

Emily

By

Caroline Susanne Cromwell

A thesis presented to the Honors College of Middle Tennessee State University in partial fulfillment of the requirements for graduation from the University Honors College

Spring 2019

Emily

by

Caroline Susanne Cromwell

APPROVED:

Rodrigo Gomez

College of Media and Entertainment

Billy Pittard

College of Media and Entertainment

Dr. Philip E. Phillips, Associate Dean

University Honors College

ACKNOWLEDGEMENTS

Thanks is necessary for Professor Rodrigo Gomez for being my advisor and being constantly involved and providing priceless insight; Professor Kevin McNulty, for making reasonable accommodations to allow the completion of my thesis in conjunction with the classes required by my degree; Professor Richard Lewis, for providing more insight during the end stages of completion; Ian Fitzgerald, for being a loving, caring, and patient fiancé as I showed the best and worst of myself throughout the creation and completion of my thesis project; End Slavery, the organization based in Nashville, Tennessee, that fights against labor and sex trafficking every day, Professor Ryan Korstange, for also providing reasonable accommodations to allow the completion of my thesis in conjunction with completing the requirements for my Honors minor; and my own family and close friends for providing support during major life changes that have occurred during the completion of this project.

ABSTRACT

This project was created with the intention of raising awareness about sex trafficking among minors and college students. I utilized all aspects of the production process and used multiple different computer programs to create a 3D animated short film to explore the issue and further my skills in computer animation, storytelling, and character design. The result was a film educating minors and raising awareness about sex trafficking by highlighting the methods that attackers in sex trafficking rings use to lure their victims away from safety.

PREFACE

When I was very young, I was sexually abused and harassed by one of my extended family members and exposed to very explicit adult material on a regular basis. Those experiences that have followed me and affected my daily life have molded me into an advocate for raising awareness about sexual abuse, harassment, and trafficking of children. The media we consume daily has only enabled this issue, but as we have become a more progressive society, the public has began lashing out against the exploitation of minors in provocative settings.

I turned my experiences into a story I could tell through a medium that I have grown to love over my college career. The hundreds of hours poured into this project, however, do not compare to the suffering endured by true victims of sexual abuse and trafficking. Through this project, I hope that my audience will spread awareness and continue fighting against that unacceptable and grotesque behavior.

TABLE OF CONTENTS

Acknowledgements.....	i
Abstract.....	ii
Preface.....	iii
Table of Contents.....	iv
List of Figures.....	vi
Pre-Production.....	1
1. Research and Script.....	1
2. Character Design.....	5
3. Storyboard and Animatic.....	9
Production.....	12
1. Modeling.....	12
1a. Characters.....	12
1b. Environment.....	17
2. Texturing.....	19
3. Rigging.....	21
3a. Characters.....	22
3b. Environment.....	29
4. Animation.....	30
4a. Layout.....	30
4b. House.....	30

4c. Bar.....	31
5. Lighting.....	32
5a. House.....	32
5b. Bar.....	32
6. Rendering.....	33
6a. Arnold and Autodesk Maya’s Legacy Render Layers.....	33
Post-Production.....	35
1. Asset creation.....	35
1a. Backgrounds.....	35
1b. Warning Flags.....	35
2. 2D Animated Overlay.....	36
2a. Emily’s Attacker.....	36
2b. Arm Binding.....	36
3. Sound.....	37
Reflection and Conclusion.....	38
Works Cited.....	40

LIST OF FIGURES

Figure 1.....	5
Figure 2.....	6
Figure 3.....	7
Figure 4.....	7
Figure 5.....	10
Figure 6.....	12
Figure 7.....	14
Figure 8.....	16
Figure 9.....	17
Figure 10.....	19
Figure 11.....	21
Figure 12.....	22
Figure 13.....	24
Figure 14.....	25
Figure 15.....	26
Figure 16.....	27
Figure 17.....	28
Figure 18.....	28

PRE-PRODUCTION

Research and Script

This project began to manifest when I attended an End Slavery meeting with my fiancé and his mother that occurred on Halloween of 2016. End Slavery is a non-profit organization dedicated to raising awareness about and providing relief to the victims of labor and sex trafficking. While I am a personal survivor of sexual abuse, the idea behind creating a short film to raise awareness about these issues did not begin to manifest until I attended this meeting. It was simple: the organization presented all the counties across Tennessee and the surrounding states that were active in End Slavery. When the time to think about a topic for my thesis came, I decided that sex trafficking was a good topic to explore because it is an issue that very closely relates to my own life.

I began my research. I attempted to reach out to the head of the organization but was never able to get in contact. Despite this obstacle, I resorted to online research and found all the information I needed to build a story right from End Slavery's website. What I needed was how exactly sex traffickers lure new victims into sex trafficking rings. What I learned was much more. However, to stay relevant, I will only discuss the points that directly affected my project.

On bethejam.org, a website promoted by End Slavery, you can find a list of the tactics that attackers will use to lure new victims into a sex trafficking ring. These tactics include using social media to pose as someone the attacker is not (such as a close friend or relative) and offering a job or opportunity that on the surface seems too good to be true, to name two that I used in my own film. Once I had solid information from a

trustworthy source, I began my script on the idea of a narrative, but also to inform my audience of the methods used by attackers by using warning flags throughout the film. The intended audience of this film for is high-school to college age students.

The film is about a young girl named Emily who is nearly pulled away from safety by a trafficker.

The script is simple, and is as follows:

PROLOGUE

Character is seen entering her house, talking on the phone with a friend. The conversation continues until SCENE 1 begins.

The house is modestly decorated with a couple of small plants, a medium-sized couch, a small coffee table, a television turned off, and a couple of dresser cabinets.

The walls and ceiling are white, and there is one window next to the front door. A hallway connects this room, the living room, with the kitchen, a small bathroom, and a staircase. The house has tan carpet apart from the kitchen which has pale blue tile.

SCENE 1

Character enters her bedroom. She's holding a flier with a phone number on it advertising for fast, easy money. The character takes out her cell phone from her pocket and calls the number.

The character's bedroom is plain with little clutter. The bed is king sized with two pillows and white sheets with a red comforter on top. The walls and ceiling in the bedroom are also white. A simple brown desk is against the wall, sporting a generic

trophy and other small decorations. A few books are stacked on the desk as well. A closet is next to the desk, with a standing mirror next to the closet.

-FLAG 1:

One tactic sex traffickers use to get victims is to pass out fliers or put up signs advertising large sums of money for no work.

SCENE 2

Character is seen using their laptop in their bedroom. The camera zooms into an instant message received from a stranger saying they're friends with the character's best friend and would like to meet up.

-FLAG 2:

Another tactic is to pose as a trustworthy person and make plans to meet the victim or have the victim come to a place where the attacker can easily capture the victim.

SCENE 3

The character is about to leave her house before her mother stops them and asks them where they're going. The character replies, saying she's going to meet a friend of her best friend.

-FLAG 3:

Never go anywhere with someone you don't know, especially if you happen to be going to a shady place.

SCENE 4

The character goes to a very run-down coffee shop to meet her attacker. The character arrives before the attacker does and sees from the surroundings that it isn't a safe place. The cups and windows are dirty, there are sirens outside, the server starts making crude comments to the character about how pretty she looks, and the same server tells the character how dangerous it is on this side of town.

The character realizes that she's making a mistake by being here and flees from the place just before the attacker enters the shop, asking if the character's waiter had seen someone that looks like the character.

We then see the character coming inside her house and greeting her mom with a big hug.

-FLAG 4 (FINAL FLAG)/END TITLE CARD

Be sure to pay attention to your surroundings and use your common sense to stay safe. Being able to recognize the signs of sex trafficking can save you and others.

Scripts are used to lay out the initial idea of any media-based creative project, whether it is a short animated film, a commercial, or a live action feature length film. Sometimes, although rare, rewrites of an entire script are necessary to best convey the story being presented. My script had three drafts before the final version, and the rest of the film evolved from the final version of the script during the production phase.

Character Design

It was decided early after the final script was approved that the main character would be a middle- to high-school aged female of a non-distinguishable race named Emily. She's a typical high schooler: active on social media and wants to make some money for herself. Her mother was created based on Emily's appearance for continuity.

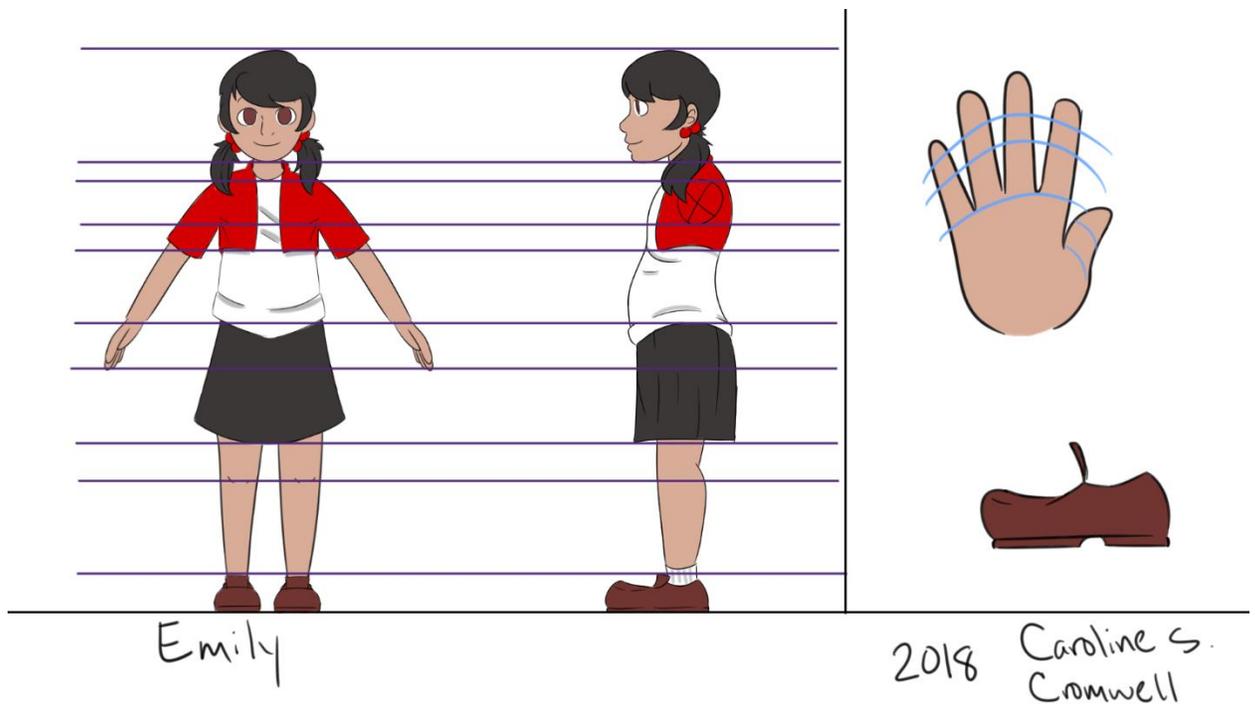


Figure 1: Emily's full body character sheet for modeling



Figure 2: Emily's head character sheet for modeling

Emily's character design evolved slightly. She was first designed wearing a red turtleneck, but her design was altered to make her align better with a school student. Her pigtails came from my desire to animate pigtails, and her red cardigan came from my favorite color being red. I wanted to create a character to whom I could relate, while making her seem generic and, as we have mentioned in a few of my animation classes, like she is a "blank slate." This term refers to a character not appearing to be in any profession or age. These traits make the character more appealing and allow the audience to connect with characters more. Of course, since the film is meant to raise awareness about sex trafficking in minors, she was created in a way where she still has a childish appearance. This can be seen in the position and size of her eyes and other facial features.

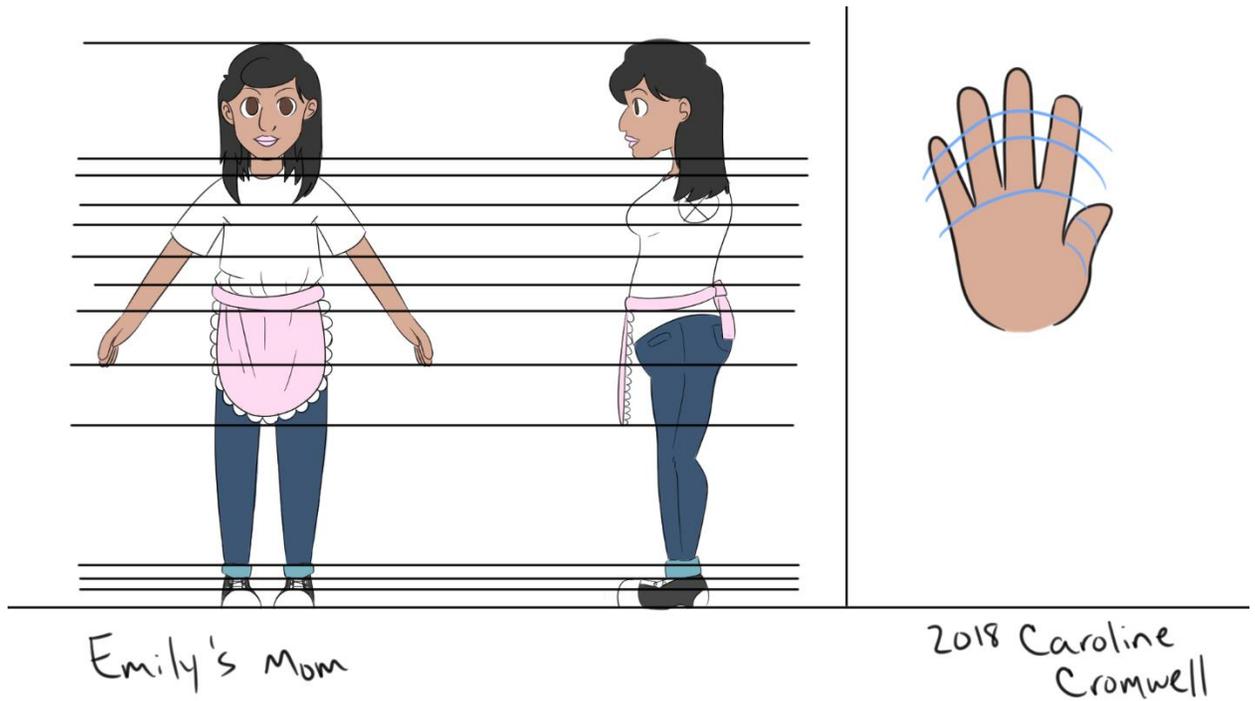


Figure 3: Mother's full body character sheet for modeling



Figure 4: Emily's mother's head character sheet for modeling

Emily's mother was created after the friendly image of a stay-at-home mom. This aspect can be determined from her casual yet adult and professional appearance. She is supportive and cares deeply for her daughter's happiness, almost to a fault.

Character sheets come in many shapes and sizes: some include multiple facial expressions, some include multiple clothing choices, and some include more angles of the character than others. All character sheets created for modeling purposes show the character in a specific position called t-pose or a-pose; the character sheets for *Emily* show the characters in a-pose. The naming comes from the positions of the arms. In t-pose, the arms are completely perpendicular to the body, while in a-pose, the arms rest at an angle to the body. A-pose tends to provide a more natural position and easier weight painting, which I will address in the Rigging chapter. For my purposes, I created a front and side view of each character for her full body and head. Character sheets took two weeks to finalize for this project. The use of two character sheets (one for the full body and one for the head) is often necessary for modeling, which I will explain in the Modeling chapter. The multiple straight lines are used for lining the images up in the 3D animation program of choice to more easily create a model once the images are imported into the program. During pre-production, these images are referred to as character sheets, but once production begins, character sheets are more commonly known as reference images; this refers to when they are being actively used in the 3D space, and I will refer to them as reference images in future chapters. There is no technical difference between the two terms.

Storyboard and Animatic

Thumbnail Storyboard Template



Emily tries to leave, Mom stops her and asks questions.



"I'm going to meet a friend!"



Emily's mom looks worried as her daughter leaves.



Emily is seen walking through town.



Emily enters a shady office shop.



Emily approaches the barista suspiciously.

Thumbnail Storyboard Template



Emily enters her house, talking on the phone with a friend.



Emily's mom greets her daughter. Emily doesn't reply and goes upstairs.



"Ah, teenagers."



Emily enters her room.



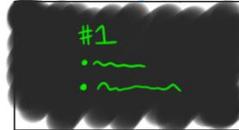
Emily looks at the file and dials the number.

● Character movement
● Speaking
● Camera work

Thumbnail Storyboard Template



- FTB



Flag #1 Appears



Emily is on her bed, using her computer



Attacker pm's Emily. "Let's meet up."

- FTB



Flag #2 appears



Emily gets up from her bed.

Thumbnail Storyboard Template



Barista makes comments on Emily's appearance.



"Uh..."



Emily glances back and forth.



"I shouldn't be here!"



Attacker comes into the shop.

● Character movement
● Speaking
● Camera work

④



Figure 5: Final storyboard for *Emily*. Read from left to right, two panels per line.

Storyboards come directly after a script is finalized. These are a series of still drawings that help begin visualization of the film. They show camera angles and movements, dialogue, and give a good foundation for the film. From this stage, further improvements can be made to camera angles, the script may be modified, casting can begin for live action or voice actors, previsualization can begin, and once the storyboard is finalized, an animatic can be created.

The storyboard for *Emily* looks different from the finished product and was finalized after three weeks. Changes during production do not get reflected in a storyboard and/or animatic due to the order of the production process. The differences between the storyboard and the final film are that an entire character was removed, all dialogue was removed, some shots were added, and some were cut.

Some other shots were modified to compensate for the lack of dialogue. There were voice lines recorded for the animatic phase, but the dialogue was cut during the animation phase. The decision to remove the character and dialogue came from the lack of necessity for those assets, which saved time during production. The story for *Emily* is very simple due to time constraints and having a clear and effective message.

After a storyboard is finalized, an animatic is created. The animatic for *Emily* was created in one week. Animatics use each panel from a storyboard to create a basic video for timing purposes. Each panel will be extended to match appropriate shot length based on multiple factors, such as dialogue length, compensating for camera movements, giving enough time for the audience to process the shot and read any text, and giving the characters enough time to complete an animation. This is another stage where shots may be modified, added, or cut to better tell the story. Shot modification can happen through the end of post-production, as was the case with *Emily*.

The animatic for *Emily* was basic. The animatic stage was an instance in which deadlines became tight, so extensive sound design did not make it to the animatic. It was as simple as shot timing and placing voice lines. Animatics are made once again towards the end of production using animation playblasts (direct video captures of animation seen in the viewport compared to a full render; I will explain these further in the Animation and Rendering chapters) to re-compile animated shots, instead of still storyboard images, for timing purposes. Even in the late stages, shots can be cut, added, or modified. This stage for creating *Emily* was much more extensive and gave a better idea of timing for the final film. After the animatic was created and finalized, production began.

PRODUCTION

The production phase is the longest and most complicated phase of the process for creating a film. Studios usually have teams dedicated to each step. Dividing the tasks across teams allows for a quicker and cleaner production process, but, of course, short films can be created by one person.

Modeling

Characters



Figure 6: Completed models of Emily's mother and Emily, respectively

In my opinion, modeling is the most essential piece to an animated feature. Without models, you have nothing to texture, rig, or animate. The workflow for 3D modeling has endless variants; each style of working just depends on what is most comfortable to the modeler. Some prefer 3D sculpting in programs like ZBrush that are built for sculpting, others prefer polygonal (poly) modeling in programs like Maya or Blender, and from those sets, you can have dozens of different workflows to create your model. The difference between sculpting and poly modeling is that sculpting is much more like molding clay, while poly modeling is more mathematical. Sculpting involves smoothing, pulling, and pushing wider areas of your 3D object, more commonly known as your mesh, while poly modeling involves manually moving the faces, edges, and vertices of your mesh to get the desired shape. There are also differences in modeling for video games rather than films; films typically have models that have double or even triple the number of polygons than video games have. For the purposes of this project, I will only describe models for films, which are typically called *high poly models* due to their high polygon count. The modeling phase took about two and a half months.

A polygon, the most basic element of a mesh, ideally consists of four edges and vertices, but only one face. This kind of polygon is specifically called a *quad*, referring to the four vertices and edges. Other kinds of polygons are triangles or *tris* and *ngons*. The ideal model is solely created using quads. Tris, while acceptable, are not ideal for a model; they have the potential to cause issues in the animation and rendering stages in which you will see strange artifacts and bumpiness or an inability to weight paint and animate properly. However, sometimes tris are impossible to avoid; in these cases, tris can be hidden in areas that do not see much deformation, and are often never seen by the

camera, which makes these places ideal to hide any imperfections. Ngons (pronounced n-gons), however, are completely unacceptable in any case. Ngons refer to a polygon that has more than four edges and vertices. These polygons are detrimental to a model because they are guaranteed to cause animation and rendering issues. Emily's model has two triangles, both located inside of her mouth. Her mother's model is the exact same model I created for Emily, only modified to her design. Using Emily's model in this way saved a lot of time that would have otherwise been spent creating a whole new model from scratch.

For Emily's model, which was reused for her mother, I started with modeling her head. I created her skull, then her eyes, and finally her hair. Her hair is comprised of multiple pieces of geometry. I then moved on to her body. Her torso came first, then her skirt, then her legs and feet, and finally her arms and hands. I chose to model her head before her body because her extremities and head would be modeled separately from her body; modeling the head first creates a good reference for how big her body and her extremities would need to be. Her arms and hands were modeled separately and attached once they were both complete. I chose to model them separately because I struggle with hand modeling due to the very specific topology they need, so modeling the hands separately allowed me to isolate any mistakes I may have made to the rest of the body if they were connected from the beginning.

This leads me to a very important aspect of modeling: *topology*. The topology of a mesh refers to how the edges flow to create the mesh. A combination of quads and loops are only the building blocks to making a good model; 3D models that are meant for animation are created with muscle systems in mind. What kind of muscle system you

reference depends on what you are creating. In this case, these are human characters, so I followed the human muscle system out of experience to create proper topology. This workflow is most important for constructing the face of a character; for the rest of the body, a modeler is mostly concerned with creating loops using the edges of polygons, known as *edgeloops*. Loops provide the information needed to properly deform a mesh for animation. Without loops, the mesh does not have enough information to bend properly. Edgeloops are critical for eyes, mouths, ears in some cases, necks, shoulders, elbows, wrists, fingers, hips, knees, and ankles. One of the most important and most overlooked loops on a face is a loop that flows around the mouth and nose. This shape can be best re-created if you place your thumb on the underside of your chin and your index finger over the bridge of your nose. You can see this loop in the figure below, as well as loops around the eyes, mouth, brow, and fingers.

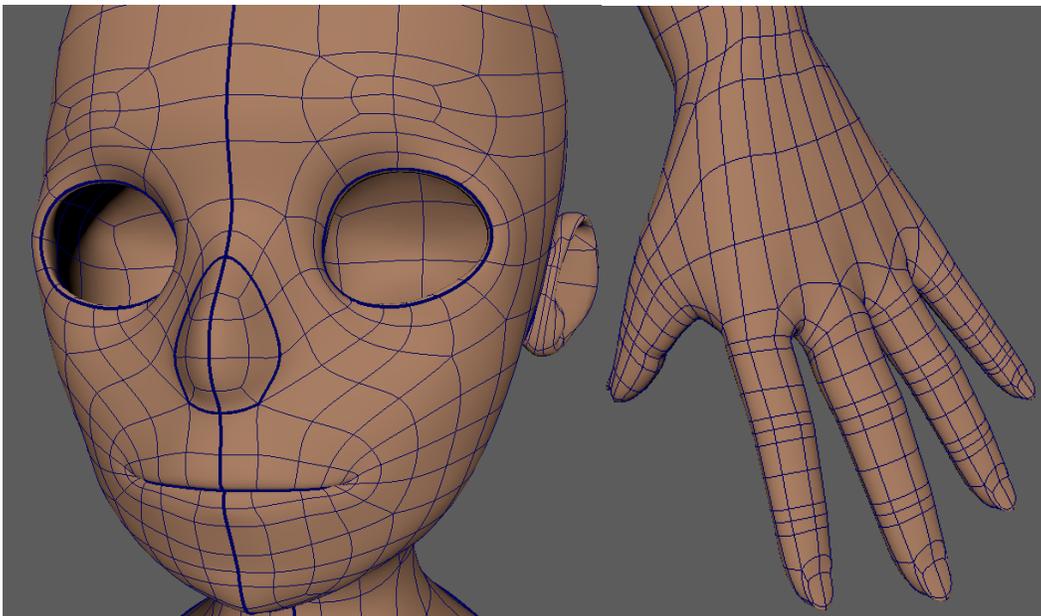


Figure 7: Emily's face and hand topology.

I mentioned in the Character Design section that having multiple reference sheets for a character is necessary for the modeling stage. This is because clothed characters that do not change outfits are often modeled in pieces; the pieces follow each other through proper and stable rigging. The thought process behind this method, seen again in the animation phase, is that if your audience does not see an aspect of the character, environment, or animation, then don't create it. This mindset saves time in that the artist focuses their time, effort, and other resources into creating what is necessary for the film, rather than spending hours on something that is never shown in the film. Most 3D characters are modeled in this way. Have you ever seen a film in which there is a shot where a character is walking, but you don't see their legs? It's very likely that their feet are not moving at all.



Figure 8: Emily with her skirt and shirt hidden, respectively

Emily and her mother are no exception. Seeing a character in the perspective shown in Figure 8 is quite humorous, but it is almost essential for productions with low-budgets for their films. The lack of mesh that needs to be modeled, textured, rigged, and animated saves countless hours and resources.

With the characters completed, the environment must then be modeled.

Environment

The environments in *Emily* are not nearly as complex as the characters; in fact, they are so simple that they almost look as if they are not part of the same film. While in the final film, the environments were drawn over to save rendering time, they were still modeled to provide the base for the drawings. In some cases, the actual environments are not even close to what they appear to be in the film. These caveats all fall back to the idea that if the audience does not see it, don't create it. You can see examples of this from *Emily* in Figure 9 below:

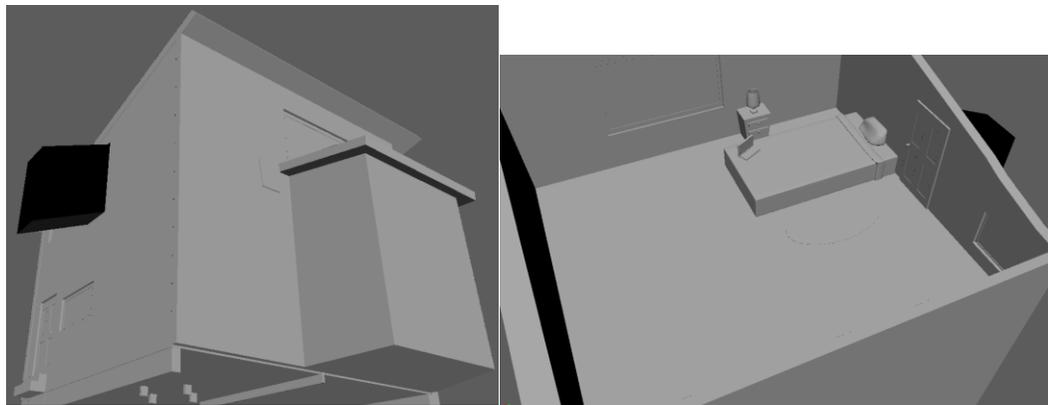


Figure 9: The outside of the house and inside of Emily's bedroom.

What in the world is that black box? Why is her room so empty? These are the illusions of animated film. The black box you see on the left is the stairwell leading out of Emily's bedroom. The audience never sees the outside of the house, so no precautions were taken to ensure that the house was realistic on the outside. In her living room during the sequence in which she ignores her mother and goes to her room, there are no stairs for her to climb; she simply floats into the air. Once again, you can see the practice of not creating what the audience doesn't see in the image on the right of Figure 9. The same is true for the bar; nothing other than the bar counter was modeled for inside the bar, and the other buildings are simply large cubes.

Texturing

Texturing refers to the appearance of the models once they are completed. Textures are simply the colors and other art applied to the model to make it look alive, rather than a gray, lifeless mass. Typically, a texturing artist will UV a model and create the art that lies on top of the model out of images they custom paint or out of the shaders (materials such as matte, wood, metal, etc.) provided by one or more programs. UVing refers to the projection of custom painted images onto a 3D model. The U and V do not stand for anything; rather, they reference the axes of a 2D texture. Instead of X, Y, and Z, textures use U and V. In Figure 7, Emily's UVs can be seen. The darker lines around her nose, mouth, eyes, and the line intersecting the middle of her face are her UVs.

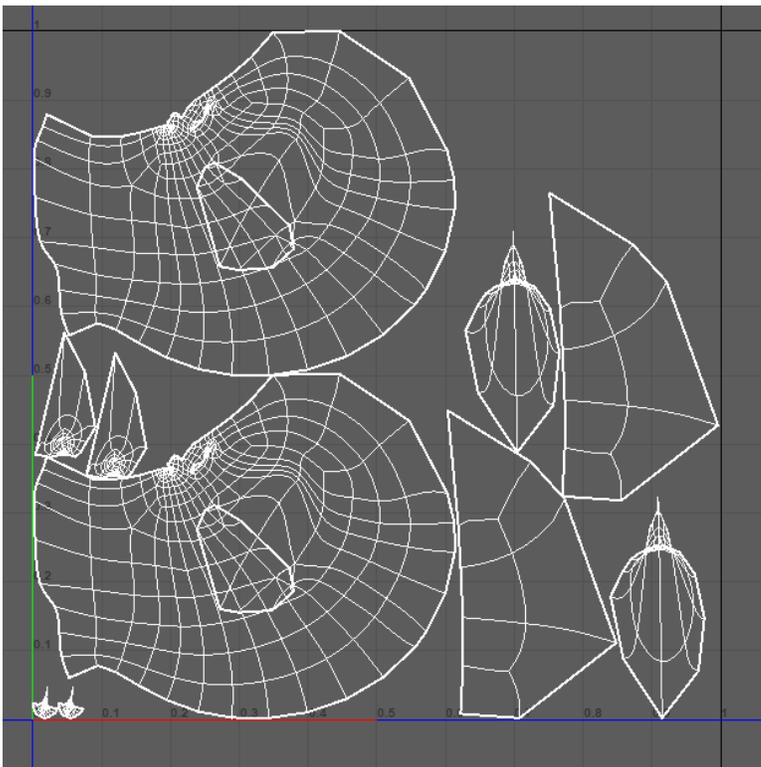


Figure 10: Emily's facial UV map

Texturing was completed very quickly, in about a week since the environments were not textured and the characters are only flatly colored with a basic material in Maya called a lambert. This material is a simple matte shader that can be changed into any color. The only objects not textured with lamberts are spheres on top of the characters' eyes; this material is called a Blinn, which is a reflective material that also has transparency capabilities, perfect for a lens cap.

Rigging

Rigging in the realm of animation is a technical and sometimes incredibly frustrating aspect of the production pipeline. I personally enjoy the problem solving that comes with rigging, but most people in the animation field despise it. To be able to do it well, a rigger, also known as a technical director, must know multiple coding languages such as Python, Java, and for very advanced software development, C+, C++, and C#. Maya is a node-based program; nodes, being small bits of code, interact with each other to create an incredibly large network of these interactions. Knowing how to code allows technical directors to write their own programs and scripts to make rigging easier and more versatile. Rigging requires perfect organization, some math, and a lot of patience. Despite the frustrations and in-depth technical knowledge needed to rig an animated character, it is one of the more rewarding parts of animation; without a rig, a character cannot move. I fiddled with a little bit of code for forearm movement to automate the rotation of Emily's forearm, but it ended up not being necessary due to how little her forearm rotates. I otherwise used the tools provided by Maya to create my rigs.

In its essence, rigging is “hooking up” a 3D model to a skeleton and making that skeleton easy to interact with, like a marionette. You’ll see me use the word “constraint” multiple times in this section; a constraint is a connection between one object and another. There are many different constraints in Maya: an orient constraint which allows for rotation of an object but not translation, a parent constraint in which the object can rotate and/or translate, a pole vector which snaps a joint to a specific orientation (think of your knees), and an aim constraint in which an object always stays pointing towards another object as the second object moves, just to name a few. These constraints are what

I used in the rigs for Emily and her mother; the rigging process took about two months, but the rigs continued to be refined during the animation stage.

Characters

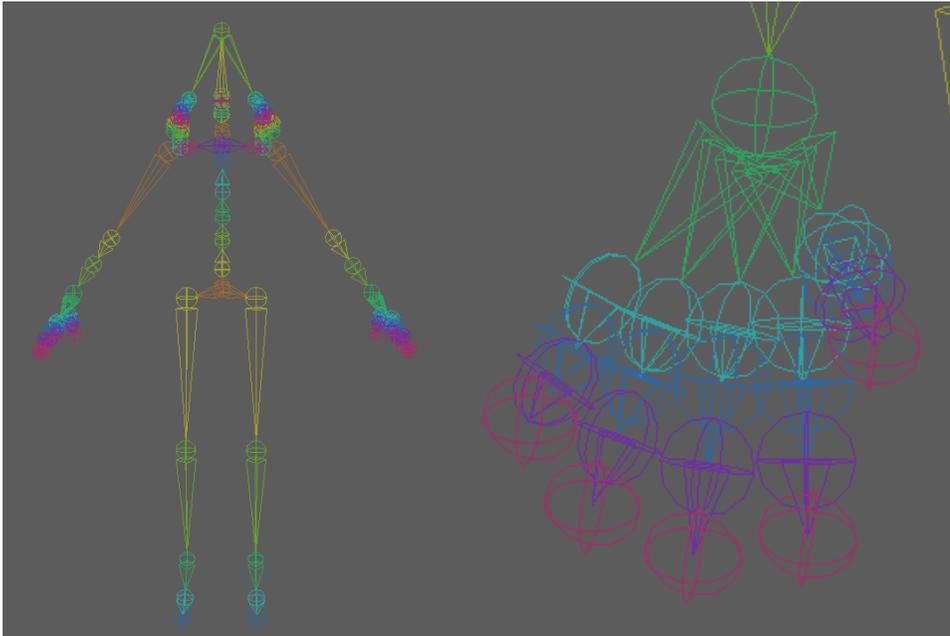


Figure 11: Emily’s skeleton and a close up of her right hand

Emily’s rig is basic; I will continue to refer to Figure 10 above when explaining it.

Each circle shown is called a joint, and they do exactly what the joints in any living thing do: they move. Almost every rig contains a series of joints arranged in a way that fits inside the model, allowing for maximum movability. All joint-based rigs have a “root” joint; this joint is the very first joint in the chain and is usually the last joint in the spine before the legs. From here, the rest of the rig is built: from the root to the hips, then knees, then ankles, and (if the character has shoes), two more joints for each foot. Going back to the root, it also leads to the rest of the spine, head, jaw, tongue, and any hair that needs to be animated, as well as the shoulders, elbows, forearms, wrists, and fingers.

Emily has joint chains in her pigtails so that they can move freely. The local orientation of a joint is extremely important for a stable rig, and I'll explain why in a moment.



Figure 12: Emily's skeleton inside her model and a small portion of the hierarchy used in her rig

Once all the joints are laid out, there are two paths technical directors can take: they can begin to create the controls necessary to animate the joints, or they can bind the model to the skeleton. I created the controls first. The controls are created out of simple 2D NURBS (Non-Uniform Rational B-Spline) circles (NURBS is a modeling method that uses defined curves to create shapes rather than polygons that uses vertices and faces) and are constrained in different ways to multiple parts of the body. The arms, spine, and head are most commonly rigged using orient constraints.

Eyes have a special aim constraint in which they will always “look at” the curve they are constrained to. I like to rig my tongues in a way where they can move up and down, side to side, and roll side to side as well. As I mentioned above, the local orientation of each joint, or simply just joint orientation, is incredibly vital to having a rig that works.

Without getting extremely technical, each joint must face a certain direction relative to the joints before and after it. If one joint is oriented with the X axis pointing upwards and the next joint has the Z axis pointing upwards, you can run into some serious issues where your joints will rotate in strange ways relative to each other, rather than logically in a chain. This leads me to what is, in my opinion, the most difficult and tedious part of the rigging process: the hands.

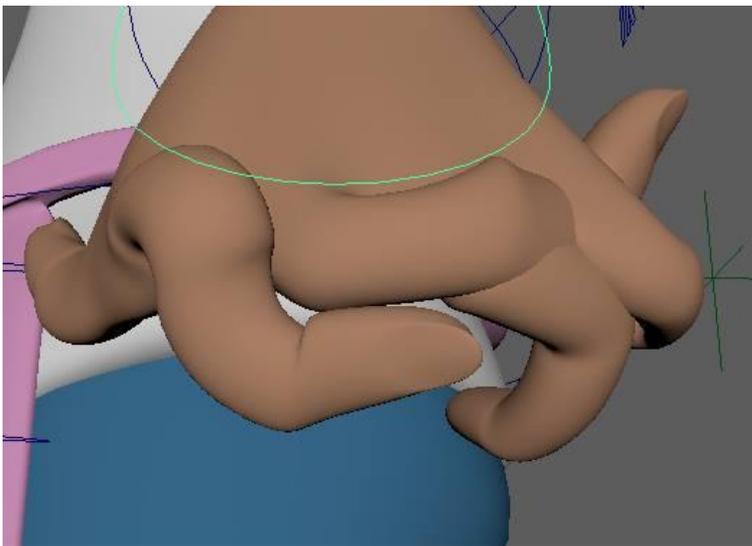


Figure 13: Incorrect joint orientation in the mom’s fingers caused a very interesting broken hand when setting up set driven keys

Rigging hands requires surgical precision. Any misstep can cause catastrophe, as seen in Figure 12. Joint orientation *must* be perfect. A very tedious process of creating a connection called a “set driven key” is required for basic functionality of fingers. This

process essentially creates a connection between two nodes that, under normal circumstances, cannot be connected. In this case, a control is placed on top of the hand that can animate each finger curling, uncurling, spreading, and forming a fist using special attributes added to the control. These attributes, using the set driven key command, can be connected to the rotation of the joints in the fingers to allow animation of the hand using the attributes in the control placed above the hand rather than having very small controls for each finger joint, which can become very cluttered very quickly. This process is done for each finger, as well as something I have not covered yet: an IK and FK switch.



Figure 14: An IK/FK switch used in both rigs

IK (Inverse Kinematics) and FK (Forward Kinematics) are methods of animating movement. This movement is required to have Emily's phone and flyer stay aligned with her hands, as well as the rest of the basic animation. FK allows for movement of individual joints, while IK uses mathematical functions to move an entire joint chain. IK can be used to keep a joint locked in a certain position or to constrain an object to a joint (holding a cell phone). It is hardly ever used to animate; FK is much more versatile and easier to control. IK utilizes pole vector constraints to keep joint chains aligned, while FK does not need this function, as each joint is animated separately from one another.

Both are useful, but both cannot be used at the same time for a set of arms. Simply put, a switch is created using set driven keys to use the arrow pictured in Figure 13 to switch between IK and FK using a node called IK blend, which allows seamless transitions between the two kinds of animation.

Legs are almost always set up in only IK due to the lack of need for FK. A series of joints grouped with themselves creates a unique circumstance in which a foot roll, toe roll, and foot pivot are created. The feet are parent constrained to a control.

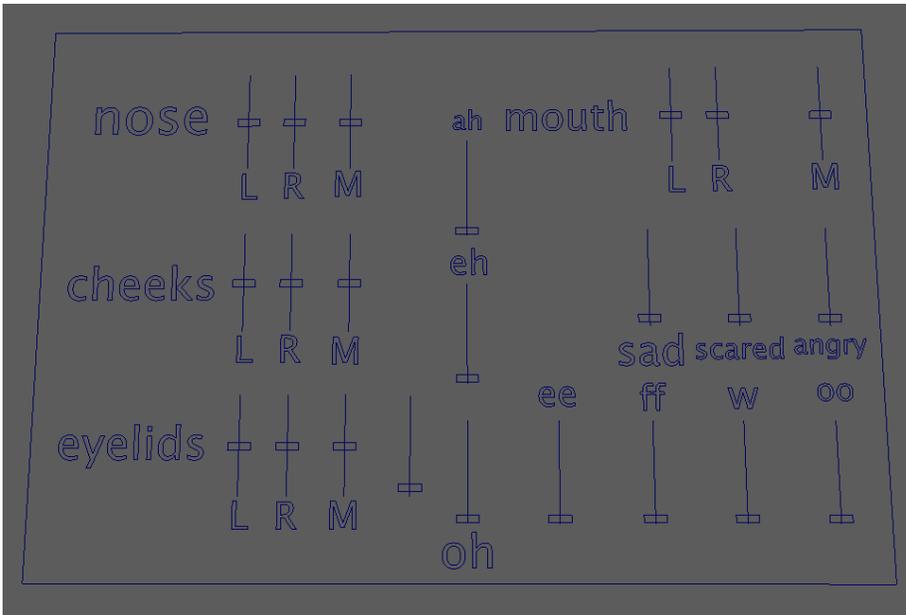


Figure 15: The GUI used in Emily's and her mom's rig

This part of rigging involves advanced facial movement using blend shapes attached to a GUI and standalone joints that are grouped and constrained to the main head joint that allow for more varied facial movement.

Creating a GUI is simple. Using text and special NURBS curves (lines, in this case), a series of sliders that correspond to specific facial expressions can be created and

bound to those facial expressions using set driven keys. These facial expressions include everything from visemes to blinking to scrunching a nose or inflating cheeks and are called blend shapes. Blend shapes are called such because they are meant to blend with your model to make a change in it. A special kind of blend shape called a corrective blend can be created to correct any trouble spots found in weight painting, which I will discuss in a moment. Blend shapes are essentially duplicates of a body part, most often the head, and the duplicated model is modified to create a facial expression or mouth shape.



Figure 16: Three of the mother’s 15+ blend shapes

It is commonplace not always to need all the blend shapes that are created; for example, I created multiple blend shapes for each human viseme and ended up not needing most of them because dialogue was removed.

The final step to rigging, leading into animation, is binding the model to the skeleton and weight painting. Weight painting involves literally painting how much influence each joint has over each part of a model. Shoulders and hips are the hardest places to weight paint due to how specific the movement in those areas is. Some clothing is harder to weight paint than others; skirts are harder to weight paint than pants because

of how they must conform to legs. Without proper weight painting, animation can be virtually impossible because the model deforms in unnatural ways. If weight painting and corrective blends still do not provide proper deformation, then a deformer node called a skin cluster can be created. Skin clusters take groups of vertices and allow them to be animated using a special cluster handle. I had to use one of these for the mom's apron, which can be seen below in Figure 17.

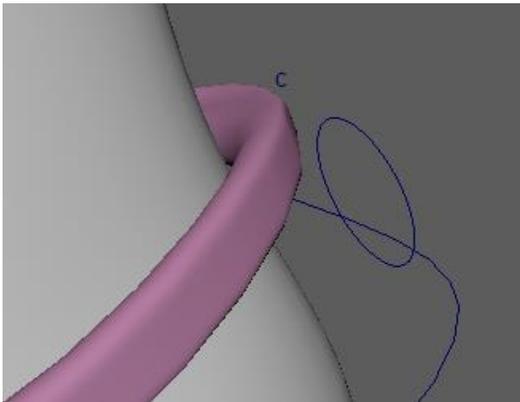


Figure 17: Skin cluster used to animate the strap of the mom's apron



Figure 18: Completed rigs

Once the rigs are completed, everything gets compiled into a sensible hierarchy and placed under a full control, which can be seen in Figure 17 as the diamonds at the characters' feet. This control allows the animator to move, rotate, and scale the entire character wherever and however they need to be. Emily and her mother essentially have the same rig. I created Emily's rig and then modified it to suit her mother's model and animation needs by adding joint chains in her apron and her hair. Now that the rigs are finally complete, animation can begin. It is common to modify a rig constantly throughout the rest of production to suit the needs of the animators; rigs break, more control needs to be added, more weight painting needs to be done, and everything that is not supposed to move needs to be locked in place so that it can't be. The ideal rig is break-proof, but there is always a way to break a rig.

Environment

The environment rig for *Emily* is minimal. The phone and flyer Emily hold needed very, very minimal and basic rigs; the phone simply has a control around it, and the flyer has a joint chain. Doors were animated directly without any controls. In bigger productions, extensive environment rigs are often necessary, but because the characters in *Emily* do not interact with the environment very much, a complex rig was not required.

Animation

Layout

Layout, also referred to as pre-visualization (pre-vis), is the beginning of the animation phase. This involves camera placement and only major character movements; often during this phase, characters slide around in t- or a-pose while the cameras for each shot are laid out according to the storyboard and animatic. The layout section of animation took about three weeks, and from there, minor camera adjustments were made as needed. I ended up having around 20 cameras for my whole film and 23 shots.

House

Animation for the shots in the house were in development until the end. These shots were rather difficult because of the confined space and necessary close-up shots for impact. Walking animations were minimized as much as possible, and most animation was done in the characters' arms and face. The animation for the shots inside the house were not technically difficult but provided a challenge due to how much subtle movement was required to make the characters still feel alive when they were not moving very much. Emily, being a phone-dependent teenager, doesn't react much, which made her animation difficult to nail down. Her mother was not as difficult to animate because she showcases a bit more body movement; being a stay-at-home mom allows her to be more comfortable with how she behaves. Because of her personality, she does not need as much subtle animation to convey her emotions. The most difficult part of animating inside the house was creating a false walking animation for Emily as she enters her house

and passes by her mother to go into her room. The goal in these shots was to establish the characters and provide the conclusion of Emily returning home safely.

Bar

The animation in the bar was difficult to plan. For the close up on Emily when she faces her attacker, the attacker's 3D model's visibility had to be animated to be able to see Emily. Emily's visibility was also toggled to get the shot of the sign at the bar, and the final shot at the bar when she runs away was difficult and tedious to animate.

Walking was also minimized in the bar shots. These shots were also in development until the end. These shots showcase the climax of the film in which Emily faces her attacker and decides at the last minute that she isn't safe and returns home, which is a decision that not all victims are able to make.

Lighting

Creating lighting for 3D animation is similar to live action lighting setups. A fill, key, and rim light are often used to sufficiently light live action sets, and 3D sets are no different. Lighting for this film was done at the time of render; many test renders are required to be able to see if your lights are working well or if they need to be adjusted.

House

Outside of Emily's room, there were four point lights (lights that emanate from a single point and decay as the light spreads) used: one in the kitchen, one in the actual living room, one just outside the front door, and one in the final hugging shot between Emily and her mother to reduce shadows. The lighting for the scenes inside the house is supposed to convey midday and a more positive tone in the beginning, and nighttime at the end.

Inside her room, there were three point lights used. One was in front of her computer, one was high up in her ceiling, and another was in front of her window to imitate sunlight. These lights were particularly tricky to work with because they caused fireflies in the rendered shots—white pixels that significantly reduce the render quality.

Bar

The lighting in the bar shots was surprisingly easy to manipulate. There are three spot lights for the street lamps outside of the bar, three point lights inside the bar, and two more point lights outside: one for night time illumination and one to act as a rim light for the attacker. The lighting for the scenes in the bar is meant to convey nighttime and a more ominous mood.

Rendering

Rendering is the process in which the computer calculates light rays, transparency, reflectivity, and sub-surface scattering (think of when you shine a light through the tips of your fingers and the light makes your fingers look red and orange) to create an image that cannot be obtained through the computer screen preview. Renders are still images that are put together in a video editing program to begin creation of the look of the final film; twenty-four frames per second must be calculated by the rendering software.

Arnold and Autodesk Maya's Legacy Render Layers

The industry standard for rendering is currently the software Arnold. It comes built into Maya and allows for realistic lighting. What can be tricky about using Arnold is setting the render in a way that makes effective use of the time the computer spends on each individual image, or frame, of animation. The ideal render takes under two minutes per frame, but this number fluctuates significantly based on how many lights are in your scene, how many polygons your models have, how many objects are in your scene, and what your samples are set at. Samples refer to a few different rendering capabilities that Arnold has: camera samples which determine how grainy, or noisy, the images are, diffuse samples which calculate bounced light caused by direct and indirect lighting, reflection and specularities which determine how well the reflectivity and shininess of a surface is rendered, sub surface scattering which I mentioned at the beginning of this subject, and more. For my purposes, I was able to eliminate the need for most of these samples; I only needed to use camera and diffuse samples, which significantly lowers the time needed to render a frame. Most of my frames were rendered in under two minutes.

Something unique I had to do for this film was set up Arnold render layers. Render layers allow for certain objects to be rendered while other objects do not show up. This is how I was able to create the drawn backgrounds. I put all the characters on one layer and put the background on another and was easily able to render them separately so that the characters did not interfere with the background drawings, and vice versa. This method of rendering is most often used when 3D objects need to be placed into live footage or a real image. Rendering in layers allows for higher samples due to the software not having to render as much at a time compared to if it was rendering every object on one layer. Higher samples combined with lower render times and the need to draw the backgrounds for each shot made render layers a requirement.

POST-PRODUCTION

Asset Creation

All backgrounds, Emily's attacker, and the shadow binding Emily's arm were done in post-production, or just post. That simply means that they were added into the film after the main animation was completed and rendered.

Backgrounds

Each background was rendered in 3D first, and in my art program of choice I re-created the scene in a 2D drawing. This method added a unique look to the film that worked well to save time during texturing and rendering, but also helped blend the multiple different moods of the film.

The art program I used to create the backgrounds was Clip Studio Paint. This software is essentially a more user-friendly version of Adobe Photoshop that is specifically for artists. By importing the 3D renders of the environment into Clip, I could lower the opacity on that image and draw directly on top of it. For some backgrounds, I had to save the images in pieces to be able to create moving objects in the final composited film. The phone screen and flyer were created in the same way.

Warning Flags

The warning flags, the messages that would appear periodically throughout the film, were created in Adobe After Effects using the text tool.

2D Animated Overlay

Emily's Attacker

At first, Emily's attacker was tedious to add into the final film. I rendered a specific layer for the attacker so that I could import each image into Clip and create a unique scribble look for each frame. Each frame that the attacker is visible showcased an image that I hand-corrected for the interesting scribble effect. I contemplated completing this in After Effects using what's called a displacement map, which can create grain and/or noise or swirling cloudy looks on an object. However, doing this would have taken a piece of the film's uniqueness away, so I decided to go with the more time consuming, finger-numbing route of hand-scribbling each frame that the attacker is seen. However, after some professional insight, I learned that After Effects has a scribble effect that can be applied to objects. I completely abandoned the time consuming, finger-numbing frame-by-frame scribbling for something much quicker, much easier, and more effective.

Arm Binding

The shot where Emily's arm is bound by the attacker was also done in post. Using the scribble effect, a series of masks, and stroke animation, I was able to create a "shadow" that wrapped around her arm. The shadow was hand animated to follow her arm.

Sound

Sound is arguably the most important part of the final cut of a film; without it, you would have a good opportunity to take a nap instead of watching an exciting film.

The sound for *Emily* was all built from scratch using open source sound found from freesound.org. I used a large library of sound effects and music. These sounds included footsteps, door creaks, dramatic flourishes, a heartbeat, female panting, and cell phone beeps, to name a few. Using my basic experience in mixing sound for film, I was able to create a custom track that helped tie the film together in Adobe Premiere.

REFLECTION AND CONCLUSION

The creation of *Emily* has been an experience that is priceless to my growth as an animator, as a professional, and as a person. While the Honors program may not in theory be beneficial for an animation major, I have learned through my experiences gained from this project that truly, theory is not law. The top professor in my own major nearly convinced me that the thesis was worthless to my future because we are not an academic discipline, but he could not be more wrong. Let me explain why.

First and foremost, I learned a lot of new techniques and a unique style of film, combining 2D and 3D graphics to create a comprehensive story that does not have to be perfect to be impactful. I learned so much from my advisor, Professor Rodrigo Gomez, and every day I am thankful to be closely connected with him and his wisdom and endless excitement for problem-solving, talent, and his kind heart. He truly inspired me multiple times throughout the process of creating *Emily* with showing me his own projects and having consistent contact with someone so excited to tackle new problems was invigorating, to say the least.

Last spring, a serious family issue caused my father to leave my family and return to his hometown. This was detrimental to our functionality as a middle-class family. I have a five-year-old sister, my mother works full-time, and I am a full-time student. Because of my father's absence, I have sacrificed friendships, good family relationships, networking opportunities, and monetary gains to help my mother care for my younger sister. This explosive issue led to a depression that still follows me, but slowly, I am recovering. It peaked this past August, before the semester started when I attempted to take my own life. Clouded judgement due to depression and a lack of motivation to

persevere led to a long period where I struggled to work on the thesis project, which further caused lack of sleep and near refusal to eat. These combined issues led to an act of desperation in which I felt truly and utterly alone.

Regardless, I persevered through the help of my fiancé and the few friends that remain close to me. I took some time to reflect on myself, my emotions, and the situation that had blown up in my family, and I came out stronger and feeling more confident about myself and my ability to succeed in the animation field. I got back to work on the thesis, and with Professor Gomez' help, I was able to complete the project. I am very proud of completing *Emily* because it is a testament to how much I have grown in the past year and how much I have learned during my time at MTSU.

I see areas where I could improve. The rigs were not fully completed; they were stable and easily usable, but the characters' eyebrows were never able to follow their heads, and there was some optimization that I never accomplished due to time constraints. Animation could be more exaggerated and fluid, the backgrounds could have more detail, and the final composite could be cleaner. However, I believe that with my level of experience, the life events I had to overcome, and having another film to work on simultaneously, I was able to create a very solid film that accomplishes its goal.

I am thankful for the opportunity to create a film that could be impactful to a generation that is still very moldable. The experience I have gained from the thesis is invaluable, and the lessons I have learned will follow me for the rest of my life.

WORKS CITED

Cheparev, Alex. YouTube, YouTube, 9 Nov. 2015,

www.youtube.com/watch?v=vRchh9ye7TY&t=1780s.

End Slavery. "Tactics." BeTheJam, End Slavery, www.bethejam.org/tactics/.

"Freesound." Freesound, freesound.org/.

SUGGESTED READINGS

End Slavery. "Tactics." BeTheJam, End Slavery, www.bethejam.org/tactics/.

Sobel, Meghan. "Sex Trafficking Isn't What You Think It Is | Meghan Sobel |

TEDxMileHighWomen." YouTube, YouTube, 14 Dec. 2016,

www.youtube.com/watch?v=wyhF7q3_bpk&t=722s.

Timms, Mariah. "Human Trafficking Is Happening in Nashville's Backyards, but Experts

Say Awareness Is the First Battle." The Tennessean, Nashville Tennessean, 1 Feb.

2019, [www.tennessean.com/story/news/2019/02/01/human-trafficking-tennessee-](http://www.tennessean.com/story/news/2019/02/01/human-trafficking-tennessee-crime-nashville-sex-workers-tbi-end-slavery-williamson-junior-league/2728612002/)

[crime-nashville-sex-workers-tbi-end-slavery-williamson-junior-](http://www.tennessean.com/story/news/2019/02/01/human-trafficking-tennessee-crime-nashville-sex-workers-tbi-end-slavery-williamson-junior-league/2728612002/)

[league/2728612002/](http://www.tennessean.com/story/news/2019/02/01/human-trafficking-tennessee-crime-nashville-sex-workers-tbi-end-slavery-williamson-junior-league/2728612002/).

https://www.dropbox.com/s/fgu37wrkdr47xc3/Cromwell_Thesis_FinalRevised.mp4?dl=0