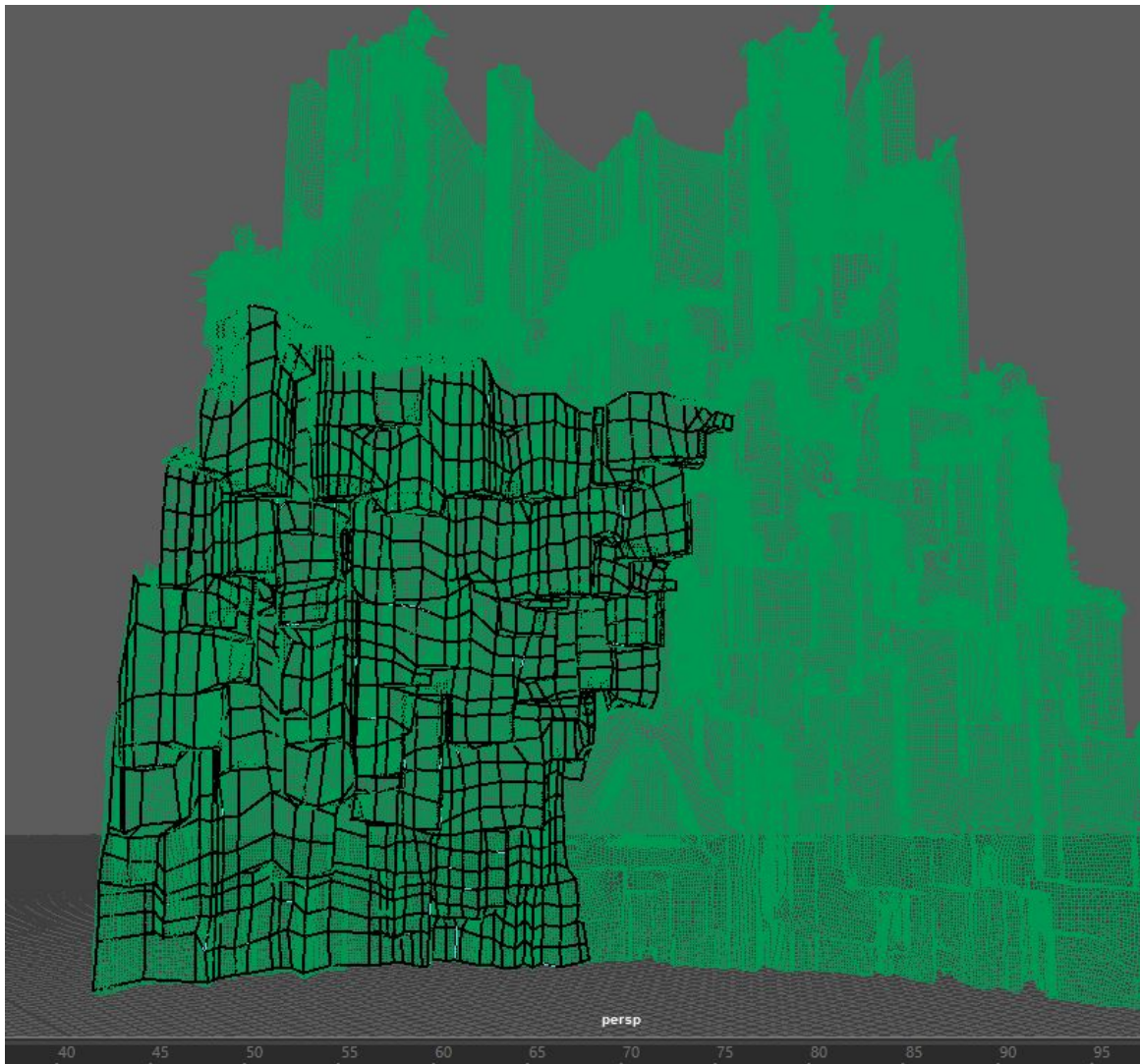
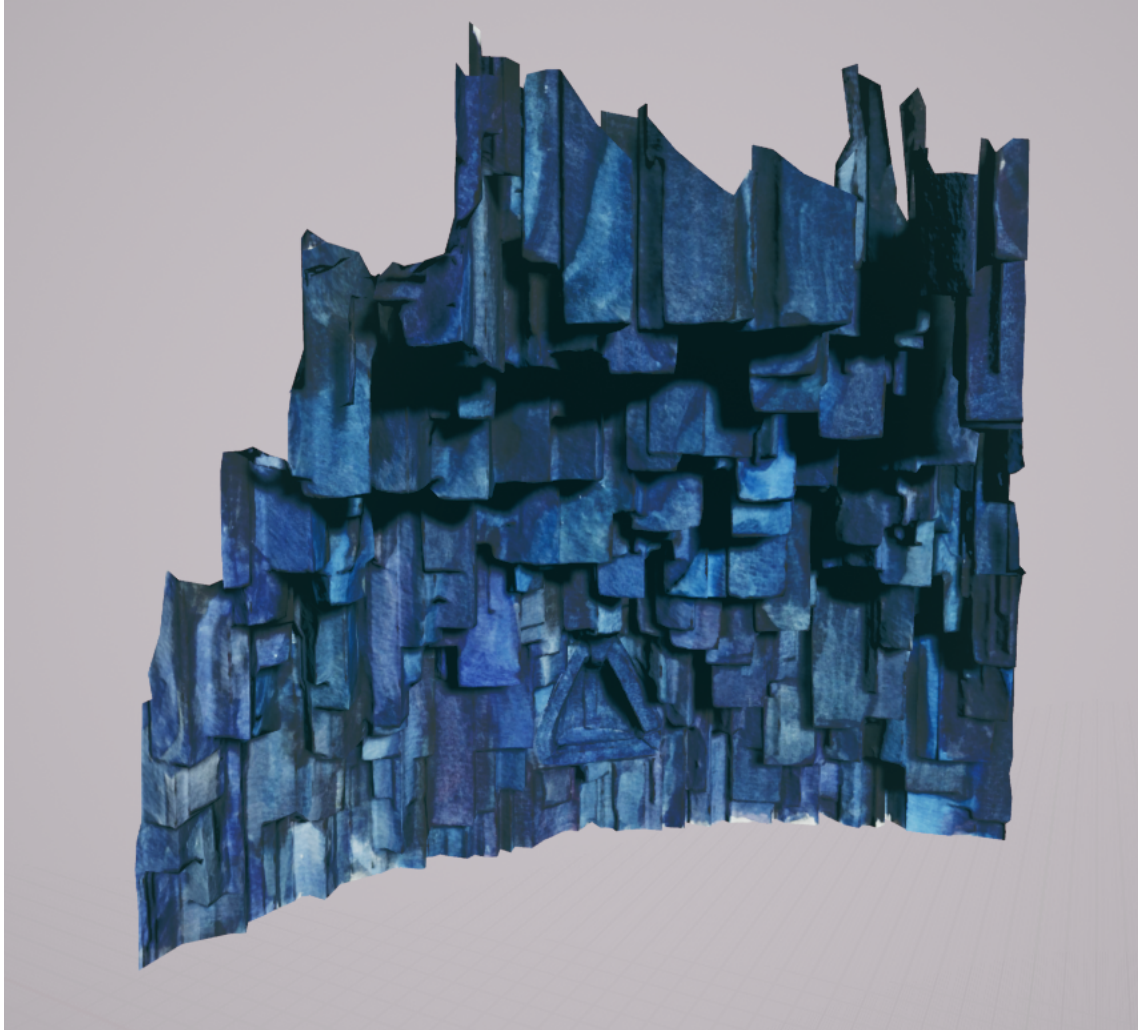


Figure IV.22 Nayaki Anandan, *Retopoligizing a wall*, 2018.

quite a bit and reducing it to as few polygons as possible, I exported the new object and took it back into Maya. In Maya, I used the Quad Draw tool to ‘retopologize’ my model [Fig 4.22] Retopologizing is essentially hand curating the polygonal structure of an object so that it has far less vertices, edges, and faces, and subsequently is much more ‘low poly’. Retopologizing the rock walls of the temple, the roof, and some of the cliffs seen around *The Forest Temple* was a painstakingly long task but resulted in some incredible environment assets [Fig 4.23].





*Figure IV.23 Navaki Anandan, Finished Temple Wall, 2018.*

Aside from MASH, however, I also used Maya to create base meshes for trees, smaller rocks, bushes, and grass. The typical pipeline for creating foliage in games is to have two perpendicular planes with a masked texture on each of them. Although I started out creating bushes, grass and leaves this way, I soon found that I needed to cut away the extra transparent space to help optimize for Virtual Reality. In Maya, I also used a special script that I created to generate the trunks of my trees. This script [Fig 4.24] takes a pre-defined base object and rotates it along an axis upwards in a random direction repeatedly until it finishes the pre-defined number of loops. This script was used to create several

```

import maya.cmds as cmds
import pymel.core as pm
import random as rand
counter=0
rad=1
height=2
par= None
while (counter<10):
    cyl = pm.polyCylinder(r= rad, sx=20, sy=1, sz=2, h=height)[0]
    pm.scale(cyl.e[60:79], 1.75, 1, 1.75)
    pm.polyExtrudeFacet(cyl.f[80:99], kft=True, ltz=-1.75, ls=(.5, .5, 0) )
    pm.rotate(cyl.f[40:59], '30deg', 0, 0, pivot=(0,1,0), fo=True, r=True )
    pm.polyBevel3(cyl.e[40:59], cyl.e[60:79], offset=0.02*rad)
    pm.delete(cyl.f[20:39], cyl.f[0:19], cyl.f[40:59])
    pm.select(clear=True)
    cyl.scalePivot.set([0,(-height*0.45),0])
    cyl.rotatePivot.set([0,(-height*0.45),0])
    cyl.ty.set(height*0.9)
    counter = counter+1
    cyl.ry.set(90)
    cyl.rx.set(rand.uniform(-10,10))
    cyl.rz.set(rand.uniform(-10,10))
    if par:
        pm.parent(cyl,par, relative=True)
        pm.scale((cyl.e[20:39], cyl.e[0:19]), 0.7, 0, 0.7)
    rad = rad*0.85
    par=cyl

```

Figure IV.24 Nayaki Anandan, Tree Script Screenshot, 2017.

trunks, which were then pieced together as branches to create the final trunk of the tree. I then used the same hand-retopologizing method to reduce the polygon count of the trees and create the low poly version of them.

Some of the assets In *The Forest Temple* were made almost entirely in Zbrush, such as the Temple altar, characters, temple exterior, the boat, and the large trees. In the cases of the temple assets, creating objects that were constructed from carved and stacked rock was easily done using Zbrush's sculpting tools. I was able to create the fine details of the temple which were inspired by Mayan and Aztec Architectural details [Fig 4.25].

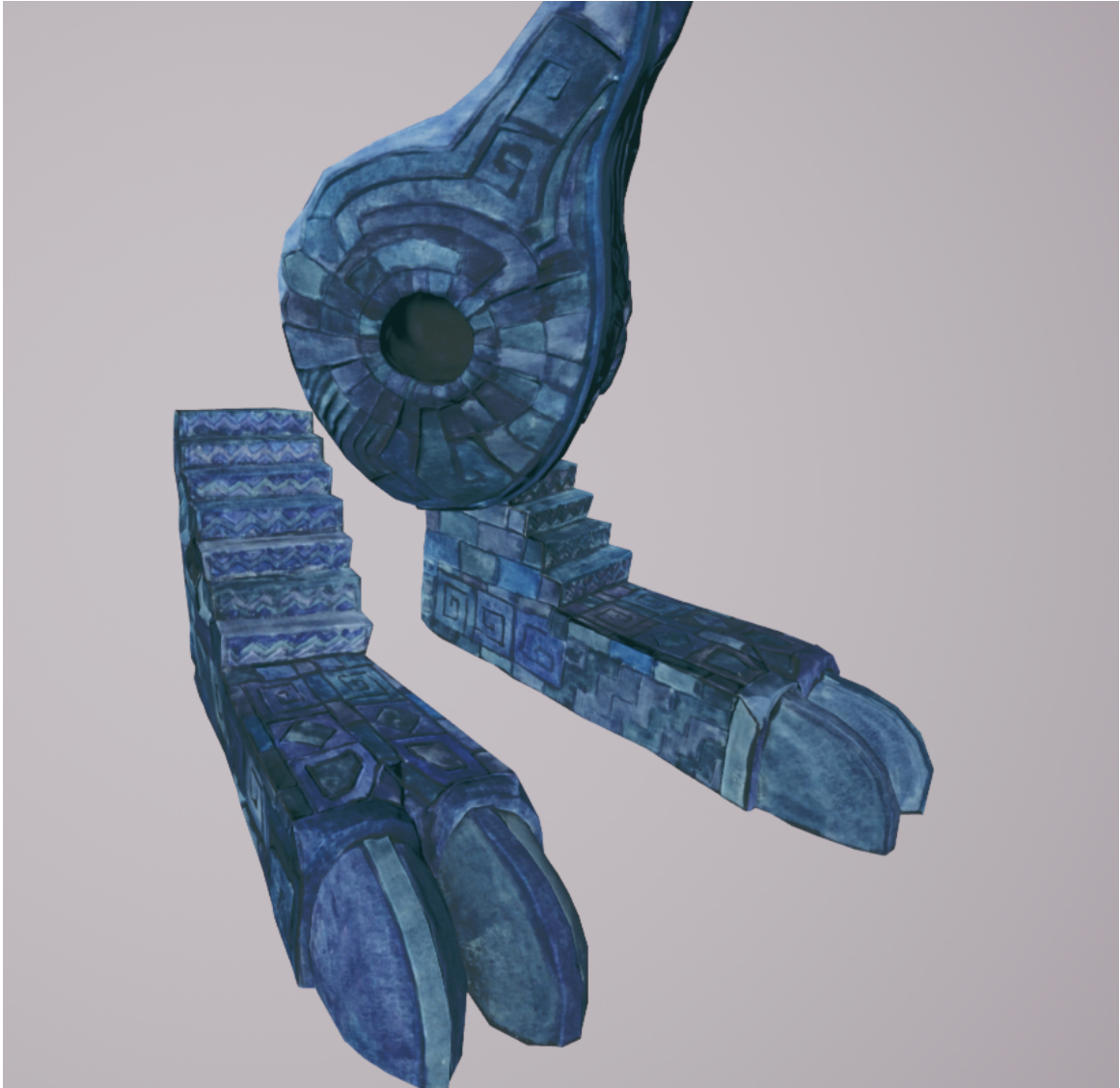


Figure IV.25 Nayaki Anandan, *Temple Altar*, 2018.

All the objects in *The Forest Temple* were designed and constructed to inform the narrative, provide visual interest, and to give a tactile and handmade feel. At first the goal was simply to create an alien world, but in order to give the sense of something truly other-worldly a surprising amount of familiarity must still be there to ground the viewer.

## V. WATERCOLOR TEXTURING TECHNIQUE

The idea of using watercolors to create the textures in my environment stemmed initially from my desire to show the artist's hand in my final product. Rather than trying to create a photorealistic experience, I wanted the viewer to feel as if they are in a storybook, experiencing the artwork just as much as the other aspects of the game. The other reason for this is time. Creating a photorealistic experience requires a lot of time not only to create textures, but also to create 3D models that are meticulously put together in a way that sells the appearance of a real object. Since I was working in VR, I decided to capitalize on the low-poly requirements by sculpting the models in such a way that was less time consuming but still worked cohesively with my texture painting. Finally, I wanted to use watercolor painting because I believe that when you thrust the player into a foreign visual experience, it is easier to take in than a hyper-realistic one. This concept has much to do with suspension of disbelief - a factor in every aspect of game design.

Suspension of disbelief is, according to Merriam Webster, 'to allow oneself to believe things that cannot be true'. Games are inherently untrue and VR games create a false environment to explore in an incredibly immersive way. Therefore, suspension of disbelief is crucially represented in a game's artwork, which must be familiar enough to be understood by the player, but accurate enough to not fall into the uncanny valley. The uncanny valley is usually attributed to humanoids and representations of humans, and the odd feeling one gets when faced with something that is *almost* 100% believably human, but not quite. In this context, however, I am referring to the uncanny valley that can cause issues in realistic representations of environments in games. For example, when you look at a game like The Elder Scrolls V: Skyrim from afar, it could almost be sold as a

photograph. When you look closer, however, it becomes easier to notice the planar cards used to create foliage, or the flat, photographic textures of soil. While realistic games require an incredible amount of technical skill and are loved by many for their impressive accuracy, stylization allows extra forgiveness by the player for errors in small details. The context one gives a player in selling the visual idea of a game is crucial in creating suspension of disbelief and avoiding the uncanny valley.

For example, take a game like *Zelda: Ocarina of Time* [Fig 5.1]. This incredibly



*Figure V.1 Nintendo, Screenshot from The Legend of Zelda: Ocarina of Time, November 1998.*

popular title has not only extremely low poly visuals, but also heavily stylized characters and environments. A player picking up the game for the first time is exposed to this style of game art from the beginning, and therefore believes in the world despite it being so unrealistic. Now if one looks again at *Elder Scrolls V: Skyrim* [Fig 5.2] and picks it up for the first time, they are introduced to a very realistic environment and that is where



*Figure V.2 Bethesda Game Studios, The Elder Scrolls V: Skyrim, November 2011.*

their belief expectations will be set. Therefore, when the person playing Skyrim finds say, a low-resolution texture or a seam, it feels far more out of place because of the artistic expectations of the player. Any game artist worth their salt is aware that it is much easier to get away with things like texture seams, low poly model edges and alpha transparency issues in a stylized game versus a realistic game. And in VR, these common difficulties become even more challenging, because of the hardware capabilities. Since I wanted to create an emotionally driven experience, and I did not have a whole team creating models and textures for me in the small timeframe I had, I chose to go the stylized route.

One might ask, “Why not just digitally paint your textures?” and to this I would again say that I wanted the player to be able to see the artist’s hand. As children many people were often exposed to storybooks with huge pages of illustrations and very little text. I remember marveling over the illustrations in books like Ferdinand the Bull [Fig

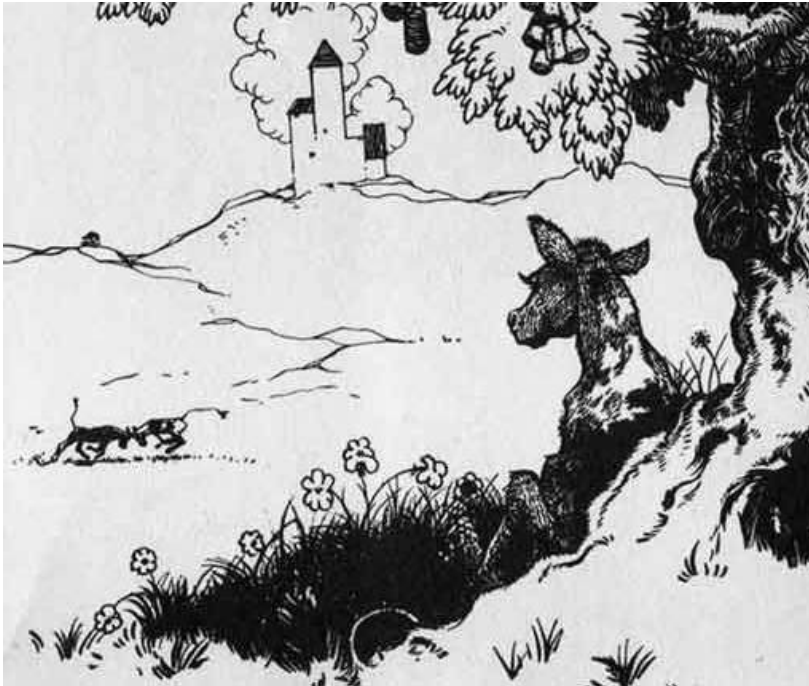


Figure V.4 Robert Lawson, *Ferdinand The Bull*, Munro Leaf, 1936.

5.3], or Stinky Cheese Man, which helped sell the stories before I could even understand the full meaning of the words. Furthermore, I could identify the brush strokes or pencil marks used to create the images, which through variation in detail helped

emphasize important parts of the story. Even some of the most famous digital painters,



Figure V.3 Sergey Kolesov, *Mermaid*, 2014. Courtesy of Artstation.com

such as Sergey Kolesov [Fig 5.4] find ways to show their hand, creating elaborate brushes that leave distinctive strokes. Sometimes they are even distinctive in the way that

they paint light and shadow, as is artist Tadahiro Uesugi [Fig 5.5]. Since my VR experience would only have my texture painting and modelling to inform the player visually, I thought it would be best to express the story almost like an illustrated book.

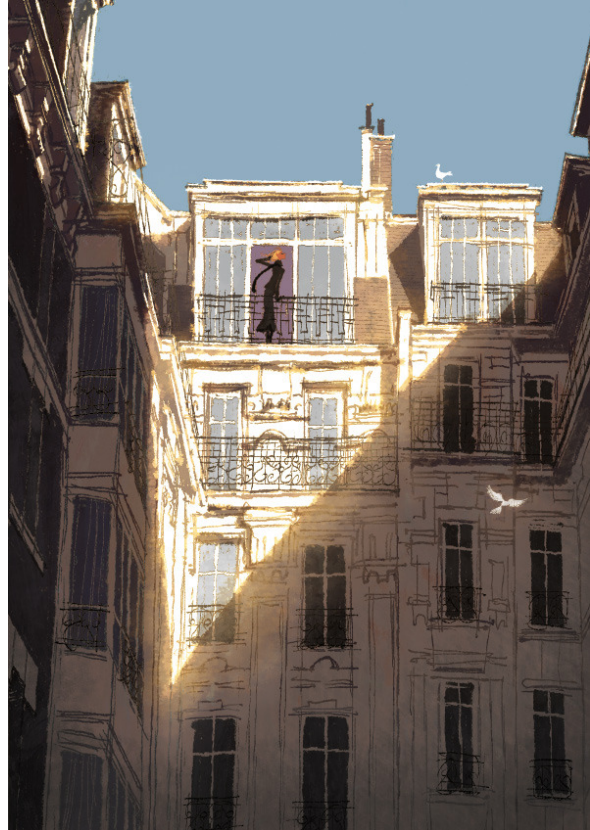
Creating watercolor textures came with more challenges than I could have anticipated. I started with the most basic, boiled down version of the process.

Step 1: Create UV maps.

Step 2: Print them out and transfer them to watercolor paper.

Step 3: Paint the textures.

Step 4: Scan them in to the computer, make appropriate photoshop edits, and apply to objects.



*Figure V.5 Tadahiro Uesugi, Courtesy of The Art of Animation.*



This first issues I ran into were immediately apparent. First, I had to make sure my objects were UV mapped in the most appropriate way for this style of painting. A UV map is a flattened expression of an objects surface area [Fig 5.6]. the small points on the

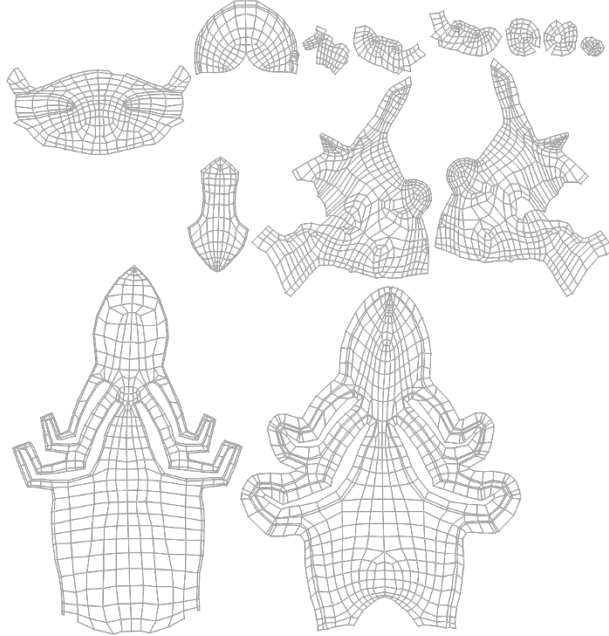


Figure V.6 Nayaki Anandan, UV map of Idol, 2018.

map correspond with vertices on the object, and the lines correspond with edges. To ‘unwrap’ an object, certain edges are selected to be seams, like how one might construct a garment. The leftover ‘UV islands’ are then flattened in a way that best represents the accurate surface area of the model in 3D space. The issue with unwrapping is choosing where to

place the object’s ‘seams’, because these will need to be painted over or hidden so that they don’t create odd texture artifacts. Solving the issue of unwrapping my objects was simple: it was just a matter of reducing seams, and I found an intuitive solution for covering these seams later in the process, using a program called Substance Painter.

The second pressing problem I discovered proved far more difficult to solve; transferring the UV maps to watercolor paper. I started out using a method of tracing the lines of the UV maps with pencil, flipping the paper over, and rubbing the pencil lines on to my watercolor paper. The UV maps were visible enough for me to stay within the lines of the islands, but I couldn’t see any of the details of the object that I might have wanted to bring out. For example, I couldn’t see where the tufts of fur were sculpted on my

characters, or where the deep grooves in the trees were. Eventually I decided to use a lightbox instead of just rubbings, which gave me clearer pencil lines, but still lacked any interior detail. But for the time being, I settled on this as my method, and my game began to take shape.

At this point, I had to take a few steps back. While the style received lots of praise for being unique and vibrant, I wasn't really selling the look of 'watercolors'. I looked at some of my older bodies of work and some of the more successful watercolors I'd made and decided to make a painting of a scene from my game. At the time, I was taking an independent study with Professor Christopher Poplin, and this painting became an assignment in defining the visual style of my VR experience. In short: yes, I was using watercolors, but I needed to figure out how *I* as an artist would use them to create my personal visual style. The main style issues this painting would help to solve were:

1. Edges
2. Level of Detail.
3. Color schemes
4. Textural quality.

In the end, the painting that resulted [Fig 5.7] provided answers to many of the questions

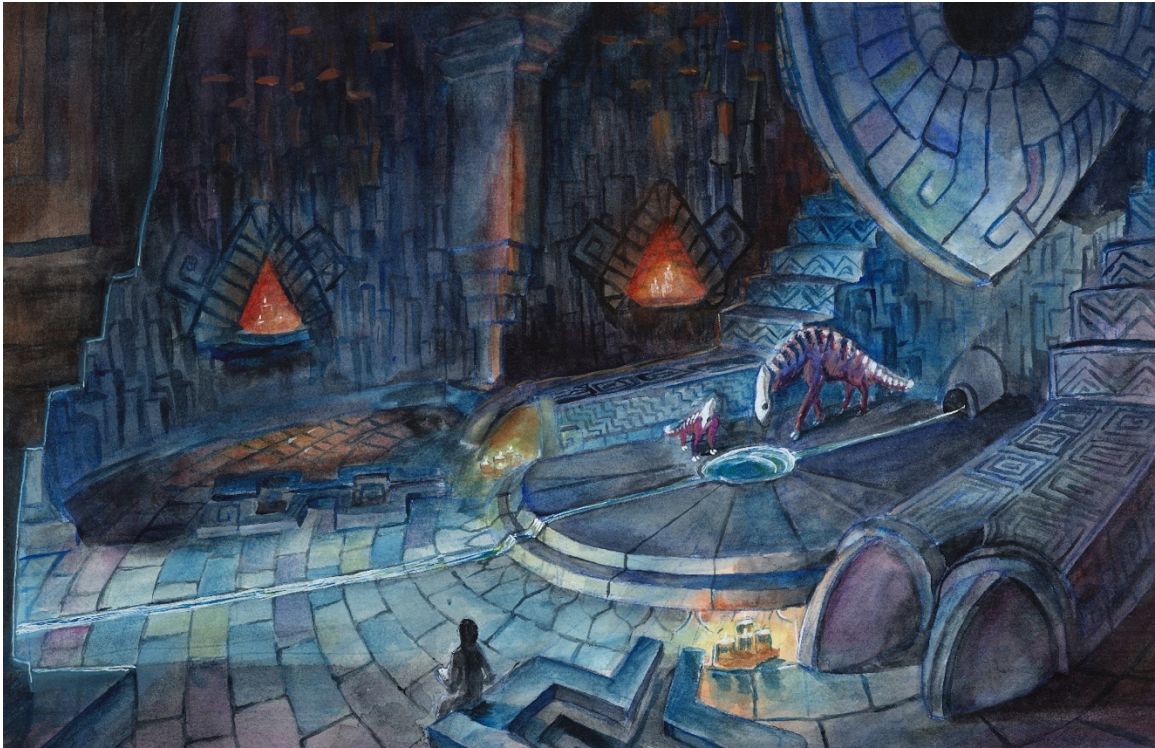


Figure V.7 Nayaki Anandan, *Temple Painting*, 2018.

and issues I had been having. It also gave me a better idea of the overall layout of the environment I was designing for my independent study.

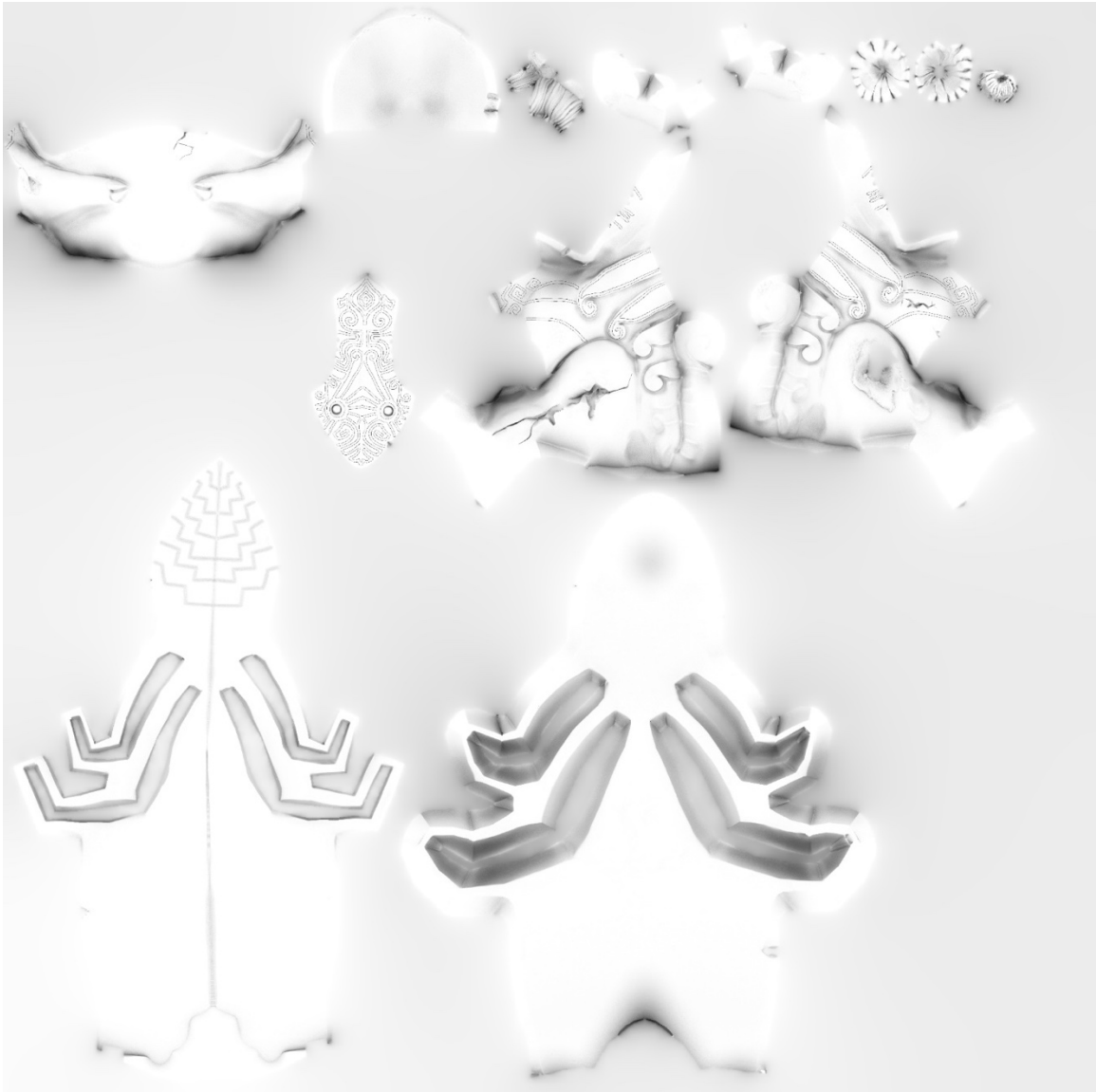
Creating watercolor edges, that have that distinctive, almost frayed appearance, required many rounds of troubleshooting. I noticed that in my painting, I had used a blue pencil to sketch out a lot of the edges, and the pencil lines were helping to define objects more clearly in the image. At first, I was trying to create this using special effects within Unreal engine. The initial method I tried was Post Processing, which involves editing the image seen by the player after all the objects have been rendered. I used a node structure that I found online to create this outlined appearance on all my objects. I then applied a watercolor paper black and white texture to it, hoping it would create the bumpy edges I desired. While this generated an interesting image, it wasn't really what I was going for.

The edges still looked too hard, and at times the effect would pick up the internal edges of the objects, which made everything seem polygonal and very low poly. I tried adjusting the edge-lines to be based on depth, but this didn't really solve the problem, especially with objects close to the viewer. After fussing with post process materials for almost a month, I gave up and tried using a more specific technique called Fresnel. Fresnel is created by calculating the dot product between the camera forward vector, and the pixel normal of an object. I used this process to add transparency to the edges of my objects. I also added a textural effect to try and get the rippled watercolor edge I was looking for. The result of this process ended up looking good, with one caveat: it only seemed to work on rounded objects. I had a decision to make; I could either keep working towards using these special effects to create the edges I wanted, or I could focus more on creating the textures for my environment and see if an edge treatment was really needed.

Instead of focusing my energy on technical solutions, I decided to go back to the watercolor painting and the transferring of the UV map issue. While I was playing around with edge techniques, I purchased some acetone transfer pens, and started using these to transfer my UV maps to watercolor paper. This proved to be a far more efficient method, and the lines were much easier to see, but I still had the issue of not knowing where the detail on my objects was. After some thought, I realized most of this detail is captured in the ambient occlusion maps baked from objects. Ambient occlusion is the natural self-shadowing of an object in ambient light. It is most noticeable where an object touches another object, or where you find deep creases or indentations of objects. Ambient

occlusion maps are generated by calculating these shadows and creating a simple black and white image that looks like this [Fig 5.8]:

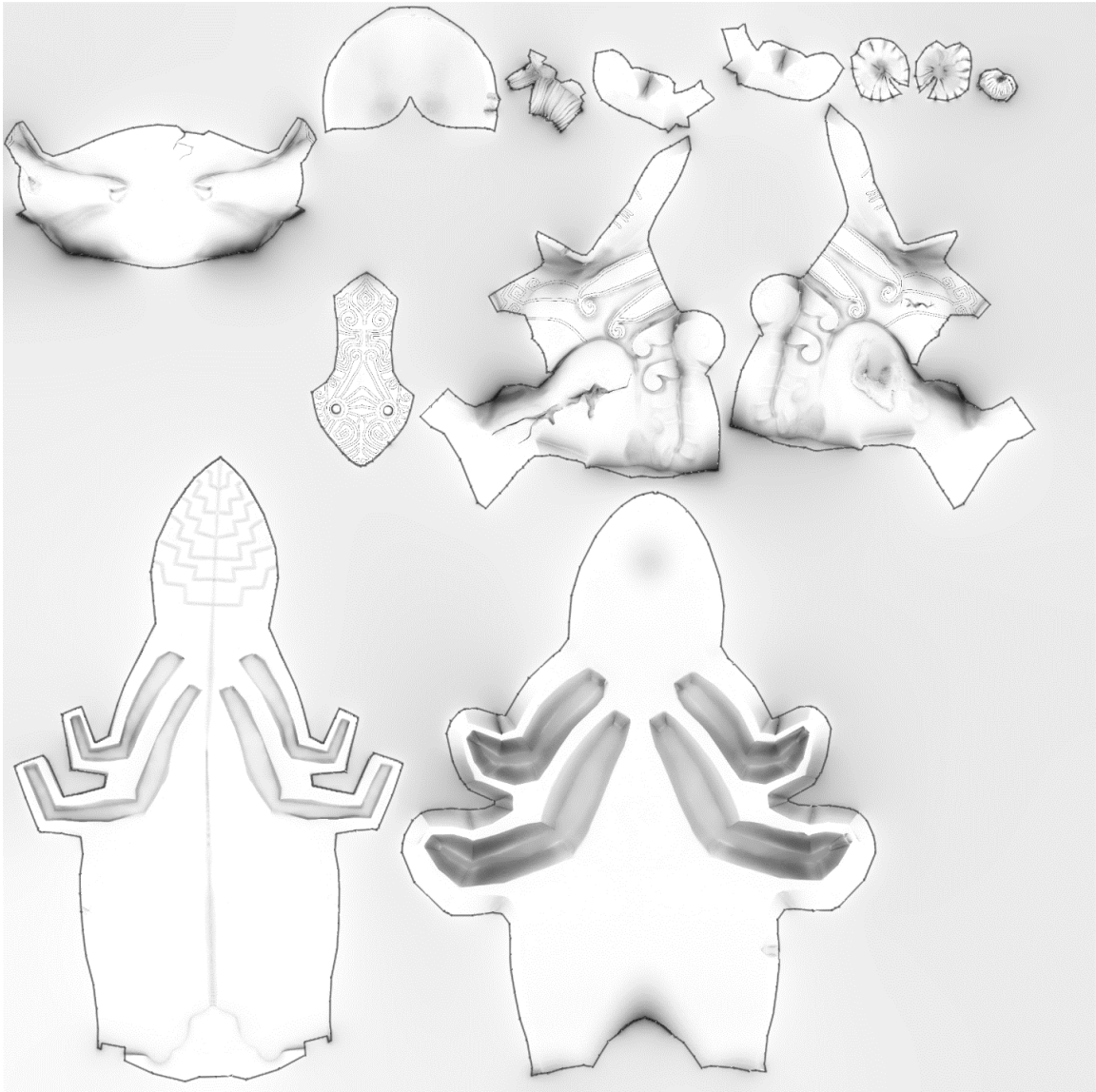
This makes it an excellent candidate for helping to point out small details. In order to get



*Figure V.8 Nayaki Anandan, AO map of Idol, 2018.*

the detail needed in my printouts, I took an ambient occlusion map, placed it underneath the UV map, and deleted the internal lines of the UV map islands. I then slightly adjusted the levels of the ambient occlusion map to really bring out the internal details of my

object. Using these maps in combination with the UV island maps gave me a solid edge for each island, and lots of internal detail to base my painting on [Fig 5.9].



*Figure V.9* Nayaki Anandan, *AO plus UV map*, 2018.

Using the acetone pens, I was able to transfer this detail onto watercolor paper and create more accurate textures. I started out texturing my characters this way. Unfortunately, the acetone pens were simply financially not sound enough of a solution, and I had done some research on better methods. What I found was that I could just buy straight acetone, and brush it over the UV maps, or purchase xylene, an industrial paint thinner, and use

that instead. I ran over a temporary bump at this point, because I realized the new UV maps I had printed were printed with an inkjet printer instead of a toner printer. After some swift google searching I found that only toner printed images will transfer. As for the chemicals, I decided to buy both and compare them to see which worked best. Both methods worked roughly the same, but the xylene left a slightly darker mark, so I decided to continue using that [Fig 5.10]. I was still frustrated with the lack of detail in the transfers, so I simply darkened the images in photoshop and reprinted them to get my final result.

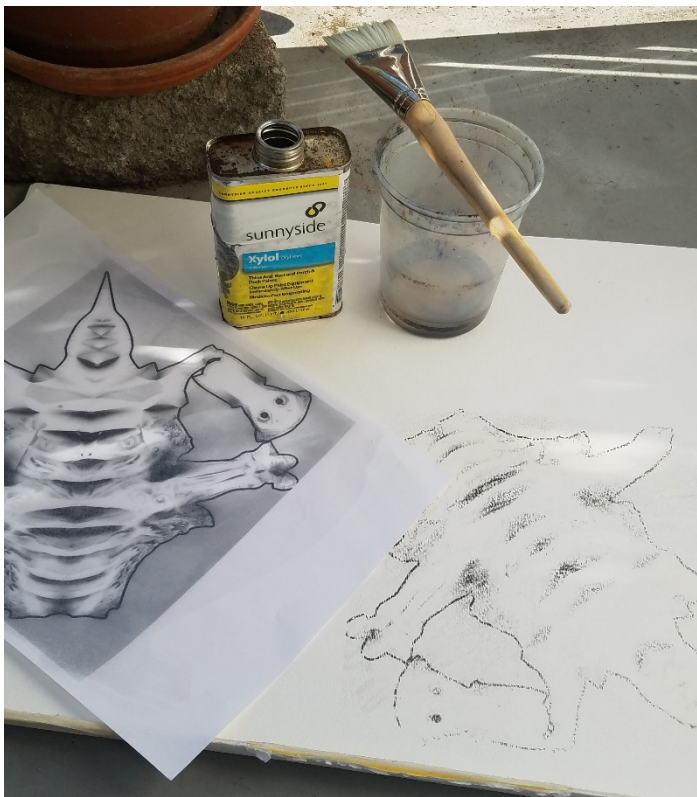
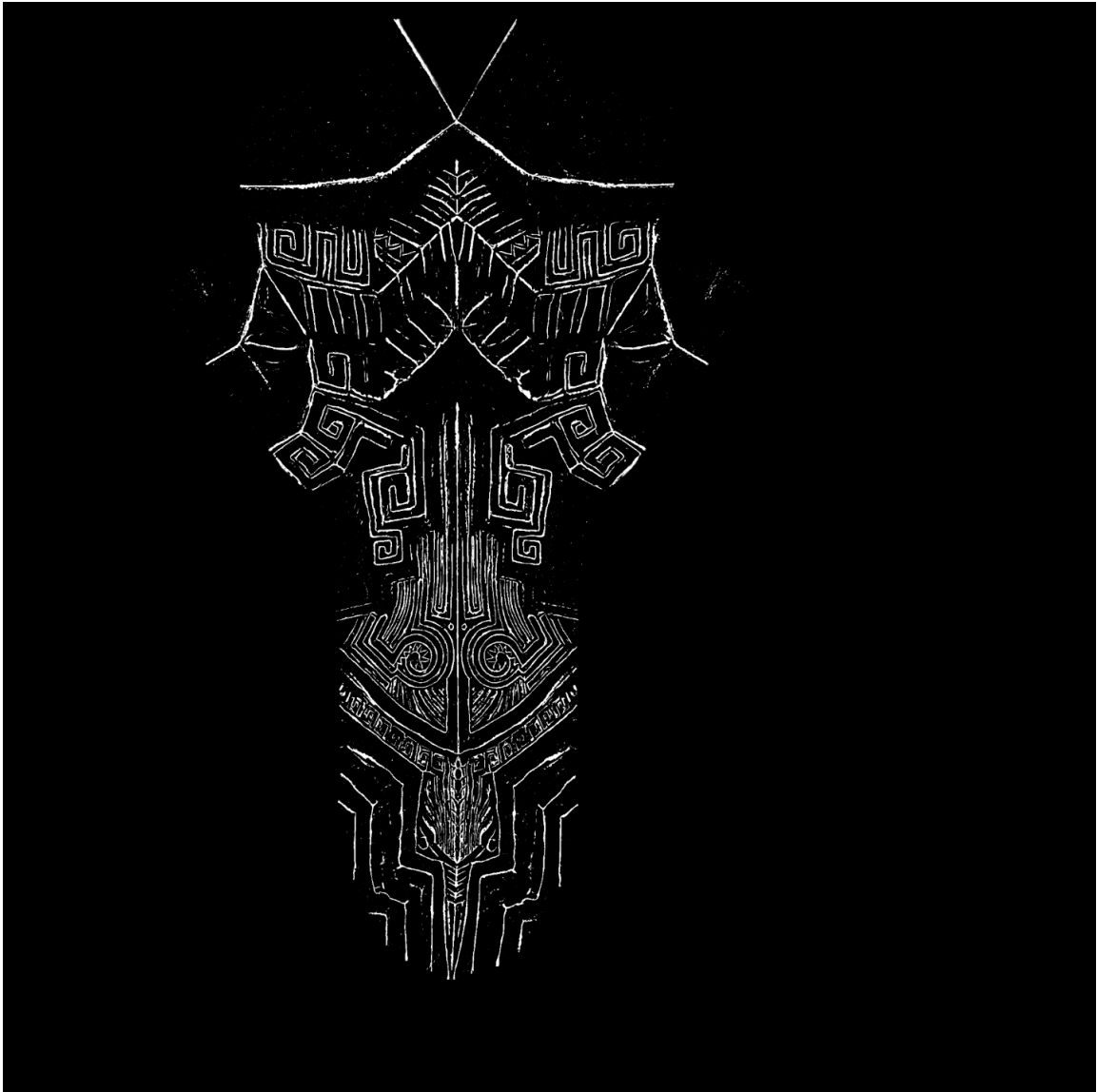


Figure V.10 Nayaki Anandan, Acetone Transfer Result, 2018.

The first place this technique was applied to was the interior of the temple. I used it to create the rocky walls and ceiling, the individual stone pieces in the altar, and the tiled floor. The end result ended up being very convincing and impressive. I still wasn't getting the edge texture I wanted, so I revisited this using a simple

method. I baked out a curvature map from Substance Painter, which basically finds all the sharp edges and grooves of an object. I took this map into photoshop and adjusted the levels until it was basically black and white [Fig 5.11]. I then used this as a mask and

multiplied the original texture over itself just to darken the texture at the edges of the object. Lastly, I added a texture of bumpy watercolor paper to the mask to give it a



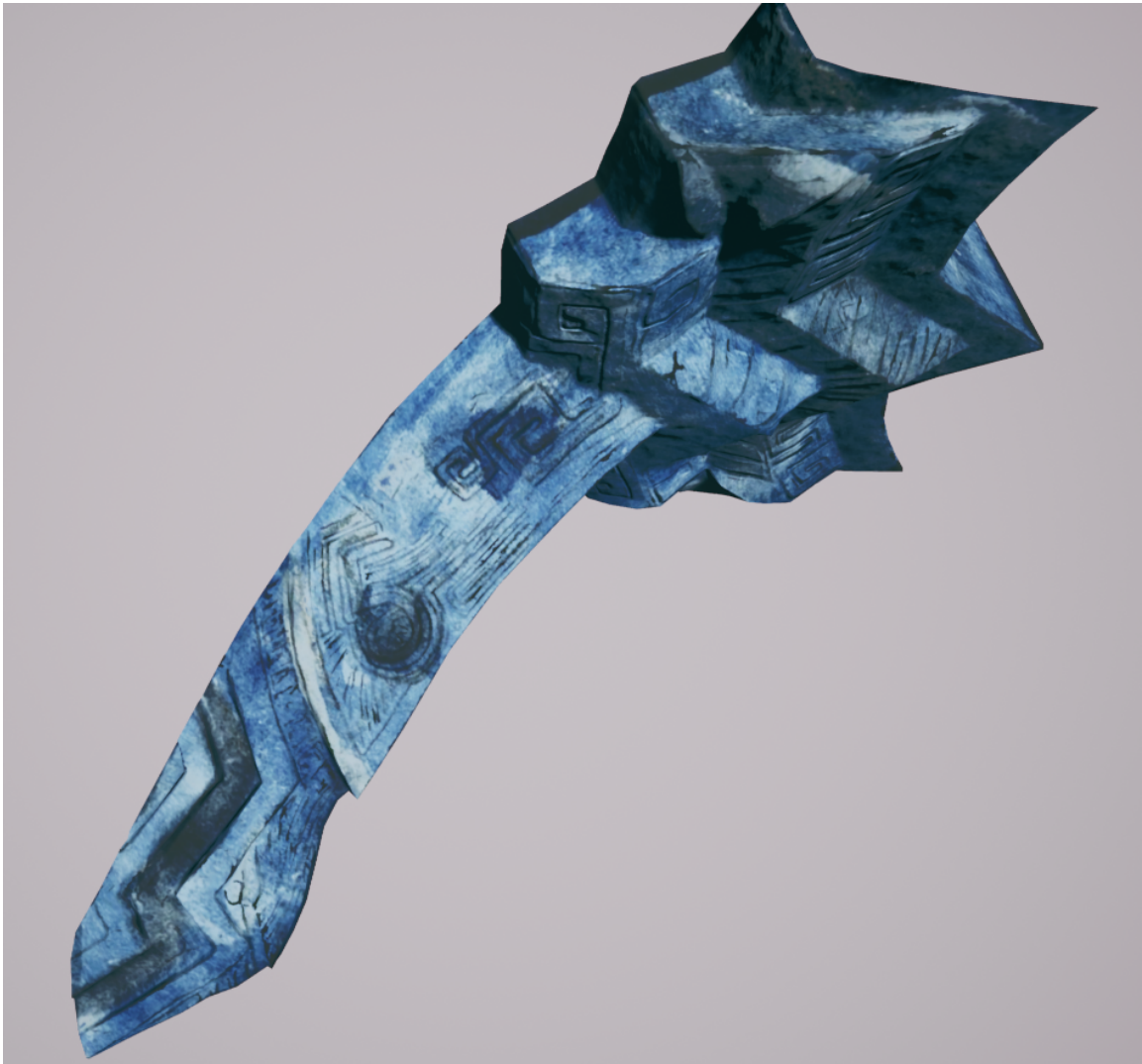
*Figure V.11 Nayaki Anandan, Curvature Map of Columns, 2018.*

scattered, rippled silhouette. The first result was a little too opaque, so I added a parameter that allowed me to change the opacity of this new edge effect .What I ended up with was a thin jagged line that read as a sort of darkened pencil line at the edge of my



objects [Fig 5.12], which could be adjusted to be very subtle. I was satisfied with this new edge technique and decided to keep it for the final version of the project.

Scanning my images presented just one small issue. The back of the scanner is white, so it made my paintings a lot less vibrant when scanned than they seemed when



*Figure V.12 Nayaki Anandan, Column with Curvature Map, 2018.*

looking at them in standard lighting. Luckily the solution to this was simple, I just placed a black piece of paper behind my images to absorb the extra light. Once the images were scanned, I brought them into Photoshop to line them up with the UV islands. Once I got

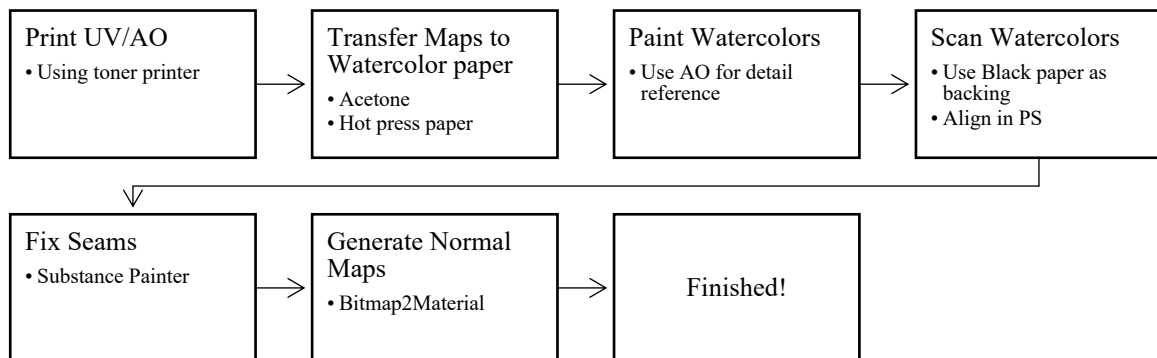
to this part of the process, I ran into a problem that I knew I'd eventually have to face: Texture seams. Substance Painter, a program specialized for creating materials and textures of any style, was the solution to my texture seam issues. After aligning the textures to their respective UV islands in Photoshop, I brought the low poly object, any previously generated maps for it, and the new diffuse map into Substance Painter. After applying the maps to my object, I created a fill layer on my object that is at maximum roughness, with no channels except roughness and color. I put the object at maximum roughness to best represent how it would be viewed in game. For the 'base color' option, I'd drag in my diffuse map, which would give me my mostly finished, colored object. I then create another layer and set it to 'passthrough' meaning it would simply sample from the layer below. Using the clone stamp tool, I would select an area near the seam and use a soft brush to cover the texture seam. I would then export my new diffuse map without texture seams from Substance Painter.

Once I applied all my new maps to my objects, they were starting to look more complete. I was frustrated, however, because I felt that the normal map from the high poly object was making the edges of the object look too straight, particularly on the altar in the temple. A normal map is created by taking a high poly version of an object and 'baking' the details of it on to a low poly version of the object. The frustration with my normal maps was coming from the lack of effect the actual paint was having on the 'bumpiness' of the texture. If one looks closely at watercolor paintings, there is clear dimension from where the water swells the paper or sinks in, creating a lot of interesting depth and texture. The paper also plays a huge part in how the pigment settles into the paper, and I felt this was a very important detail to capture. Luckily my independent

study professor, Christopher Poplin, introduced me to a program called Bitmap2Material. This program was created by the company that made Substance Painter, Allegorithmic.

To use Bitmap2Material I simply dragged my new Diffuse texture from substance painter into the main input of the program. I then navigated to the ‘normal map’ tab and adjusted the settings so that the outputted texture would show a little bit of the bumpiness of the watercolor paper, and a lot of the depth and puffed edges caused by the paint strokes. I then exported this new normal map, labelling it as the normal map from watercolors. At first, I tested out just using the watercolor normal but found that it completely erased some valuable details in the object. I ended up using a normal map blend node to merge the two normal maps together to create an object that looked intentionally sculpted, but also influenced by painterly detail.

By the end of my Independent Study I had a fully formulated watercolor technique. The process ended up looking like this:



The finalization of this technique was first fully realized in the temple section of the game. The end comparison of the concept watercolor painting and the 3D model was very similar, save for some small issues I would like to fix in the future. Given more time, I’d perfect painted lighting on my objects, and find a way to make the edges even more convincing. My ideas for these include creating edge alphas for individual objects, and

finding a way to control the edges of shadows to make them look more inky and painterly. For the time being, however, I had a technique that was ready to be implemented.

## VI. SOUND AND COLOR COMPOSITION

*The Forest Temple* not only uses posing and color, but also sound and composition to direct the player through the diorama sequences in order. The music and sound effects in this project were created by James Borchers, an adjunct professor at DigiPen Institute of technology. Ambient and diegetic sounds are used in combination with naturally flowing compositional techniques to move the player forward in the intended direction. Although I had not originally intended to add sound and music to *The Forest Temple*, it ended up being a vital player in telling the story.

Since the final Virtual Reality experience is meant to be several moments frozen in time, it makes sense to have sounds that may have been pulled from those moments such

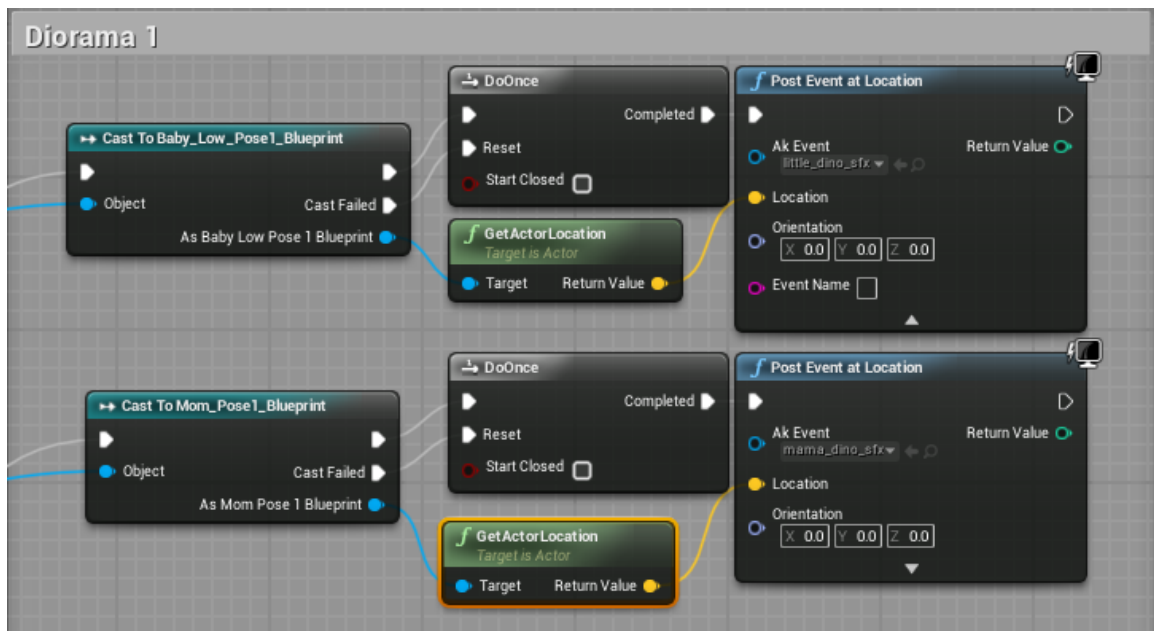


Figure VI.1 Nayaki Anandan, Diegetic sound integration, 2018.

as the rustling of leaves, or the bubbling of water on the beach. These are called diegetic sounds, and the Oculus Rift uses a spatializer plugin<sup>10</sup> to orient the sound around the player. In this way, if the player is looking towards where the sound is coming from, it will be more pronounced and in focus. When the player turns their head, the sound will be played at a different volume in either ear, depending on its location. Diegetic sounds were used for the characters in *The Forest Temple* as events that are triggered when the player looks at the characters. This was achieved using the blueprint system [Fig 6.1] and, like the Idols, detecting if the player is looking at a character. When it is determined that the player is looking at one of the characters, a sound event is posted at the location of the character object. Professor James Borchers introduced me to a program called Wwise, and within this program helped me set up “events” that play when called in unreal. For example: Whenever a sound event is posted in game for the baby, it is pulling a sound from a bank of baby-noises and randomly selecting one to play. That way, each time the player looks at the character, a different sound can be made. While this triggered-sound function was used for all the characters in the game, there are also some diegetic sounds that are not triggered. The sound of leaves rustling in the wind or the sound of the ocean can be heard by the player depending on where they are standing. If they look up while in the forest, the sound of the leaves will become more intense.

---

<sup>10</sup> Oculus, “Integrating the Oculus Spatializer” (Oculus), accessed December 10, 2018, <https://developer.oculus.com/documentation/audiosdk/latest/concepts/osp-wwise-integration/>.

The inspiration for the sound in *The Forest Temple* was once again the game *Child of Light*. One can look up videos of gameplay and hear the symphonic music<sup>11</sup> featuring the piano and cello melodies of Coeur de Pirate. Coeur de pirate is actually the solo-act name for Béatrice Martin, who is known commonly for her pop and rock music<sup>12</sup>. Much of the soundscapes of *The Forest Temple* were intended to sound tonal and melodic to emphasize the cinematic qualities of the experience. The mood of each scene changes thanks to the attenuation spheres of each sound event (seen as yellow spheres below) [Fig 6.2] These spheres are visualizations of the area in which a sound can be heard so that

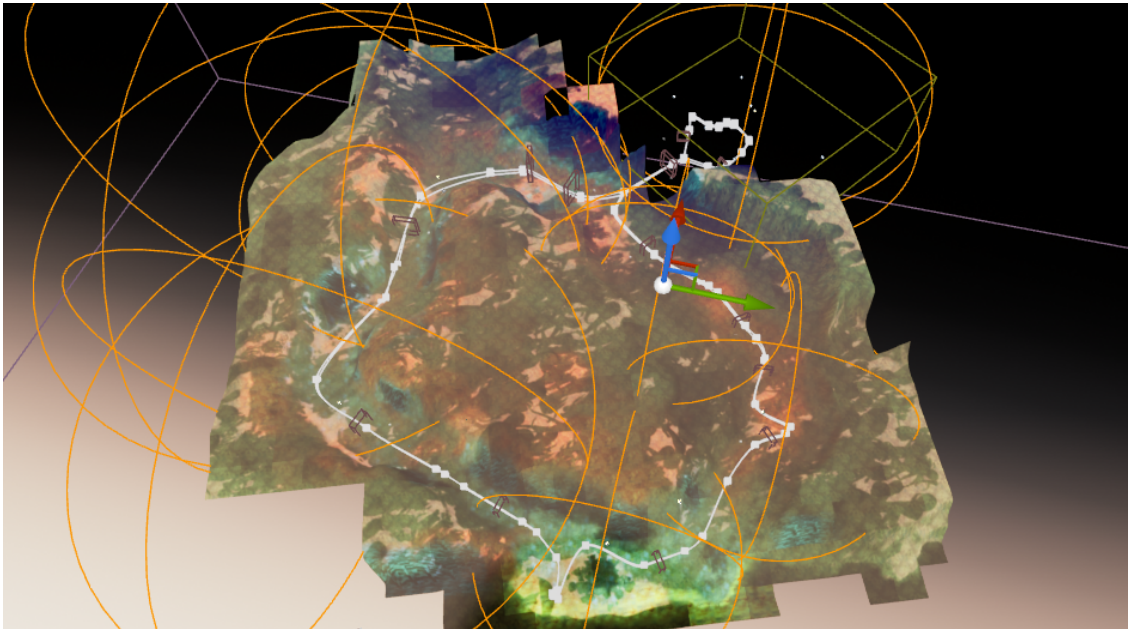


Figure VI.2 Nayaki Anandan, *Sound Attenuation Spheres*, 2018.

when the viewer progresses onward certain ambient sounds will be faded out and others faded in.

<sup>11</sup> Béatrice Martin, *Child of Light*, 2014, Spotify.

<sup>12</sup> Béatrice Martin, Coeur de Pirate: Brave Heart, interview by Sarah MacDonald, Blog Post, May 12, 2014, Noisey, [https://noisey.vice.com/en\\_ca/article/r7p5db/coeur-de-pirate-child-of-light-ubisoft-release-interview](https://noisey.vice.com/en_ca/article/r7p5db/coeur-de-pirate-child-of-light-ubisoft-release-interview).

Timing the sound events was crucial to giving the entire narrative context, as it helped create moods for each scene. While I have already discussed posing, I mentioned a few chapters back that I used the color script to structure my composition, and that color was an important factor in doing so. I wanted to emulate the increasing redness seen in the color script as the player moves through each diorama. I achieved this with another post processing material, the node structure of which desaturates the scene based on box triggers placed in each spline. Here is a snapshot of the node structure of the base material [Fig 6.3]:

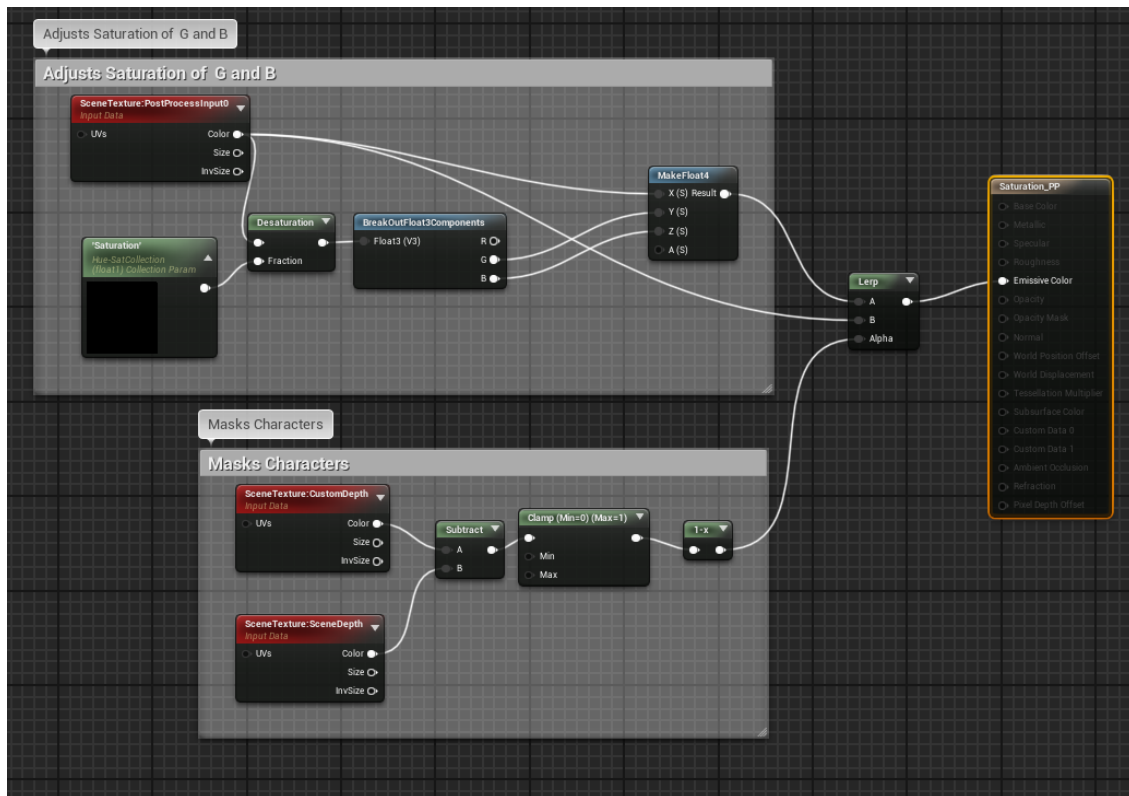


Figure VI.3 Nayaki Anandan, Node structure for saturation, 2018.

In the section commented out called ‘Adjusts saturation of G and B’, the blueprint is using the final rendered image of the scene for each frame. After getting this image, I used a break out node to get just the g and b values of the scene, and desaturate them based on a collection parameter that I can call from other blueprints. In the blueprint of

Path A for example [Fig 6.4], I have created a node structure that detects if a player is overlapping a box trigger. The ‘Branch’ checks to see if the scene has already been

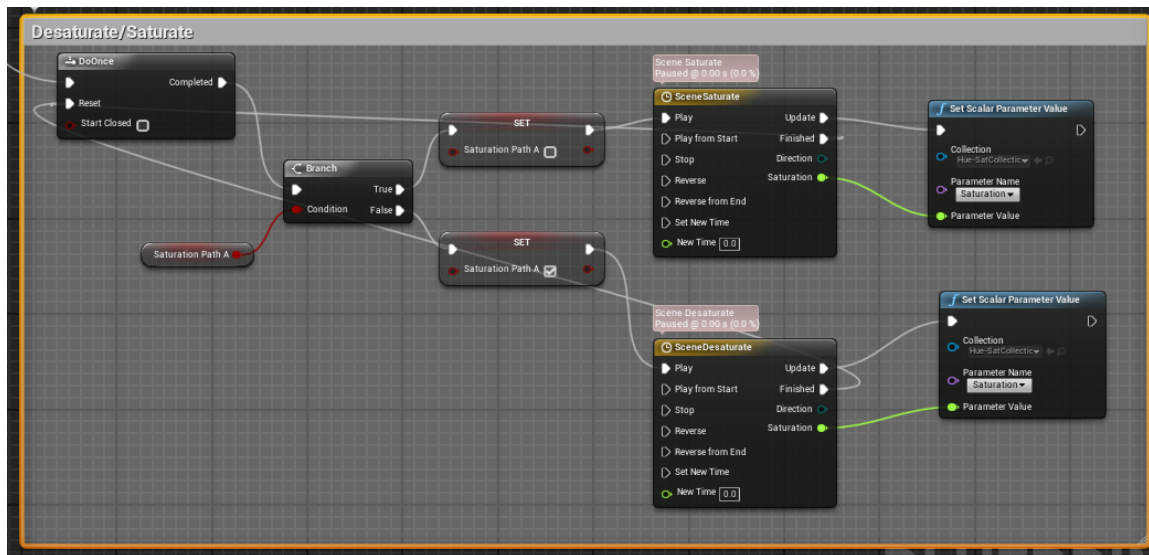


Figure VI.4 Nayaki Anandan, Desaturation technique, 2018.

desaturated (in case the player is moving the opposite direction), and desaturates or saturates depending on the player’s destination. I have a timeline hooked up to the actual scalar parameter change, so that the scene will desaturate gradually rather than all at



Figure VI.5 Nayaki Anandan, Snapshot with Desaturation level 0, 2018





Figure VI.6 Nayaki Anandan, Snapshot with Desaturation level 0.8

once. This just makes for a less jarring change, but if one compares snapshots with a desaturation of 0 [Fig 6.5] to that of 0.8 [Fig 6.6] It is easy to see the effect of desaturating the blue and green values of the scene. One might notice that the small creature's coloring does not change, and this was an intentional choice to make the characters stand out from the rest of the scene. Looking back at Figure 6.4 one can see the 'Masks Characters' Section of the blueprint. This uses a custom depth channel applied to all the character meshes to get a separate rendering of a mask that can be subtracted from the rest of the scene depth. This is then used to mask the desaturating effect. One can see just looking at the two snapshots above how the mood can be changed drastically by a simple color shift.

## VII. OPTIMIZING FOR VR

While finalizing the watercolor technique and implementing all the tricks for adding mood to the game were a huge success, I still had to optimize *The Forest Temple* for a

Virtual Reality format. Following a few artistic and technical standards for VR made *The Forest Temple* run smoothly and with a high framerate and low latency. The basic rules I followed are these:

1. Material Optimization
2. No transparency.
3. Dither temporal AA
4. Low poly objects
5. Aggressive LODS
6. Level streaming
7. Static lighting only

In order to optimize my materials, it was best to use material instances wherever possible. A material instance is a ‘child’ of a material node network, with adjustable

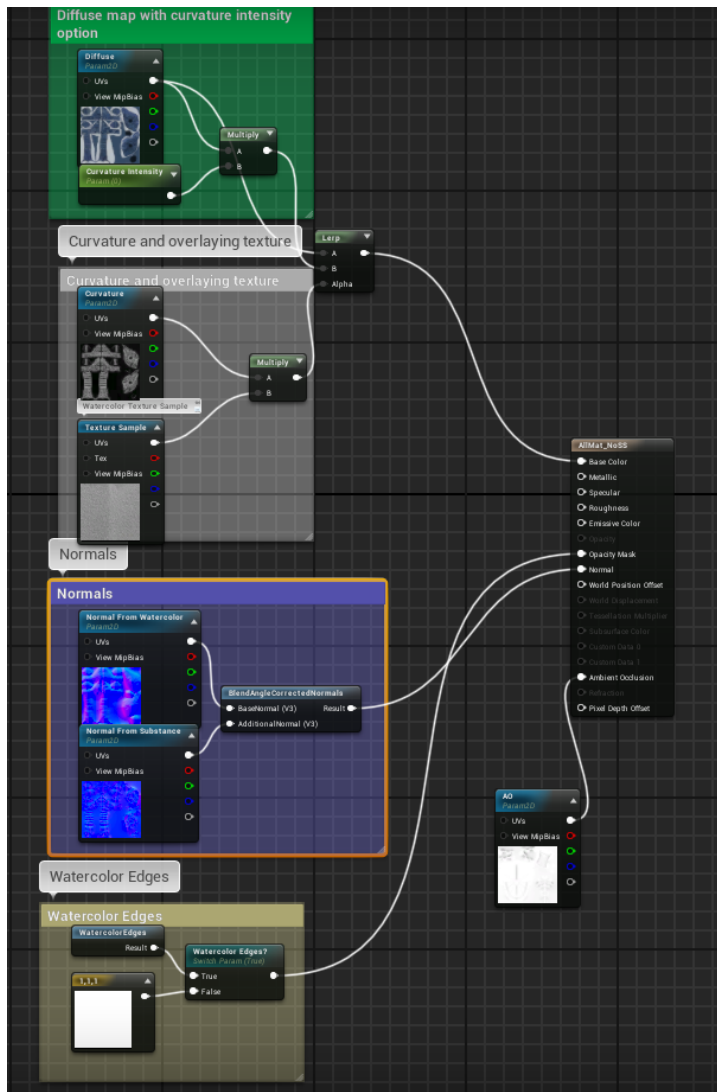


Figure VII.1 Nayaki Anandan, Parent Material, 2018.

parameters. Here is an example of a material instance [Fig 7.2] versus a parent material [Fig 7.1]. In the main material, I can set ‘parameters’ (the navy-blue nodes) that can be changed in each material instance, while having them all share the same node network. In this case, I have set all the texture maps to be parameters so that I can change them out individually. I also added parameters for the curvature line that appears on the edge of objects, and a parameter for the “watercolor

edge” which I went over in previous chapters. The benefit of instancing materials is efficiency and speed. All parent materials have parameters for the necessary maps, such as: Ambient occlusion, Normal map, Normal map from Watercolors, Curvature map, and Diffuse map. In addition to this material parenting optimization, all the materials in my game are fully rough. This basically means that they do not cast reflections at all and

have no specular value. Specularity is what causes the small white highlights on a person's eyes, or sharp light reflections on metal<sup>13</sup>. Luckily, having fully

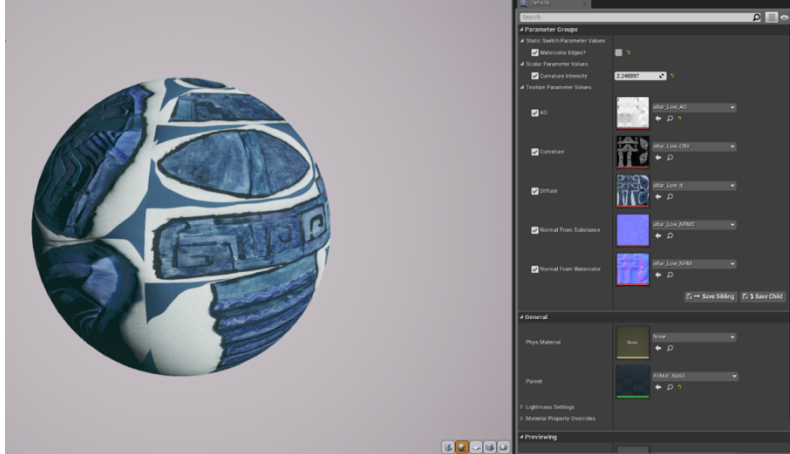


Figure VII.2 Nayaki Anandan, *Instanced Material*, 2018.

rough materials works in tandem with the watercolor texturing to create a unique paper-like appearance on objects.

In order to make this material instance process work best, I created 4 basic materials. These were: No SS, SS, Transparency, and an extra transparency material with no normal map. When a material is labelled SS, it is referring to Subsurface Scattering, which is the distribution of light beneath the surface of an object. The best of this is in skin or plant material. Take, for example these snapshots of the baby character from *The Forest Temple* with and without Subsurface Scattering:

<sup>13</sup> Epic Games, “Material Nodes” (Unreal Engine Documentation), accessed December 10, 2018, [https://docs.unrealengine.com/en-us/Resources/ContentExamples/MaterialNodes/1\\_3](https://docs.unrealengine.com/en-us/Resources/ContentExamples/MaterialNodes/1_3).



Figure VII.4 Nayaki Anandan, *Baby Creature with NO SS 2018.*



Figure VII.3 Nayaki Anandan, *Baby Creature with FULL SS, 2018.*

Although the difference is subtle, it is easy to see the importance of this material setting because if one pays attention to the shadows, they are far less sharp and intense in Figure 7.4 I also have a material that does not have Subsurface, for objects like stone which do not reflect much light beneath the surface of the object. The final parent material is for transparency, which is used for objects like foliage and the water in the temple that require a mask.

This may seem counterintuitive, as I just listed transparency as one of the things that one *should not* put in a VR game. There is an important distinction here that must be made, between transparency and alpha masking. Transparency, in game-art terms, implies a gradient from white to black that is used to determine the opacity of an object. The only place I used true transparency in my game is in the temple, where the water runs down the middle of the environment. The reason to avoid transparency in games is because of *overdraw*, the term for what occurs when a scene has several layers of transparency that overlap, like you might find in dense foliage areas. Overdraw is extremely expensive because “the rendering cost to render transparency becomes more

and more expensive for each layer of Transparency that you introduce”<sup>14</sup>. The other issue with transparency is sorting-priority, which is what determines the order in which the engine draws transparent objects. Most of the time, Unreal does this well on its own, but sometimes the user must manually set the channel that each object is being drawn on, to prevent popping. Alpha masking greatly reduces the processing power needed to create convincing foliage. The rest of the two-sided objects in *The Forest Temple*, such as leaves, grass and bushes use alpha masking. Alpha-masking uses a white and black map, with no grays in between, resulting in a much less complex shader that is far easier to render. This type of transparency also has the problem of overdraw, but because there is simply a 0 or 1 value of opacity, it is still far less expensive. Transparency is widely known as something to be avoided wherever possible in VR, as it requires a huge rendering expense, but if it is required, there is another method of rendering that can help. This is called Temporal dithering, and it uses a method of quickly flickering pixels to give the *illusion* of transparency. This is the one true way to reduce overdraw and fix sort ordering issues, and I used it for all the transparent objects the final project. There are also aspects of object modelling that can help with transparency and alpha masking.

One way of cutting down on complex shaders that use alphas is to cut foliage cards to very precisely fit the alpha masks. This involves removing as much transparent space as possible from the object. Unreal engine has a ‘shader complexity’ viewer that really shows you the difference between an object with a lot of masked space versus one with very little [Fig 7.5]. The large fronds have not yet been optimized and therefore have a lot

---

<sup>14</sup> Epic Games, “Using Transparency,” *Unreal Engine Documentation*, Materials How-To’s, accessed December 10, 2018, <https://docs.unrealengine.com/en-us/Engine/Rendering/Materials/HowTo/Transparency>.

of red space around them, while the smaller leaves in the bottom left have been optimized and are mostly green.

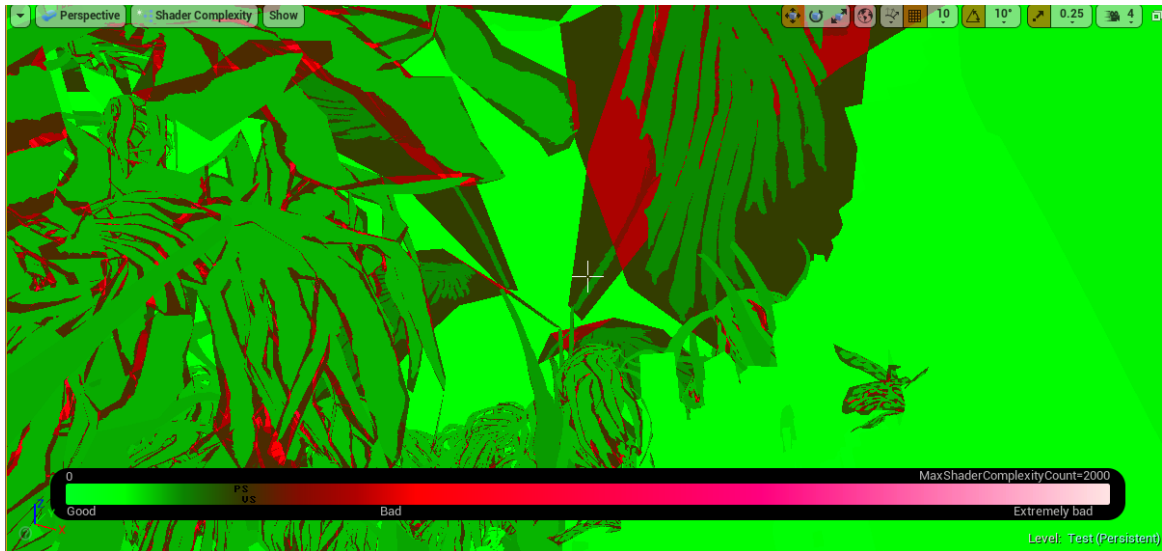


Figure VII.5 Nayaki Anandan, Shader Complexity Viewer in Ue4, 2018.

I used this technique of cutting down masked space on the grass, bushes, and trees in *The Forest Temple*. In this tutorial I found in optimizing shaders for VR, the writers discuss having to create a dense jungle scene with large palm trees<sup>15</sup>. The main techniques they used for achieving this is having very little masked space on their foliage cards and using aggressive LODS [Fig 7.6].

<sup>15</sup> Phosphor, “Creating Dense Foliage in VR,” *Phosphor*, November 2, 2017, <http://phos.ph/2017/11/02/creating-dense-foliage-vr-pt-1/>.

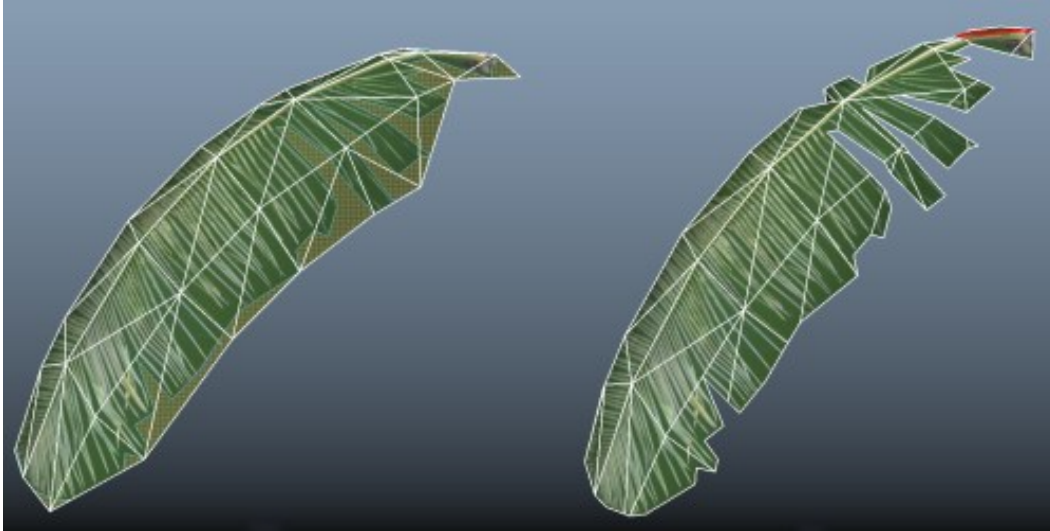


Figure VII.6 Phosphor. "A Palm Branch before and after excess alpha space is removed". November 2, 2017.

In games, LODs or Level of Detail meshes are used to optimize high polygon objects in games. These extra meshes help a game run faster by switching out the higher poly mesh for the lower poly mesh depending on how far it is from the viewer or how



Figure VII.7 Nayaki Anandan, LODs for Trees, 2018.

much of it is in view. Unreal auto-generates these for most objects, but many prefer to hand tweak their LODs so that the silhouette of the lower poly models doesn't generate a 'popping' effect. In Unreal Engine, one can manually set the 'Screen Percentage' at which an LOD will appear<sup>16</sup>. For the trees in *The Forest Temple*, I created 5 separate mesh stages of LODs that also have changing materials for each stage [Fig 7.7].

<sup>16</sup> Epic Games, "Creating and Using LODs" (Unreal Engine Documentation), accessed December 19, 2018, <https://docs.unrealengine.com/en-us/Engine/Content/Types/StaticMeshes/HowTo/LODs>.



The materials for these LODs work like this:

LOD 1: Everything enabled

LOD 2: Normal map on leaves disabled.

LOD 3: Lowered lightmap resolution, no normal map.

LOD 4: No alpha mask, no normal map, low lightmap resolution.

LOD 5: No alpha mask, no subsurface scattering, no normal map, lowest lightmap resolution.

Adjusting materials for the LODs is another way to speed up rendering times because there are less lighting and masking calculations needed. On LOD 4, I scrap the alpha mask on the leaves entirely to get rid of any transparency overdraw problems.

Materials and LODs are a small part of a much larger picture having to do with *when* to render each part of the game. To really get a smooth 90 FPS result, I had to set

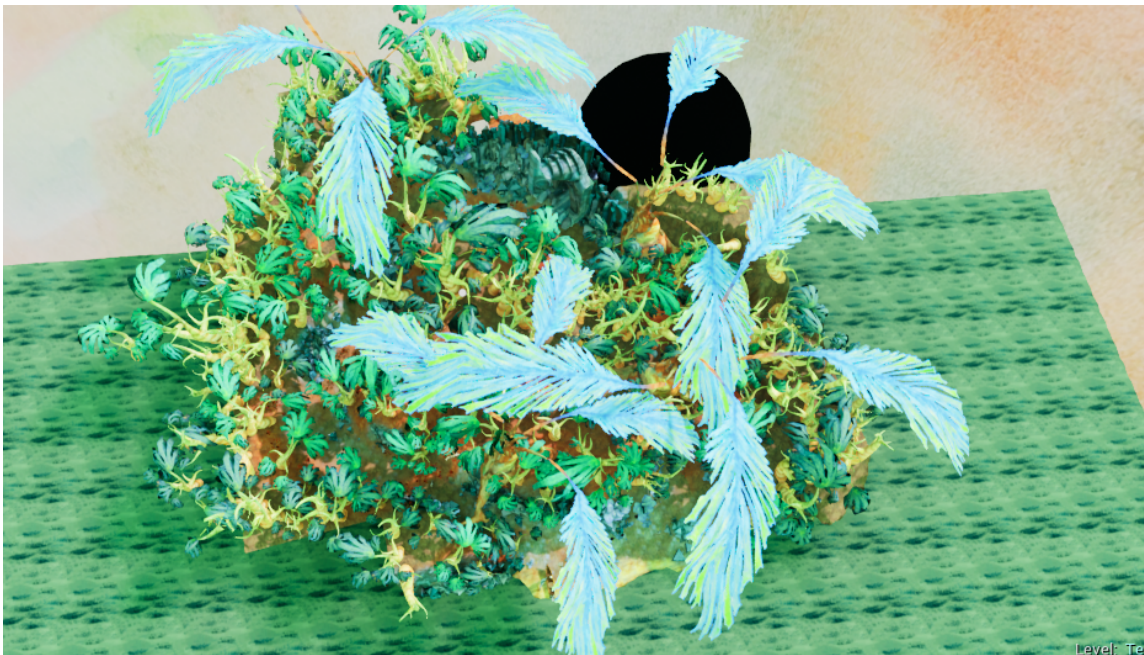
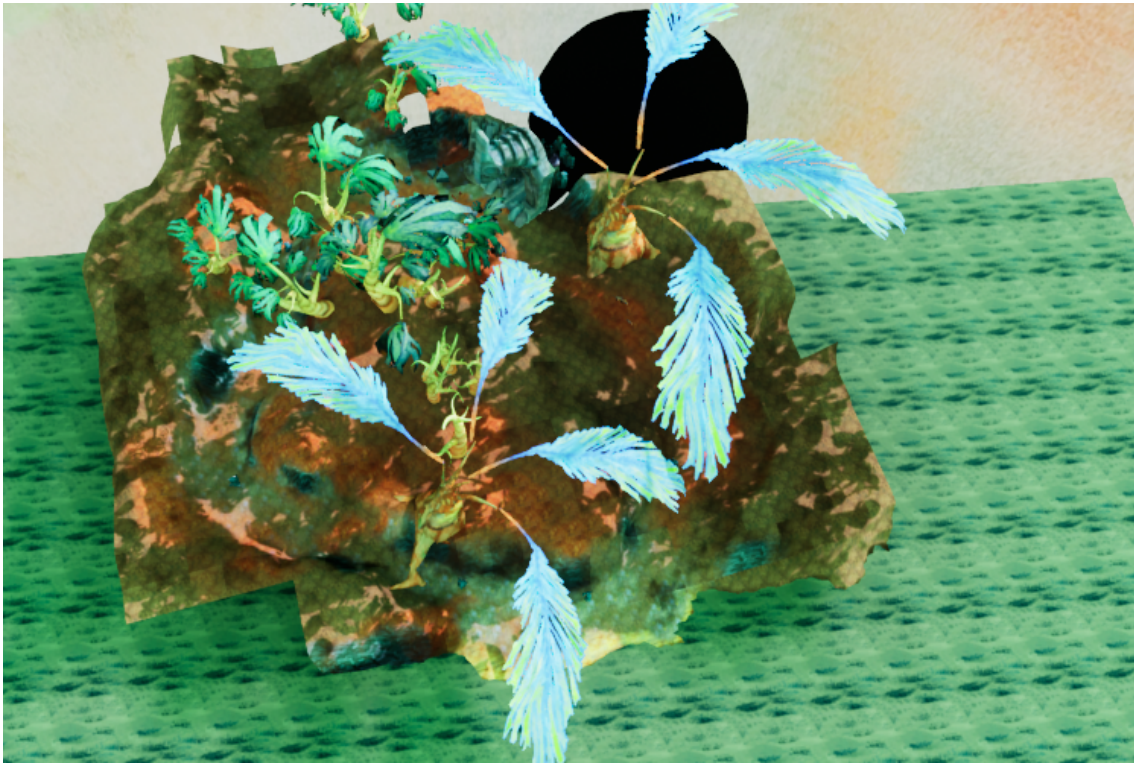


Figure VII.8 Nayaki Anandan, *All levels visible*, 2018.

up properly streamed levels in *The Forest Temple*. Level streaming allowed me to cull

certain meshes and parts of the scene, depending on where the player is at any given moment<sup>17</sup>. For example, when the player is inside the temple, most of the outside area is unloaded. Here is an example of what the landscape looks like all levels visible [Fig 7.7] and when the player is inside the temple [Fig 7.8].



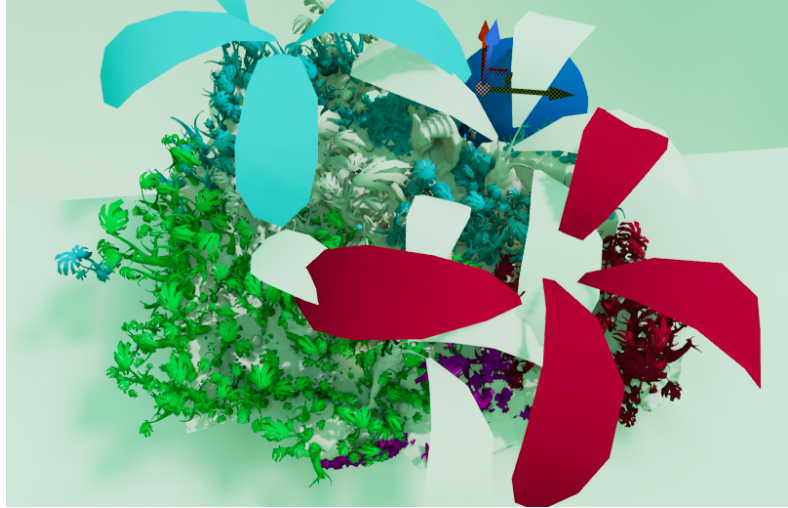
*Figure VII.9 Nayaki Anandan, Inside the Temple Level Streaming, 2018.*

---

<sup>17</sup> Epic Games, “Level Streaming” (Unreal Engine Documentation), accessed December 20, 2018, <https://docs.unrealengine.com/en-us/Engine/LevelStreaming>.

As one can see, the foliage, rocks, characters, and other objects have been completely culled from the outside in the second image. Therefore, when the player is inside the temple the game is not attempting to render all the extra objects outside. I ended up with

a total of 9 Levels including the persistent level. This image with level coloration [Fig 7.9] displays all the separate levels as colors applied to objects in the



environment. I streamed

Figure VII.10 Nayaki Anandan, *Level Streaming*, 2018.

levels in and out using some of the same box triggers that were used for the saturation changes in the scene. Simply put, when the player overlaps a certain box trigger, a level may be streamed in or out. Level streaming is a vital part of optimizing for any game-running hardware and is an easy way to keep a high framerate without losing any quality in the game.

## VIII. GAME TESTING

Once I had the pieces of *The Forest Temple* mostly together and the game running at a minimum of 75 FPS, I decided to test the game. Testing required me to develop a series of questions that players could answer to help me find holes and issues with the game, and it was incredibly informative in developing the final product. When I tested my game, the boat at the ending and fruit bowls were not present, and some of the sound

effects were not there. There was also no title screen or credits screen at the time. I had 6 testers, 4 of which I knew very well, and 2 who I am acquainted with.

I went about testing by briefly explaining to testers that the game is intended to be an immersive storytelling experience. I then had them play, and only answered questions when technically important. Each player was then given this list of questions to answer:

- a. While Playing the game, did you sense that there was a narrative? If yes, what was it (summarize)?.
- b. Were you able to understand who each character was consistently in the experience?
- c. What do you think your place in the story was, if any?
- d. Looking at the environment, is there a word that describes the appearance or style?
- e. Did you find this aesthetic enjoyable? Why?
- f. Do you think this style is unique? Have you seen it before?
- g. Did the experience make you nauseous? Please circle which you chose:
 

Blink Teleport	Move Teleport
----------------	---------------
- h. Did the movement mechanic make sense? Was it confusing? Why/when?
- i. Did you find the sound effects helpful for the experience?
- j. If you experienced an emotional response while playing the game, please describe where and what it was.

- k. From 1-10, how would you rate your overall experience in terms of interest, 10 being very interesting, and 1 being frustrating or boring?
- l. What was your favorite part of the experience?
- m. What was your least favorite?
- n. Was there anything you wanted to do that you couldn't?
- o. If you had a magic wand and could change anything, what would it be?

Based on the responses I got to these questions, I created a few diagrams to help me understand what needed changing [Fig 8.1].

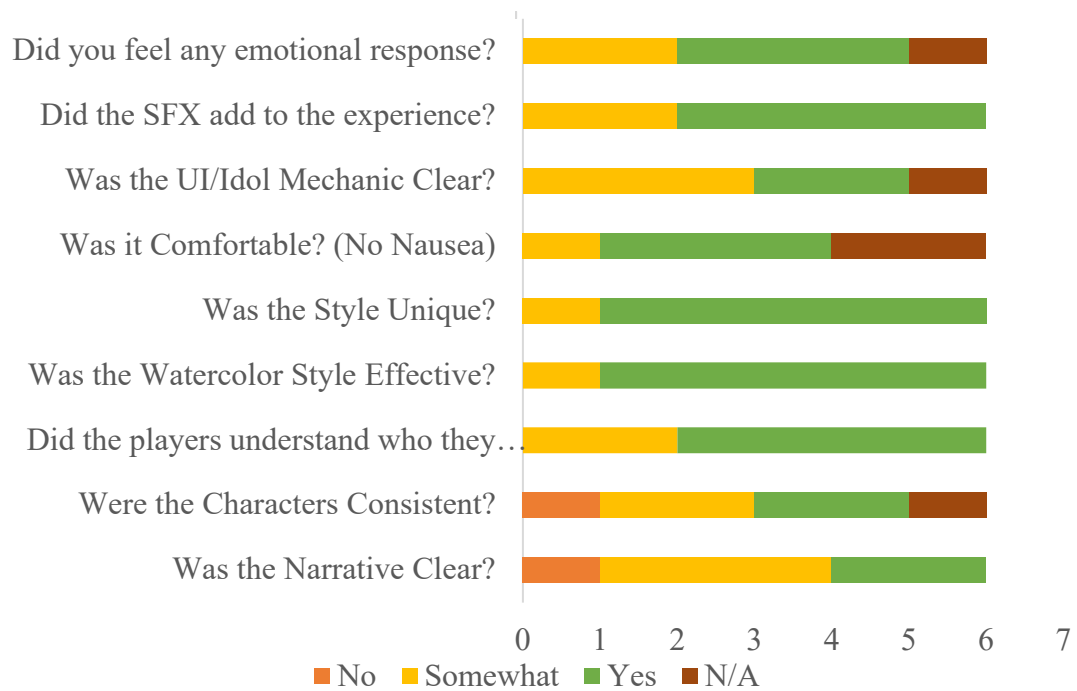


Figure VIII.1 Nayaki Anandan, Data from Tester Experience Survey, 2018.

This first diagram gave me a good idea of how the narrative was or was not working in the game. Most people, based on individual responses, felt that the narrative didn't seem apparent until the final few dioramas, and the emotional quality was lacking. People

were also having a hard time following the character progression and were mistaking it as being many characters rather than a pair on a journey. The rating of the game averaged at 8, going no lower than 6. All testers except for one chose the move teleport option.

The main issue during testing was with the story not fully coming across to the players. In order to refine the narrative impact of the game, I tuned the sound and added whimpering sounds for the small creature in the last few scenes. I also added distorted versions of the parent sounds to further imply a change. I also added timestamps to the idols to give an indication of who the player represents in the story and help to orient them in the environment. I also added a few goodies to the dioramas, such as the fruit bowls and spilled fruit in the temple. Finally, I added the boat and the note from the adventurer at the end of the game to give the player even more context.

I did not have time to retest the game in an official manner, but I feel based on personal responses I received and the outcome of the final product that the narrative is much clearer in the finished app. I also added a small explanation of the experience at the beginning of the game that really helps guide the viewer. There are still several changes I would make, but I believe the goal of creating an impactful and emotional experience was achieved.

## IX. LOOKING FORWARD

In general, *The Forest Temple* achieves the goals of this thesis. I have created an emotional experience that drives the player forward via their own curiosity and intrigue, in an artistically unique environment that exemplifies a specific artist's style and shows

the artists hand in the artwork. That said, I'd love to delve into this medium in a variety of other ways, maybe even adding interaction and animation.

While I am satisfied with the game I created, there are still a few things I'd like to build on given more time. I would love to create an entire, interactive game based on the narrative given in *The Forest Temple*. This would require challenging the hardware available in new ways, and a much bigger understanding of programming than what I currently have. That said, I'd still love to see how far I can push interaction in a VR game like *The Forest Temple*, and how I could introduce new mechanics without inducing nausea or distracting too much from an immersive experience. I am also interested in the versatility of art in conjunction with this technology, and how it could help expand the existing uses of VR.

I'm very interested in how programs like *Quill* and *Medium* challenge artists to create work in 3D space, using easy-to-learn tools. The VR movie *Dear Angelica* was made using quill, and it is important to note how watching the brush strokes come to life helps focus the viewer on the important details of the scene [Fig 9.1]. I am curious to see how programs like medium and quill could be expanded upon to include even more brushes and mediums, essentially becoming the photoshop of Virtual Reality.



Figure IX.1 Wesley Allsbrook, *Dear Angelica*, Oculus Story Studio, January 21, 2017.

Many people who experienced *The Forest Temple* described feeling calmed and peaceful in the space, particularly in the first few dioramas. Currently, VR is being used to treat a variety of mental health disorders, ranging from PTSD to phobias and anxiety disorders<sup>18</sup>. The method of treatments available currently focus on exposure and response therapy (ET), and cognitive behavioral therapy (CBT), and are used to expose the player to situations that trigger a specific mental response. For example, someone who suffers from PTSD may be exposed to vibrations or sounds similar to an explosion, to help clear their mind of the imprinted fears and learned responses from traumatic experiences. In the future, I would like to use what I discovered while making *The Forest Temple* to

---

<sup>18</sup> Alex Senson, “Virtual Reality Therapy: Treating the Global Mental Health Crisis,” *Tech Crunch*, 2015, <https://techcrunch.com/2016/01/06/virtual-reality-therapy-treating-the-global-mental-health-crisis/>.



combine existing treatment techniques with specific artistic aesthetics, essentially creating personalized therapeutic spaces for patients. In these spaces they could choose to explore and perhaps problem solve, while being exposed to the same stimuli that is used to help their specific disorder.

Virtual reality is also currently being used to train workers in a variety of fields including medical, military<sup>19</sup>, and even astronaut training<sup>20</sup>. NASA and the US military have actually been using VR as a training device for some time, and the further development of VR devices has served to make this training more effective. While in these specific cases it is required that graphics be as representational of the real world as possible, I am interested in seeing how similar training techniques could be applied to teaching children problem solving and other basic skills. With the ability to manipulate things like gravity and the laws of physics in VR, there comes an opportunity to use puzzles and games in VR as learning devices for young children.

Although there are many obstacles still to overcome for VR, there are many paths that this technology could take. Art, which has existed in the form of entertainment, recording, symbolism, expression and so much more for so long, can be used in conjunction with this technology. Through storytelling, teaching, entertainment and exposure these two mediums present a world of possibility.

---

<sup>19</sup> Unimersiv, "How the Military Is Incorporating VR into Troop Training," *Unimersiv Blog* (blog), May 18, 2016, <https://unimersiv.com/military-incorporating-vr-troop-training/>.

<sup>20</sup> Loren Grush, "Walking Through Space in NASA's Virtual Reality Lab," *The Verge*, August 22, 2017, <https://www.theverge.com/2017/8/22/16178138/nasa-virtual-reality-lab-mars-rover-simulator>.

## X. CONCLUSION

*The Forest Temple* offers a unique, emotional Virtual Reality experience with a striking watercolor aesthetic. The development of this thesis led me to understand the medium of Virtual Reality and all its challenges as a whole. The thesis explores possible solutions for these problems and attempts to boil down the essentials of a narrative in Virtual Reality, but there are still many obstacles to overcome. In the end, I have presented a stimulating, emotional narrative, where the player is driven forward by their curiosity and desire for knowledge.

Overall, the goal of this project was to portray an emotional experience. While this was challenging to implement throughout the creation of *The Forest Temple*, the final game presents a few must-haves for a compelling VR experience. The use of the watercolor textures is the first thing that pulls the player in, exposing them to a unique expression of an alien world. This is but one aspect of many things that drive this thesis to success.

The watercolor texturing technique I created for this thesis gives a new and extremely effective pipeline for bringing traditional media into a digital realm. While programs like Photoshop and Substance Painter have allowed for artists to create a plethora of styles, the technique discussed in this thesis offers many new opportunities for stylistic work. The same watercolor technique could be applied to charcoal drawings, oil paintings, even traditional sculpture. In this way, the artist's hand is visible in the final product, and the evidence of the creative process can be enjoyed by the viewer.

One of the main problems I tackled in the creation of this these was to implement a smooth gaze-based interaction mechanic. While this mechanic is not my original idea, I

believe in conjunction with the diorama exploration style I have proposed a unique way of telling stories in the medium of VR. This raises questions of what else could be achieved simply using the players gaze, and how movement and interaction can be knitted into the functionality of this element.

There are many ways in which this thesis could still be improved upon. I am an artist, and given more time, I would always choose to improve the artwork and spend much more time texturing and individually constructing my objects. In this way, I could improve the performance of the game, and perhaps make an even bigger experience. I would also add even more assets to the environment to just aesthetically add some visual breakup. While VR has its limitations, I feel that there is still much to be explored in how you can push the technology to create beautiful applications, films, and games.

Originally, I had intended to deploy this project on the Samsung Gear, which is a VR headset for cell phones. It turns out that in order to have the visual experience I desired, I needed a more powerful format, and scaling this project down just wasn't a possibility. I am interested in the future to see how I could achieve this using extremely low poly objects with the same or a similar watercolor technique. Having this project on a cell-phone would increase the amount of exposure to the game, and help to inspire others to create using VR technology.

I hope that those who play *The Forest Temple*, especially artists, will be driven to create experiences like these that help to challenge the traditional definition of what a video game is. Many who played the final game expressed that they didn't understand how it qualified as being a 'game', since you have little actual interactive experience during play. To this I responded that *The Forest Temple* was meant to be an experience

that entertains, questions, and challenges the viewer, and in that way is almost more of a work of art than a game. In the future, I hope that the artwork created for games and even video games overall can be seen through a broader lens, one that becomes an expression of philosophy and education *and* entertainment.

## BIBLIOGRAPHY

- Cady, Becca. "Vomit Reality: Why VR Makes Some of Us Feel Sick and How to Make It Stop." *Wareable*, October 19, 2016. <https://www.wareable.com/vr/vr-headset-motion-sickness-solution-777>.
- Campbell, Joseph. *The Hero with a Thousand Faces*. 2008th ed. The Collected Works of Joseph Campbell, Book 17. New World Library, 2008.
- Epic Games. "Creating and Using LODS." Unreal Engine Documentation. Accessed December 19, 2018. <https://docs.unrealengine.com/en-us/Engine/Content/Types/StaticMeshes/HowTo/LODs>.
- . "Level Streaming." Unreal Engine Documentation. Accessed December 20, 2018. <https://docs.unrealengine.com/en-us/Engine/LevelStreaming>.
- . "Material Nodes." Unreal Engine Documentation. Accessed December 10, 2018. [https://docs.unrealengine.com/en-us/Resources/ContentExamples/MaterialNodes/1\\_3](https://docs.unrealengine.com/en-us/Resources/ContentExamples/MaterialNodes/1_3).
- . "Using Transparency." *Unreal Engine Documentation*, Materials How-To's. Accessed December 10, 2018. <https://docs.unrealengine.com/en-us/Engine/Rendering/Materials/HowTo/Transparency>.
- Fernandes, Ajoy S., and Steven K. Feiner. "Combating VR Sickness through Subtle Dynamic Field-Of-View Modification." Columbia, March 19, 2016. <http://www.cs.columbia.edu/2016/combating-vr-sickness/images/combating-vr-sickness.pdf>.

- Grush, Loren. "Walking Through Space in NASA's Virtual Reality Lab." *The Verge*, August 22, 2017. <https://www.theverge.com/2017/8/22/16178138/nasa-virtual-reality-lab-mars-rover-simulator>.
- Lewis-Evans, Ben. *Designing To Minimize Simulation Sickness in VR Games*, 2015. <https://www.gdcvault.com/play/1022772/Designing-to-Minimize-Simulation-Sickness>.
- Martin, Béatrice. *Child of Light*, 2014. Spotify.
- . Coeur de Pirate: Brave Heart. Interview by Sarah MacDonald. Blog Post, May 12, 2014. Noisy. [https://noisy.vice.com/en\\_ca/article/r7p5db/coeur-de-pirate-child-of-light-ubisoft-release-interview](https://noisy.vice.com/en_ca/article/r7p5db/coeur-de-pirate-child-of-light-ubisoft-release-interview).
- Oculus. "Integrating the Oculus Spatializer." Oculus. Accessed December 10, 2018. <https://developer.oculus.com/documentation/audiosdk/latest/concepts/osp-wwise-integration/>.
- O'Lunaigh, Patrick. *Travelling Without Moving - Controlling Movement in Virtual Reality*. Youtube Video, 2015. <https://www.youtube.com/watch?v=Zsg8L43k7QY>.
- Phosphor. "Creating Dense Foliage in VR." *Phosphor*, November 2, 2017. <http://phos.ph/2017/11/02/creating-dense-foliage-vr-pt-1/>.
- Plourde, Patrick. *The Art of Child of Light*, 2014. <https://www.gdcvault.com/play/1020561/The-Art-of-Child-of>.
- POP 2Review. *Land's End for Gear VR - A Stunning VR Adventure from the Creators of Monument Valley*. Youtube Video, 2016. <https://www.youtube.com/watch?v=Jlt5OasHOH0&t=379s>.

Roddenberry, Gene. "Star Trek: The Next Generation." Paramount Pictures, n.d.

Senson, Alex. "Virtual Reality Therapy: Treating the Global Mental Health Crisis." *Tech Crunch*, 2015. <https://techcrunch.com/2016/01/06/virtual-reality-therapy-treating-the-global-mental-health-crisis/>.

Unimersiv. "How the Military Is Incorporating VR into Troop Training." *Unimersiv Blog* (blog), May 18, 2016. <https://unimersiv.com/military-incorporating-vr-troop-training/>.