PALIMPSEST:

SHIFTING THE CULTURE OF COMPUTING

by

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Table of Contents

Acknowledgements 4

List of Figures 5

Abstract 7

Keywords 8

Chapter 1: Introduction 9

1.1 About This Document 16

1.2 Defining The Problem 17

1.3 Hypothesis 17

1.4 Terms 18

Chapter 2: VR Game Overview 19

2.1 Walkthrough 20

2.2 Methodology 23

2.3 Designing For A Novice To VR 28

2.4 Origins 29

2.5 Target Behavior Change 32

2.6 Usability Testing 33

2.7 Accessibility 34

2.8 Difficulty Settings 35

2.9 Feedback 36

2.10 Avoiding Motion Sickness 37

2.11 Testing Frame Rate 38

2.12 Illustration 39

2.13 Audio 40

2.14 Diversifying Media And Technological Bias 40

Chapter 3: Curriculum Overview 43

3.1 Institutional Review Board Approval 43

3.2 Critical Roles For Ethical Community Service 46

3.3 Research Goal And Methodology 47

3.4 Research Tools 53

3.5 Walkthrough Of The Palimpsest Program Launch 54

3.6 Feedback On The Palimpsest Program Launch 56

3.7 Walkthrough Of A Typical Session 61

3.8 Feedback On A Typical Session 64

Chapter 4: Integrating My Takeaways Within Myself 71

4.1 Burning The Candle At Both Ends 72

4.2 Shifting Priorities With A Shifting Context 78

4.3 Protect Stories 86

4.4 Limits And Revelations 88

4.5 Where Playtesters Fall Short 89

4.6 Branding And Framing 90

4.7 The Future Of The Palimpsest Program 91

Bibliography 93

Appendices 95

Appendix A: RITE Analysis Of Palimpsest VR game 95

Appendix B: Internal Review Board Application 96

Appendix C: Internal Review Board Application Approval 103

Appendix D: Curriculum Youth Assent Parental Permission 104

Appendix E: Curriculum Mid Assessment Questions 108

Appendix F: Curriculum Mid Assessment Form Results 110

Appendix G: Field Notes For March 7 Launch 113

Appendix H: Programming Curriculum Overview 115

Appendix I: Curriculum Vocabulary 120

Appendix J: Programming Curriculum Lecture, “3D Space” 123

Appendix K: Programming Curriculum Exercise, “3D Space” 129

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List of Figures

Figure 1: Lenna 9

Figure 2: Code Camp students 12

Figure 3: Percentage of bachelor's degrees to women 14

Figure 4: Screenshots of the VR game 21

Figure 5: Screenshots of the VR game 23

Figure 6: Poster of game (left) and image of student playing game (right) 24

Figure 7: Concept art for how the Sentients were inspired by transistors 26

Figure 8: Concept art for how the Capacitor Fish are inspired by capacitors 27

Figure 9: Concept art for restrained figure (left) and liberated figure (right) 28

Figure 10: Screenshots of the VR game 36

Figure 11: Concept art and poster 39

Figure 12: Concept art of protagonist (left) and 3D art of protagonist (right) 41

Figure 13: Lecture slide 49

Figure 14: Lab partners 51

Figure 15: Workbooks 55

Figure 16: Class overview slide 59

Figure 17: Workshop and vocabulary 60

Figure 18: Curriculum github repository 62

Figure 19: "Big Bang" lab and exercise 64

Figure 20: Student teaching piecemeal graph 68

Figure 21: Curriculum intro slides A and B 68

Figure 22: Photo by student for their game (left), student remixing assets for game (right) 69

Figure 23: Students 69

Figure 24: Student showcase in library 71

Figure 25: Student playing VR game (left) and coding their own game (right) 73

Abstract

To better understand how to diversify computer science, we need to examine the multiple factors that shape identity and power in computer science culture. Axes of identity might include gender, race, ethnicity, class, and sexuality. The concept of intersectionality addresses how combinations of these axes can affect how an individual experiences power and oppression differently in different contexts. "Kyriarchy is a theory of power that describes the power structures intersectionality produces" (Osborne, 1). Kyriarchy is the Greek word for "sovereignty" in English. This document describes the creation of two cultural interventions designed to empower women of color and nonbinary people of color in computer science: a virtual reality (VR) game and a high school enrichment computer science curriculum. Both artifacts were developed at the Interactive Media & Games Division of the School of Cinematic Arts at the University of Southern California during the 2017-2018 school year with fellow classmate Allison Comrie for our MFA joint thesis project.

In evaluating the successes and failures of our creations, I must acknowledge how my own identity as a white cisgender woman engineer struggling with post traumatic stress disorder (PTSD) from sexual assault (SA) has contributed to both positive and negative feedback loops throughout the design and development process. Within the context of a South Central Los Angeles High School, I could very easily, unintentionally, occupy the role of an oppressor who triggers feelings of fear in my students. As a SA-survivor in a computer science classroom mainly populated by cisgender men, feelings of fear could be triggered in me (unintentionally, I believe) by predominantly male classmates, teachers, and TA's.

Proof of efficacy of the curriculum and VR game we created is beyond the scope of this document. What I intend to illustrate is the value of clearly and truthfully defining the problem in the myriad of asynchronous interactions that occur while engaging in cultural change. In order to gain control over not only our own actions, but how those actions operate in an evolving culture of shifting power dynamics, we must strive to be honest with ourselves about how we participate — intentionally or not — in patterns of oppression, often alternately as the oppressor and the oppressed depending on our actual and perceived environment. I have come to believe that the bulk of the "oppressors" in the culture of computer science actually perceive themselves as the oppressed, and thereby avoid, ignore, deny, or justify their own acts of oppression. Through interviews, research, project documentation and my own experience, I will define a first step towards reforming the deeply imbalanced culture of computer science via defining the problem within a personal context, and addressing one's own fears therein.

Keywords

Intersectionality, kyriarchy, computer science, games, education, interaction design, virtual reality, post traumatic stress disorder, sexual assault.

Chapter 1: Introduction

Computer science is a young field. "The first computer degree program in the United States was formed at Purdue University in 1962" (Purdue Computer Science & Purdue University). It is likely that many of my computer science teachers did not have teachers of their own. In the absence of a long history, cultural references of the present and recent history play a unique role in forming bonds of trust amongst computer scientists.

Take the case of Lenna. Lenna is the face of Playboy model Lena Söderberg, cropped from her 1973 Playboy Centerfold image and scanned into a Hewlett Packard 2100 minicomputer by University of Southern California assistant professor Alexander Sawchuk as the subject of studying image dithering. "Lenna" is widely used in computer science courses and publications as the test image for image processing (Lenna 2018).

Figure 1: Lenna. Source: Wikipedia.

I first encountered Lenna four years ago in a Mathematics for Computer Science Applications graduate course as part of a non-degree program at NYU. My professor was an older Russian man. Initially, I empathised with him as he strove to appeal to the youthful, mainly male classroom with the titillating story of Lenna and her photo. At the same time, I felt

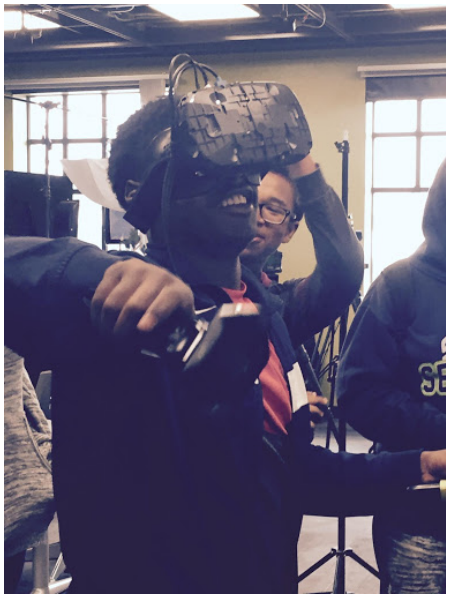
confused and distant. Scanning the classroom for disapproval and finding rapt students (several years younger than I), alienation set in.

Weeks later, the same professor used the O.J. Simpson trial to explain Bayes Theorem. I remember my teacher explaining that "the number of women killed by men was *not that much* compared to the number of women killed by abusive husbands." In class, I argued with his choice of words. Through hot tears, I attempted to articulate that any women killed by men or their abusive husbands is *too many*. He replied that the O.J. Simpson trial was the "textbook example" for explaining Bayes Theorem, and that O.J. might have been found guilty if the jury had understood this theorem. And he was right.

I returned home in a fog. I remember staring into dull glitter concrete in wan winter light wondering when I'd last had a coherent thought. For days I did not study. I considered dropping out of this class and the pursuit of learning computer science in general. Lenna's photo and Nicole Simpson's murder are "textbook" applications of computer science designed by and for a culture dominated by cisgender men. From my seat in the classroom, I interpreted this message: beautiful, naked, sometimes murdered women are exciting to us. This is probably the opposite message of the one my professor consciously intended to communicate. But it is the one I took away. My interpretation triggered feelings of fear, sadness, and isolation. In the next four years of studying computer science, emotional challenges within the culture would trump intellectual challenges with the material, by far.

During the summer between my first and second years at USC, I created a program called Code Camp to promote diversity in computer science. Once a week, I invited people to come to the MxR Studio on the 3rd floor of IMGD to study coding. The initial ages ranged from thirteen

to forty three. I ran the program for ten weeks, inviting guest lecturers, designing hands-on curriculum, and nurturing student projects. At the end, participants invited friends and family to play our class' collaborative final project.



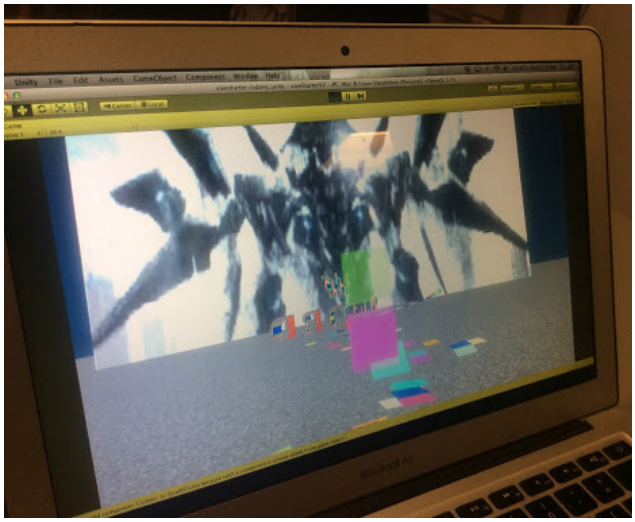


Figure 2: Code Camp students. Source: Atley Loughridge

Over the next year, I iterated on Code Camp. I began visiting schools instead of requiring students visit USC in order to increase reach. I modified exercises for whatever computers and software the schools wanted to use. I recruited new teachers to run sessions in parallel with various age groups: elementary school, middle school, and high school. I remember a five year old student sounding out words in order to read the error messages in their console. One thing I learned was that anyone, any age and background, could learn the material I wanted to teach. But students participated more in classrooms where their age group, gender expression, and race represented the majority of the room. I began to wonder why I'd not yet succeeded in attracting a woman of color majority to one of our Code Camp classrooms.

In book *Stuck In The Shallow End*, author Jane Margolis reports the findings of a Los Angeles study investigating why so few African and Latino/a high school students are learning computer science. Zweben (qtd. In Margolis) states that "a recent survey showed that at the nation's PhD-granting departments of computer science and engineering, just 8 percent of the bachelor's degrees and 4 percent of the master's degrees in computer science are awarded to African Americans and Latino/as" (Margolis 6). California Department of Education and

College Entrance Examination Board (qtd. In Margolis) notes that “in California, where underrepresented students of color make up a combined 49 percent of the high school student population, they account for only 9 percent of the AP computer science test takers” (Margolis 6). Margolis introduces her book with a comparison between computer science and the sport of swimming. “The two endeavors share many qualities, from powerful historical legacies to inequitable trends rooted in false assumptions and beliefs” (Margolis 23). Margolis reports on how high school computer science curriculum, spaces, normalized racial divides, counselors, teachers, course structure, and students access to a computer at home can coalesce to deter students who don’t fit the stereotypical computer science white or asian “boy wonder” from enrolling in computer science courses.

Researching potential solutions, I came across "Why Are Some STEM Fields More Gender Balanced Than Others?" by Sapna Cheryan and Sianna A. Ziegler of the University of Washington. While the participation of women in the science, technology, engineering and math (STEM) fields of the biological sciences, chemistry and math has been consistent or on the rise in the last quarter century, the participation of women in computer science, physics and engineering has failed to increase or has actually decreased.

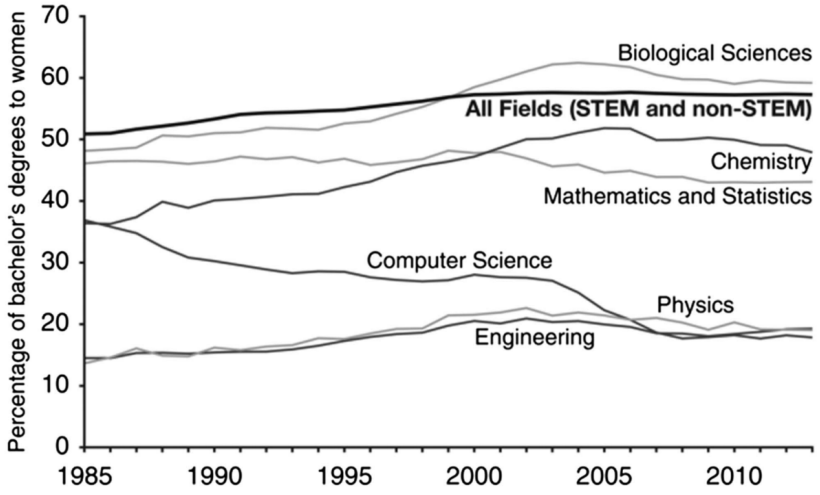


Figure 3: Percentage of bachelor's degrees to women. Source: National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (qtd. in Cheryan et al..)

The researchers state: "To close gender gaps in participation in computer science, engineering, and physics, cultures of these fields should signal equally to women and men that they belong and can achieve success in them." Their study relied on data that unfortunately defined gender as a binary of men and women. We do not subscribe to binary thinking, but this data did inform Allison and my decision to focus on transgender and cisgender women of color and nonbinary individuals of color in high school. Our mission was for computer science to signal belonging to this group in a project called *Palimpsest*.

The word "palimpsest" originates from the Greek roots *palin* 'again' + *psēstos* 'rubbed smooth.' The word describes an object that contains traces of prior versions that have been effaced to make room for new versions. It is often applied to writing materials such as pieces of parchment or stone, but could also be applied to new architecture built atop the old, or layers of society. My favorite definition of palimpsest is by Daily Beast editor Jill Bialosky, who writes

that, “in a figurative way, palimpsest refers to an object or place that reflects its own history” (Bialosky 2013).

To me, “palimpsest” held a number of meanings depending on the context. Within the context of identity, palimpsest referred to the transformational process through which we all decide to make room for new drafts of self. This view of palimpsest filled me with calm in the sense that it acknowledged the limits of our time, access, resources, and mental capacities; we cannot be all things. Pursuing a dream meant tough choices and stark compromises. Letting go of prior versions of self was a highly intimate, personal process, and one I would have to revisit repeatedly in order to continue pursuing a place for myself in the field of engineering.

I view code as Greek philosopher Heraclitus’ river, which one cannot dip one’s foot into the same place twice. Code is constantly evolving in an intensely collaborative way over the internet. Before coming up against the firm (and necessary) safeguards against cheating in university computer science courses, I wanted our high school students to freely borrow, break, remix, and edit source code. We attempted to emulate this by having our students remix our VR game’s code as part of their curriculum. The changing source code is another form of palimpsest.

The goal of our MFA thesis project *Palimpsest* was to create an educational intervention, using a high school class and a VR game, that would allow women of color and nonbinary people of color to gain or reclaim access to early positive experiences with computer science. Our VR game stars a woman of color who uses technology to transcend challenges. In our high school engineering class, students remix our game’s code and assets to create their own pieces of expression. Through this constant edition process, we, the participants and creators, collectively

write ourselves into the field of computer science, and thereby signal our own belonging and potential for success to each other.

1.1 About This Document

This document is intended to reflect upon an ambitious, imperfect project *Palimpsest* within the context of the ambitious, imperfect field of computer science. Aided by perspective afforded to me by the time between my implementation of thesis and this current reflection, I would like to candidly outline what did and did not work, and why.

Many people design media with the goal of social change. While I describe the design processes for our game and curriculum, I will circle back to the theme that one's motivations for "social good" can also mask blind spots. Inequality is bred by the choices and considerations humans make when designing and engineering technology; our intentions are limited by each of our individual abilities to face our own truth. I will take the design process as the set or situation, motivated by world events, to hone in on specific interpersonal conflicts, which illuminated the challenges and stakes involved in this effort. I will argue that any reader of this paper could and should find a way to support diversity in computer science.

Chapter 1 will detail the origins, goals, structure, and terminology of this document.

Chapter 2 will outline the VR game *Palimpsest* within the context of our MFA thesis. While capturing the narrative, gameplay, art and musical elements, I will assess how each did and did not succeed in attaining our player experience goals. I will also describe the design and technical challenges involved in designing for a newcomer to VR.

Chapter 3 will detail the high school curriculum component of *Palimpsest* within the context of our MFA thesis. This chapter will discuss the various stages of designing, implementing, and receiving feedback on a pilot enrichment education program for high school students.

In chapter 4, I will examine my takeaways from *Palimpsest* and the potential futures for this varied project. I will explain the intersectional and cross platform challenges and benefits that emerged while implementing *Palimpsest*. Most noteworthy are the positive and negative feedback loops that developed within the two contexts of USC and our classroom in a South Central high school.

1.2 Defining The Problem

From the mid-2000's to now, about twenty percent of computer science bachelor's degrees in the United States are awarded to women (National Science Foundation). One reason for this is that men are disproportionately exposed to learning experiences with computer science before college. Such experiences are often opt-in based on the student's preference. Students opt-in based on their sense of belonging to the culture signalled to them by the learning experience. The culture of computer science learning experiences currently mainly signals belonging to cisgender men (Cheryan, S., Ziegler).

1.3 Hypothesis

Our hypothesis is that nonbinary people of color and trans/cis women of color will study computer science if the culture signals to them that they belong in that culture. Due to scope and

interest, we have identified two elements of "culture" through which to signal belonging. The primary element is a twelve session pilot program of computer science curriculum for women of color and nonbinary people of color highschool - our primary audience. The second element is a VR game for our students and industry professionals - our secondary audience. We believe that the interaction of these two elements, both in their content and their audiences, provides an opportunity for us to study the impact of cultural signals on the academic preferences of our students.

We aim to interrellate our cultural elements in as far as crossover proves effective. Meaning, the curriculum and game are not necessarily interdependent. This is not a transmedia project. Our macro design provides complementary experiences to multiple people within a culture rather than a cohesive experience for one person.

Within the scope of this thesis, we were not able to test these hypotheses. We are able to create the material that we deem is worth piloting in an environment that includes control group data. This document with examine positive and negative feedback loops in our collaborative development process.

1.4 Terms

Palimpsest is a reaction to our perceived dominance of white cisgender men in computer science departments of secondary schools in the United States. In defining a target audience, the layers of identity we aim to address include sexuality, race, and gender presentation. Some of the layers of identity we do not address include sex, ethnicity, and socioeconomic status.

"Sex" is often assigned based on genitalia at birth and might include male, female, or intersex (*Understanding Gender*). We do not define a target audience based on sex.

"Sexuality" refers to who a person is attracted to. This could refer to lesbian, gay, bisexual, or queer (*LGBT* 2018). We do not define a target audience based on sexuality.

"Gender" refers to the gender a person presents as, if any (*Understanding Gender*). Terms denoting gender include nonbinary people, men, and women. "Transgender" describes people whose "sense of of personal identity and gender does not correspond with their birth sex" (*Transgender*). "Cisgender" describes people whose sense of identity and gender does correspond with the sex they were assigned at birth. Therefore, any term denoting gender includes transgender people, e.g. transgender nonbinary, transgender man, and transgender woman. Palimpsest views gender expression as a fundamental right, and aims to welcome all people of color who identify as women or nonbinary individuals. For those who identify as transgender or cisgender men, *Palimpsest* adopts a stance that is not oppressive.

"People of color" refers to anyone who identifies as a race that is not white (*People of Color*).

Chapter 2: VR Game Overview

The VR game is a five to seven minute rhythm action experience in a surreal environment. The player is cast as a woman of color who is tasked with freeing a mountainous figure lodged in earth. The core mechanic is timing when to reach out with an open hand and when to punch with a closed fist. Our design goal was to use an abstract context to teach players to alternate between self defense and reaching out for support in order to achieve a colossal task.

During our MFA thesis year, we created two prototypes. The first was narrative-driven, with voiceover triggered by touching objects in the main character's home. We scrapped this in December as a result of disappointing playtests. We felt we did not have the special effects support to create a user interface that could effectively guide players through a narrative. Reading text, a common fallback for PC and console games, was not a viable option in VR. After watching fifteen of our classmates struggle to simply traverse our narrative, let alone process it, we opted to ditch the narrative altogether and focus on the core gameplay.

At the same time, we taught a semester-long engineering course once a week after school for sixteen students at a Los Angeles South Central high school. Our students identified as transgender or cisgender women of color or nonbinary individuals of color; they were our target audience. Our primary goal for the VR game prototype was to create a five to seven min experience that our students enjoyed and could win. We wanted to capture their interest from the beginning to the end of the game, in one session, without them becoming frustrated. This goal dictated much of what this chapter describes.

2.1 Walkthrough

Please find a playthrough video of our VR game shown at the MFA thesis show here: https://vimeo.com/269604390.

The player begins by putting on a VR headset and holding two controllers, one in each hand. Each controller has several buttons, but we only used the triggers. Here is a summary of what the player experiences upon launching the game:

The lights fade up on the form of a giantess lodged in the ground, her torso stuck in earth, hair cascading into a rippling mountain. Circuitous veins flicker with fading health along her arms, torso, and visage. Clenching your fists, you see your own veins merge with technical gloves that appear over your fists. These are your two main choices as a player: connect with an open hand or with a closed fist. Light pulses through your veins, indicating high health. You are not dissimilar to the temple-like figure before you. Perhaps she is a sister, or an alternate version of yourself.

Figure 4: Screenshots of the VR game. Source: Atley Loughridge

With a thunderous crack, the sky unfolds a veil of falling dark matter, which accumulates on the mountainous creature like snow. From the accumulation, Cordyceps-like parasites emerge from her limbs, sapping her vascular system of whatever light it had left, pinning her down. (Cordyceps is a fungi that is fatally parasitic, mainly to insects.) The giant continues to struggle in a slow motion battle to free herself from the confining growths. The organ of her heart,

exposed to the air through a fault line running down her sternum, beats defiantly. From this beating emits a far-off wail of music.

Slowly approaching is a Sentient — a circular, semi-intelligent enemy that will seek and damage the player if the player doesn't hit it first. The Sentient contains a transistor with circuits lodging it in a protective shell that expands and contracts to the beat. Punching it offbeat damages you, but punching it on beat makes the recoiling sentient a tool with which to errode the crystalline parasites locking the giantess down.

Sentients approach in patterns of ones, twos, and threes. With each punch, ranks of "Codycrystals" (cordycep-like crystals) shrivel. If enough time passes, they regrow. A velocity of hits kills the first level of them off for good. Light fills the circuits piping into the giantess' heart. Her newly healed arm cracks free and lifts you to the remaining congregation of parasitic growths around her upper extremities.

Figure 5: Screenshots of the VR game. Source: Atley Loughridge

Her lips part and blow out a long fish-like creature, which swims toward you. Hollow, it pulses with charge, similar to a capacitor. Touching this creature with a clenched fist yields nothing, but opening your naked hand to the beast allows its power to transfer and restore your health. Like playing a theremin or reaching your hand into a rushing river, your depth of contact changes the pitch of the creature's data: a song from the giantess.

A school of these Capacitor Fish passes. Your fists glow mightily. The giantess looks at you eerily. The boss battle ensues, combining both the Sentients and the Capacitor Fish so that you must alternately punch with a clenched fist and reach out for reserves with an exposed palm. Upon eradicating the parasites, the giantess lights up with energy flowing through her veins. Circuits spread from her roots through the vague darkness beyond, passing through root systems of foliage previously unseen. A long silence breaks with the tentative chirps of birds welcoming the break of dawn.

2.2 Methodology

Our design goal was to signal to women of color and nonbinary people of color that they belong in technology. One method to positively align technology and our target audience was to

use the exciting technology of VR to create a game that stars a woman of color. Even without playing the game, the marketing and platform of the game conveys our message.

Figure 6: Poster of game (left) and image of student playing game (right). Source: Atley Loughridge

Within the VR game, we tried to communicate as much of our message as possible through the characters, creatures, and environment, without text or voiceover. Our thinking was that, if we took this route first, we could always retrofit a narrative to supplement what players were missing later.

The VR game embodies our core assertion: the player can transform their reality via technology. The game begins with a large figure who is stuck and struggling. The game ends with the player healing and freeing that figure. We did not explicitly tell the player who this character was, because that narrative system was out of scope for our thesis year. And to a certain extent, we wanted to see how far multiple interpretations would feel acceptable to us. We wanted to discover what various players would discern from the art and mechanics and world we created. Largely, the results were acceptable for the thesis year prototype. Most of our target audience interpreted the figure as a reflection of themselves, a goddess, or the life force of their

environment, and all or these interpretations generally map to “positive transformation of my experience.”

Players who did not fit our target audience were more likely to take the headset off and say, “that was really cool, but what did it mean?” While it is important to us to eventually reach this secondary audience, we decided that reaching them would require more robust narrative tools for voiceover and animation, which were outside of scope for our thesis year.

Our core assertion was that, even while the technosphere signals unbelonging to minorities, minorities can use technology itself to remedy their experience; it is not the computers and code, but how we use them, that sends a message. Technology itself can be a haven and a resource for everyone. Even if white men intentionally or not signal ownership over the technosphere, resist that errant message of ownership, but still use the technology. Use technology as a tool for resistance.

We intended to convey this by having the creatures in our game inspired by technology. We wove our target behaviors into the creatures such that the player must use the techno-creatures in order to progress.

The Sentients are inspired by transistors. The transistor is the basic building block of how computers make decisions. On a computer chip, a transistor switches between the binary states of zero and one. Packing ever smaller microchips with evermore transistors enables computer processors to compute more calculations faster. By morphing the shape of a transistor into a Sentient creature, we wanted to convey to the player that the basic building blocks of computing might work against or for the player, depending on the player’s actions. Sentients begin by propelling towards the player. If they hit the player without the player punching them

first, the player will take damage. However, if the player hits the Sentients to the beat, when the they are open and vulnerable to change, the Sentients transform into a tool that frees the giant figure by shattering her Cordycrystal restraints. This rhythmic mechanic shifts the question from whether or not to fight back to when and how.

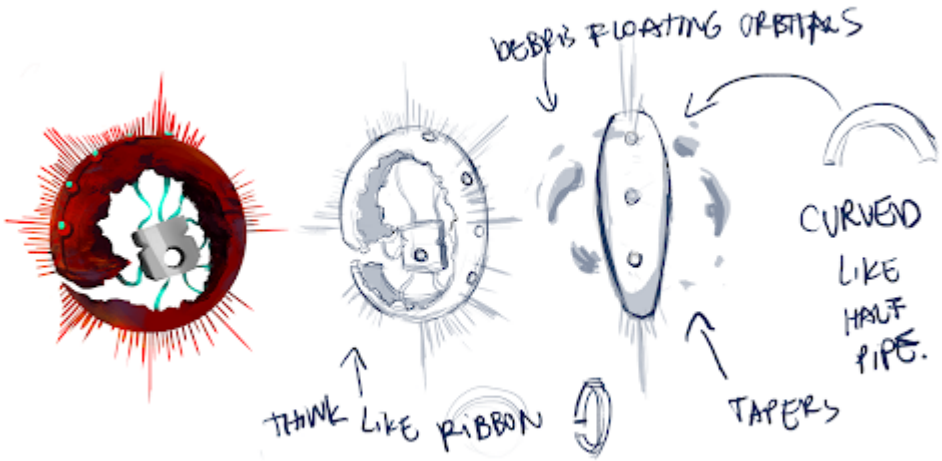


Figure 7: Concept art for how the Sentients were inspired by transistors. Source: illustrator Karen Tsai

The Capacitor Fish are inspired by capacitors. The capacitor is the basic building block of how computer store data in memory. Like the transistor, the capacitor also has binary states of 0 and 1. If the capacitor holds a charge, it is a 1. No charge means 0. In concert, the states of many capacitors add up to blocks of data. We took the shape of the capacitor and morphed it into a fish-like creature. If the player pets the Capacitor Fish with an open palm, it will slow and restore the player's health. If the player pets the Capacitor Fish with a closed fist, it will turn red and quickly swim away without restoring the player's health, but without causing damage either. The Capacitor Fish are a second way we are attempting to convey that the player can use technology to help themselves — or not.

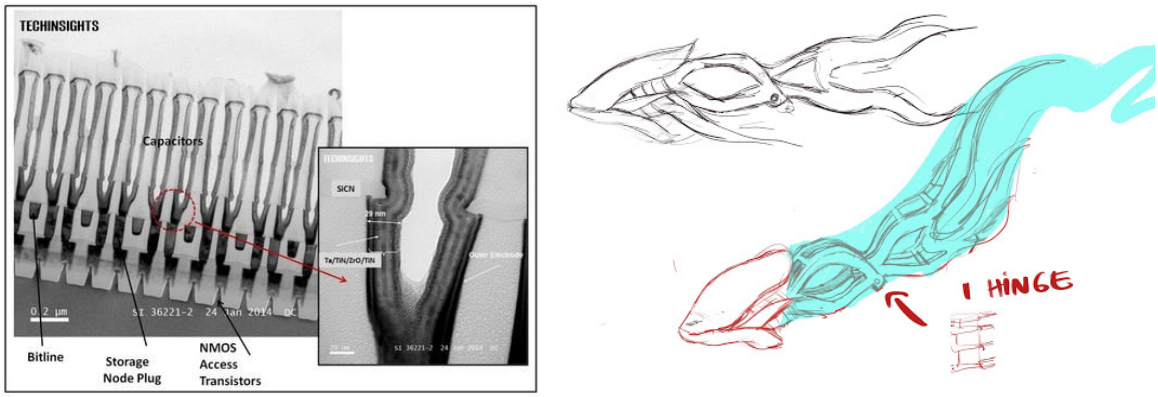


Figure 8: Capacitors (left) and concept art of the Capacitor Fish (right). Source: illustrator Karen Tsai

While admittedly complex, it's important to note that the villain or opponent in the game is the Cordycrystals restraining the figure. The Cordycrystals — their negative presence — is what we intend for the player to map to signals of unbelonging in technological spaces. The techno-creatures are what we intend for the players to map to the technological tools of that environment, which the player can weild to their benefit or not, depending on their action and timing. Player choice is centered on when and how they make contact with the other creatures in the game. These mechanics are intended to develop the player's skill in discerning when to punch versus when to reach out, and switching between these actions quickly.

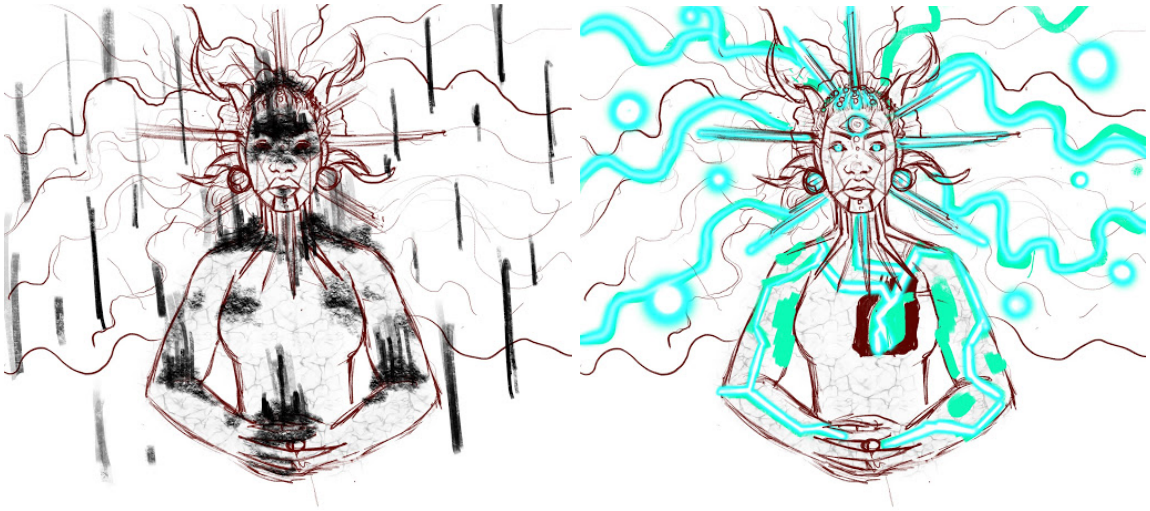


Figure 9: Concept art for the figure restrained by Cordycrystals (left) and the liberated figure flush with energy (right). Source: illustrator Karen Tsai

2.3 Designing For A Novice To VR

Several design choices resulted from the goal of making our game playable to a novice in VR. Each area of interest is oriented straight ahead of the player's starting direction. This eliminates the possibility that the player will turn around and get lost, dizzy, and frustrated.

The game is designed to be easy enough for a novice to beat in under seven minutes. We wanted our game to be completed in one session. VR headsets are not yet light and comfortable enough for long-term wear. Often, a novice will be playing our game in a public setting such as a school or expo using a headset shared by many. The headset may not be adjusted correctly for the player. The lenses may not be the correct distance apart. All of these risks contribute to the player's potential discomfort in VR, and our decision to make our game as short as possible. Brevity demanded we implement the "haiku" version of our original design.

A newcomer in VR is learning how to perceive and interact with a digital space for the first time. As babies, we learned to connect depth perception with physical movement to grab an object. The biggest indicator of a novice in VR is that they have trouble determining how "far" away an object is in virtual space in order to collide their hand with the object. Therefore, we designed our player actions in VR to require the dexterity of a toddler in the real world. Our interactive objects are comparable to the size of the player themselves. The environment is sparse, dark, and static so that bright, animated interactive objects are obvious. While hitting on beat is required, the margin for error is large enough to accept imprecise timing. While hitting a target is required to progress, targets cover the player's field of view so that imprecise aim may still reap rewards.

The triggers on the Oculus or Vive controllers are intuitive and visceral for players to grab. The only controls in our game are the player's movement in space and the trigger controls. Using fewer controls means that more of the player's brain can be dedicated to depth perception, moving through space, and timing.

2.4 Origins

We began with the common sentiment that thriving as a minority in technology required the skills of reaching out for support and defending oneself from oppressive forces.

In real life, everyone is simultaneously participating to some degree in supportive and oppressive forces. Creative Director Allison Comrie and I agreed that a minority student studying computer science in college was apt to encounter some of the same challenging and even triggering experiences that we had encountered in settings like engineering classrooms and

mixed media labs. The danger was getting stuck on either side of the spectrum of trust: being trusting to a degree that makes you vulnerable to attacks, and/or isolating oneself to a degree that maims your education. The trick to survival, in our experience, was learning to be dexterous and even playful with our trust. An example of this is asking a professor for support on a homework assignment while, in the same conversation, drawing a boundary when the professor expresses surprise that you haven't yet dropped the class since the material is so hard for you.

In my personal experience, more than half of my computer science professors (all men) encouraged me to drop their course and take something easier or "closer to my interests" at the start of the semester, when homework assignments are designed to weed students out. Margolis expands on the phenomenon of computer science teachers dissuading minority students from taking their courses within the context of race:

> Teachers are also in incredible positions of power when it comes to influencing the ways that students see themselves. Our interview with Janet, the only African American female who was enrolled in AP computer science during the course of our study, illustrates the power of teachers' attitudes and comments, and the subtle and not-so-subtle ways that they can impact students' lives. Janet enrolled in AP computer science because she thought it would be interesting and enjoyable. The curriculum was different from what she had expected, and as a result, she struggled with the material. Nevertheless, Janet felt she had to persist: "I think it was mainly because we [African American females] were so limited in the world, you know, and just being able to be in a class where I can represent who I am and my culture, I think, was really important to me. And so I think that was really the main thing that kept me there."

> Janet noted that despite the fact that many of the students were experiencing difficulty with the concepts (and eventually, about half the class dropped the course), she was the only one who was approached by the teacher, Carter, about how she was faring in the class. Carter, who later told us that she was worried about how the class would affect Janet's overall GPA, pulled her aside and in a quiet but public conversation during class, suggested to Janet that she drop AP computer science, adding that she should not feel bad because some people just do not have "the aptitude" for this kind of study.
>
> Admittedly, the concepts in the course were difficult and new to Janet, but just as crucial, the hard drive in her home computer had broken and this led her to have problems completing the assignments. Despite the teacher's intention to help her, and despite Janet's own knowledge that there were extenuating circumstances, what she ingested from the conversation was the impression that her teacher felt she did not have the necessary talent and was not smart enough to handle the work. Moreover, she felt humiliated in front of her peers.
>
> One of the more painful lessons we learned through this project was just how, well, painful it can be for students of color to be isolated on the accelerated track. The decision to enroll in these courses, when no other students of color are enrolled, requires an enormous amount of psychological risk. It is therefore easy to see why some students choose to stay in "regular" classes, where they have more friendship groups and support networks. (Margolis 90-91)

Every computer science course I've taken has been markedly more difficult than the last, and just as essential to my grip on the field. While I often began in the bottom quarter of the class, I

finished in the top quarter. I cannot imagine what would have happened had I listened to my dissuading professors, who bragged that the other (almost entirely male) students in the course "ate code for breakfast" or that their course covered "a galaxy" of material compared to the "solar system" that my last course covered. Our galaxy is 4.12 septillion times the volume of our solar system, and the comments of my professors (who I came to trust and admire) were obviously made in jest. When asking a male coder if his professors ever dissuaded him from taking a course, he said, "I never asked." It's possible that, different from Janet's experience above, my voluntary inquiry raised flags of concern in my professors. But that does not change my stance that professors should think critically before dissuading their students from taking their courses. If that student is a minority in the class, it is all the more important (in my view) that they tangle with that material. Rather than attempting to influence professor behavior, I am attempting to influence student behavior. In order for our target audience overcome the unjust and uninformed discouragement from the powers at be, they must not only correct their professor's underestimation of their ability, but also assert their right to the professor's tutelage on assignments. In essence, the student must alternate between self-defense and reaching out for support within a brief conversation. This is the type of scenario that *Palimpsest* is designed to prepare our player for.

2.5 Target Behavior Change

A core design question is, what is the best way to teach our player to alternate between self-defense and reaching out for support? We could have made Palimpsest a text-based "choose your own adventure" story on a computer. Why make a surreal, rhythm-action VR game?

Allison Comrie and I felt that targeting behavior change on the muscular level would be more effective than the cognitive. We felt that we logically understood that we deserved a safe and supportive place to learn coding, but that when tech environments challenged us, our barrier to reacting in kind with our cognitive beliefs was a physical disconnect between our brains and our bodies. My personal experience was of paralysis and dissociation. Framing our target behavior change as a physical accomplishment felt true to the nature of the beast.

That said, we did not want to risk traumatising or re-traumatising our players with realistic scenarios of oppression (such as the classroom experiences described above). We did not want to unnecessarily incite feelings of fear in our students for the road that lay ahead. We simply wanted to ingrain in their bodies the skill of quickly alternating between defensive and connective actions in hopes that this skill would prove useful someday. Because of this, we chose a surreal representation of overcoming oppressive forces for the environment of *Palimpsest*.

In kind, the physical actions of punching and reaching are intended as metaphors. We wanted the player to interpret how to apply these skills to their lives outside of our VR game. Whether or not our intended semiotics came across to the player required independent evaluation to determine.

2.6 Usability Testing

In the weeks leading up to our thesis showcase, we used the Rapid Iterative Testing and Evaluation (RITE Method) to prioritize usability of the game while debugging. (Please see Appendix A for a version of our RITE Method table containing a list of bugs, player feedback,

and our progress in resolving these bugs.) This method enabled us to fix several usability bugs with a few number of playtests. By our thesis showcase in early May of 2018, more than half of our players could finish the game without assistance.

Notably, we did not formally test for comprehension. Lacking the time to fully flesh out the VR game's narrative within the scope of our thesis years, we prioritized usability. Our knowledge of player comprehension is based on informal interviews with playtesters following their playtest of the game. Player answers to comprehension questions seemed to vary greatly depending on their identification with the main character and any context they had as to our design goals prior to playing the game. I will explore player comprehension of the VR game's message and target behavior change in chapter four section three entitled, "Protect Stories."

2.7 Accessibility

The largest barrier to accessibility is the price point, marketing, and design of VR hardware itself.

The roughly $400 price tag on an Oculus Touch in 2017 obscures the need for a $2000 computer to run VR experiences at frame rates that will not make the player ill. $2400 for a personal gaming console is out of range for most of our target audience. Hardware providers could offer subsidised rates to schools, but they seem to be prioritizing gamers over educational communities.

Lastly, the straps on the Oculus and Vive have clearly not been designed with the hairstyles of people of color in mind. The straps are not large enough for many of our students to comfortably fit the headset over their hair. This oversight is a clear example of how homogenous

tech spaces yield technology designed for the few — a reality that underscores the need for programs like *Palimpsest*.

2.8 Difficulty Settings

We support the difficulty settings of Speedthrough, Easy, Normal, and Hard. Greater difficulty increases the number of opponents and the time they remain dormant before growing back.

That said, most players seem to have the best experience on the Speedthrough setting. This is because some players still experience difficulty in hitting opponents to the beat. We were surprised to observe that many players experience difficulty responding to our definition of what was on beat versus offbeat. Rhythm is up to interpretation to some extent. We experienced some technical difficulty with anticipating the beat so that collisions occurring slightly ahead of or after the beat were just as likely to be deemed “on beat.” Lastly, we had difficulty getting our system to effectively dynamically respond to where the player chose to stand. Therefore, a player who happened to be standing with an offset from the opponent’s target, and who did not consider moving their body in addition to their hands, would be consistently less likely to hit on beat. Ultimately, we opted to automate the Speedthrough setting to force the player to the next level regardless of their performance. Defaulting to Speedthrough has enabled us to share the game more broadly for the time being.

2.9 Feedback

Balancing visual feedback is the main area where our game must improve. Players in VR are already re-learning depth perception. Their visual, spatial, and auditory senses are overloaded. We quickly learned that we could not use text or voiceover to guide players. Balancing visual, auditory, and haptic feedback loops was essential to guiding a player through the game. These effects also comprised a significant portion of our development time.

Getting a player's attention required animating an object in their field of view (forwards and slightly downwards). Moving objects towards the player was effective in motivating the player to act.

Large, in-world visual effects were much more effective than smaller, on-body fx. No matter how flashy and detailed we made the players' gloves, players examined their surroundings before their person. Placing the player's health bar on their gloves largely failed. What players did attend to was a large blue/red band that swept the sky when they hit/missed an opponent.

Figure 10: Screenshots of the VR game. Source: Atley Loughridge

While we resisted some common color coding (e.g. dark = bad and light = good), we committed to blue indicating health/ally and red indicating harm/foe. Even so, many players requested more creature sound fx and animation to indicate the creature's mood and intentions.

2.10 Avoiding Motion Sickness

VR triggers motion sickness when the player's visual feedback regarding movement contrasts with their physical experience. This poses a strong challenge for traversing a three-dimensional world. We leaned into theatrical techniques to bring the action to the player rather than requiring them to move.

The culminating narrative sequence for each level included the giant figure lifting the player closer to its gaze. These sequences were the scariest for me as a designer, but they turned out to be favorites for players. We were successful because we moved the player for a short amount of time at a constant speed in a linear upwards/forwards direction. Additionally, the slight effect of butterflies in the player's stomach seemed to align with the narrative progression that they were experiencing.

A low frame rate will also cause nausea as a result of the player's eye no longer being able to integrate the stereoscopic images into a three dimensional image. My target frame rate was ninety fps on a medium specification machine such as my desktop's GTX 1070 graphics card. Part of the reason we discarded our first narrative prototype from the fall was because the asset package we mistakenly used had thousands of large, unique textures, resulting in several thousand draw calls to the renderer each frame, which greatly lowered our frame rate.

To avoid dips in frame rate due to mid-game garbage collection, we avoided dynamically allocating memory on the heap (e.g. using "new") during the game. Instead, we attempted to instantiate the entire game at startup and cycle through game objects by turning them on and off as needed.

2.11 Testing Frame Rate

Our frame rate analysis in Unity happened at three levels: in the game view stats, in the profiler, and in development builds. Hindrances to an accurate read are that having the scene and game views open while in VR will significantly lower the frame rate. Similarly, the profiler itself takes a toll on the frame rate. The profiler only points to the method that is costing processing time, not the statement (line of code). To read the profiler, you must break your code into informative methods or code which lines you specifically want the profiler to sample.

To speak on some of the best practices we learned, developing on a minimum specification machine is a good idea. Know the performance jump from minimum, medium, and maximum specification machine. Have your program sense what it's running on and adjust the quality settings accordingly.

Expect art to bring the frame rate down. We tried to keep major characters to under 6k polycounts. We only had two major characters per scene. We did not render anything outside of the main camera’s view, such as the player’s face. We used mirrors sparingly and only during lulls in the gameplay. Plan to have your game run at around twice your target frame rate before you bring art into the game.

From the beginning, we wanted volumetric light. This effect is expensive because instead of 2D pixels, the graphics card is processing 3D voxels that overlap along the camera's local Z-axis to imply depth. We integrated this affect early on to pressure other features to be comparatively inexpensive.

2.12 Illustration

I was surprised to realise that our illustrator, Karen Tsai, would play as much of a role in shaping the storyworld and gameplay of *Palimpsest* as any other team member. Illustration is the step at which much of the logic of the characters, world, and game logic is sorted out. Lastly, visuals are the most powerful element in drawing players into the game. Everything from our main character's hair, jewelry, attire, body type, and skin tone was designed to signal belonging to our target audience.

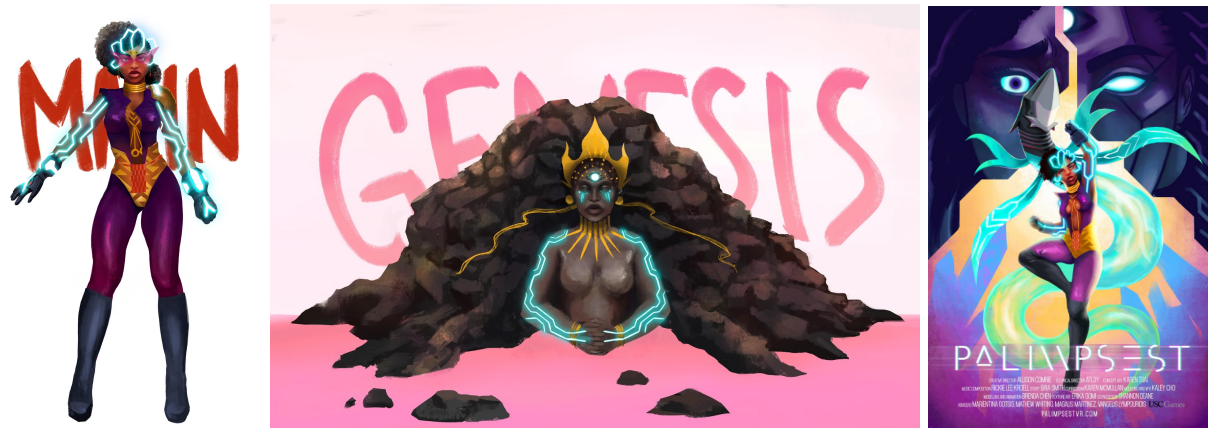


Figure 11: Concept art and poster. Source: Illustrator Karen Tsai

2.13 Audio

If illustration draws the player into the game world, then audio keeps them there. Sound design and music are a powerful way to feed contextual and emotional cues to the player.

Sometimes to the detriment of the pacing and narrative, music trumped sound design in our MFA thesis showing of *Palimpsest*. Our design challenge was to make the music sound good while ceding control to the player. Our solution was two fold: overlapping music stems and triggering music clips.

In level one, players punch to the rhythm to trigger song-amplifying music clips. We each streak of hits, the background stem progresses to a more intense loop of the song.

In level two, players reach out and pet swimming creatures to trigger musical stems that layer onto the base track.

In level three, both of these systems play out simultaneously, layering the more rhythmic music of level one onto the melodic vocals of level two. The result is a full expression of a song whose dynamics emulate our core mechanics of progress via alternating defensive and connective actions.

2.14 Diversifying Media And Technological Bias

Attempting to represent a character not often seen in games can bring to the fore interesting technical challenges. For example, in creating our protagonist's hair, we ruled out twists or dreads early on due to how difficult and programmatically expensive it would be. It was easier for her hair to be static, with simpler shapes. From the concept art to the 3D art, you can see how that decision contributed to a certain rigidity in the character.

Figure 12: Concept art of protagonist (left) and 3D art of protagonist (right). Source: Illustrator Karen Tsai and Allison Comrie

Attempting a lesser represented body type was also challenging. The easiest 3D shapes are simple, rigid shapes like cubes. Human bodies have curves. Muscle, fat, and skin all move differently on the body. It is difficult to create the flexing of a muscular back, and more difficult still to create the jiggle of a soft tummy. I cannot even imagine how I would attempt to create the way my own underarm skin folds when I cross my arms. I realized that characters in video games are not just fit because the media idolizes fitness, they are fit because static muscular builds are easier to technologically create.

With our protagonist, we had two primary concerns with implementing the concept art. First, we were concerned that our static model limitation would show more on a body that should have more bounce to it. Secondly, we were concerned about how the player's hands and arms were crashing into their legs. For computer graphics animators, "crashing" describes when one model is erroneously passing through another. We worried that this would disrupt the player's sense of immersion in their new avatar.

We tried to fix the problem of the player's avatar limbs crashing through each other. To animate the player's avatar, we used the plugin Final IK Puppet Master. This enabled us to map the player's head and hand movement to a rig that puppeted the in-game avatar to move in a human fashion. If the player seemed to pass a controller through their body, this plugin would attempt to solve that action in the game by rapidly moving the arm from one side of the body to another in as human a way as possible. However, this type of solving — the plugin attempting to match the player — was constrained by a potential range of animation, not by colliders throughout the avatars body. The more girth we gave to the avatar's body, the more we had to limit the avatar's range of motion to prevent their virtual hands from crashing through their virtual body. This was a risky choice for a rhythm action game, which depends on alignment between the player's avatar and the player's body.

A second solution was to integrate a "ragdoll physics" collider system, which would specifically guard against the avatar's body crashing through itself. "Ragdoll physics" got its name because it prevents the limbs of a ragdoll from colliding with each other while the ragdoll is tossed about. But my tests with ragdoll physics introduced strange bugs that were more worrisome than the crashing. Rather than an aesthetic bug, the new bugs were affecting the physics of the game.

In the end, we opted to slim our protagonist down to the body type that Final IK Puppetmaster's range of motion constraints expected and was designed for — a slim, muscular build… basically, the body of a male soldier. These are the types of technical challenges which, I believe, would be given more attention by the games community if their engineers were more diverse.

Chapter 3: Curriculum Overview

The *Palimpsest Program* was an after school program dedicated to increasing the motivation in high school nonbinary individuals of color and cis and trans women of color to study computer science in college. We taught three-hour sessions after school on Wednesdays at a South Central Los Angeles high school for twelve weeks. Our classroom was comprised of sixteen students ranging from 9th to 12th grades, although most of our students were in 10th grade.

Our goal was to design a flexible curriculum that could be tailored to the students. We prepared lectures, exercises, labs, and individual creative projects that the students could choose from.

3.1 Institutional Review Board Approval

The *Palimpsest Program* was a pilot designed to determine teaching methodologies that would be worth testing in a future research project. We applied to the Institutional Review Board (IRB) for protocol. (Please refer to Appendix B for our IRB application and Appendix C for our IRB application approval). "The mandate of the NIEHS Institutional Review Board (IRB) is to provide ethical and regulatory oversight of research that involves human subjects" (Institutional Review Board). The IRB deemed that the Palimpsest Project was not a research project and approved it for exception, category 1:

> Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as: (i) research on regular and special education

> instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods. (Institutional Review Board)

I welcomed the IRB review and valued the training modules and tests required to apply and gain approval. Five years prior, I co-founded two new media startups, Reboot Stories and Connected Sparks, both of which aimed the create media to serve "at risk" communities. There, I got a front row seat in seeing how well-intentioned artists can undermine the communities they claim to serve. The work my thoughts are in reaction to are well documented by Ele Jansen Phd dissertation, "Creativity Unbound – An Analysis of Open Collaboration between Experience Design and Poietic Practice." While out of scope for this document, what I would add to her analysis would be that many of the dangers of "social good art" are stifled by a cultish aversion to critical thought, broadcast from the true beneficiary of this confidence trick — the self-proclaimed "Creator." Below is my analysis of some of the ways this confidence trick is performed by the "Creator" of artistic projects that use pseudo science, vulnerable communities, and unpaid/underpaid and uncredited/undercredited collaborators to con social good investment dollars into amplifying the creator's portfolio:

1. The artist assumes that if their intentions seem good to them, their impact is also good.
2. The artist does not apply critical thought and procedural data collection to understanding the community or the community's needs.
3. The artist places the community at risk by pressuring them to divulge sensitive information outside of scientific data collection procedure and the ethical standards that accompany human testing.

4. The artist places the community at risk by documenting them without their consent and framing them in a narrative that they did not write.
5. The artist uses documentation of the community to frame the community as “in need” and the artist as the “benefactor” to benefit the artist in the form of financing, marketing, and otherwise amplifying the artist’s portfolio.
6. The artist acquires resources — mainly money and the time of collaborators who are often working pro bono — that could be put to better use.
7. The artist appropriates the community’s culture.
8. The artist searches for a problem that fits the artist’s solution rather than serving the community.
9. Amongst peers, the artist promotes a dangerous culture of self-aggrandizing, unethical, damaging social experimentation.
10. The artist uses sensational images to actively mislead financiers into thinking their money is having a positive impact on the world, relieving them of the social pressure to apply their resources more effectively to better the world.
11. Like a virus equipped with a self righteous belief in their own power to do no harm, the artist reinforces systemic oppression in ever more disturbing and inventive ways.

These were some of my reasons for leaving my prior startups for graduate school. Having seen the bulk of our financial resources go to outside coding support, I decided to study computer science initially at NYU, and then computer science within the context of interactive media design at USC.

My personal goal with the *Palimpsest Program* was to intervene in the systemic exclusion of minorities in computer science and to do so with ethical integrity.

From this vantage point, the name "Palimpsest" takes on new meaning. By its nature, the implementation of ethical principles is a moving target. To be a person of integrity in a constantly shifting context is to forever call my ethics into question. My aim is not to win at ethics, or to get and "A" in ethics, but rather to design my environment so that I am ever more quickly hearing and responding to feedback from the community I claim to serve.

3.2 Critical Roles For Ethical Community Service

Ethical service is easier said than done, and checks and balances were necessary for the *Palimpsest Program*. Being a white woman from a privileged background, on many levels I can never fully understand the perspective of our students and target audience. Two roles were critical to checking my influence over the *Palimpsest Program*:

1. Creative Director and my MFA Thesis partner Allison Comrie
2. Experiential Learning Designer and Community Advocate Grace Almodóvar

Allison Comrie is a black woman who grew up in South Central Los Angeles. As a partner, she had equal power to mine over all aspects of our project — the VR game and the high school curriculum. As the partner who could identify with our students and target audience, Allison had final say over all aspects of the project.

Our Experiential Learning Designer, who I am referring to by the pseudonym of Grace Almodóvar, led our interactions with the high school. Grace developed a slate of experiential learning initiates in her lab at the high school, of which *Palimpsest* was only one module. Grace

had been present on a daily basis at the high school for several months before the *Palimpsest Program* launched. She knew many students by name, as well as their passions and their families. She served not only as a producer and designer of the high school program, but also as a community advocate for her students. Without someone like her serving the students directly on academic, cultural, and interpersonal levels, the *Palimpsest Program* would not have been able to receive the feedback we needed in order to serve our students.

3.3 Research Goal And Methodology

The *Palimpsest Program* was not deemed to be human subjects research by the IRB because we did not aim to obtain data that was aimed at generalization about our target audience. Our evaluation was meant to pilot the course material to determine what would be worth testing in a future research project. For the pilot, we developed several teaching strategies that could be tailored to the needs of our students. The purpose of these teaching strategies is to motivate our students to consider pursuing computer science after high school. In researching motivational teaching strategies, we delved into Ryan and Deci's Self-Determination Theory (SDT):

> SDT is an approach to human motivation and personality that uses traditional empirical methods while employing an organismic metatheory that highlights the importance of humans' evolved inner resources for personality development and behavioral self-regulation. Thus, its arena is the investigation of people's inherent growth tendencies and innate psychological needs that are the basis for their self-motivation and personality integration, as well as for the conditions that foster those positive processes. Inductively, using the empirical process, we have identified three such needs— the needs for

> competence, relatedness, and autonomy— that appear to be essential for facilitating optimal functioning of the natural propensities for growth and integration, as well as for constructive social development and personal wellbeing. (Ryan 68)

SDT outlines three components of motivation: autonomy, competence, and relatedness. In order to want to pursue computer science, our students needed to feel that they had freedom of choice, the ability to succeed, and meaningful connections to their identity and lives.

We integrated autonomy into the curriculum by giving students the chance to shape the content, pace, and direction of the curriculum. We designed labs, lectures, exercises, and open creative time for them to choose from. We built in feedback loops to attempt to hear how our students wanted to spend their time.

During open creative time, students worked on self-directed projects of their own design. This tier of the curriculum was most geared towards autonomy.

Competency dealt not only with the students' comfort with the material, but also their perception of how well they were doing in the course. To convey competency, we designed each class to have roadmaps and check-ins. The roadmap would describe what we were going to do. Then we would do it. Then we would review what we did and discuss how it went.

Competency also related to Grace Almodóvar' approach of culturally responsive teaching. Grace argued that we should attempt to use aspects of our students' culture as metaphors for concepts in computer science. For example, using hopscotch to teach programming loops. Grace believed that the students' comfort with hopscotch would translate to greater comfort with programming loops. Having experienced how the use of Lenna's photo translated to *less* comfort with image dithering for myself, I agreed the inverse experience would

be true as well.

Grace also suggested multi-sensory learning experiences to reach students with affinities for different learning styles. Hopscotch is a physical activity, which might make a deeper and longer lasting impression on students who respond positively to movement. Other ideas included using tactile objects like beads and fuzzy pipe cleaners, or using a meal like cooking tamales, to teach concepts such as storing data in data structures. Not only might these experiences be more memorable, but they also might signal belonging to our students. We aimed to instigate thoughts like, "If I can play hopscotch, I can learn to code." Although we were a long way from testing this, we hoped that the neurons that fire with the mention of "hopscotch" would start to fire with the mention of "code."

We tackled relatedness from a variety of directions. Our first and most direct strategy was to program a VR game starring a protagonist who resonated with our target audience. We then filtered images of the character throughout the course material. (See Appendix J for a sample lecture.)

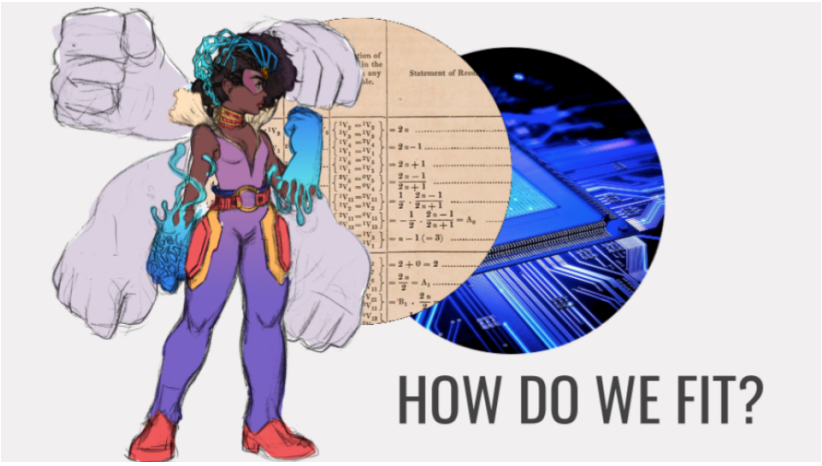


Figure 13: Lecture slide. Source: Karen McMullan

We also aimed to put our students in touch with relatable role models. One strategy was

to represent women of color and nonbinary people of color at the head of the classroom. But research has shown that a teacher simply matching a student's gender or race does not mean that that teacher has a significant impact on the student's sense of belonging to the teacher's field of study. "Relatable role models are those with whom students feel a sense of connection, similarity, and identification. Gender-matching may be one component that increases relatability, but there are other characteristics as well" (Cheryan 14). To communicate belonging, the teacher must also be relatable to the student.

What makes a potential role model "relatable?" Therapist Laura Garcia suggested that relatability could come through admission of our own humanity. For example, rather than striving to appear as though we, the teachers, know all the answers, admit the limits of our knowledge and understanding in the classroom. This approach dovetailed into our goal of autonomy. In letting the students explore self-directed prompts and self-defined projects, we were increasing the likelihood that students would develop questions that we did not know the answer to. However, in embracing the mantra of, "I do not know, let's find out," this uncertainty could be channeled into a collaborative journey that nurtured relatedness between the student and teacher.

A third approach to relatability was encouraging friendships, partnerships, communication, and play. At the university level, computer science departments must be careful about cheating. They use automated harnesses and teacher's assistants to evaluate student work and catch similarities that indicate collaboration on homework assignments. Talking is generally discouraged in class. Tests are silent. Students are asked to cite any sources of help on their work, including websites, classmates, and teachers. While understandable, such an environment

can be isolating for a student who may not feel comfortable going to their teacher for help. Gratefully exempt from the confines of academia, as enrichment learning experience, the *Palimpsest Program* could embrace collaborative learning openly. Our goal was to have the treble notes of friendship fire along with the bass notes of a challenging computer science lab. We felt that both the bond of friendship and the courage that yields would make it more likely for our students to stick with the course material.

Figure 14: Lab partners. Source: Grace Almodóvar

Lastly, we integrated resilience skill-building activities such as mindfulness into each class. The exercises we followed were from Marsha Linehan's development of Dialectical Behavioral Therapy (DBT), and the modules we focused on were Mindfulness and Interpersonal Effectiveness. This strategy was intended to support all aspects of motivation. Our intent was to start each class with clarifying our minds, our intention, and uniting ourselves as humans beings sharing a common space. We aimed to develop our awareness of how the curriculum was

impacting ourselves and each other, and to develop communication skills for how to effectively respond with changes to the curriculum.

In summary, the responsive teaching strategies we sought to develop in the *Palimpsest Program* pilot were:

1. Teaching approaches based on psychological theory of motivation
2. Resilience skill-building activities, e.g. mindfulness
3. Visuals/metaphors/objects that disrupt current computer science stereotypes
4. Nurturing relatability between student and teacher

Rather than adopting linear structure to our curriculum and pilot development, we found hyperbolic forms to better suit our needs. We strove to tell the entire story of our goals and tools as often as possible. The story of code could be told in a myriad of simple, single phrases. For example, the story of code is:

- Data and functions
- Machines that read patterns of 0's (no charge) and 1's (a charge)
- A 50-yr-old field replete with human error and potential for your improvements
- Senior programmers adopting access modifiers to protect or "encapsulate" their code from interns who might mess it up
- Getting machines to serve our needs

By continually revisiting and revising the basic building blocks of why we are joined together in this classroom studying computer science, we are able to strengthen each student's foundation in the field. Over and over again, we would learn that a solid foundation trumped a shaky structure. Trust and communication between student and teacher preceded any possibility of learning. It

was better for us to aspire to be kindly grandmothers weaving a secure basket of space for computer science in our students' lives: regularly returning to the macro, circling back over material, and progressing on several teaching strategies simultaneously. In a hyperbolic structure, students of varying levels graduate to more influential roles with each pass on the material.

To reinforce trust, one ground rule we began with was, "Do not touch the students or their computers without gaining verbal consent first." This rule was one pillar of a safe space. This rule also guarded against anxious teachers going in and doing the student's exercise for them for the sake of speed. Developing muscle memory to operate computer inputs (keyboard, mouse, controllers) and autonomy in technical problem solving is critical to increasing the student's comfort with their computer.

3.4 Research Tools

Our pilot study methodology used a community-based, participatory approach. Our tools for documenting the Palimpsest Program included ethnographic field notes, written surveys, and filmed student interviews.

During classes, we sought verbal feedback on what the students preferred to study and how the material was landing for them. In response to feedback, we modified curriculum in real time. Our field notes documented changes to the curriculum, why we made those changes, and what we observed following the changes. Grace Almodóvar also served to give us verbal feedback during and following lessons. (Please see Appendix G for an example of our field notes.)

Written surveys documented student feedback on our teaching strategies. Our written surveys comprised of a mid-course check-in, which we distributed halfway through the program. The mid-course check-in was used to determine how we could improve the program to better serve our students. (Please see Appendix D for our mid-course check-in survey.)

We filmed and photographed lessons and student interviews for the purpose of recruitment to future iterations of the program.

In addition to this manuscript, there are two outputs of the documentation of this pilot study:

1. A document that describes the interactive curriculum we developed for use by teachers, which can be found at https://palimpsestvr.com/.
2. A short film documentary that may be used as recruitment for the next phase of research, which can be found at https://vimeo.com/user5271511/review/303847755/de3f584cbd.

3.5 Walkthrough Of The Palimpsest Program Launch

The *Palimpsest Program* launched with a tour of the University of Southern California's School of Cinematic Arts Interactive Media & Games Division. We showed students the Mixed Reality Lab, the Game Innovation Lab, the Creative Media and Behavioral Health Center, and the Mobile and Environmental Media Lab. We browsed a hallway installation on how VR devices have changed over time, and discussed some of the benefits and challenges of VR. At the end of the tour, we hosted presentations and workshops in the common area, affectionately named the "Fish Bowl."

There, we handed out workbooks for each student. Each workbook contained a journal, exercises, pen and pencil, and a color printed cover of the protagonist from our VR game leaping through the air. We explained that this is where students could organize their thoughts and coursework, and we would continue to hand out printed worksheets at each class as we shaped the curriculum together.

Figure 15: Workbooks. Source: Atley Loughridge

Allison presented on the history of gender and racial stereotypes in games. She argued that this was a result of the homogenous culture that was making the games; we needed people like the students of the *Palimpsest Program* to shape the media landscape, and that our program was designed to prepare them to do just that. Allison then guided an exercise where the students imagined a game they wanted to make with the sky as the limit.

I led a discussion about some of the vocabulary we were using to describe our goals for the course. I also led a hands-on workshop about 3D space. Sitting in a circle on the carpet, we used pipe cleaners to shape a 0-dimensional point, a 1-dimensional line, a 2-dimensional plane, and a 3-dimensional space. We positioned beads on the coordinate system we'd built, and brainstormed various ways to move, rotate and scale these objects in space.

3.6 Feedback On The Palimpsest Program Launch

I had a slide presentation for this material, but skipped it due to time constraints. I prioritized the hands-on workshop. Days later, Grace delivered feedback that I had alienated the students by diving into an abstract exploration of 3D space without first presenting the key ideas and vocabulary in a slide. She said that many of the students were confused by my workshop, and that they were nervous to tell me so because of the intrinsic power dynamics of them visiting a big-name university from a local high school. I had a hard time hearing this feedback, and I will explain why.

At the time, I was viewing myself as the minority woman in my 90%-male engineering courses. I was recovering from experiences of being inappropriately touched by computer science classmates who had said they would help tutor me. I invested in *Palimpsest* in order to tackle this issue, and I had not yet considered how I, as a white privileged woman with glasses at the University of Southern California, could quite understandably be interpreted as intimidating and even threatening to our students. My seriousness about the subject also might have signaled an authoritarian personality. One thing I had to learn was how to soften my presentation and show my authentic self. Another thing I had to learn was to be transparent all the information I had around a concept and let the students choose how they wanted to process what.

Before designing the abstract 3D space workshop, I had had the privilege to learn about vector spaces in traditional college courses. I'd bought the books, learned the universally accepted vocabulary, and passed the tests. All the while, I resented that nearly all of the course material was written by and taught by men. In "The Structure of Scientific Revolutions,"

Thomas Kuhn describes how scientific breakthroughs are largely the result of the social canvas being primed for experimentation to yield certain results:

> When … an anomaly comes to seem more than just another puzzle of normal science, the transition to crisis and to extraordinary science has begun. The anomaly itself now comes to be more generally recognized as such by the profession. More and more attention is devoted to it by more and more of the field's most eminent men. (Kuhn 82)

Kuhn goes on to note a pattern amongst breakthroughs like Newton's second law of motion, Maxwell's theory, Galileo and the Copernican revolution, Thomas Young's first accounts of the wave theory of light, and Einstein's quantum mechanics:

> Almost always the men who achieve these fundamental inventions of a new paradigm have been either very young or very new to the field whose paradigm they change. And perhaps that point need not have been made explicit, for obviously these are the men who, being little committed by prior practice to the traditional rules of normal science, are particularly likely to see that those rules no longer define a playable game and to conceive another set that can replace them. (Kuhn 90)

Not only were these breakthroughs made by minds who were open and supple enough to discover them, but they were also made by minds who had the time, food, shelter, safety, education, money, freedom, network, workspace, guidance, and all forms of social support necessary to dedicate oneself to scientific study: white male minds.

I didn't want racism and sexism of the past to come in between the minds of our students and the universal language of math. I didn't want the white-male-written-vocabulary of math

and computer science to subconsciously convey that white men have more power in this domain because they were the ones who were privileged enough to put their names on it first.

Interestingly, what I was actually doing was withholding information from the students. Unlike me, they did not read the phrase “vector space” first and then decide to rewrite it. Their experience was more like playing charades, trying to guess what I — the white woman — was thinking, with their only clues being beads, pipe cleaners, and my verbal array of abstract questions.

While there is something to be said for letting the student make their own discoveries, this instance of the 3D Space hands-on workshop was a failure. Rather than being in a safe space, the students were in a public common area of a big university. Rather than being able to take their time and ask questions, I rushed into too much material with too little time to cover it. Rather than being given options for how to process the material — e.g. via slides and/or a workshop — I had prioritised the workshop because of my own biases.

And it was my own biases, and the emotion I attached to them, that interfered with my ability to read the expressions of confusion on the students’ faces and respond to *their* needs.

The launching of any educational program should be all about getting to know each other, building trust, and the students and teachers developing feedback loops so that the teachers can tailor the program to the students’ needs. USC Creative Media & Behavioral Health Center Director Marientina Gotsis says:

> Humor and warmth are important factors for teachers… The only hope for liberation is being your best self for your students and explaining your affect when you can’t (cranky, tired, serious, etc.) It may seem burdensome, but when you teach younger people, they

are reading your raw signals with a lot of critique and their empathy is less developed. (Gotsis)

Success in the classroom might not relate to the teacher's personal experiences or motivations at all. Removing my ego from the equation of what is working in the classroom was a task I returned to repeatedly over the development of the *Palimpsest Program*.

The feedback that was initially so difficult for me to hear was straightforward to implement. Grace had specific requests for our course:

1. Begin and end with a roadmap.
2. Integrate "Checking For Understanding" as we go.
3. Make a vocabulary list that defines important terms or jargon.

USC Information Technology Program lecturer Karen McMullan had teamed up with me on the computer science curriculum, and had spearheaded amendments based on Grace' feedback. Karen created a roadmap slide that summarized the flow of the class. Everytime we transitioned from one module to the next, we brought up this slide as a visual aid to review what we did and what we were going to do next.

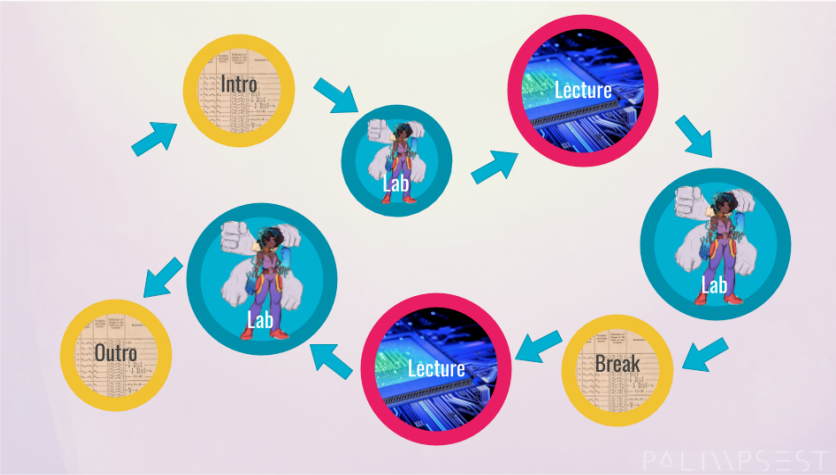


Figure 16: Class overview slide. Source: Karen McMullan

For each lecture, Karen created related exercises for us to check in with the students on their comprehension of the material. (Please see Appendix J for a complete sample lecture and Appendix K for the complementary exercises.) Karen also created a vocabulary list with definitions. At the second class, we handed out printouts of the vocabulary for students to place in their binders. Each class, we added new terms to the end of the list as they came up during the lesson. In this way, we complimented our more abstract, tactile exercises with concrete definitions. (Please see Appendix H for our full vocabulary list.)

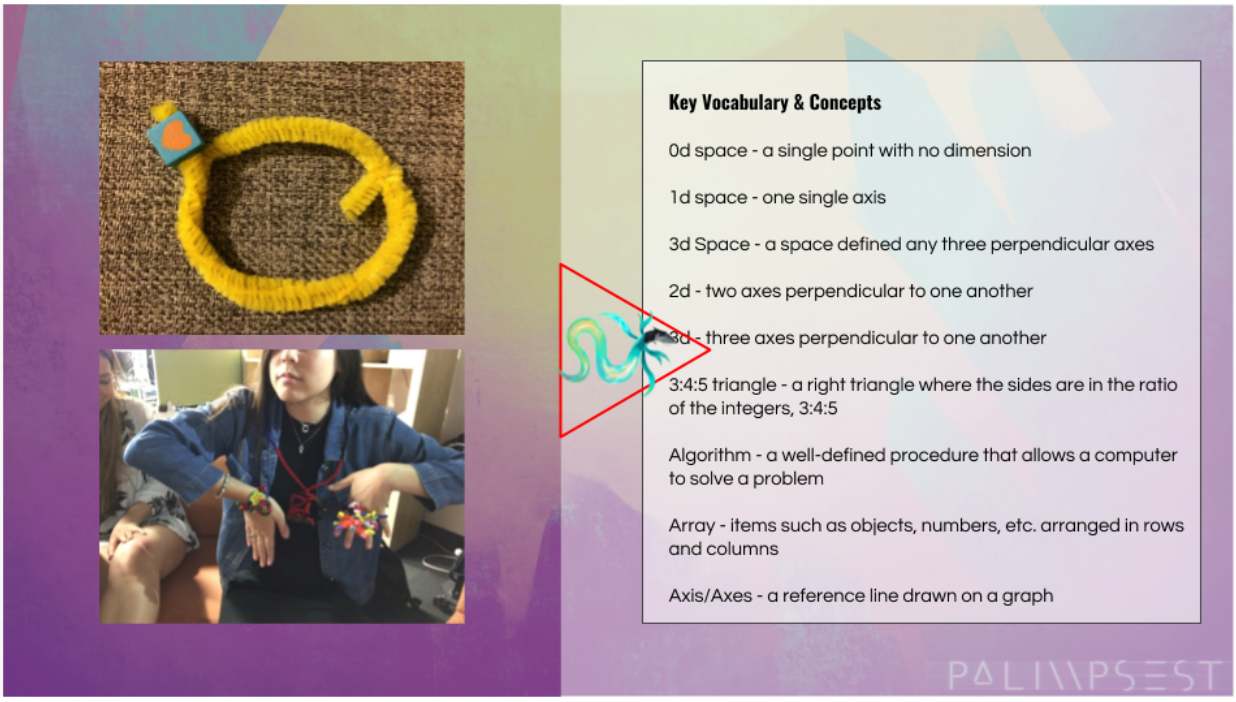


Figure 17: Workshop and vocabulary. Source: Atley Loughridge

Notably, Karen McMullan's ability to incorporate Grace' feedback was essential to our progress. I will speak more on Karen's leadership at this pivotal moment in chapter four section two entitled, "Shifting Priorities With A Shifting Context." What I learned from Grace and Karen on that day, and what I hope I never forget, is that the goal is to hear and incorporate feedback as quickly as possible. Feedback is not personal. While I may have created the

Palimpsest Program in part to heal my own feelings of loneliness and isolation in computer science, successfully implementing the program hinged on my ability to compartmentalise my own needs from the needs of my students and the community I had signed up to serve. This is not to say that I ignored my own needs. To the contrary, I took up the work of addressing my needs more effectively outside of the classroom with renewed focus.

3.7 Walkthrough Of A Typical Session

Per our goal of developing a curriculum that could be tailored to the needs of our students, our class evolved from week to week. Karen McMullan had shown me several quick and exciting labs she had created to introduce students to programming. I thought her work was more accessible than my relatively dry exercises. Karen and I teamed up to shape the class around a computer science/design lab built in Unity, a 3D game engine.

We posted six labs to a public repository on Github, and each student downloaded that repository onto their school laptop. (Refer to Appendix H for the full overview of programming curriculum labs and lectures.) We hypothesized that if we got the students interested in solving a problem first, the lecture material might feel more relevant.

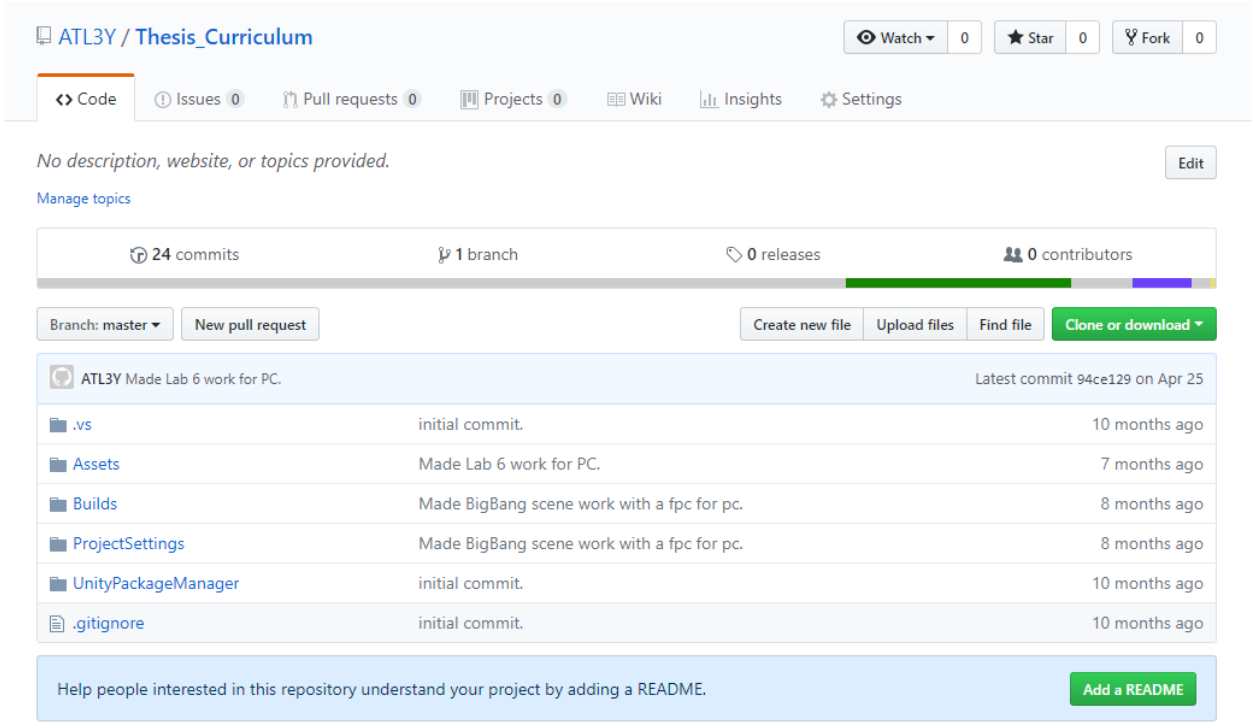


Figure 18: Palimpsest Curriculum github repository. Source: Atley Loughridge

Initially, we had broken up the curriculum so that Allison Comrie and Grace Almodóvar taught the design classes and Karen McMullan and I taught the programming classes. At that point, a typical programming class went like so:

1. Intro (15 min: 2:00-2:15 pm)
    a. Each student brings their folder to class. Instructors pass out new worksheets.
    b. Instructors introduce the plan for the day.
    c. Mindfulness reading material and exercise(s). Mindfulness may include capturing inspiration for today's lesson.
2. Lab (15 min: 2:15-2:30 pm)
    a. Students observe a working version and a broken version of the lab.
    b. Students map causal relationships and form questions about the broken lab.

3. Mini Lecture and Exercises (30 min: 2:30-3:00 pm)
    a. Teacher answers the questions formed during the lab.
4. Lab (30 min: 3:00-3:30 pm)
    a. Students attempt to define the problem with the broken lab.
    b. Students code, hypothesize, implement, and test solutions to make the lab work.
    c. At end, instructors walk the class through one solution.
5. Break (15 min: 3:30-3:45 pm)
6. Lab (30 min: 4:15-4:45 pm)
    a. Students code, hypothesize, implement, and test solutions.
    b. At end, instructors walk the class through one solution.
7. Outro (15 min: 4:45-5:00 pm)
    a. Instructors review what we set out to do and what we did.
    b. Instructors facilitate a class discussion about observations and outcomes.
    c. Students save their work and review class materials folder.
        i. Lectures and worksheets
        ii. Walkthrough of the lab
        iii. Online programming tools

Figure nineteen shows our students exploring one lab entitled, “The Big Bang.” The way the lab worked was that, when a student used the WASD keys to guide their player into a pink box, the box instantiated tons of blue spheres. Depending on when the spheres were programmed to self-destruct, they might collect on the floor, fall through the floor, or almost immediately disappear. In the supporting lecture and exercise (Appendix J and K), we discussed object

movement in 3D space. Many of the students had studied 2D algebra, but not 3D. So we improvised a game to explore object movement in 3D space.

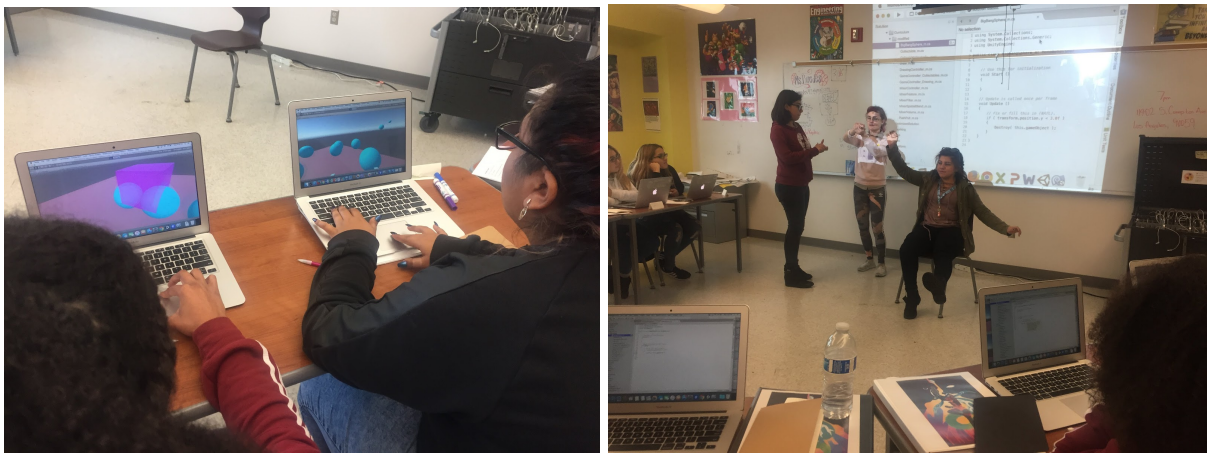


Figure 19: “Big Bang” lab and exercise. Source: Grace Almodóvar

In the right hand image above, the seated student is pretending to be a vector space. Her right arm is the y-axis, her left arm the x-axis, and her left leg is the z-axis. The standing student is pretending to hold a blue sphere, which is falling downwards in space. I am asking the class to shout out points along the y-axis when the sphere should self-destruct. When the standing student’s sphere falls past that point, the class yells for the sphere to destruct. This is one example of how are planned curriculum might change depending on the interests and questions of the students.

3.8 Feedback On A Typical Session

Five weeks into the program, we handed out mid curriculum assessment forms (Appendix E). The results (Appendix F) were only from half of the class (eight out of sixteen students) and reflected some miscommunication about how to respond. Nonetheless, a few results were illuminating.

One question asked, “How comfortable do you generally feel asking a question in class?” On a scale of 1 (uncomfortable) to 5 (very comfortable), the results were: 2, 2, 2, 3, 4, 4, 5, 5. Three of the eight respondents gave their comfort level with asking questions in class a two out of five. While the mean of the responses was 3.375 — closer to “very comfortable” than “uncomfortable,” the three responses of “2” were worrisome.

Another question asked, “Have you ever looked at a programmer and thought, “Hey, that could be me!” Three respondents said, “Yes,” and five respondents said, “No.” All of the students who replied with a “2” for their comfort level asking questions also replied with a “No” to envisioning themselves as a programmer. Of these three students, one of them described a con of the program as, “If you don’t understand a concept, it’ll be hard to understand everything.” The other two simply stated their con for the program as, “Confusing.”

I interpreted the responses of these three students to mean that more than a third of the class was spending a significant amount of class time feeling confused and uncomfortable with asking questions. The fact that I was the main programming teacher, and five out of the eight respondents said they had not seen a programmer and thought, “that could be me,” gave me the feeling that the majority of the class was not finding me relatable.

Another question asked, “What do you hope to get out of this program?” (Rate the following from 1 to 5):

A: [ ] New friends

B: [ ] A cool project

C: [ ] Knowledge of how to program

D: [ ] Knowledge of how to make art with technology

E: [ ] A mentor who I can relate to

Five out of the eight respondents gave a rating of 5 to option D: Knowledge of how to make art with technology. The remaining three respondents did not use numbers, and marked three options with an "x." All three placed an "x" beside option D. My interpretation of this result was that the majority of the class hoped to make art with technology in the *Palimpsest Program*.

My core takeaway from the survey was that we needed more class time allocated to creative personal projects, and more class time dedicated to Allison's design and games-focused curriculum. That said, we wanted to make changes to the curriculum in explicit collaboration with the students. The following week, we presented the results of the survey to the class and brainstormed ideas for how to modify the curriculum accordingly.

With respect to increased comfort asking questions in class, students verbalized that many of their questions arose during lectures that felt rushed and resistant to stopping for questions. Many students verbalized an aversion for the lectures. Trying to conceive of a new structure for the course, I listed the four core course activities on the board and had students rate them from most important to least important by a show of hands. The highest rated activities below got the most votes:

1. Personal Projects
2. Labs
3. Meditation
4. Lectures

Even though the lectures had taken us the most time to prepare, they were the least motivating to the students. As a result of this class discussion, we deprioritized lectures by implementing a 15-min time limit, truncating them, and removing wordy slides. However, we also decided to keep lectures in the curriculum for a specific purpose: exposure to new ideas. Many students played volleyball. I likened lectures to setting up a volleyball and creativity to spiking it. As a class, we agreed that both had some value.

Allison and I also made personal statements about the importance of asking questions. We stated that research showed that, perhaps unintuitively, people interpret the person asking questions as being smart. We stated that our primary intention was to serve them: if they were lost, we were losing. We also spent some time role playing asking questions, and discussing some of the barriers to asking questions and how to overcome those. Lastly, I attempted to build more verbalization into class exercises. When learning about passing parameters into methods, I acted out a personality while students shouted out traits: “high-pitched voice!” “superficial!” “heartbroken!” they shouted. The students were delighted to watch me devolve into a blithering mess while they puppeteered my improv. This exercise gave the students reason to speak and put them in the driver’s seat within a fun context where I was the one being goofy and ridiculous.

Personal creative projects were designed to give students autonomy, and that activity was clearly the class favorite. We brainstormed ways to increase student autonomy in other aspects of the class. One idea was to make a list of what students wanted to cover at the beginning of each class. That way, teachers could steer the material into more relevant areas of the student’s life. If the teacher could not address the area, we asked if another student could. In this way, we

developed time for students to teach each other. In figure 20, an older student teaches a younger student how to make a piecemeal graph.

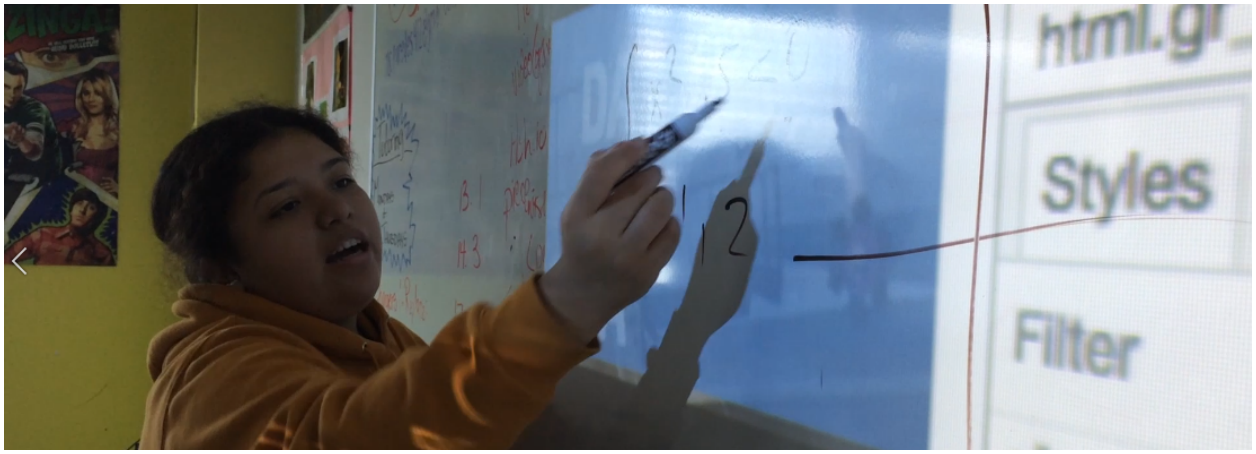


Figure 20: Student teaching piecemeal graph. Source: Atley Loughridge

Another idea was to use meditation time to go outside and capture inspiring material for personal projects. This was a great amendment to the start of each class. It took more time to go outside, but the outdoor creative activity added focus to our remaining time together. Figure 21 shows how our roadmap slide changed after the mid curriculum assessment feedback. Figure 22 (left) shows a photo that one student took during an observational meditation outside. The student then used this photo in their personal project as a texture.

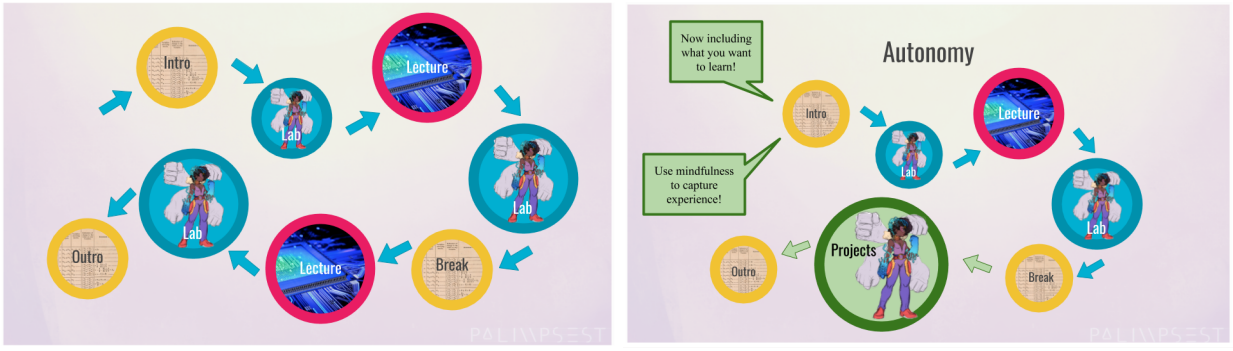


Figure 21: Curriculum Intro slides A and B. Source: Karen McMullan

Figure 22: Photo taken by student for their game (left), student game using remixed assets from *Palimpsest* the VR game (right). Source: Students

Following the mid curriculum assessment feedback, the class took on a much more creative and collaborative tone. Rather than separating programming and design curriculum, Allison and I made more of an effort to seamlessly integrate them. Rather than labs taking the entire class, the second half of the class was reserved for freely directed creative time. We had always planned to make our VR game assets available for students to remix in their personal projects. This was a core tenant of "palimpsest" as a theme: students overwriting our work. But Allison added new exercises around students making, finding and integrating their own creative assets into their projects.

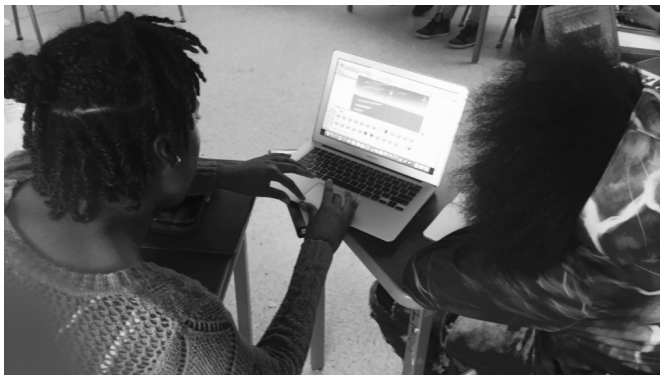


Figure 23: Students. Source: Grace Almodóvar

Grace had the idea to fold student personal projects into a festival of games at the end of the year. Her announcement was heard with a combination of nervousness and excitement. We extended the curriculum from eight to twelve weeks in order to support student projects for the festival. While we did not force students to participate, and we were careful not to pressure them to show work before they were ready, working towards a possible showcase for classmates, teachers, friends, and family was a fantastic way to focus the second half of the *Palimpsest Program*.

Figure 24: Student Showcase In Library. Source: Atley Loughridge

Chapter 4: Integrating My Takeaways Within Myself

Within the scope of our thesis year, for me, *Palimpsest* embodied two primary integrations. The first was integrating the development cycle of a VR game with that of a highschool curriculum. To some degree, the entire development team experienced that strain. The second integration was specific to my experience. I had to integrate my motivations for beginning the project with what was needed from me in order to complete it. I had to inch my way out of my perspective into that of my target audience.

When assessing what appears to be progress or a setback, what I am most interested in are positive and negative feedback loops. Progress is not linear. Many confusing days may pass

before they yield evidence of progress. Differently, positive and negative feedback loops are omnipresent. The barometer is not the success of the project, but the team member's power to continue work on the project. At any given time, I can ask myself, “Am I in my wise mind? Am I ready to make a wise decision? Is my work coming from the right place?” If the answers are yes, then why? Tracking the events that yield positive and negative responses to these types of questions can help reveal the positive and negative feedback loops that are either sustaining or eroding my ability to do good work on a project over time.

An exciting element of this way of thinking is that, with every interpersonal interaction, one can contribute to the positive or negative feedback loops in another person’s experience.

4.1 Burning The Candle At Both Ends

Many professors dissuaded Allison and I from doing both a VR game and a highschool curriculum for our thesis project. We both loved VR, and we essentially felt it was unfair that we could not reach our target audience with VR simply because our target audience did not have access to VR headsets. Both Allison and I had encountered VR for the first time at an academic lab. We felt that making a high school engineering curriculum was the best way to reach our target audience with the project we wanted to make. If there were challenges in carving this path from VR to our audience, we wanted to understand them, even if that meant failing at producing a cohesive, polished thesis by our academic deadlines.

The primary positive feedback loop to marrying the VR game and the high school curriculum was that the game inspired our students to code, and the students inspired us to create. One student, who I’ll refer to by the fictional name of Alyssa, exemplifies this pattern

well. Early on in the program, Alyssa could be found in our classroom either giggling with her classmate (who I'll call Kat) or with her head laid in her forearm on the desk. "She's introverted," Kat explained. For Alyssa's game exercise, she proposed a platformer about trying to reach the bathroom through their fortress-like highschool. She fought a smile as she described locked doors, long hallways, five stories of steps, tempting water fountains, and potential outcomes of relief or devastation. As a teacher, it can be intimidating to attempt to reach a mind with such clarity of vision and convince them to that your material is actually worth their time.

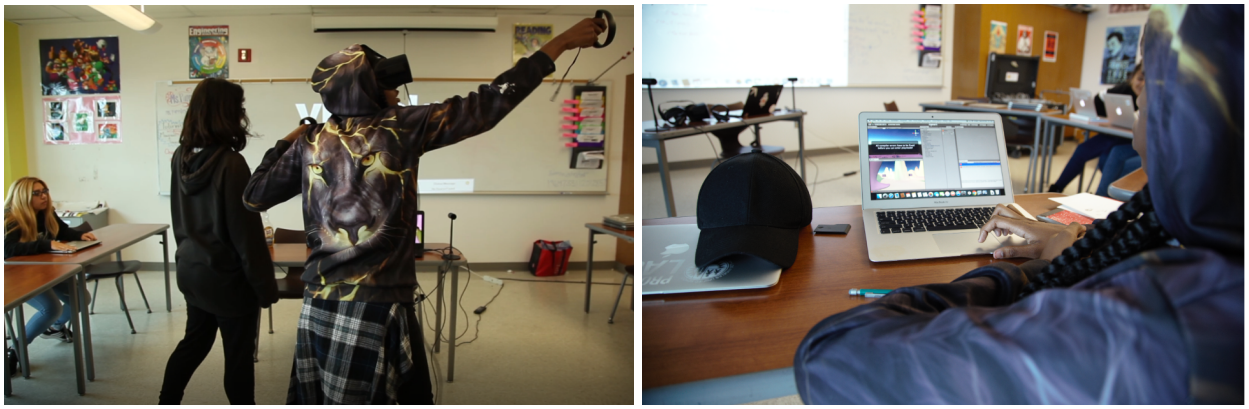


Figure 25: Student playing VR game (left) and coding their own game (right). Source: Allison Comrie

Around the third class, we brought the VR game of *Palimpsest* into the classroom and asked the students to playtest it and give us feedback. Alyssa wanted to try it. Kat set Alyssa up in the headset, ran the game, and intermittently tickled Alyssa as she adapted to her virtual surroundings. When the Sentients approached, Alyssa punched. (Kat ducked.) When the giantess picked Alyssa up, Alyssa screamed. When the Capacitor-Fish approached, Alyssa reached as far as her body could stretch. I'd never noticed how tall she was.

When Alyssa took off the headset, her behavior as a student changed. I wouldn't argue that she was paying better attention, because I well know how much easier it can be for me to

listen with my eyes closed and cheek laid on a cool desk. I know how much easier it is to attend a class with a friendly face to look forward to. I would argue that I felt more connected to Alyssa after she played our game. Instead of her hair poking out of her hoodie, I saw her eyes. Instead of responding to code exercises with phrases like, "I can't do it," I saw her pressing on with whatever parts of the Unity game engine that interested her. Once she figured out how to bring a humanoid figure into the scene, she was hooked. Alyssa was motivated to create. In my view, the VR game was evidence that code could lead to creating cool stuff, and that Allison and I knew the way. Alyssa stayed in our program for the full twelve weeks and showed her final project at the highschool showcase. Amidst the crowds of students, teachers and parents who attended, Kat drew in playtesters with enticing descriptions of Alyssa's work while Alyssa watched… and smiled.

A candle burning at both ends is a candle over twice as bright. The stick held parallel to the ground forces the flames to burn perpendicular to the wick. Melted wax drips automatically to the ground, and there's nothing to stop the flames from burning as quickly as they can. Simultaneously implementing two projects with wildly different needs feels like going from putting out one fire to another. Neither Allison or I knew how to code when we began our MFA program. In a way, that was our bond. I cannot speak for Allison, but I spent my years in graduate school feeling considerably less skilled than my classmates. Presentation days only underscored how far behind the curve I was. The curse of being unskilled is that it is so hard to scope. You don't know enough to know what your options are, or why one route will take twenty times more time than another. Being behind the curve of your group skill-wise is not a negative feedback loop in of itself. To complete the loop, you also have to be isolated from help.

Isolation from a resource depends on two forces: movement away from dependencies and movement towards dependents. In this case, the resource is someone who could have helped me solve or avoid technical problems with the VR game and high school curriculum. I avoided resources because, by my third year, I essentially interpreted them as threats. I will explain this more deeply in a later chapter. Let me suffice to say that getting help programming entails sitting near to someone while you share a computer. I'd enough experiences with that resource demeaning, assaulting, or otherwise sapping my lifeforce to know that I could not afford a negative experience in my thesis year. I could not afford the shock, the days of fog, the night of tears, the spiral of hopelessness, the adjusting to new meds, the sleeping through morning classes, or the resurgence of fear. I had students half my age depending on me. I chose to tackle technical bugs late into the night at our thesis space (I couldn't afford a separate VR setup at home — another vulnerability) when I could feel safe, and focus, alone. Working out technical bugs alone is slow work. What computer science teachers don't tell you is that most of the job is experience. You become a stronger programmer with exposure to new types of problems. Having ten people to ping with a question means you are ten times more likely to transcend an impasse in twenty minutes rather than two weeks. Technology is a team sport. Isolating myself from help was a great disadvantage for the project. I was the technical director. But at the time, it seemed the lesser of two evils.

The opposing force necessary to lock in this negative loop is to commit your time to dependents. This part has to do with caring. Being isolated from a supportive community makes you care more about the project. The project becomes your main source of self worth. Rather than asking your loved ones to love you, you're asking your players to. Rather than devoting

your energy to restorative activities like cooking and exercise, you devote all of your energy to a computer. Playtesting projects like this is more like putting your soul on trial than playing a game. The people who stick around to support you don't do so because it's fun or successful. They do so because they care about what you care about. Many of our (unpaid) teammates were women who had, like Allison and I, missed out on early high school learning experiences with technology. I was the most experienced programmer on the team, and that made everything harder. Because I cared, I was also spending half of my time on the high school program. I was trying to fix the problem that had produced my situation at the same time that I was trying to claw my way out of it. Because I cared, I could not hear the advice from anyone who could have helped me. It was much too easy for me to rationalize that they didn't understand me, or my project, because I could not imagine them caring even ten percent as much as I did. Because I cared way too much.

And the world is unjust. And that injustice stokes the caring. During the eight years I spent as an actor, waitress, bartender, bike taxi, busker, production assistant, and camera operator, I worked with black people everyday. Allison is the second black person to graduate from the Interactive Media & Games Division MFA program in thirteen years of graduates. At the time of our thesis, there was one black person on the faculty of our department. I didn't need statistics to motivate me to spend half my time developing the high school curriculum. All I had to do was set foot on campus.

That said, I was barely a strong enough programmer to pull off the thesis that I did. The situation was a feedback loop — a negative one. Feeling isolated at USC motivated me to try to be a better resource to my highschool students. Seeing the obvious potential of my students

made me even more frustrated with the lack of diversity amongst the strongest programmers at USC. But going from positioning myself as a resource at the highschool and scorning my potential resources at USC burned my energy from both ends.

I'm not saying we should have chosen between the VR game and the high school curriculum. I'm saying that "Scope down" is the beginning of the conversation. The rest of the conversation is about debunking the mental myths about why scoping down is not an option: "I can do it alone, you just don't believe in me," "the world needs this project more than it needs me," "no one can understand my goals, so there's no point in discussing why I cannot scope down," "polish is for people who don't care enough to reach for more," etc.

The sad truth is that your work will go nowhere without polish. There is no getting around that. Independent games is a rough industry. If your work does not ooze ease and elegance in some form, if it does not hang neatly at the center of a simple contextualizing frame, if it's not surrounded with air for your player to breath, if it smells of blood and sweat and tears when it arrives in a stranger's inbox, you will not get a response. It's not because they don't care. It's because the market is so rough that they cannot afford to take a chance on something that smells desperate and feels less than fully baked. Making games is brutal. You need 50% of the development cycle for polish just to clean up the stink. If you're trying to make something your care for desperately, make that 75% of what you envision the development cycle to be. This isn't music or film. There's no Jackson Pollock of games. Players need to *do* something *correctly* in order to eat your food. Serving medicine in a file on the internet, without you there in person to sell it, requires battlesque strategies.

To new game designers, I recommend being committed at the finish and non committal in the beginning. Don't bother touching code until you have a sense of your release strategy. Don't let yourself get attached until the project is running on its own. It shouldn't just feel inevitable, it should feel easy. Even then, especially with projects you care about, you have to stay detached and cold enough to be strategic. You have to be able to set boundaries with the dependents you're bringing on and make demands of your dependencies. You have to override your impulses to give and isolate with the knowledge that doing so spells failure. If you get too impassioned, if you start crying in front of people, go home, go to bed, read a book made of *ink and paper* and don't come back to school until you've set up a ninety minute meeting with an experienced advisor who you trust to pave you a pathway out. Then do what they say. Pack half of your project up and put it on the shelf for another year. You'll make other projects, so long as you're there to make them, and they'll be better than this one. Remember that the candle is you.

4.2 Shifting Priorities With A Shifting Context

The most difficult day for me on *Palimpsest* was March 14, 2017. Karen, Grace and I regrouped at the high school for our first class following the launch at USC. As described in chapter three section six, Grace had given me straightforward feedback to include a roadmap, check-ins for understanding, and a vocabulary sheet with definitions. I had (wrongly) resisted her feedback. At our meeting preceding our first class at the high school, Grace suggested that I and the curriculum we'd planned take a back seat until we integrated her feedback. I actually rolled my eyes. That eye roll nearly spelled the end of the *Palimpsest Program*. Grace was the

student advocate. She recruited the students for the program. She had discussed their hopes and fears with the students, and I'd disrespected her.

Grace barred me from teaching that class until I changed my attitude. At the time, I was stunned. Karen began teaching the second class instead of me while I watched. And I learned something. I learned that my inability to swallow my pride and be effective in that moment was my problem.

My reasons for wanting more nonbinary people of color and trans/cis women of color in computer science were personal. I felt like a lone woman in CS courses at NYU and USC. If there were other women in the course, they did not seem to want to associate with me. Although I was a good student on paper, in computer science courses I struggled. When called on during class or while taking tests, I experienced terror. My voice and hands shook so much that I would cry with frustration at my inability to speak clearly or write legibly. After several years of this, I was eventually diagnosed with Complex PTSD as a result of Sexual Assault (SA). It had been many years since my traumatic experiences. Sitting in classrooms packed with men was triggering to me.

Interestingly, PTSD has only been a diagnosis for twenty five years. Dr. Van Der Kolk describes working at the Veterans Administration before the existence of PTSD as a diagnosis:

> In those early days at the VA, we labeled our veterans with all sorts of diagnoses—alcoholism, substance abuse, depression, mood disorder, even schizophrenia—and we tried every treatment in our textbooks. But for all our efforts it became clear that we were actually accomplishing very little. The powerful drugs we prescribed often left the men in such a fog that they could barely function. When we

> encouraged them to talk about the precise details of a traumatic event, we often inadvertently triggered a full-blown flashback, rather than helping them resolve the issue. Many of them dropped out of treatment because we were not only failing to help but also sometimes making things worse. (Kolk 20)

Reaching a wall in trying to get the VA to recognize PTSD, Dr. Kolk took a position at the Massachusetts Mental Health Center, a Harvard teaching hospital. There he recognized what would be the impetus for developing Complex PTSD as a diagnosis. Of psychiatry's understanding of incest in 1982, Dr. Van Der Kolk writes:

> I was particularly struck by how many female patients spoke of being sexually abused as children. This was puzzling, as the standard textbook of psychiatry at the time stated that incest was extremely rare in the United States, occurring about once in every million women. Given that there were then only about one hundred million women living in the United States, I wondered how forty seven, almost half of them, had found their way to my office in the basement of the hospital. (Kolk 19)

Dr. Kolk goes on to describe the extent of trauma in the United States at the time of writing his book in 2015:

> While about a quarter of the soldiers who serve in war zones are expected to develop serious posttraumatic problems, the majority of Americans experience a violent crime at some time during their lives, and more accurate reporting has revealed that twelve million women in the United States have been victims of rape. More than half of all rapes occur in girls below age fifteen. For many people the war begins at home: Each year about three million children in the United States are reported as victims of child abuse and

> neglect. One million of these cases are serious and credible enough to force local child protective services or the courts to take action. In other words, for every soldier who serves in a war zone abroad, there are ten children who are endangered in their own homes. This is particularly tragic, since it is very difficult for growing children to recover when the source of terror and pain is not enemy combatants but their own caretakers. (Kolk 20)

Reading this, it is unsurprising that I or anyone might be triggered by a computer science classroom packed with men watching pictures of pornstars on the blackboard in order to understand image dithering. It is also unsurprising that this environment would provide opportunity for me to live out repeats of my trauma.

Research has shown that a victim of trauma's pattern reflects their survival options at the original traumatic event. Human responses to trauma include fight, flight, or freeze. If a victim was restrained during their traumatic event and unable to move, then they may have dissociated and frozen up in order to protect themselves from the event. That victim would then be more likely to respond to triggers with a freeze response later on. Sadly, research shows that the victim is more likely to experience trauma in the future due to desensitized fear responses, belief that the trauma was their fault, and a host of other reasons that are beyond the scope of this paper. What I want to describe is the vulnerable population in CS courses — the population I squarely belong to — and my prospects of success in the field.

My point can best be made with an example. Late one Saturday night during my first term at USC, I was working on programming an assignment for one of my core classes for my MFA. I had been programming for a year already, but it was clear that I was one of the worst

coders in my cohort of fifteen classmates. I desperately wanted to progress and prove my worth on a team. I was working through a triple four loop at about 11:30 pm in the MxR Studio when a classmate appeared at the door. I needed the studio to look at my work in VR, and I worked there on the weekends when the headsets were free. I was reluctant to let my classmate in. I had a key to the lab and he did not. But I had been struggling for several hours, and he promised to help me. I had an inkling that something else might be going on, but I had also become slightly desensitized to men in computer science being awkward around me. Not only was I a woman and older than most classmates, but I wasn't good at computer science initially. I wasn't a star example of female empowerment. I was struggling and scared. If I needed help on a computer science problem, I had to ask the one person I was essentially wired to fear — a man. Hoping to overcome this fear and improve as a coder, I let this young man into the lab to help me.

He sat behind and slightly to the side of me as I worked. After some time, he began feeling my ribs, kissing my shoulders, smelling my neck, and otherwise fondling my body. I froze up and continued coding. This went on for about forty five minutes. After I'd finished my work, I whispered, "Why are you doing this?" I packed up my things and left him alone in the lab. I later learned that he was angry with me for being "a tease." Our interpretations of that night could not have been more different. This event was preceded and followed by other instances of computer science classmates pretending to help or tutor me when in fact they ended up making a pass at me. I've been sent graphic messages and images and called disgusting names. These experiences, combined with the constant questioning of my capability as a coder by teachers and mentors, lead to my survival tactic of isolating myself from any potential resource which I perceived to be a potential threat.

My long term plan was to teach computer science to more diverse groups of youth in order to make the field itself more livable for me. I began teaching Code Camp, a once-a-week after-school program for whomever wanted to attend. After six sessions of Code Camp among various age groups, I realized that the group I most wanted to reach was women of color. Code Camp had taught me that any age group could learn to code, but that the most effective classrooms held students of similar ages. Because of this, and our desire to impact student choice of a major in college, *Palimpsest* focused on high schoolers.

Upon entering our *Palimpsest Program* as a teacher, my mindset was that of a woman who had remained in this field long enough to teach by a narrow margin. In developing the *Palimpsest Program*, I was pursuing a safe space *for myself*. However backwards that sounds, that was my starting mindset. I had to go from there to realizing that, within the context of our classroom, I was the person who could most easily slip into the role of the oppressor.

In order to effectively hear and integrate Grace' feedback, I had to accept that, regardless of how I saw myself, the only thing that mattered in this classroom was how my students and collaborators saw me. As the teacher of a curriculum I helped design, I held the power. Consequently, I am the one who needs to seek consent from the students to go on this educational journey with me. In order to receive consent, I need to recognize the signs of non-consensual classroom experiences: furrowed brows, quiet voices, and concerned student advocates like Grace. Essentially, I had to shift my focus from myself to them.

In order to shift my focus, I redoubled my efforts to meet my needs outside of the classroom so that I could attempt to meet the needs of my students in the classroom. Meeting my needs meant getting more sleep, eating more nutritious food, taking a day off a week, and

committing myself to therapy at Cognitive Behavioral Therapy California. If I completed less lesson preparation for the high school class, but walked into the classroom with an authentically warm attitude that was ready to greet the students and hear them, then that was the right tradeoff. Marientina Gotsis has helped me understand this process as "mindful integration."

This was only dawning on me as I sat in that first class at the high school watching Karen teach. From the outside looking in, one might conclude that I was too weighed down with my own "issues" or "baggage" to serve a community that I know little about. I don't want you to make that conclusion. Trying to figure out how you can be useful to a community you don't belong to is illuminating. Grace told me, "Learn from them. They know things that you don't." In releasing my grip on the knowledge that I'd fought so hard to acquire, I opened my heart to new relationships and new perspectives of the world. At the start of one class I asked them what they wanted to change about the world, and if learning to code could help. Their concerns were about the environment, equal opportunity, and beauty. We had to acknowledge that maybe coding couldn't help. Maybe what I was putting forth with the 1's and 0's was irrelevant to their paths in life. But maybe not. In my view, this was one of the best discussions I lead with the class.

Personal motivations to attempt something are important. They are the flame beneath the pot of water. Motivation can carry one's commitment to a task over long stretches of time and difficult transformations of self. Motivations arise from our vulnerabilities, and if handled well, they can strengthen us and the communities around us. Our vulnerability in one context can be our strength in another. The challenge is to shift your priorities with your context.

CBT has taught me that my priorities fall into three buckets: objectives, relationship, and self-respect. As an aspiring programmer at USC, my priority was usually maintaining my self-respect. My second priority was doing a good job, and my third priority was maintaining positive relationships with computer science classmates and teachers. Within the context of being the oppressed, my default stance was drawing boundaries: don't touch me, don't insult me, don't talk down to me, don't underestimate me. I prioritized my self-respect because that is what the context called for.

As a teacher in a South Central LA high school, my priorities had to change. In order to avoid being oppressive, I had to prioritize my relationship with the students. If I lost their consent and trust, I'd lost everything I came there to do. Meanwhile, I'd based our curriculum on half the content of a college level computer science 101 course. I did this to prepare them for success in the field and to help them avoid the feelings of fear that paralyzed me. I pushed Allison and Grace and Karen to create four times the amount of curriculum content that we could possibly cover in the time we had. Essentially, I was too hard on the students. That was evident in their mid curriculum assessment form results (Appendix F), in which more than a third of the students reported feeling uncomfortable asking questions in class. I'd recreated the power dynamics that I was trying to undo.

In order to prioritize my relationship with my students, I had to demote my external objective of getting through all of the curriculum to second place. In order to make myself available to the students' feedback, I had to stop trying to defend my self-respect. That was a habit I'd picked up at NYU and USC that was no longer useful to me in the high school

classroom. After I made this shift in priorities halfway through the course, the *Palimpsest Program* improved.

"That's the juice," Grace told me. She was describing to me how a student had been arguing with her. "If they're quiet and compliant, you're failing. If they're asking questions, you're doing ok. Shouting questions is better. But arguing with me, in my class? That's the juice." Her eyes lit up as she smiled, delighting in the memory of her student's defiance for the sake of clarity and understanding.

4.3 Protect Stories

There is still little narrative in the VR game of *Palimpsest*, but Allison and I have been writing and rewriting the narrative for this past year and a half. The story we initially connected on was that of an overprotective mother inflicting her fears onto her daughter in order to teach her to survive life's challenges. In this case, the player was the daughter and the giantess was the mother. Both Allison and I deeply connected to this narrative.

When we began teaching the high school program though, we were inspired by how our students worked together to write about the main character and giantess as sisters. When the students broke off to make their own personal projects, we wrote the story as a dialogue between the main character and her inner self. When Allison got a job and I attempted to finish Palimpsest on my own, I wrote the story as a programmer who was being assaulted while coding, and dissociating. I wrote about the main character freezing up and projecting her spirit into the world of *Palimpsest* —- her coding project — in order to work out how to escape her real life assault.

There is a tradeoff when the story is vague. So long as they can see themselves in the main character's role, playtesters and the game designers alike can more easily project their meaning into a more vague story architecture. But those who cannot see themselves in the main character's role are lost. While Allison and I regularly play games starring cisgender white men, cisgender white men are not as used to playing characters that do not match their identity. Additionally, this group of playtesters tended to become anxious about resolving the uncertainty they felt. One cisgender white man playtester took off the headset and asked me, "What does it mean?" I explained that the game was currently up to his interpretation. He asked again, "Yeah I know, but just tell me what I am supposed to think. What does it mean? Who is the girl?" "Which girl?" I asked. "The girl, the one in the costume." "The main character?" I asked. "Yeah her." I said, "She's you." And then I wondered about that.

She's not him. And she's not me, either. She's not a blank, lovable, gender neutral cartoon designed for as many people as possible to identify with. She's a black teen woman. She does have a story, but it's not mine. I've come to believe that it would be unethical for me to inject my story into *Palimpsest*. *Palimpsest* — both the VR game and the high school program — is about the personal transformation of a black woman using technology to thrive in a challenging technological environment. Not only am I not black, and not from Los Angeles, but my experience with personal transformation is indelibly tied to trauma caused by sexual violence. While I have experienced my technological environment as sexually violent, injecting that narrative into *Palimpsest* would be destructive to our design goals. My experience could actually needlessly frighten young women of color from studying computer science.

Palimpsest is Allison's story. My only current goal for the narrative of our VR game is to be the midwife for her vision. Our primary challenge is scheduling, as we are both working full time and our efforts on *Palimpsest* as yet do not translate to food or rent or, in my case, even a steady job.

4.4 Limits And Revelations

I will underscore that the antagonist to story in games is scope. Ten years ago, I'd dropped out of a film program in Southeast Asia to teach middle schooler students in Manila how to make films on their cell phones. The program was open to all, but only girls stayed in the course. The week the girls wrote the stories they wanted to film, they shared with me multi page manuscripts handwritten in small print on single spaced lined paper. We then began the painful work of reading them in full and choosing the single paragraph that they would choose to film.

With games, I would shrink that buffer to a sentence. If the story of your game can be told in the title, you're in the right zone. The curse of being of a less supported minority in the games industry is you have more to say and less skill to say it. Writing is editing. Design by omission. For the impassioned minority newcomer to games, I advise taking an hour each morning to write the song of your heart, to code the fragments of your dreams, and carefully catalogue these snippets for a later date. When it comes to coding something that you hope the games community will understand, tackle one word: a feeling.

For us, "palimpsest" began as the feeling of making difficult choices within known constraints. Limited resources required people to etch out the writing on a tablet in order to inscribe something new in its place. For me, this resourcefulness mirrored the feeling of having

this one mind, and only twenty four hours in each day, within this one life, to live. To write something new, you must first make space. You must try to erase what was there before. Let it go. The more space you make, the more centrally it's located in your life, the more people will see your focus. The duelling counter thought is that the past cannot be changed. Nothing can be entirely erased. Nothing is lost. We are a shifting focus. "Palimpsest" is this shifting feeling of attachment and detachment, of reaching out and letting go. It is a power struggle. It's an ethical struggle. On what will you spend your precious time on Earth? True to form, Allison and I chose a difficult word to express in a game. In the event that we never finish it, I'm relieved to have unloaded my thoughts here.

4.5 Where Playtesters Fall Short

Playtesters will tell you if you've expressed what you intended to express. They will not tell you what to express. For that, you need a coven: a close-knit group of individuals who, for whatever reason, have invested in you and all of your flaws and beauty. These are the people who can read the whole story on your face. They require little explanation. They are proficient in their own craft, you trust them, and they can effectively convey to you the things you do not want to hear. These are the people with whom you share all your shelved experiments, your flash in the pan ideas, your deepest design fears and desires. These people are trustworthy with your secrets. Process media with your coven. Play games together, watch playthroughs, share articles, and surgically decide what to focus on. Building your coven takes time. Members need to earn your trust. This is a great place to practice building healthy trusting relationships.

4.6 Branding And Framing

Our students so clearly map to our protagonist that they do not need her to have a fully fleshed out story in the VR game. For our students, the core narrative is the trajectory of their lives. Each class they attend is marked by tangling with technology in order to thrive. Our VR game does not have to be good, finished, or even existent for it to effectively function as branding for the curriculum. Branding serves to recruit program participants and communicate the program tenants.

Initially, I'd thought we would remix code from the VR game to flesh out the high school curriculum, but this idea did not work at all. Our game's source code was too complex for us to debug, let alone our students. What we ended up doing is remixing the art assets from the VR game and sprinkling those throughout the curriculum. Concept art of our protagonist punctuates our slides. Music from our score and characters from our cast make delightful appearances in our curriculum exercises and labs. The poster for *Palimpsest* is the face of student binders. It's possible these artifacts carry more meaning within the context of student effort to learn computer science than they do within the game itself. Currently, the VR game serves as a container for our goal: students using technology to thrive. It is like a mascot or mantra. The VR game is a powerful suggestion.

Branding also serves to attract potential supporters. I prefer branding the Palimpsest Program with illustrations of a fictional character created by the program's founders rather than photos of real students, or work made by real students.

Work that attempts to benefit a community poses the risk of framing that community as being in need of said benefit. Taking pictures of our students coding might imply to the viewer

that the subject needed our service in order to code at a computer, which is not true. An alternate approach might be to showcase what the student created with code. But this puts undue pressure on the student to process new material and perform at the same time - pressure that is counter to learning, and often results in experts propping up student projects behind the scenes for the sake of a photo opportunity.

External-facing marketing material not for the viewer who "gets it," but the one who doesn't: the busy investor who needs a bright shiny object to appeal to social good tech blogs as evidence of corporate social responsibility. Instead of serving up our students as the unwitting subject of disenfranchised framing, we are serving up the fruits of our own labor. Allison and I have taken years to process digital art and coding course material and now we are ready to perform. Our protagonist is designed to represent our students as we see them: the hero who *the viewer* needs to heal our broader technological culture. Activist Lila Watson credits these words and meaning to Aboriginal activists group in Queensland in the 1970's:

> If you have come to help me, don't waste your time. But if you have come because your liberation is bound up with mine, let us work together. (Lilla Watson 2018)

Our students — their mere occupation of technological spaces — is in of itself a heroic resource for the future of our increasingly digital existence. When VR game imagery is used to market our high school program, that is what I intend for it to say.

4.7 The Future Of The Palimpsest Program

The VR game aside, there are a number of directions the *Palimpsest Program* could go from here. Our curriculum is composed of traditional computer science course materials

(lectures, labs, exercises) within a teaching framework for tailoring the classroom experience to the students. During the pilot program within our thesis year, we developed the course materials and framework. The next step would be to use our learnings to iterate on these elements. We could design a formal research study to test our teaching strategies. We could release a curriculum package online for teachers. We could license our framework and take a fee to run workshops or programming. Or we could simply use what we have to try to develop an online hub for aspiring developers who fit our target audience. A great example of this is Daniel Shiffman's processing.org, which hosts a visual programming language. Visitors can download the coding environment as a free app. The online site holds numerous tutorials labelled with their difficulty level. Tutorials are a concise text post with code, pictures, video, and example where relevant. The site also has an examples section where community members post their creations and code. *Palimpsest* could pursue making a storified version of this online hub for making games in Unity.

Going from a face to face interaction to an interaction online is difficult. An in-person guide can clarify so much confusion. Making our curriculum usable for teachers and students finding it online will take a sustained effort. Due to the inaccessibility of VR, we should redo the curriculum for a pc experience. Coding in C# for Unity has a markedly steeper learning curve than coding in processing. For the online route, it may be better to redo our work for GameMaker Studio or Construct, which are more friendly to new game designers.

Whatever the direction of our development, you can find it by visiting https://palimpsestvr.com/.

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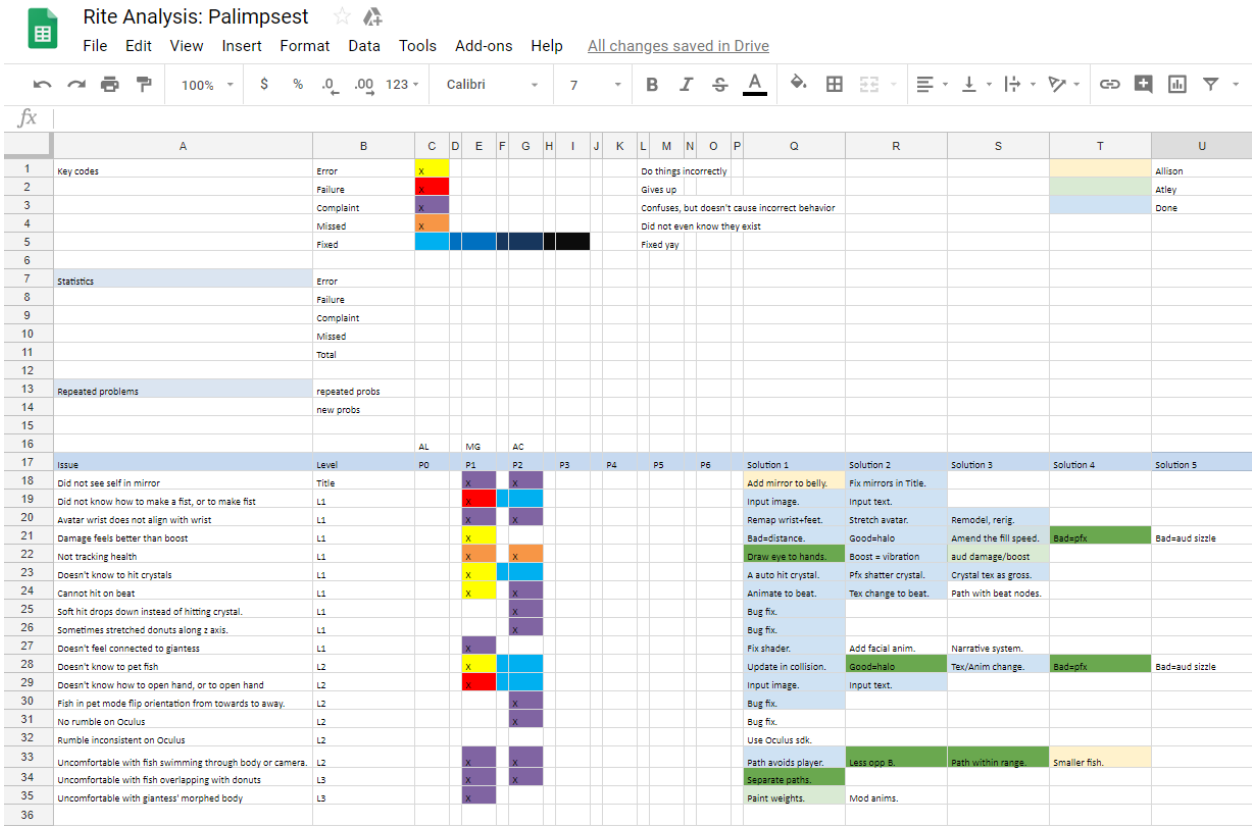
Appendices

Appendix A: RITE Analysis of Palimpsest VR game



Rite Analysis: Palimpsest

File Edit View Insert Format Data Tools Add-ons Help All changes saved in Drive

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Key codes	Error	x									Do things incorrectly									Allison
2		Failure	x									Gives up									Atley
3		Complaint	x									Confuses, but doesn't cause incorrect behavior									Done
4		Missed	x									Did not even know they exist									
5		Fixed										Fixed yay									
6																					
7	Statistics	Error																			
8		Failure																			
9		Complaint																			
10		Missed																			
11		Total																			
12																					
13	Repeated problems	repeated probs																			
14		new probs																			
15																					
16			AL		MG		AC														
17	Issue	Level	P0		P1		P2		P3		P4		P5		P6		Solution 1	Solution 2	Solution 3	Solution 4	Solution 5
18	Did not see self in mirror	Title			x		x										Add mirror to belly.	Fix mirrors in Title.			
19	Did not know how to make a fist, or to make fist	L1			x												Input image.	Input text.			
20	Avatar wrist does not align with wrist	L1			x		x										Remap wrist+feet.	Stretch avatar.	Remodel, rerig.		
21	Damage feels better than boost	L1			x												Bad=distance.	Good=halo	Amend the fill speed.	Bad=pfx	Bad=aud sizzle
22	Not tracking health	L1			x		x										Draw eye to hands.	Boost = vibration	aud damage/boost		
23	Doesn't know to hit crystals	L1			x												A auto hit crystal.	Pfx shatter crystal.	Crystal tex as gross.		
24	Cannot hit on beat	L1			x		x										Animate to beat.	Tex change to beat.	Path with beat nodes.		
25	Soft hit drops down instead of hitting crystal.	L1					x										Bug fix.				
26	Sometimes stretched donuts along z axis.	L1					x										Bug fix.				
27	Doesn't feel connected to giantess	L1			x												Fix shader.	Add facial anim.	Narrative system.		
28	Doesn't know to pet fish	L2			x												Update in collision.	Good=halo	Tex/Anim change.	Bad=pfx	Bad=aud sizzle
29	Doesn't know how to open hand, or to open hand	L2			x												Input image.	Input text.			
30	Fish in pet mode flip orientation from towards to away.	L2					x										Bug fix.				
31	No rumble on Oculus	L2					x										Bug fix.				
32	Rumble inconsistent on Oculus	L2															Use Oculus sdk.				
33	Uncomfortable with fish swimming through body or camera.	L2			x		x										Path avoids player.	Less opp B.	Path within range.	Smaller fish.	
34	Uncomfortable with fish overlapping with donuts	L3			x		x										Separate paths.				
35	Uncomfortable with giantess' morphed body	L3			x												Paint weights.	Mod anims.			
36																					

Appendix B1: Internal Review Board Application

1. **Full Title of Research Protocol**
   Palimpsest Program Pilot Development

2. **Short Title**
   Palimpsest Program

3. **Abstract: Provide a simple explanation of the study and briefly address (in 1 to 2 sentences) each of the following points: rationale; intervention; objectives or purpose; study population or sample characteristics; study methodology; description of study arms (if appropriate); study endpoints or outcomes; follow-up; statistics and plans for analysis.**

   The Palimpsest Program is an after school program dedicated to increasing the motivation in high school femmes to study computer science in college. We propose an eight-week pilot study to develop the Palimpsest Program curriculum. After curriculum development, we intend to apply to the IRB with a plan to research the efficacy of said curriculum. The ultimate goal of Palimpsest is to contribute towards a cultural shift towards femme culture in the field of Computer Science.

   Because many computer science courses at the high school level give the student the freedom to opt-out, cultural stereotypes can play a greater role in shaping that student body. By tailoring an optional curriculum to femmes, we seek to intervene with the trend of femmes opting out of early experiences with computer science.

   Our pilot study population will consist of 16 femmes at Augustus F. Hawkins High School's Critical Design and Gaming School (C:/DAGS). The setting will be two classrooms that make up the school's makerspace, which offers a slate of after school programs in art and technology to the student population. The school will manage recruitment for The Palimpsest Program. The key sample characteristics of the pilot study population are that they are:
   1. Femme
   2. Students of C:/DAGS
   3. Who want to learn programming within the context of creating interactive experiences for virtual reality

   Our pilot study methodology will include a community-based, participatory approach. We, the instructors, will take ethnographic field notes of changes to the curriculum, why we made those changes, and what we observed following the changes. Written surveys will document student feedback on our teaching strategies. We will film lessons and student interviews for the purpose of recruitment.

   There will be three outputs of the documentation of this pilot study:
   1. Two Interactive Media and Games Division MFA thesis papers written by instructors Allison Comrie and Atley Loughridge, respectively. Each thesis paper will be available to the public through USC's library both online and in person.
   2. A document that describes the interactive curriculum we developed for use by teachers.
   3. A short film documentary that may be used as recruitment for the next phase of research.

4. **What is the maximum number of subjects you plan to recruit for this site?**

   16 high school students will be recruited for the program.

Appendix B2: Internal Review Board Application

5. **Describe the inclusion criteria for enrollment.**

   As we are collaborating with Augustus F. Hawkins High School's Critical Design and Gaming School, the inclusion criteria for this program is that the participants are femme-identifying students, grades 9th-12th, who want to participate in this program.

6. **Describe the exclusion criteria for enrollment.**

   Non-femme-identifying participants or femme identifying participants that do not attend Augustus F. Hawkins High School grades 9th-12th will not be accepted into the program.

7. **If there are any age, ethnic, language, or gender-based exclusion criteria, please provide justification.**

   As our ultimate goal is a cultural shift, our study population consists of those who identify with femme culture. "Femme" is an alternative to gender binary terms of "woman" or "female." "Femme" explicitly includes women, trans, non-binary persons, as well as anyone who identifies as, "femme". In the future, we intend to develop methods to safely recruit students who self-identify as "femme." However, we currently lack the safeguards to protect trans and non-binary students from possible stigmatization for their participation in a femme program. Therefore, this current pilot study will be advertised to a group that is already identified as "women" at the high school. However, the advertisement and recruitment materials will use the term "femme."

   From the mid-2000's to now, about 20% of computer science bachelor's degrees in the United States are awarded to women (National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System (WebCASPAR), https://webcaspar .nsf.gov). One reason for this is that men are disproportionately exposed to learning experiences with computer science before college. Such experiences are often opt-in based on the student's preference, student's opt-in based on their sense of belonging to the culture signalled to them by the learning experience, and the culture signalled by computer science learning experiences is often stereotypically masculine (Cheryan, S., Ziegler, S.A., Montoya, A.K., Jiang, L. (2016). Why Are Some STEM Fields More Gender Balanced Than Others? Psychological Bulletin 2017, Vol. 143, No. 1, 1–35). Our justification for excluding males from this pilot study is to clearly signal to femmes that they belong to the culture of our pilot study.

   The age restriction is in place because we want to expose students to computer science while they are making plans for higher education.

8. **Describe the specific objectives or aims of the study and hypotheses or research questions.**

   The objective of the pilot study is to develop curriculum to later test for its efficacy in motivating femmes to study computer science in college. Our current research question is, "Which education strategies are most worth testing?" We will evaluate the student's enjoyment of the education strategies and the ease with which these strategies could be employed by another teacher at another school.

Appendix B3: Internal Review Board Application

We hypothesize that the following teaching strategies may be worth testing:

1. Teaching approaches based on psychological theory of motivation (Ryan, R.M., Deci, E.l. (2000). Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. American Psychologist January 2000, Vol. 55, No. 1, 68-78)
2. Resilience skill-building activities, e.g. mindfulness
3. Lecture visuals/metaphors/objects that disrupt current computer science stereotypes
4. Representation of femmes in a relatable way amongst the teachers and visiting lecturers (e.g. represented femmes in computer science provide an explanation for how they went from being a high school student to being a practitioner)

Ryan and Deci describe three components of motivation: autonomy, competence, and relatedness. We aim to provide autonomy for students to influence aspects of the content, pace, and direction of the curriculum by integrating their verbal feedback on the lesson as we teach. For the second part of the program, students will work on a self-directed project of their own design.

There will be no formal evaluation of competence (e.g. written exams). Rather, within the context of programming within a game engine, students will visually observe the results of their growing computer science skill set.

Relatedness is defined as the need to feel belongingness and connectedness with others. Motivational theory suggest that relatedness is centrally important for internal motivation. We aim to integrate relatedness into our curriculum by making more than half of the exercises collaborative, open-ended explorations. By de-emphasizing pre-defined, "correct" outcomes, we aim to place a premium on relational bonds formed with peers.

Cheryan, Ziegler, Montoya, and Jiang point to the value of relatable role models over role models who only match the student's gender. Letting the students explore prompts and self-defined projects is that we the instructors will, at times, not know how to solve bugs that arise in their programs. One strategy with which we aim to make ourselves relatable to the students is be honest about the limits of our knowledge, and to share in leaning on the same design and bug-solving tools that they do in order to problem solve. Another version of this strategy is to be honest about our limits in understanding what learning strategies are working for the students, and to make space for them to vocalise in class how they would prefer to learn.

We feel that much of what we need in order to develop this curriculum will be evident in our field notes of the pilot study. However, anonymous surveys before students enter the study and once students leave the study would reinforce and challenge our own assessment of the pilot study. Before starting the program, knowing a little about student expectations will help us start off in a place that is relevant to them.

Questions are designed to track changes in the following areas from before starting our pilot study to after completing our pilot study.

- Motivation
- Competency (self efficacy)
- Autonomy
- Relatedness

Appendix B4: Internal Review Board Application

- Role models
- Enjoyment
- Anxiety
- Assessment of the program
- Resilience
- Emotional regulation
- Executive function
- Cultural perception of computer science

Pre and Post Assessment

1. What do you hope to get out of this program? (rate the following from 1 to 5)
    a. New friends
    b. A cool project
    c. Knowledge of how to program
    d. Knowledge of how to make art with technology
    e. A mentor who I can relate to
2. How would you describe this program to someone who was thinking about applying? (short response)
3. Have you ever looked at a programmer and thought, "Hey, that could be me!" (y/n)
4. How would you rate your programming skills? (scale of 1 to 10, low/high)
5. What are the pros and cons of studying computer science? (short response)
6. How often do you find yourself problem-solving? (rarely/sometimes/often/all the time)
7. Describe a moment when a science concept really "clicked" for you. What helped it click?
8. Have you found you're able to apply your "engineering mind" to other aspects of life? (y/n)
9. If someone said they were having trouble with a programming problem, how comfortable would you feel trying to help them? (not/maybe/very)
10. Tell us about an outdoor activity that helps you clear your head. (short answer
11. For you, what's the most important ingredient to being able to focus?
    a. Quiet space
    b. An environment I like
    c. Seeing how the task at hand fits into the bigger picture
    d. Feeling like I can do the task at hand
    e. Feeling like I have a say in what I want to focus on
12. How likely are you to study programming in the future? (scale of 1 to 5, not likely/likely)
13. How much say do you feel like you have over what you learn in school? (scale of 1 to 10, no say/lots of say)
14. How comfortable do you generally feel asking a question in class? (scale of 1 to 5, uncomfortable/comfortable)
15. Is there anything you want to share that we haven't covered? (short response)

Post Assessment

1. Rate your favorite parts of this program:
    a. Lectures
    b. Tactile Activities (with beads and pipe cleaners)
    c. Tutorial Activities (on the computer)
    d. Group Activities (mindfulness exercises)

Appendix B5: Internal Review Board Application

    e. Team Project
2. Have you learned any skills that actually help you solve problems? (y/n)
    a. If so, what?
3. How would you describe this program to someone who was thinking about applying? (short response)
4. How would you rate your programming skills? (scale of 1 to 10, low/high)
5. How often do you find yourself problem-solving? (rarely/sometimes/often/all the time)
6. Have you found you're able to apply your "engineering mind" to other aspects of life? (y/n)
7. Describe the best moment of this program. (short response)
8. If someone said they were having trouble with a programming problem, how comfortable would you feel trying to help them? (not/maybe/very)
9. What was your favorite part of the program? Least favorite? (short response)
10. What are the pros and cons of studying computer science? (short response)
11. How likely are you to study programming in the future? (scale of 1 to 5, not likely/likely)
12. In which course activities did you feel that you had the most control?
    a. Lectures
    b. Activities
    c. Team Project
13. How would you describe your mood during our classes? (scale of 1 to 5, anxious to joyful)
14. Did you feel you bonded with your classmates? (y/n)
    a. If so, what brought you closer together?
15. What was the most challenging part of this program? (short response)
16. What did you most look forward to before coming to class:
    a. Seeing friends
    b. Working on projects
    c. Learning new material
    d. Meeting professionals from the industry
17. How much say did you feel like you had over what was taught? (scale of 1 to 10, no say/lots of say)
18. How comfortable did you feel asking a question in class? (scale of 1 to 5, uncomfortable/comfortable)
19. Did you tell anyone else about your work in this program? (y/n)
    a. If so, who?
20. During this course, was there any one you learned of or met who made you think, "wow, I could do that!" (y/n)
    a. If so, who? When did you have that realization? (short response)
21. Is there anything you want to share that we haven't covered? (short response)

9. Provide a summary of the background of the study, and explain how this research will contribute to existing knowledge. Describe previous work that provides a basis to show that the proposed research can be carried out without undue risk to human subjects. Include relevant citations.

This pilot study aims to contribute to an eventual research plan that applies motivational theory to gender disparities in computer science participation.

"Why Are Some STEM Fields More Gender Balanced Than Others?" points out that "more research is needed on whether the lack of female role models, the lack of relatable role models, or both contribute to current gendered patterns in STEM participation." By creating curriculum that

Appendix B6: Internal Review Board Application

aims to integrate role models and relatability to those role models, we aim to eventually contribute to the understanding of whether or not role models and/or relatable role models contribute to the current gendered pattern in computer science participation.

The researchers of the above article also state that "more research is needed on STEM enjoyment and anxiety to determine whether these factors can explain variability in gender participation within STEM." The researchers cite conflicting findings for the relationship between anxiety/enjoyment and performance, and divergent findings for whether or not women have more STEM anxiety than men. In developing a curriculum that aims to make learning computer science enjoyable for femme students, we could eventually contribute to the knowledge of whether or not our teaching strategies increase enjoyment and decrease anxiety for femmes studying computer science, and whether or not increased enjoyment yields higher performance or higher motivation.

However, the scope of this application to the IRB only includes the development of the pilot study. From this study, no generalizable claims can be made. In of itself, the pilot study resembles not a research protocol, but an educational enrichment program for women. Similar programs include:

- Code Liberation catalyzes the creation of digital games and creative technologies by women, nonbinary, femme, and girl-identifying people to diversify STEAM fields (http://codeliberation.org/). This organization runs multi-week classes, workshops, game jams, hackathons, and social game nights in nyc and London.
- Black Girls Code have the vision to increase the number of women of color in the digital space by empowering girls of color ages 7 to 17 to become innovators in STEM fields, leaders in their communities, and builders of their own futures through exposure to computer science and technology (http://www.blackgirlscode.com/). This organization runs hackathons, workshops, and summers camps in 10+ United States cities and around the world.
- Girls Who Code was founded to close the gender gap in technology (https://girlswhocode.com/). This organization runs courses, workshops, and summer camps at secondary schools and universities in 6 United States cities.

All three of these organizations provide computer science curriculum to high school females in association with a nearby university or secondary school, which may also be the student's actual school. These organizations pose and manage similar risks to the subject as ours does:

1. The risk that the subject is identified as a participant by a fellow classmate (not in our pilot study). Students of Augustus F. Hawkins High School's Critical Design and Gaming School and their families have already opted in to a gaming-focused high school. As computer science is a critical component of gaming, we infer that the school's culture and the student's familial culture already positively correlates with computer science.
2. The risk that pre and post assessments are accessed by an outsider. Pre and post assessments will be anonymous, and we will not collect any personal information about the student. We will also keep paper copies in a locked container and digital copies on a computer with up to date security and firewall protection. We assess this risk to be low probability and low magnitude.
3. The risk that the subject is identified as a participant by the recruitment documentary. An outsider could view the recruitment documentary on our site online and compare a student's image with their yearbook image and identify the student. This is low

Appendix B7: Internal Review Board Application

probability. We also assess it to be low magnitude of risk because it's more likely than not that perception of a student's participation in this pilot study will be positive. Students will be made aware of this risk in the media release form and they will also have "final cut" rights on how their image in used in the documentary - meaning all students will have to approve the documentary before it is able to be published online.

4. The risk that the subject is made to feel uncomfortable as a result of their performance. We are not collecting data on student performance. We assess this risk to be a moderate probability and a moderate magnitude. We don't know what the range of experience will be in the class, but there will be a range. We aim to mitigate this risk by pairing students with a teammate who seems to be at a complimentary skill level. We aim to de-prioritize product, and prioritize process, so students do not feel pressure to perform. We also aim to discuss student work using "growth mindset" rather than "fixed mindset" terminology. Rather than saying, "you're a good programmer!", we would say, "I see the way you broke down that challenge into manageable parts."

With these risk assessment and risk mitigation strategies in place, we assess that we are able to offer this pilot study to our students without posing any more risk than the three organizations mentioned above.

10. **Describe how you will minimize the potential for employees and/or students to feel coerced to participate. Discuss how the potential confusion in roles will be addressed.**

We have no employees. All persons assisting with this pilot study are doing so of their own volition. We will minimize the potential for employees to feel coerced by reminding them that participation is voluntary. We will also remind them that formation of the curriculum is intended to be collaborative, and invite feedback on their activities. Lastly, we will go through the program design with volunteers one week before start so that they have time to articulate concerns and comments.

In conjunction with several other after school programs, students for our pilot study will be recruited through the makerspace at the Augustus Hawkins High School's Critical Design and Gaming School. If interested in our pilot study, students apply to participate in our study through the makerspace. There is no pressure for students to apply to our pilot study over the other after school curriculum offered by the makerspace. The makerspace will then accept students into the various after school programs based on availability. At that point, we will give the student assigned to us by the makerspace a consent form (containing all the basic elements of consent) and media release for them and their parents to read and sign. Both forms will be provided in English and Spanish. Accepted students will have a week between receiving the consent and media release forms and the pilot study start date.

The consent form will state that participation is voluntary, refusal to participate or discontinuing participation at any time will have no effect on the student's grades, and no penalty or loss of benefits to which the student is entitled.

11. **If there is any additional information that you wish to communicate about the study include it below. Please note, this section should not be used instead of the standard application items.**

Appendix C: Internal Review Board Application Approval

Atley Loughridge <aloughri@usc.edu>

Study Approval Notice Sent

3 messages

istar-DoNotReply@usc.edu <istar-DoNotReply@usc.edu> Thu, Mar 8, 2018 at 2:36 PM
Reply-To: istar-DoNotReply@usc.edu
To: acomrie@usc.edu, mgotsis@cinema.usc.edu, aloughri@usc.edu

University of Southern California University Park Institutional Review Board
3720 South Flower Street Credit Union Building (CUB) #301
Los Angeles, CA 90089-0702
Phone: 213-821-5272
Fax: 213-821-5276
upirb@usc.edu

Date:	Mar 08, 2018, 02:36pm
Action Taken:	**Approve**
Principal Investigator:	Allison Comrie, SCHOOL OF CINEMA-TELEVISION
Faculty Advisor:	Marientina Gotsis SCHOOL OF CINEMA-TELEVISION
Co-Investigator(s):	Atley Loughridge, SCHOOL OF CINEMA-TELEVISION
Project Title:	**Palimpsest Program**
Study ID:	**UP-18-00100**
Funding:	N/A - no funding source listed

The University Park Institutional Review Board (UPIRB) designee determined that your project meets the requirements outlined in 45 CFR 46.101(b) category (1) and qualifies for exemption from IRB review. This study was **approved on 03/02/2018** and is not subject to further IRB review.

Consent and recruitment documents are not required to be uploaded for exempt studies; however, researchers are reminded that USC follows the principles of the Belmont Report, which requires all potential participants to be informed of the research study, their rights as a participant, confidentiality of their data, etc. It is recommended that you utilize the Information Sheet For Exempt Research and revise the template to be specific to your study. This document will not be reviewed by the IRB. It is the responsibility of the researcher to make sure the document is consistent with the study procedures listed in the application.

Please check with all participating sites to make sure you have their permission to conduct research prior to beginning your study.

Per USC Policy, someone may not collect data about people he or she oversees in a professional capacity. Please ensure that someone on the study (represented in 2.1, with the required human subjects certification) is able to serve as an independent data collector. Further, data must be stripped of any identifying information before being provided to people who have the supervisory relationship in order to protect the confidentiality of the participant responses.

Appendix D1: Curriculum Youth Assent Parental Permission

University of Southern California
Interactive Media and Games Division
3470 McClintock Ave (Room #201)
Los Angeles, CA 90018

Palimpsest Program

You are invited to participate in a pilot program conducted by Allison Comrie and Atley Loughridge, MFA candidates, and Marientina Gotsis, MFA, from the University of Southern California. Your participation is voluntary. You should read the information below, and ask questions about anything you do not understand before deciding whether to participate.

Please take as much time as you need to read the consent form. Your child will also be asked his/her permission. Your child can decline to participate, even if you agree to allow participation. You and/or your child may also decide to discuss it with your family or friends. If you and/or your child decide to participate, you will both be asked to sign this form. You will be given a copy of this form.

PURPOSE OF THE PROGRAM

The Palimpsest Program is comprised of lessons and tutorials centered around computer science and game design. During an eight week pilot, we will collaborate with the Critical Design and Gaming School (C:/DAGS) to develop teaching methods tailored to the students using a community-based participatory approach. In addition, we will be exposing the students to industry and professional opportunities by inviting guest lecturers to co-teach lessons.

This program is the thesis project of MFA students Allison Comrie and Atley Loughridge, who will be serving as instructors for the program. Instructors hope to learn whether students enjoy the experience, what they learn from it, and how it may inspire them to pursue computer science or game design after high school.

TEACHING METHODOLOGY

Our teaching methods will be informed by our students' experiences. It is our goal to collaboratively develop our curriculum.

- Providing autonomy/agency:
    - Students will complete a pre-assessment survey, which will inform teaching methods.
    - In class, students will complete individual and group exercises in which they will design their final project.
- Providing opportunities for security and relatedness:
    - Students will have the opportunity to disagree with and amend curriculum in real time.

Appendix D2: Curriculum Youth Assent Parental Permission

    - Students will have the opportunity to participate in group exercises designed to facilitate expressing thoughts, interests, and concerns about the curriculum.
    - Students will choose partners with whom to develop a project of their choosing.
    - Some lectures will feature potential role models in computing as guest lecturers.
- Providing clear measures of competency:
    - Computing exercises will provide visual and auditory feedback or proof of the student's programming input.
    - Week by week, computing exercising will build on each other. By the end, students can compare their final program with their first program.
- Encouraging resilience:
    - Each class will include mindfulness exercises.
    - The final class will invite friends and family to see the student's work.
    - The final class will give friends and family information about free resources for their child's interest in computing.

A post-assessment survey and ethnographic field notes, including documentary footage, will complete our documentation of the pilot. The pilot will develop curriculum that incorporates ways for the instructors to collaborate with students in tailoring a motivation-centric approach to teaching computer science to femme students.

POTENTIAL RISKS AND DISCOMFORTS

There are no potential risks to your participation. If you feel any discomfort, you are free to not participant in any activity.

CONFIDENTIALITY

We will keep your records for this program confidential as far as permitted by law. However, if we are required to do so by law, we will disclose confidential information about you. The members of the research team and the University of Southern California's Human Subjects Protection Program (HSPP) may access the data. The HSPP reviews and monitors research studies to protect the rights and welfare of research subjects.

The data will be stored on a password protected computer and kept indefinitely.

PARTICIPATION AND WITHDRAWAL

Your participation is voluntary. Your refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this program.

INSTRUCTOR CONTACT INFORMATION

If you have any questions or concerns about the program, please contact:

Appendix D3: Curriculum Youth Assent Parental Permission

RIGHTS OF RESEARCH PARTICIPANT – IRB CONTACT INFORMATION

If you have questions, concerns, complaints about your rights as a participant and are unable to contact the program team, or if you want to talk to someone independent of the program team, please contact the University Park Institutional Review Board (UPIRB), 3720 South Flower Street #301, Los Angeles, CA 90089-0702, (213) 821-5272 or upirb@usc.edu

SIGNATURE OF PROGRAM PARTICIPANT

I have read the information provided above. I have been given a chance to ask questions. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

Name of Participant _____

Signature of Participant _____ Date _____

SIGNATURE OF PARENT(S)/LEGALLY AUTHORIZED REPRESENTATIVE

I have read the information provided above. I have been given a chance to ask questions. My questions have been answered to my satisfaction, and I agree to allow my child participate in this study. I have been given a copy of this form.

Name of Parent/ Legally Authorized Representative _____

Signature _____ Date _____

Appendix D4: Curriculum Youth Assent Parental Permission

AUDIO/VIDEO/PHOTOGRAPHS

□ *I agree to be audio/video-recorded /photographed*

I agree to have my footage used in:
- □ *Lecture materials for educational purposes*
- □ *Promotional materials (website, applications for funding)*
- □ *Assessment/ Evaluation purposes by program team*
- □ *I would like to be credited if my footage is used in the documentary*
  - □ *I agree to be credited by first name*
  - □ *I agree to be credit by my full name*
  - □ *I would like to be credited by a different name:* _____

□ *I do not want to be audio/video-taped/photographed*

Name of Parent/Legally Authorized Representative _____

Signature of Parent/Legally Authorized Representative _____

Date _____

SIGNATURE OF INVESTIGATOR

I have explained the research to the participant and his/her parent(s)/Legally Authorized Representative, and answered all of their questions. I believe that the parent(s) understand the information described in this document and freely consents to participate.

Name of Person Obtaining Consent _____

Signature of Person Obtaining Consent _____ Date _____

Appendix E1: Mid Curriculum Assessment Questions

Palimpsest Program Pre Assessment Questions

What do you hope to get out of this program? (rate the following from 1 to 5)

[ ] New friends
[ ] A cool project
[ ] Knowledge of how to program
[ ] Knowledge of how to make art with technology
[ ] A mentor who I can relate to

How would you describe this program to someone who was thinking about applying?

Have you ever looked at a programmer and thought, "Hey, that could be me!" (circle one) Y / N

How would you rate your programming skills? (circle a number)

low 1 2 3 4 5 6 7 8 9 10 high

What are the pros and cons of studying computer science?

How often do you find yourself problem-solving? (circle one)

Rarely Sometimes Often All the time

Describe a moment when a science concept really "clicked" for you. What helped it click?

Do you feel that you apply your engineering skills to other aspects of your life? (circle one) Y / N

If someone said they were having trouble with a programming problem, how comfortable would you feel trying to help them? (circle one)

Not Comfortable Maybe Comfortable Very Comfortable

Tell us about an outdoor activity that helps you clear your head.

Appendix E2: Mid Curriculum Assessment Questions

For you, what's the most important ingredient to being able to focus? (rate from 1 to 5)

[ ] Quiet
[ ] An environment I feel comfortable in
[ ] Seeing how the task at hand fits into the bigger picture
[ ] Feeling like I can do the task at hand
[ ] Feeling like I have a say in what I want to do

How likely are you to study programming in the future? (circle a number)

not likely 1 2 3 4 5 likely

How much say do you feel like you have over what you learn in school? (circle a number)

no say 1 2 3 4 5 6 7 8 9 10 lots of say

How comfortable do you generally feel asking a question in class? (circle a number)

uncomfortable 1 2 3 4 5 very comfortable

Is there anything you want to share that we haven't covered?

_____

_____

Appendix F1: Mid Curriculum Assessment Form Results

	A	B	C	D
1	What do you hope to get out of this program? (rate the following from 1 to 5) A: [ ] New friends B: [ ] A cool project C: [ ] Knowledge of how to program D: [ ] Knowledge of how to make art with technology E: [ ] A mentor who I can relate to	A: 1 B: 3 C: 4 D: 5 E: 2	A: 3 B: 5 C: 3 D: 5 E: 5	A: B: x C: x D: x E:
2	How would you describe this program to someone who was thinking about applying?	It's a fun program, a program that is interactive, enjoyable, and a way to release your creative imagination.	You can learn some amazing things about aming + tech, even if you're not interested in doing this as a career.	If the person is into programming and design, they should join.
3	Have you ever looked at a programmer and thought, "Hey, that could be me!" (circle one) Y / N	Y	N	Y
4	How would you rate your programming skills? (circle a number 1 to 10)	8	5	7
5	What are the pros and cons of studying computer science?	Pros: being able to progress. Cons: Bugs, errors, unable to find out what's wrong.	Pros you have the advantage of others. Cons it can be a long boring process.	Pros you'll learn computer science and do some games on your own. Cons it is a hard concept.
6	How often do you find yourself problem-solving? (circle one)	All the time	All the time	Often
7	Describe a moment when a science concept really "clicked" for you. What helped it click?	A photosynthesis concept.	The process of photosynthesis, on the Magic School Bus.	I am good in Chemistry
8	Do you feel that you apply your engineering skills to other aspects of your life? (circle one) Y / N	Y	Y	N
9	If someone said they were having trouble with a programming problem, how comfortable would you feel trying to help them? (circle one)	Maybe Comfortable	Maybe Comfortable	Very Comfortable
10	Tell us about an outdoor activity that helps you clear your head.	Drawing Outdoors	Playing Volleyball / and Skating	Just to walk
11	For you, what's the most important ingredient to being able to focus? (rate from 1 to 5) A: [ ] Quiet B: [ ] An environment I feel comfortable in C: [ ] Seeing how the task at hand fits into the bigger picture D: [ ] Feeling like I can do the task at hand E: [ ] Feeling like I have a say in what I want to do	A: 5 B: 4 C: 2 D: 1 E: 3	A: 4 B: 5 C: 4 D: 5 E: 5	A: x B: C: x D: x E:
12	How likely are you to study programming in the future? (circle a number)	4	3.5	3
13	How much say do you feel like you have over what you learn in school? (circle a number)	10	10	3
14	How comfortable do you generally feel asking a question in class? (circle a number)	4	5	4
15	Is there anything you want to share that we haven't covered?	No	I'm really excited to be in this program.	No.

Appendix F2: Mid Curriculum Assessment Form Results

	A	E	F	G
1	What do you hope to get out of this program? (rate the following from 1 to 5) A: [ ] New friends B: [ ] A cool project C: [ ] Knowledge of how to program D: [ ] Knowledge of how to make art with technology E: [ ] A mentor who I can relate to	A: 2 B: 4 C: 5 D: 5 E: 3	A: 2 B: 4 C: 5 D: 5 E: 3	A: x B: x C: D: x E:
2	How would you describe this program to someone who was thinking about applying?	Fun, knowledgable, interesting and engaging.	It's fun and you experience how to make a game. It's very informative and you learn how to code and use a software to code.	I would describe it fun and creative.
3	Have you ever looked at a programmer and thought, "Hey, that could be me!" (circle one) Y / N	Y	N	N
4	How would you rate your programming skills? (circle a number 1 to 10)	3	3	1
5	What are the pros and cons of studying computer science?	Pro: It helps for the future career I want. Con: There is no con unless you don't want to be in the field.	Cons is if you don't understand a concept it'll be hard to understand everything. Pro it's good for your reputation, it's fun to learn new things and achieve something that was hard to make.	Cons-confusing
6	How often do you find yourself problem-solving? (circle one)	Often	Sometimes	Often
7	Describe a moment when a science concept really "clicked" for you. What helped it click?	Astronomy: Super Novas. I watched a TV show about it.	The galaxy what helped it click was perhaps knowing you are in a galaxy in a vast openly space that has many other galaxies.	
8	Do you feel that you apply your engineering skills to other aspects of your life? (circle one) Y / N	Y	Y	
9	If someone said they were having trouble with a programming problem, how comfortable would you feel trying to help them? (circle one)	Not Comfortable	Not Comfortable	Not Comfortable
10	Tell us about an outdoor activity that helps you clear your head.	Sitting & enjoying nature + listening to music	Art	Walking
11	For you, what's the most important ingredient to being able to focus? (rate from 1 to 5) A: [ ] Quiet B: [ ] An environment I feel comfortable in C: [ ] Seeing how the task at hand fits into the bigger picture D: [ ] Feeling like I can do the task at hand E: [ ] Feeling like I have a say in what I want to do	A: 3 B: 4 C: 4 D: 3 E: 4	A: 5 B: 5 C: 3 D: 5 E: 4	A: B: x C: x D: x E: x
12	How likely are you to study programming in the future? (circle a number)	4	3	3
13	How much say do you feel like you have over what you learn in school? (circle a number)	7	6	9
14	How comfortable do you generally feel asking a question in class? (circle a number)	3	2	2
15	Is there anything you want to share that we haven't covered?	Graphic Art	No.	

Appendix F3: Mid Curriculum Assessment Form Results

	A	H	I	J
1	What do you hope to get out of this program? (rate the following from 1 to 5) A: [ ] New friends B: [ ] A cool project C: [ ] Knowledge of how to program D: [ ] Knowledge of how to make art with technology E: [ ] A mentor who I can relate to	A: B: C: D: x E:	A: B: x C: x D: x E:	A: B: C: D: 5, x (highest) E:
2	How would you describe this program to someone who was thinking about applying?	IT's where you get to learn how to program and make UR and how it all works.	As an opportunity to learn and open doorways to skills you didn't know you had.	
3	Have you ever looked at a programmer and thought, "Hey, that could be me!" (circle one) Y / N	N	N	Y: 3, N: 5
4	How would you rate your programming skills? (circle a number 1 to 10)	1	6	Mean: 4.25/10, Mode: 1 and 3
5	What are the pros and cons of studying computer science?	Cons - confusing. Pros - learn how they work	Pros are that I get to learn and it'll help me in future situations. Cons aret that it's hard to understand.	
6	How often do you find yourself problem-solving? (circle one)	Often	Often	
7	Describe a moment when a science concept really "clicked" for you. What helped it click?	I don't have a moment.	In 8th grade we would do a lot of hands on science, it "clicked" for me because it was fun. I've only done hands on science for a little bit though.	
8	Do you feel that you apply your engineering skills to other aspects of your life? (circle one) Y / N	N	Y	Y: 5, N: 2
9	If someone said they were having trouble with a programming problem, how comfortable would you feel trying to help them? (circle one)	Maybe Comfortable	Not Comfortable	Not: 4, Maybe: 3, Very: 1
10	Tell us about an outdoor activity that helps you clear your head.	Sitting outside listening to music	I like to play volleyball	7/8 are outside
11	For you, what's the most important ingredient to being able to focus? (rate from 1 to 5) A: [ ] Quiet B: [ ] An environment I feel comfortable in C: [ ] Seeing how the task at hand fits into the bigger picture D: [ ] Feeling like I can do the task at hand E: [ ] Feeling like I have a say in what I want to do	A: B: C: D: x E:	A: x B: x C: D: E:	
12	How likely are you to study programming in the future? (circle a number)	2	3	
13	How much say do you feel like you have over what you learn in school? (circle a number)	5	8	
14	How comfortable do you generally feel asking a question in class? (circle a number)	2	5	Mean: 3.375/5, Mode: 2
15	Is there anything you want to share that we haven't covered?		No.	

Appendix G1: Field Notes for March 7 Launch

What We Did

- Fieldtrip to USC
  - The Gil, CM&BHC, Thesis Space, presented in the Fish Bowl
- Design Introduction
  - Slides (Allison)
    - 00_Design_Intro
  - Cultural Smudging Exercise
    - A student asked, "What does demographic mean?" The instructors gave examples of their own demographics in terms of age, gender, education, race, and interests.
  - World Building Exercise (Allison)
    - Students paired up and wrote in their notebooks a main character, world, world characteristics, main character actions and purporse.
- Engineering Introduction
  - Intended to cover:
    - 00_Intro
    - 02_3DSpace
    - Tactile Ex: pipe cleaners point, line, plane, space (5 min)
  - Actually covered:
    - 00_Intro pgs 1-26 (30 min)
      - Changes made in class:
        - Discuss the definition of each word.
        - Discuss how Derrida's "Structure, Sign, and Play" argued that definitions change over time depending on context - validating multiple points of view of what a word means.
      - To do:
        - Put general definition(s) in the presenter notes
    - Tactile Ex: pipe cleaners point, line, plane, space (15 min)
      - Changes made in class:
        - Skipped 02_3DSpace slides. The outcome was that the exercise took longer, and students were confused.
        - Magalis observed that the students were confused and asked, "What is a dimension?"
      - To do:
        - Define dimension.
- VR experience
  - Drawing exercise on the Oculus, experienced one at a time
  - Students helped each other try the experience and made verbal observations about how it worked.
- Handed out binders

Appendix G2: Field Notes for March 7 Launch

- Palimpsest poster on cover
- Observation Worksheet template
- Mindfulness and Interpersonal Effectiveness handouts/worksheets

Feedback

- From Magalis:
  - I am meeting with the girls on Tuesday to dissect some of the content that was presented to them... going to run a "checking for understanding" process with them.
  - Atley: there was a lot of content in your section that the girls were confused by...
    - Later, Magalis specified that confusion was from 4 students following the hands on activity about dimensions.
    - During the activity, Magalis had asked Atley to define, "dimension."
  - We will need to integrate "checking for understanding."
  - We need to put together a list of important or jargony key terms that they think they need to define. If it's a word they're not sure they should define--when in doubt, ask the crowd, make them define it.
  - Ask students to summarize points before they move on to new ideas. If it's worth it for them to write it down, ask them to write it down
  - ALWAYS keep in mind the experience of a woman of color who was either raised in South Central or another country. Find what you know that is relatable to what they know
  - Ask them questions. Get to know them. They know more about some aspects of life that you don't. It will validate their existence in these elite institutions
    - Later, Magalis specified some ways to get to know the students without prying into their personal lives: find an authentic way to connect on topics of mutual interest, such as fashion or comedy.

Changes based on feedback

- Karen added the following material to support lessons:
  - Exercise Key
    - Learning Objectives
    - Activity Description
    - Questions Posed
    - Key Vocabulary and Concepts
  - Visual Flowchart of Class Modules: Intro_Roadmap
  - Palimpsest Vocabulary (All)
- To Do:
  - Create Exercise sheet
  - Print Exercise sheets
  - Print flowchart
  - What was the checking for understanding process?
  - Can we have a photo of Magalis' notebook describing the flow?

Appendix H1: Programming Curriculum Overview

THE PALIMPSEST PROGRAM

shifting the culture of computing

noun pa·limp·sest \ ˈpa-ləm(p)-ˌsest , pə-ˈlim(p)- \

:an object or place that reflects its own history

"To close gender gaps in participation in computer science, engineering, and physics, cultures of these fields should signal equally to women and men that they belong and can achieve success in them."

-"Why Are Some STEM Fields More Gender Balanced Than Others?" Sapna Cheryan and Sianna A. Ziegler, University of Washington

PROGRAMMING CLASS STRUCTURE

1. Mindfulness reading material and exercise(s)
2. Students play working exercise; ask questions; record questions; take turns
3. Students examine 'broken' exercise; identify what's different/broken; ask questions
4. Enter the exploration loop:
    a. Students form questions
    b. Students vote on a mini lecture to address questions
    c. Instructors deliver mini lecture
    d. Students hypothesize, implement, and test solutions
    e. Repeat
5. Instructors facilitate a class discussion about observations and outcomes
6. Students save their work and receive printouts:
    a. Walk-through of lesson with extension challenges
    b. Link to lectures of the day
    c. Links to online programming tools

PREPARATION

There are six programming tutorials. Each has:

1. A working version of the tutorial, with classes labelled: class.cs (the working script)
2. A broken version of the tutorial, with classes labelled: class_m.cs (m for "modified")
3. A written walk-through with extension challenges

Appendix H2: Programming Curriculum Overview

MINI LECTURE OUTLINES

UNIT ONE
Tutorial: Unity scene "BigBang"
- BREAK BY In "Create Prefab" on "Trigger," give Z = 5 to item position (make sure it's visible)
- BREAK BY In "Trigger," uncheck Trigger

3D SPACE (10min)
- 0d, 1d, 2d, 3d (5 minutes)
- Labels vs relationships
- Tactile Ex: pipe cleaners point, line, plane, space
- Physical Ex: yoga in 0, 1, 2, and 3 dimensions

VECTORS & TRANSFORMATION
- Point vs a vector
- Moving in 3d and on a coordinate system
- Dot Product (direction)
- Transformation matrix
- Unity Helix Ex: Transform scale, rotate, translate. Parent a child. Explore object space vs world space.

HARDWARE
- Inputs
- Processor
- Outputs
- Binary
- Base 10; Base 2
- Tactile Ex: Binary addition

PROGRAMMING LANGUAGES
- Labels vs relationships
- High Level
- Low-level
- Tactile Ex: Pseudocode

UNIT TWO
Tutorial: Unity Scene "PushPull"
- BREAK BY PushPull.cs line 66: swap order

DISTANCE FORMULA
- Distance formula
- Tactile Ex: Physical proof of pythagorean theorem

BASICS
- Assignment
- Comments
- Braces
- Code Block
- Unity Ex: Answer prompts from exercise slide

PROGRAM DESIGN

Appendix H3: Programming Curriculum Overview

- Unsolvable problems and constraints
- Define the problem
- Algorithm is a method with a series of steps, like a recipe
- Writing Ex: How do algorithms impact your daily life?

DATA & VARIABLES
- Data types: int, float, bool
- Data in memory
- Variables
- ASCII
- Tactile Ex: Binary program with a lightswitch

UNIT THREE
Tutorials: Unity Scene "Collectable"
- BREAK BY omitting omitting contents of CollectableController.CreateAllCollectables(Vec3 pos)

OPERATIONS
- Arithmetic
- Logical
- Operator precedence
- Boolean type
- If statement, if else
- Conditional Statements
- Tactile Ex: Use media of choice to illustrate patterns of if/else statements, and nested if/else statements. Draw all possible paths. Would they compile? What could you use them for?

LOOPS
- purpose
- types
- application
- common errors
- Update()
- What a frame is
- Unity Ex: frame rate change
- Physical Ex: In teams of 2, choreograph a dance using loops. Write out your dance in as few lines of pseudocode as possible. Run 4 frames of dance moves.

ERRORS
- Syntax and Vocabulary
- Runtime and Logical Error
- Crash
- Unity Ex: delete a semi-colon; delete a bracket; delete variable declaration; empty a field in Editor

GAME ENGINES
- Examples: Unreal, Cryengine, custom engine, Quake, Source, and you could make your own engine! All it does is take care of... physics simulation, rendering, collisions, libraries, plugins... what else...
- Activate / Deactivate
- Instantiate / Destroy
- Collision & triggers
- Raycasting - collision without proximity
- Unity Ex: Use UnityEngine class Input.mouse and Input.key to provide alternate ways to change the tutorial without going into VR. Why might this be helpful?

Appendix H4: Programming Curriculum Overview

UNIT FOUR
Tutorial: Unity scene "Drawing"

- BREAK BY changing public variable in code
- OPTIMIZE BY overloading CreateDraw to create the added param int passed in
- OPTIMIZE BY changing to an array rather than a list

METHODS

- Definition
- Tactile Ex: pseudocode a character using behaviors (methods) and properties (variables) (slide 4)
- Declaration: mod, return, params
- Naming
- Return type
- Overloading
- Scope
- Unity Ex: create a method
- Physical Ex: In groups of 2, play computer and programmer. Pseudocode a class with 3 methods. The person playing the computer chooses where a variable is defined - in one of the methods or the class. The computer "reads" the program in 3 frames. The programmer has 3 chances to "breakpoint" and ask the value of the valuable. At the end, the programmer must guess where the variable is defined. Then switch roles.

DATA STRUCTURES - anything more complex than a primitive type

- Lists
- Arrays
  - Vector3
- String
- Object
- Struct
- Queue
- Stack
- Tactile Ex: In groups of 4, draw a memory bank. Store 4 objects in an array (side by side). Store 4 objects in a list (all over the place). Put a processor somewhere. Draw one set of lines from the processor to the array, and another set of lines from the processor to the list. Which takes longer? Why might you use one method over the other?

DEBUGGING

- Investigate what something means on your own: Unity reference manual, Stack overflow
- Intellisense
- Use VS to more deeply investigate code
- *Look at the assembly (first figure out how)
- Unity Ex: Use the debugger with Intellisense. Make a breakpoint with F9, Attach to Unity and Play, observe and record the difference between F5, F10, and F11. How do you "watch" a variable? How do you see the values of any variable? When does a variable value change? Why? How long is one frame taking right now? Who's controlling the frame rate?

UNIT FIVE
Tutorial: Unity Scene "Mixer"

- BREAK BY omitting the raycast offset
- BREAK BY making base class modifiers private

OBJECT ORIENTED PROGRAMMING

- Classes
- Data Members
- Method Members

Appendix H5: Programming Curriculum Overview

- "New"
- Assignment
- Unity Ex: EXERCISE: Access Members of a Class from INSIDE and OUTSIDE of the Class. (slide 9)
- Unity Ex: EXERCISE: Construct something

ENCAPSULATION

- Encapsulation and Unity's Game Objects & Components
- Data and Method modifiers
- Principle of least privilege
- Scope
- Class Modifiers
- Physical Ex: Let's play a spy game called, "Encapsulation." Everyone has some data, some functions, and some functions calls. Try to get the most data! Find the people with your functions calls and ask for their data. But be quick! Don't lose all your data in the process. In the bonus round, players find their parent or manager, which has the permission to access the data.

REFERENCING OBJECTS

- Garbage Collection
- "this"
- Pass by Reference vs Pass By Value
- Tactile Ex: Draw the difference between a reference and a value. Where is the original object in memory? If passing by reference, what is passed, the object, a copy of the object, the object's address, or the object copy's address? What about for passing by value? Why pass by reference versus passing by value?

UNIT SIX

Tutorial: Unity Scene "Scene Switch"

- BREAK BY omitting the Scene Manager
- VARIATION: simulate scene switching in one scene
- VARIATION: Make a new child
- VARIATION: Make the mixer behaviors not inherit from the MixerFeature.cs

APPLICATION

- Game concept creation
- Game design document
- Asset list
- Prototyping and priorities
- Written Ex: Create concept document, asset list, set priorities

Appendix I1: Curriculum Vocabulary

Key Vocabulary & Concepts

0d space - a single point with no dimension

1d space - one single axis

3d Space - a space defined any three perpendicular axes

2d - two axes perpendicular to one another

3d - three axes perpendicular to one another

3:4:5 triangle - a right triangle where the sides are in the ratio of the integers, 3:4:5

Algorithm - a well-defined procedure that allows a computer to solve a problem

Array - items such as objects, numbers, etc. arranged in rows and columns

Axis/Axes - a reference line drawn on a graph

Base-10 Number System - a number system where there are 10 possible values for each digit: 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9

Binary - also called base-2; a number system where there are only two possible values for each digit: 0 and 1

C# - pronounced C Sharp; a high level programming language developed by Microsoft; it is one of the languages that can be used to code behaviors in Unity

Cross Product - also called a vector product; a binary operation on two vectors in three-dimensional space. It results in a vector which is perpendicular to both of the vectors being multiplied and therefore normal to the plane containing them.

Compiler - a computer program that turns high level language into machine language

Coordinates - set of values that show position in 2d or 3d space

Data - information processed or stored by a computer

Direction - where something is pointing

Dot Product - also called a scalar product; an algebraic operation that takes two equal-length sequences of numbers (usually coordinate vectors) and returns a single number.

High level language - allows a programmer to write largely independent of specific hardware or device; more closely resembles human language

Inputs - a device that gives information to the computer; can also be software

Line - a segment of a single axis

Low level language - a programming language that is very close to the commands and functions run at the hardware level; a type of low level language is assembly

Appendix I2: Curriculum Vocabulary

Machine language - binary

Magnitude - size of a mathematical object

Matrices - an array of numbers

Memory - also called storage; device that stores information for immediate or later use

Normal - to be at right angles; a vector at a right angle to a plane

Outputs - data generated by a computer; this can be physical (a printed document) or data produced by software (the result of a calculation)

Peripherals - electronic equipment connected to a computer wirelessly or by cable; can include both input and output devices

Plane - a space defined by any two perpendicular axes

Point - a location with no direction or dimension

Programmer - a person who writes computer programs

Processor - the component of a computer that performs the basic operations (processing data) of the system; it exchanges data with a systems memory and peripherals; manages the system's other components

Program - a collection of instructions that performs a specific task when executed by a computer

Proof - a deductive argument for a mathematical statement; the physical proof of the Pythagorean Theorem shows - physically - how the principles work

Pseudocode - a simple way of writing programming code in human language; it uses programming structure, but is not concerned with syntax
Rotation - a circular movement around one or more axes

Scale - the ratio (or relationship) of the length in a drawing or model to the length of the real thing; that length can be along any of an object's axes

Syntax - is the set of rules that defines the combinations of symbols that are considered to be a correctly structured document or fragment in that language

Transformation - changing a space using turn, flip, slide, resize; translation is a kind of transformation; rotation is a kind of transformation; scaling is a kind of transformation

Translation - sliding or moving a shape without rotating or flipping it

Vectors - a mathematical structure that has a magnitude and a direction

class
comment
bracket
curly brace
method
syntax

Appendix I3: Curriculum Vocabulary

declaration
body
codeblock
keyword
modifier
variable
camelcase
syntax
terminator
string
parameter
convention
assignment
integer
floating point
char
boolean
naming convention
assignment operator
operator

Appendix J1: Programming Curriculum Lecture, “3D Space”

3D SPACE

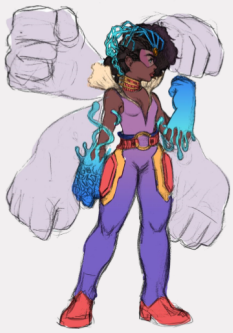
PALIMPSEST

3D SPACE

- Representations of Space
- 0D
- 1D
- 2D
- 3D
- Coordinate Systems
- EXERCISE

3D SPACE

What is it?



It’s the world as we perceive it.

Objects have:

Positions

Objects have:

Positions relative to one another

Objects have:

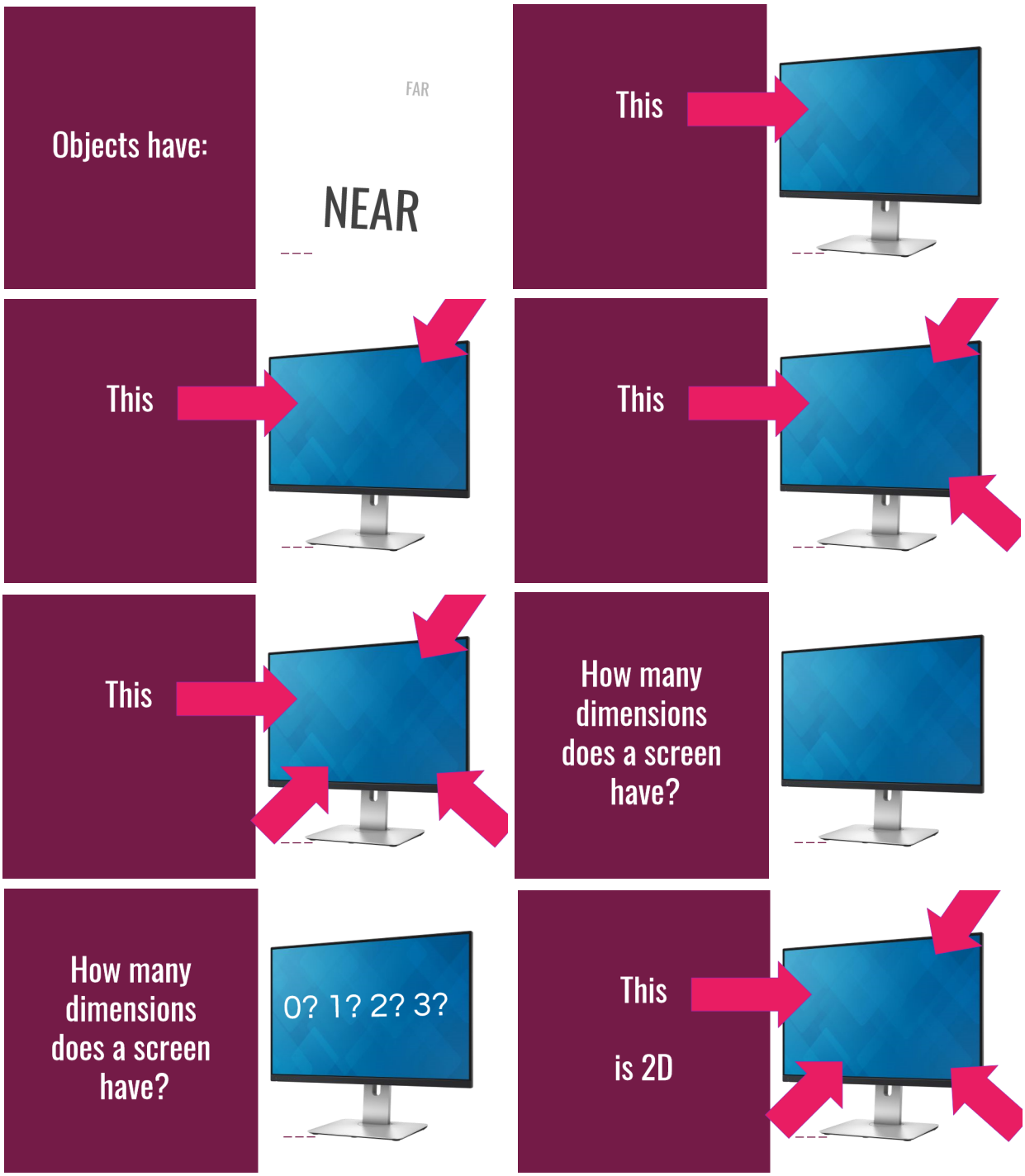
THERE

HERE

Appendix J2: Programming Curriculum Lecture, “3D Space”

Objects have:	FAR NEAR	Objects have:	FAR  NEAR
	DUH, RIGHT?	It matters because:	
It matters because:	To make a game we have to FAKE **ALL** OF THIS	It matters because:	To make a game we have to FAKE ALL OF THIS
It matters because:	To make a game we have to FAKE ALL OF THIS WITH MATH	It matters because:	To make a game we have to FAKE ALL OF THIS WHY???

Appendix J3: Programming Curriculum Lecture, “3D Space”

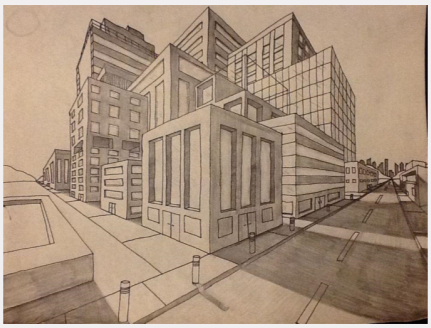


Appendix J4: Programming Curriculum Lecture, “3D Space”

Objects have:

FAR

NEAR



DIMENSIONS

0d

3D SPACE

DIMENSIONS

0d

Point

DIMENSIONS

1d

x

DIMENSIONS

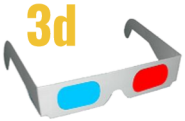
1d

x

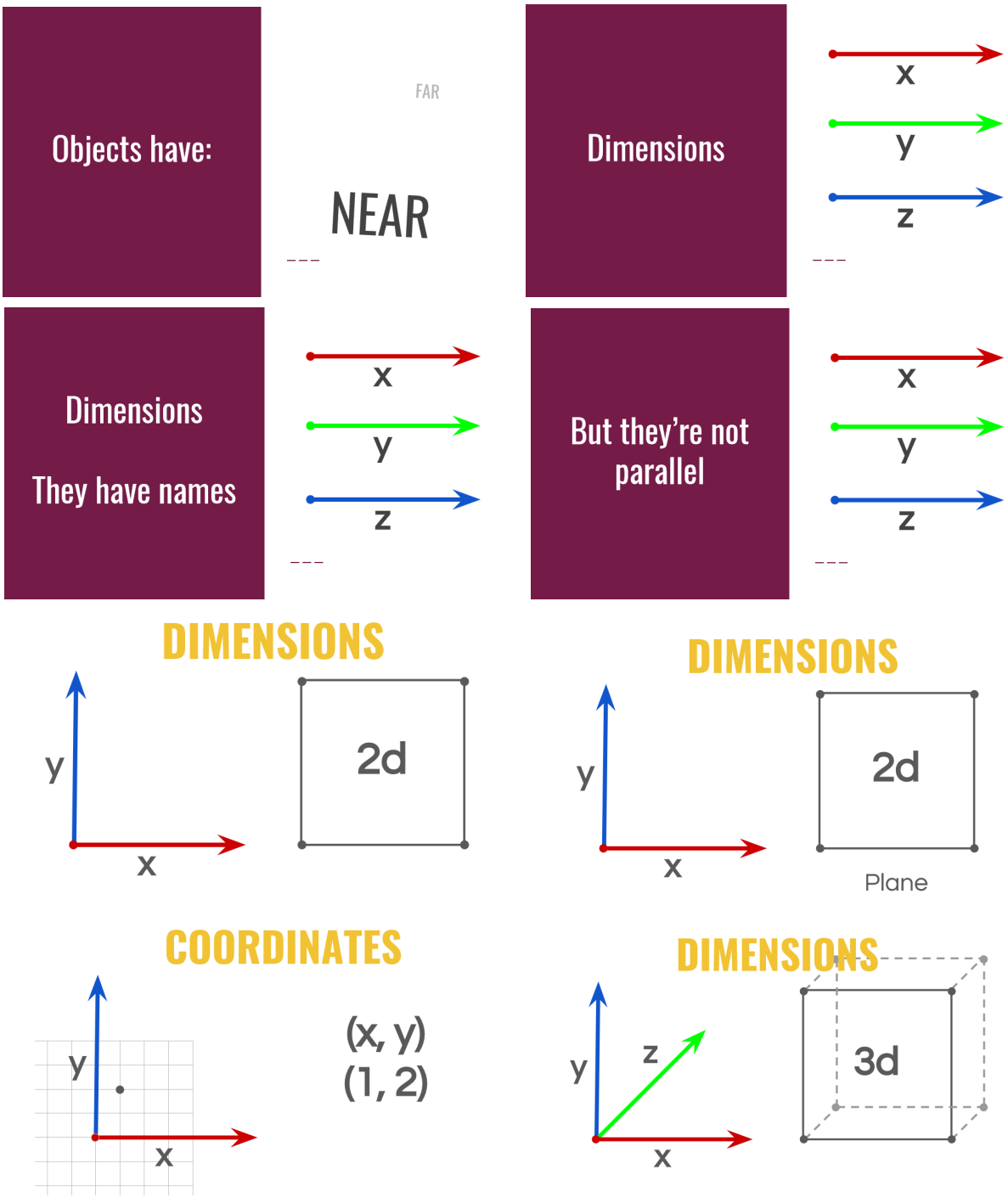
Line

What does the letter ‘d’ represent?

0d
1d
2d
3d



Appendix J5: Programming Curriculum Lecture, “3D Space”



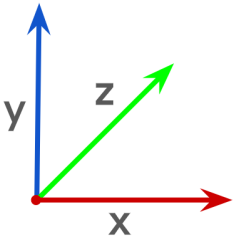
Appendix J6: Programming Curriculum Lecture, “3D Space”

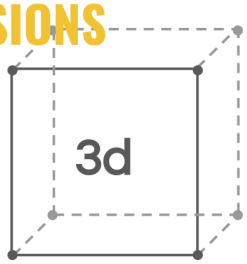
Objects have:

FAR

NEAR

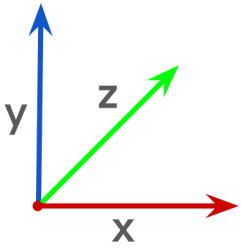
DIMENSIONS



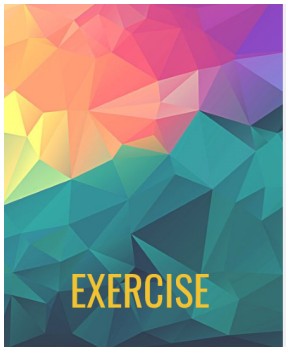


Space

COORDINATES



(x, y, z)
(1, 1, 2)



Define a plane

Define a space

What do we need for a plane?

0d
1d
2d
3d

What do we need for a space?

0d
1d
2d
3d

For 4D Space, go see A Wrinkle In Time

NEXT UP

Vectors

Appendix K1: Programming Curriculum Exercise, “3D Space”

EXERCISE - DAY 1 - 3D SPACE

Learning Objectives:

1. Define planes and spaces
2. Create representations of 2D and 3D space with physical materials.

Activity:

Using pipe cleaners or other materials, represent a:

1. 2d plane
2. 3d space

Questions Posed:

Q1: How many vectors can occupy 1d, 2d, & 3d?

A1: 0, infinite, infinite

Q2: What is the minimum number of vectors needed to define 1d, 2d, & 3d?

A2: 1, 2, 3

Q3: What are these called?

A3: line, plane, space

Q4: How do we define them?

A4: ??

Appendix K2: Programming Curriculum Exercise, “3D Space”

Key Vocabulary & Concepts:

Axis/Axes - a reference line drawn on a graph

0d space - a single point with no dimension

1d space - one single axis

2d - two axes perpendicular to one another

3d - three axes perpendicular to one another

Point - a location with no direction or dimension

Line - a segment of a single axis

Plane - a space defined by any two perpendicular axes

3d Space - a space defined any three perpendicular axes

Coordinates - set of values that show position in 2d or 3d space

Vectors - a mathematical structure that has a magnitude and a direction