Jingle Lizard: An Undergraduate 3D Animated Short and Investigation into the 3D Animation Process

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# Table of Contents

Abstract ........................................................................................................................................ 2

Background Information ....................................................................................................... 2
  Development ........................................................................................................................................ 3
  Pre-production ...................................................................................................................................... 11
  Shot production .................................................................................................................................. 24
  Post-production .................................................................................................................................. 40

Problem Description .............................................................................................................43

Design Methodology ..............................................................................................................44

Data Collection............................................................................................................................47
  Overall Production Pipeline – Calabash Animation .............................................................. 48
  Modeling and Texturing – Calabash Animation ...................................................................... 52
  Animation – Calabash Animation, RTC, Phosphor Games .................................................. 55
  Special Effects and Compositing – Calabash Animation ...................................................... 64

Results of the Study ................................................................................................................66

Conclusions and Further Research ......................................................................................69
  Areas for Further Research ........................................................................................................ 72

Bibliography .............................................................................................................................73

Appendix ....................................................................................................................................74
  Research Study Interview Questions ......................................................................................... 74
    Storyboarding .................................................................................................................... 74
    Modeling ............................................................................................................................. 77
    Animation ............................................................................................................................. 79
    Special Effects/Post-production ......................................................................................... 81
    Scheduling ............................................................................................................................. 83
Abstract

Creating a 3D animated short is far from a simple task; countless hours of work go into every few seconds of a completed film. Considering the incredible time commitment and skills needed to complete a task of this magnitude, it’s essential to use the most efficient and effective approaches to the animation process. Additionally, successful 3D animation is predominantly a commercial enterprise, as proprietary concerns currently limit the amount of published literature available on production methodologies.

This twofold project investigated ideal approaches to 3D animation with the goal of identifying methods that can translate to the single, independent animator. For the investigation portion of this project, I was granted access to interview production team members from companies that are traditionally closed to the public, where I learned about practices used by smaller-scale studios. My findings were synthesized into this document, which outlines a proposed methodology for small entrepreneurial filmmakers. For the second part of this project, I combined my findings with conceptual and technical research to produce an original short film demonstrating this methodology.

Independent animators will benefit from this study that pares down the production pipeline for smaller teams, as will educators, whose limited time and resources pose challenges for teaching 3D animation.

Background Information

Like nearly all complex endeavors, creating an animated film involves a multi-step process, often known in creative fields as the ‘production cycle.’ This cycle can be
divided into four major stages: development, pre-production, shot production, and post-production, and each of these stages can be further broken down into more concrete tasks (Cantor and Valencia 155).

Development

The first stage of development consists of story development, character design and art direction, and storyboards. One of the challenges of creating a short story in any time-based medium is fitting a full plot into a limited time frame. One of the ways to work with this limitation is to scale things down to ‘one’: one character that’s having trouble getting something he or she wants badly, one character or environmental element that creates a conflict, and one idea, theme, or concept presented in the story’s resolution (Sullivan, Schumer, and Alexander 23). The story writing process can thus be simplified down to a single sentence: “A character wants something badly, something happens that moves him to action, he meets with conflict, things get worse until the character is in crisis, he nearly loses all, (then) learns a lesson (and) makes a hard choice in order to succeed” (Sullivan, Schumer, and Alexander 24).

Before even beginning to work through the story structure, one must develop a premise: a couple of sentences that lay out the main character, his or her situation, and the conflict. Then one must determine whether this premise is the best way to relay the idea, concept, or theme – might there be a more entertaining way to communicate the same idea? For an animated film, it must also be clear that animation is the best medium for the piece, rather than film or a non-time-based medium (Sullivan, Schumer, and Alexander 129-130).
The classic linear structure for story writing is to begin with an exposition that introduces the main character and setting. Particularly in a short film, it’s crucial to immediately know who the character is and be able to identify his or her goal. Following the exposition is the inciting incident, when an unexpected event initiates the action and sets the main character in pursuit of the goal. Next comes rising conflict, in which obstacles prevent the character from reaching this goal; in a short film, this typically occurs through a series of two to three events. This puts the character in crisis, when he or she is at the lowest point and must make a decision or figure out a way to ultimately solve the problem. Then comes the climax, which positions the character in direct opposition with the obstacle and the character must act to overcome it – “the point of no return.” Oftentimes, the crisis and climax are combined into a single event in a short film. Finally, the story concludes with a resolution in which the character either succeeds or fails in reaching the goal (Sullivan, Schumer, and Alexander 133-136).

This linear structure can be used to tell a countless number of stories, but variations on this basic storytelling format have been developed as well. Some of these other versions include parallel structure, in which multiple events occur simultaneously and come together at the story’s resolution; circular structure, in which the character finds him- or herself in nearly the same situation at the end of the story as at the beginning; and ping-pong or zig-zag structure, in which the character “moves back and forth between similar but escalating obstacles” in trying to reach the goal (Sullivan, Schumer, and Alexander 136-138).
The conflict can be developed in multiple ways, by either compounding the conflict – building it up in layers through a series of related, often increasingly important events, or by accumulating the conflict – combining multiple, unrelated problems that build in complexity. Compounded conflicts are most common in shorts because there it requires less time to develop a series of related events than unrelated ones. Examples of compounded conflict include the domino effect – a chain reaction of problems that progresses in a linear fashion, and the cascade effect – a single problem that causes a multitude of similar problems that proceed in a “branching structure” (Sullivan, Schumer, and Alexander 145).

Developing the ending is particularly crucial since it is often what the audience will remember most. A good ending “transforms your character, your audience, or both” (Sullivan, Schumer, and Alexander 141). The theme of the story often helps determine the resolution, as it influences what the character learns or how the character chooses to act when faced with crisis (Sullivan, Schumer, and Alexander 142).

Once the story has been established, the next step in development is to determine the art direction of the characters and the world they will inhabit. Visually, the character is a combination of character genre and character style. Examples of genres include animal, human, alien, monster, mythological creature, machine or robot, and inanimate object. The style determines the appearance of the character model and the level of detail it will require. The main styles are real, semi-real or slightly caricatured, cartoony, and abstract. Each character style has its own benefits and drawbacks; for instance, an audience will find it easiest to relate to a realistic-looking character, but that is also the
hardest type of character to animate since the audience will expect its movements to be equally realistic (Cantor and Valencia 58-62).

The audience is primarily informed about a character through the character’s design and behavior. The character’s design arises from mixing a variety of visual elements into the best combination to express that character’s unique personality. These visual elements include design elements (such as line and shape); specific biological or anatomical features; color; posture and facial expressions; style, grooming, and condition; clothing and accessories; and exaggeration (Cantor and Valencia 79-83). Model sheets are drawn out to show a given character from multiple angles and in a variety of poses. When developing a character, ‘behavior’ refers to one to two “quick initial actions or gestures” that help convey personality. Behavior is the most effective way to develop character in a long story, but for the purposes of a short film, design is a more important consideration, since the medium does not allow enough time for the number of behaviors needed to sufficiently define the character (Cantor and Valencia 85).

Aside from the character, the art direction of the story’s setting must be established before pre-production can begin. One of the main goals of a film’s visual style is to evoke a particular mood or emotion in its audience. This can be achieved through careful consideration of the film’s overall art style; the quantity, style, design, color, and texture of environments and props; weather and related effects; and lighting, rendering, and post-production filters. In particular, the overall art style is defined by the level of realism, color palettes, texture themes, and composition of items in the scene (Cantor and Valencia 102-105). Often the art style is influenced by how original the story
or characters are; the less original the story or characters, the more crucial that the art style be unique (Cantor and Valencia 121).

In designing both characters and the rest of the story environment, it’s important to consider how much time it will take to actually create these assets. Some questions to ask during this stage are how time-consuming it will be to model and texture these elements, whether 2D matte paintings can be used as substitutes for any 3D models, and whether effects can be added via 2D post-rendering layers instead of generated in a 3D design program (Cantor and Valencia 122-123). The answers to these questions may require reconsideration or simplification of character design and art direction.

The final stage prior to pre-production is storyboarding, in which the script is translated into rough, loose visuals that lay out the characters and props and position the cameras in the scene. Two of the most important considerations when creating storyboards are simplicity and clarity (Sullivan, Schumer, and Alexander 177) – simplicity so that ideas can be worked through quickly, and clarity so that other members of the production team can understand them. One entirely visual approach to storyboarding is to “start by arranging basic images in an order that seems to follow the simplest, most direct depiction of the narrative” (Sullivan, Schumer, and Alexander 182). Doing so is a freeform way to experiment with story and visuals without needing to be conscientious of exactly how the plot will be divided among the shots. A more verbal, structured technique is to write out a beat sheet (a ‘beat’ simply being any main story point). A beat sheet is “a beat-by-beat (written) description of what will happen in a scene” that allows the initial visualization to occur in the artist’s imagination rather than
on paper or on screen (Sullivan, Schumer, and Alexander 182). The most precise process for creating storyboards is the shot list – a description of how each individual shot will appear on film, in terms of camera angle, camera distance from subjects, direction of motion, etc. It is during the creation of the shot list that the artist determines exactly how many shots are required to tell each story point (Sullivan, Schumer, and Alexander 183).

Using a beat sheet, shot list, or similar device, the storyboards themselves are drawn out. Each storyboard panel typically includes three main components: character(s), object(s), background imagery, and icons; indication of movement; and text (Cantor and Valencia 135). The most important elements to include for the characters in this stage are their overall gestures and head orientation (i.e., the direction they are facing). Movement is indicated via frames and arrows positioned strategically in each panel. One example is a secondary frame – a smaller frame either drawn inside or overlapping the main storyboard panel that “shows the initial or final framing of a shot” (Cantor and Valencia 137). The direction of the arrows indicates whether the camera will zoom in to focus on the smaller frame, or zoom out to reveal the entire panel. Finally, text is used for written dialogue, narration, notes, sound effects, or explaining movement. It’s generally written beneath the storyboard panel, but may also be included in word balloons or simply written wherever there is space (Cantor and Valencia 136-138).
In addition to these three components, other crucial considerations for the storyboarding stage are the types of shots that will be used and what techniques will be used to transition between them. Examples of traditional shots that may be conveyed in storyboards include: establishing shot, which reveals the setting in which the scene will take place; reverse shot, in which the camera direction from the previous shot is reversed; “over the shoulder” shot, where the camera is positioned directly behind the character’s shoulders, allowing the audience to view the scene from his or her perspective; “cut on the look” and point-of-view shots, in which the character is looking at something and the camera cuts to that object from a first-person point-of-view; and thinking, deciding, and reaction shots, particularly crucial shots that reveal the character’s thoughts and feelings regarding whatever he or she is experiencing at the moment (Sullivan, Schumer, and

Figure A. Sample storyboards from “Jingle Lizard.” ©Amber Dvorak
Alexander 195-196). Using different shots throughout the course of a film adds variety and allows the audience to experience the story from multiple perspectives.

One crucial rule to obey in setting up shots and establishing camera placement is the 180-degree rule, which serves as “a guide to maintain a consistent positioning within the two-dimensional frame of the movie” (Sullivan, Schumer, and Alexander 188). In order to maintain continuity, the camera should not completely reverse direction – or rotate 180 degrees – between shots. Characters moving from the left side of the screen to the right in one shot should not appear as if they were moving from right to left in the subsequent shot, unless of course they actually reversed direction themselves. Following the 180-degree rule prevents a great deal of unnecessary audience confusion (Sullivan, Schumer, and Alexander 188).

For as many possible shot types as there are, there are nearly as many different ways to transition between them. Basic technical editing transitions include the standard cut, a fade-to-black or fade-to-white (often used to suggest the passage of time), and the cross-dissolve, in which the new shot fades in while the old one fades out. Transitions can also be pictorial, based on the types of images shown in succession. For instance, a match cut shows an image that is similar to the one preceding it in content, shape, size, color, or movement, and is used to tie together multiple shots. Another unique cut is the jump cut, in which “the same character or image moves abruptly from one shot to the next,” another way to show time passing (Sullivan, Schumer, and Alexander 204-206).
Pre-production

The first part of pre-production is typically assembling a 2D animatic, “a digital slideshow of sequential storyboard images displayed for appropriate durations and synched up to any audio files crucial to story point delivery,” especially dialogue (Cantor and Valencia 219). A simple formula for explaining a 2D animatic is that it equals storyboards plus timing plus audio. The main purpose of this step is to see the story play out in moving picture form, since the element of timing has been added to the static storyboard images. Alterations in story structure or pacing should be made at this point, as it will become more expensive in both time and resources to make changes later in the production cycle (Cantor and Valencia 220-221).

Whether audio is added to the 2D animatic or during a later stage depends on the extent to which audio plays a role in the final production. If the film is “primarily visual” (has little to no dialogue, and audio is limited to sound effects and/or a score that can be added after the final images are rendered), audio is not necessary at this point. If, however, “story flow is dictated by a piece of prerecorded music” or the film has many lines of dialogue, the audio should be added prior to establishing the timing for each storyboard image (Cantor and Valencia 223). Once the storyboards have been brought into non-linear editing software, they are appropriately timed, and if desired, camera moves – such as panning or zooming – can be simulated as well (Cantor and Valencia 226-227).

The equation for the 3D animatic, the next part of pre-production, is 2D animatic plus spatial depth plus staging and camera direction. A 3D program is used to assemble
individual shot layouts that establish the placement and general trajectory of the characters, props, and cameras in each shot (Cantor and Valencia 231-232). Often, low-resolution models substitute for full-resolution models at this stage, but it’s left to individual preference. Before situating objects in the scene, however, the shot length, or duration, must be translated from the 2D animatic and finalized. For instance, for a film running at 24 frames per second, two seconds of screen time in the 2D animatic would equate to 48 frames on the 3D animatic’s timeline. To account for slight timing changes and ensure continuity between shots, it’s customary to leave “margin-of-error padding” on the timeline by creating “frame handles,” typically 4-8 additional frames at the beginning and end of a shot. These frames can always be omitted in the end, but they’ll be available if the shot ends up requiring a slight extension (Cantor and Valencia 233-234).

Next, the characters and props are positioned in each shot sequentially. The most important considerations for each object’s trajectory at this point are its location and orientation. As an object is moved, an animator manually sets keyframes – individual frames in the animation that record all of an object’s attributes in that frame. Keyframes mark all major changes in location and orientation, and the software automatically creates transitions between them. The first step is to set a keyframe to record the object’s initial location and orientation, then the object is moved to its location for the end of the shot, and another keyframe is set to record the change. If the object’s movement in the shot is particularly complex, additional keyframes can be set in between these, but the overall
movement should be kept very simple at this stage while timing and positioning are still being finalized (Cantor and Valencia 233-234).

Figure B. Keyframing a character in “Jingle Lizard.” ©Amber Dvorak

Once the characters and objects have been staged, the final part of assembling the 3D animatic is positioning the camera (or cameras) and keyframing its movements.
accordingly. First, the point-of-view for the film must be decided upon. Possible perspectives include: participant (a character directly involved in the story action), witness (someone who could potentially be present in the scene, but does not affect the story action), or objective observer (someone who does not participate in the story action and therefore can be placed at any location in the scene that provides the best framing of the shot). Keeping the chosen perspective in mind, each shot should be carefully framed, or arranged within the rectangular screen frame (Cantor and Valencia 237).

The camera can then either move or remain static (called a “lockoff”) for the duration of the shot (Cantar and Valencia 236). The options for camera movement are numerous and vary based on the movements of the other objects in the scene. The basic categories for camera movement include fixed rotations (where the camera rotates from a fixed point), translations (where the camera moves between positions in 3D space), zooms (where the camera remains in place but its lens changes its angle of focus), and combinations of these (Cantor and Valencia 241-242). The types of cuts and transitions explored in the storyboard stage are implemented here to make sure they work as intended in the 3D environment, and are changed if necessary.

Following the creation of both animatics, the next step is creating the assets that will become the characters and props in the film, assuming that simple placeholder models were utilized up to this point (alternatively, one could model the assets first and then import them into the 3D animatic, if preferred). One should first consider the models the film will require based on their style, category, and type. Style here refers to the models’ level of realism, which directly impacts their complexity and the time required to
assemble them. Category refers to whether the model is to be a character, a prop, or a background element; characters require the most detail and need to be able to undergo a full range of motion when they’re later animated.

Type refers to the specific geometry that will be used in the 3D program to create the object, typically either polygons, NURBS, or subdivision surfaces. A polygon consists of at least three vertices, or points, connected by edges. Because of the linear nature of polygonal edges, polygons are the best choice of geometry for modeling angular objects. They also render the fastest and can be used in the widest range of 3D software programs. NURBS, on the other hand, are preferable for creating organic, curved objects. NURBS are created from “mathematical calculations between the weights of control points that are connected by a typically invisible hull encasing the actual surface of a model” (Cantor and Valencia 259). In other words, the control points defining the shape of a NURBS object are not actually part of the object like vertices are for polygons; therefore, fewer control points are needed to create a curved surface. Subdivision surfaces are a cross between polygons and NURBS, but they are specific to individual 3D software programs and offer less compatibility than the other geometry types. Each of these geometry types has its own pros and cons, so often the determining factor for which one is used for any given model is the modelers’ experience and comfort level working with each type and which type would best fulfill the requirements of the model (for instance, being more organic or geometric) (Cantor and Valencia 255-260).
Figure C. A sphere modeled using polygons (left) and a sphere modeled using NURBS (right).

Figure D. Lizard character model from “Jingle Lizard.” ©Amber Dvorak
Before starting any work in a 3D program, reference materials are gathered and drawings and/or sculptures of the model are made to get a sense of its two- and three-dimensional qualities in real-life. These drawings are often scanned into the 3D program to use as a guide to keep the character’s proportion and overall design consistent with the original vision. Depending on the 3D program being used – such as Maya, Softimage, Cinema 4D, or Zbrush – the modeler determines the best tools and techniques to use for the given model. One of the last steps is creating blend shapes, particularly for facial animation. A blend shape, in the context of facial animation, is a copy of the face in its neutral state that is then altered to show any of the expressions that the character will have throughout the film. When using blend shape-based animation, a different blend shape is created for each distinct expression (such as sadness, anger, shock, etc.) and elements of each blend shape can then be combined to create a nearly infinite number of expressive possibilities (Cantor and Valencia 260-268). Another option for facial animation is to use a skeleton- or deformer-driven system. This involves creating a skeletal set-up, consisting of bones and joints, for the face – just as is done when assembling the rig for the rest of the body (see page 20-23).

Assigning materials and creating and applying textures is the process of adding a visual, tactile quality to otherwise flat 3D surfaces. ‘Material’ describes the surfaces of objects and what they would be made of in the real world – such as wood, glass, or plastic – and how the surfaces reflect light from the light sources in the scene. When assigning a material to a model in a 3D program, one must select between several different shaders – another name for material types – each of which is more appropriate
for replicating specific surface textures in real life. Each shader has properties that react differently with the lighting set-up in the scene to create a wide variety of surface appearances. The most common shaders are lambert (used for dry, unpolished, matte surfaces), Phong (used for well-polished surfaces with concentrated highlights), and Blinn (used for metallic surfaces with more diffuse highlights) (Cantor and Valencia 274).

While materials define the basic surface quality of a model and how it reacts with light, textures provide the visual detail and tactile appearance. They are also commonly used as a timesaving alternative to modeling complex details. Textures are two-dimensional files that are projected onto the surface of a 3D model to add colors, patterns, and the perception of depth. Depending on the project and the artist, textures can be made using traditional media, such as acrylic or watercolor paints; digital photographs; 2D digital textures, like those created in Adobe Photoshop or Corel Painter; 3D digital textures, like those created in Deep Paint or BodyPaint 3D; or procedural textures calculated in the 3D modeling program. Lastly, textures are applied to the 3D models via a mapping system that uses UV coordinates, similar to a traditional x-and-y coordinate system. In a UV coordinate system, the U coordinates correspond with horizontal space and the V coordinates correspond with vertical space. This two-dimensional grid is then mapped, or placed, onto a 3D model so that the points on the grid match up with the points on the model. The 2D textures are projected onto the 3D model using a planar, cylindrical, spherical, or cubic projection, based on the model’s shape. From there, the artist can individually manipulate the UV points on the two-
dimensional grid to affect changes on the three-dimensional model. Further detail can be added via specialized texture maps, such as bump maps – which create an illusion of surface depth, and displacement maps – which actually modify the geometry to create truly three-dimensional surface depth. It should also be noted that texture maps are often used for creating background plates, flat surfaces in the background of a scene that are locked to the camera in a way so as to disguise their two-dimensionality (Cantor and Valencia 276-283).
The final part of pre-production is arguably the most technically demanding: rigging and binding the character so that it is ready to be animated. Rigging, the first of the two steps, is defined as the process of “creating a character’s internal skeleton and any necessary movement controllers and special functions” (Cantor and Valencia 286). Characters are generally modeled in one of two main poses that facilitate the rigging and binding steps. In the da Vinci pose (also called a ‘T-pose’), the character is standing straight with feet together and arms outstretched at the sides, forming a 90-degree angle with the body. In the relaxed bind pose, the character’s joints are bent at the elbows and knees. The da Vinci pose is easier to texture but harder to bind, and vice-versa for the
relaxed bind pose, since the pre-bent limbs in a relaxed bind pose do not have to rotate as far to reach their extreme positions, thereby minimizing inaccurate deformations (Cantor and Valencia 286).

Rigging begins with laying out a foundation of joints – digital bones – along the geometry of the character, typically in a wireframe view. The general rule of thumb is to place a joint at each location on the character that is expected to bend, but it’s possible to make do with a smaller number of joints with effective binding. After laying out the joints, animators decide which of the characters’ limbs will be controlled by forward kinematics (FK) and which will be controlled by inverse kinematics (IK). The control scheme chosen determines how the animator will be able to move the character’s joints and so is a crucial consideration (Cantor and Valencia 287-289).
FK works by allowing the animator to rotate each individual joint on a joint chain for any given limb with FK controls. For instance, to move a character’s arm via FK controls, the animator would first rotate the shoulder joint, then the elbow joint, and finally the wrist joint. In contrast, IK works by allowing the animator to place the end joint – in this case, the wrist – in a specific location in 3D space, and have the rest of the joints automatically follow. The end joint is called the “end effector” and is controlled by moving an “IK handle” (Cantor and Valencia 289). FK controls are preferable when one wants to control or isolate the movement of an individual joint in the middle of the joint chain. They’re also able to create more natural arc movements and overlapping actions of subsequent joints on a joint chain. IK controls are best used when one needs to place an end joint, such as a character’s hand, in a specific point in 3D space, since it’s more precise than trying to calculate multiple joint rotations via FK. Oftentimes, FK controls will be used to rig a biped (two-legged) character’s arms while IK will be used for the legs, which need to be more specifically positioned on the floor surface of a scene. However, it’s also possible to create FK/IK dials that allow the animator to control the same set of limbs with either FK or IK, depending on which control is turned on (Cantor and Valencia 290-291).

Finally, control objects are set up to facilitate the character’s movement in the animation stage. Control objects can either be in the form of constraints or expressions. Using constraints is like producing “a ‘digital magnet’ where the position, orientation, scale, or aim of one object is ‘glued’ to that of another” (Cantor and Valencia 291). By
attaching a joint to a control object via constraints, the animator can move parts of the character without selecting the character’s geometry directly, making the process easier and more intuitive. Control objects can be created out of nulls, primitive objects, or curves in the 3D program; curves are often preferable because although they’re fully visible when working in the program, they don’t show up in the final render. The other way to control a character’s movement is through using expressions, in which codes are used to program various movements (Cantor and Valencia 292).

After rigging, the second step of character set-up is binding, also known as skinning or enveloping. When binding or skinning, the geometry must be assigned to be influenced by the appropriate joints to simulate realistic movements. For example, in the middle of the forearm, the geometry should be influenced by a combination of the wrist joint and the elbow joint; the degree to which each joint influences the forearm’s movement affects how it deforms, or changes shape with motion. The 3D program will automatically assign influences to the model geometry, but it needs to be precisely tweaked for the character to deform correctly. This is done through vertex weighting – manually adjusting the extent to which a given joint influences specific vertices, resulting in smooth skin deformations (Cantor and Valencia 295-296). Depending on the program, vertex weighting can be done using a variety of methods, often used in combination to ensure the highest level of accuracy: pruning small weights – eliminating areas where the vertices are slightly weighted to the wrong joint(s); painting skin weights – using a brush tool to add or subtract weights to or from a specific joint; using capsules, which surround the object and can be interactively dragged to alter the extent to which areas of the
surrounded object are influenced by a given joint; and using a component editor, in which joints are manually selected via a list and values are entered for their weights (Maestri).

As mentioned when discussing modeling, the face can be animated via blend shapes (also called morph targets) or skeleton- or deformer-driven manipulation, like most of the rest of the body (Cantor and Valencia 298). For advanced facial animation, one should create a control panel out of curves so that individual areas of the face can be manipulated without having to select those areas of the face directly. The visual appearance of a control panel is based on individual preference, but in order to have it work with the rig, the joints must be attached to it via expressions or set-driven keys, both forms of coding too complicated to fully detail here.

**Shot production**

In the shot production stage, all of the detailed planning and meticulous asset development come together to set the stage for the actual animation of the film. To track the production of each individual shot, a global shot schedule and shot progress chart are often used in conjunction.
A global shot schedule provides an overall timeline for completing entire shots, seeing every shot through from beginning to end throughout the period of time allotted for production. A shot progress chart more specifically tracks the completion of each individual shot through each stage from blocking animation through compositing (Cantor and Valencia 180-183). The shot progress chart allows the animators to track work on a smaller scale while the global shot schedule keeps the big picture constantly in perspective.
There are three different schedules that can be used to complete shots in an animated film. The first is the “straight ahead” method, in which all shots are completed sequentially, with shot one taken from the initial blocking stage all the way through to final tweaks before working on shot two. The second method is called “hero shots,” in which the most crucial shots of the film are entirely completed first, then the animator works on completing the shots that come in between. The third method is “layering,” essentially completing all shots in overall stages; for instance, using the layering method would mean that every shot in the entire film is blocked before any shots go through the first stage of animation refinement (Cantor and Valencia 184).

There are twelve fundamental principles that every animator should be familiar with, but *Inspired 3D Short Film Production* provides an additional twelve important considerations to the basic list. Following is a brief overview of each of these principles and how they are applied to the animation stage.

Perhaps the most fundamental of the animation principles is that of squash and stretch. This means that when forces act upon objects, they must deform appropriately and maintain their volume (Cantor and Valencia 316). In other words, the object must not actually increase or decrease in size, but its shape must change to account for the forces acting upon it. The most basic example of this principle is the classic bouncing rubber ball, which squashes as it hits the floor and stretches when it’s in the air. The amount of squash and stretch applied to any given object depends on the level of realism in the animation, but it should never be omitted entirely.
The principle of anticipation is a build-up for the object’s subsequent action, often achieved by moving parts of the object in the opposite direction prior to a big movement (Cantor and Valencia 317). This can be seen in a pitcher who bends his or her arm backward before a throw or someone who crouches down before taking a big jump.

Staging and composition are how the characters and props are positioned within the frame of the screen and how the camera is placed and angled in order to tell the story from the most effective point-of-view. The guidelines of still image composition are equally applicable to time-based media such as animation, for “an arbitrary freeze frame should be a well-composed work of art” (Cantor and Valencia 317).

“Straight ahead” versus “pose to pose” refers to the two main methods of proceeding through an animation. When using the straight-ahead approach, each frame is animated in sequential order from start to finish. This method requires more pre-planning since the animator needs to know roughly where in the timeline the major actions will occur, without having placeholder poses on the timeline to indicate this. The preferred method among computer graphics animators, and the one that will be detailed later, is pose-to-pose animation, in which each of the major poses is created and placed on the timeline and the animator smoothly transitions between them (Cantor and Valencia 318).

Follow through and overlapping action are related principles that focus on the movements that follow a main action and add realism. Follow through can also be considered the “extension of a main action,” in that it continues the motion after the main action has been performed. For instance, continuing a bat swing past the point of contact with a ball, or a character’s appendage continuing to move after the character stops
walking both demonstrate follow through. Overlapping action means that each action
does not necessarily take place at a separate point in time, but that instead, a second
action may begin while the first action is still finishing. In other words, “not all moving
parts of a body will start and end at exactly the same time” (Cantor and Valencia 318).

Slow in and slow out are techniques that create smooth, natural transitions
between movements. By accelerating or decelerating into and out of a keyframe,
movements become more fluid and less choppy and robotic. Another principle based on
natural movement is using arcs instead of linear translations (Cantor and Valencia 319).

Secondary action is any movement that is subordinate to the main action. Blinks,
a forehead crinkle, and lip biting are all examples of secondary action that help reveal the
inner emotions of a character without distracting from the main action (Cantor and
Valencia 319).

Timing is important not only to accurately express movement, but also to indicate
force and weight, create anticipation, and imply attitude. Different parts of the animation
should be faster or slower than others to prevent monotony and establish mood (Cantor
and Valencia 319).

Exaggeration is one of the most important principles for any type of animation,
whether cartoony or realistic. Exaggerating movements by making them significantly
bigger or smaller, or longer or shorter, makes the action more readable when the
animation is playing in real-time (Cantor and Valencia 320). An exaggerated movement
that might seem too extreme in the production stage usually appears perfectly natural in
playback.
The principles of solid drawing and appeal ensure that the animation is something visually pleasing to watch. Solid drawing refers to having a “solidly modeled character” that can accurately perform the movements required, and appeal means that the character and his or her performance is “visually interesting” to the viewer (Cantor and Valencia 320).

Simplicity and readability mean that extra, superfluous actions should not confuse the main action in the shot. Adding secondary action is important, but it must be done in moderation to avoid distracting from the main elements of the animation. The advice in Inspired 3D Short Film Production is to “do just enough to tell the story” (Cantor and Valencia 320).

There are many elements to consider in character posing, including: paying attention to the body’s center of gravity, making sure there is not too much symmetry in each pose (for instance, inserting a slight hip rotation), and defining extreme poses (those that occur when an action begins, ends, reaches its climax, or changes direction). Every pose in an animation should be related to relaying the story point at hand, and should not be included arbitrarily (Cantor and Valencia 320-321).

Other principles to consider in relation to character posing include the forces both exerted on and by the character and creating a believable sense of the character’s weight. The latter is done by carefully placing the character’s center of gravity and paying attention to pivot and leverage points – the points of contact between the character and the surfaces against which he or she moves, such as flooring (Cantor and Valencia 321-322).
Avoiding twinning means having realistic – but not identical – movements in the different body parts of a single character, or in large groups of characters or moving objects. ‘Twinning’ occurs when body parts or characters move in perfectly symmetric unison and can give a robotic appearance. The different limbs of a character should not be performing the exact same movement to the same degree at the same time, but should instead be offset to resemble how the body really moves. Similarly, objects in a large group, such as a swarm of bees, should have differentiations in their movements, creating a more organic simulation (Cantor and Valencia 322-323).

The broad principle of details is a reminder that the smallest flaw in an animation can make the entire performance appear unbelievable. Some things an animator can do to show extra attention to detail are: making character movements naturally imperfect, adding moving holds to characters standing still, and considering the propriety of an animation in relation to an object’s material (for example, a plastic object will show a different amount of squash and stretch than a metallic one) (Cantor and Valencia 323-324).

Planning ahead ensures that by the time the animator actually begins the animation in the 3D program, it’s fairly accurate and will not require major reworking. Planning ahead can involve gathering reference material, making preliminary drawings, and acting out the character’s movements, often while timing and recording them (Cantor and Valencia 324).

Hookups and continuity refers to shots cleanly matching up before and after a cut. Characters and objects should keep a consistent spatial relationship between shots, and
the trajectory of a moving character or object should correspond with its position in a
subsequent shot. In addition, if a scene is cut away from and later returned to, the
positions of the characters and objects should make sense in relation to the amount of
time elapsed between shots (Cantor and Valencia 324).

The principle of acting prevents the characters in an animation from becoming
lifeless puppets. The animator needs to consider how the character’s motivations, unique
personality, and emotional state influence each of his or her movements (Cantor and
Valencia 324-325). Acting out the scene oneself can help put the animator in the
appropriate mindset to accomplish this.

Layering is another method of animating, in addition to the aforementioned
‘straight ahead’ and ‘pose to pose’ approaches. In layering, the global position and
trajectory and the overall pose and timing are worked out first, followed by posing details
and other subtleties. This method is preferred when the most important consideration is
the character’s overall position and orientation, while pose to pose is preferred when the
character’s individual poses are most crucial. Many animators use a combination of the
two (Cantor and Valencia 326).

The last two principles listed in Inspired 3D Short Film Production are to
understand these animation principles, and to apply them “instinctually” rather than
“methodically.” Noticing where an animation looks unnatural and then questioning how
the misapplication of these principles could be causing it will result in a better animation
than by constantly trying to apply all of the principles 100 percent of the time (Cantor and
Valencia 327).
With these guiding principles in mind, the animation step picks up where the 3D animatic left off. At the end of that stage, the basic positions and trajectories of all characters, props, and cameras were keyframed throughout the film’s duration. However, the movement in the animatic is typically no more complex than sliding a character from point A to point B. Looking at pose-to-pose character animation as an example, the first step in the actual animation stage is to create and then line up all of the character’s major poses for a shot on the timeline in the 3D animation program. Unlike in the animatic, the character’s poses now closely approximate how they will look in the actual film. At this point, the exact placement of the character’s different poses on the timeline is not important; what needs to be established is the sequence of poses the character will move through in the shot (Maestri).

After keyframing these initial poses in the correct order, the blocking pass adds the element of timing. The length of time for the first pose is determined from the animatic, and the other poses’ keyframes are moved an arbitrary distance further down the timeline so as not to interfere with the timing of the first pose. The first pose’s keyframes are copied and placed on the timeline to reflect the number of seconds – now translated into frames – that the first pose will be held. The ‘step tangents’ feature is used to prevent the program from automatically creating movements to transition between the different poses, as that will be handled manually in the next step. This is then repeated for each of the main poses in the shot (Maestri).

After the main poses are both sequenced and appropriately spaced throughout the timeline, transitions are refined through the in-between blocking pass. The poses are
released from the step tangents previously imposed, and the animator can select a more gradual change between poses, such as ‘plateau’ or ‘clamped’ tangents. However, the action often appears “floaty” and rotations may be incorrectly calculated, so the animator needs to step in and make manual adjustments to the program’s automatic in-betweening. The animator can first fix any rotation errors, then add moving holds between poses as appropriate. A hold is a manually inserted keyframe between poses that ensures each pose is read separately, instead of having the first pose immediately begin shifting to the next without any time for the viewer’s eyes to recognize it. A moving hold is when very slight movements are added to the keyframe in between two poses, such as subtle movements or rotations of the hip or spine. This adds realism to the pose, since rarely is every single part of a living being entirely still. Another way to make the in-between poses more realistic is to create a believable sense of weight for the character. This is done by translation, rotation, compression, and expansion of various body parts to imply that the character’s bones and muscles are contributing to his or her movements (Maestri).

Once the character is accurately transitioning between the established poses, the next step is to add secondary action. Secondary actions include some of the animation principles previously mentioned – such as overlap and follow through – as well as drift, in which extended limbs tend to drift downward due to gravity; and drag, which demonstrates an object’s tendency to remain at rest. An example of drag in an animated character would be the delay of the character’s hand, almost hesitating in the air, in following his or her downward-moving arm (Maestri).
Next, it’s time to animate the character’s dialogue for shots in which the character is speaking. To make this step easier, the animator can make the virtual camera in the scene a ‘child’ of the character’s head, meaning that the camera will follow the head wherever it goes. This ensures the head is always in the frame and the animator can clearly see the results of the changes being made to the character’s facial movements. One way to animate dialogue involves creating a 2D control panel with switches that control the movement of various parts of the face, such as the eyes, eyebrows, and mouth. Different premade blend shapes (see page 17) are assigned to these controls so that, for instance, moving the switch on the ‘smile’ control will curve the character’s lips accordingly (Maestri). In order to correctly synch the facial animation to the dialogue, the audio track must be opened and turned on in the program.

The animator can go back through these last few steps and continue to tweak things until satisfactory. Some specific considerations when finalizing the animation are adding blinks, moving the head slightly in tempo with the dialogue, moving the eyebrows to indicate emotion, and fine-tuning the eyelids (Maestri).

The next main part of shot production is lighting and rendering the scene. The purpose of lighting a 3D scene is threefold: to make the elements of the scene visible to the viewer, to indicate spatial depth, and to set the mood. In order to light each scene in the most effective manner, lighting attributes can be individually adjusted, such as the light’s intensity, color, and falloff (the rate at which light fades as the distance from it increases). The type of light used can also vary based on where the light emanates from and how wide its target is. Examples include a spotlight, which begins at a single point.
and radiates outward in a cone shape; a point light, which begins at a single point and shines equally in all directions; and directional light, which comes from a single direction and emanates outward in the form of parallel rays (Cantor and Valencia 360-363).

Different combinations of light attributes and types can be combined to create lighting styles designed to instill a specific mood in the viewer. One such style is known as high-key or hard-key light. This lighting style evokes a dramatic mood via its use of high contrast; certain areas of the scene are illuminated with bright, vibrant light, while other areas may be entirely dark. Another style is low-key or soft-key, in which light is evenly distributed throughout the scene, minimizing shadows and contrast and allowing all elements to be seen. Soft-key lighting would be used to create a more peaceful environment whereas hard-key would be more appropriate for creating a sense of unease. The most natural and subtle lighting style is tonal lighting, which lies in the middle ground between soft- and high-key (Cantor and Valencia 362-363).

No matter how carefully lighting is considered, the scene won’t appear to be lighted realistically unless shadows are manually enabled. Unlike in real life where all lights cast shadows, the computer graphics software can control whether individual lights will cast shadows and how those shadows will appear in terms of their edge hardness and opacity. Generally, one of two shadow types can be selected: depth-mapped shadows, “calculated based on whether a specific surface can be ‘seen’ by a particular light source”; and ray-traced shadows, created from a complex calculation involving the source, direction, and attributes of rays emitted from the lights as well as from the characteristics of the surrounding objects in the scene (Cantor and Valencia 367). Ray-
traced shadows can simulate reflectivity, translucency, and refractivity and therefore convey a higher level of realism, but the tradeoff is that they also take longer to render (Cantor and Valencia 367).

With all of these customizable options, there are countless ways to set up the lighting for a scene. One recommended approach, in order to avoid getting overwhelmed by the available options, is to first consider which light types would be most appropriate for the scene – such as ambient light, spotlight, point light, or directional light. Next, determine the quantity of lights the scene will require. Lastly, determine the lights’ placement and attributes – such as intensity, color, and falloff. In placing the lights, consider where the main action of the scene takes place and what needs to be visible. Also consider whether the lights need to replicate the lighting setup of a previous or subsequent scene to maintain continuity (Cantor and Valencia 368-369).

Rendering is the process by which the animated scene is converted into either movie files or still image files (to later be sequenced into movie files). In more technical terms, rendering is defined as “the process by which CG software calculates every pixel of the final image by using algorithms that consider all of the necessary scene information” (Cantor and Valencia 370). While computer graphics software actually creates the rendered files on its own, the animator needs to first manually set up the render. This is done by adjusting the settings for the scene file, which contains all of the information required to create the scene: the models, textures, animations, lights, shadows, and so on.
The four main considerations are quality, optimization, resolution, and image format. Quality specifies visual attributes such as image sharpness and motion blur. Optimization involves finding the best balance between image quality and render time, since the higher the image quality, the longer it will take to render. Resolution refers to the final dimensions of the still image or movie file, and varies depending on the media it will be played on (such as a CD-ROM, website, DVD, video, or film). Image format specifies the encoding or compression algorithms that will be used for either the final still images or movie files. Sample extensions used to specify encoding for each include .gif, .jpeg, or .tiff (stills) and .mov, .avi, or .mpeg (movie files) (Cantor and Valencia 370-374).

Before starting what could be a time-consuming render of a scene, it’s advisable to first do a test render to see if any scene elements need to be altered before investing time in rendering. Depending on the computer’s hardware capabilities, it’s generally recommended to render small parts of a scene individually instead of rendering the entire scene at once (Cantor and Valencia 376-377).

Shot production is completed by adding special effects and compositing where needed or desired (compositing is categorized either at the end of shot production or at the beginning of post-production; Inspired 3D Short Film Production groups it with the former, as does this writing). Special effects are varied and usually intended to create a very specific result. While it’s possible to create some special effects by hand, it’s generally advisable to instead rely on procedural animation, “allowing the computer to follow the natural rules of physics to create motion on objects or hierarchies based on
parameters previously defined for the moving elements” (Cantor and Valencia 380). In other words, the animator manually defines the attributes for the moving elements in the effect, and the computer calculates the rest.

The two main categories of procedural animation are particle effects and motion dynamics. Using particle effects involves creating an emitter object, then determining how it emits particles and how the particles behave. Particles can be used to simulate real-world elements as diverse as rain, fire, hair, and smoke, and complex group movements like a swarm of bees or a school of fish (Cantor and Valencia 381-383). Motion dynamics are “used to make objects … move based on real-world physics and the application of external forces” (Cantor and Valencia 380). Motion dynamics are applied by assigning properties, forces, and collision specifics to various elements, then letting the computer calculate the simulation. Examples of effects created by motion dynamics are falling rocks, loose clothing, hair in a ponytail, and bodies of water (Cantor and Valencia 384-385).

Special effects can also be added two-dimensionally through compositing. Compositing is the process of combining different layers of visual elements into a cohesive whole, similar to forming a “digital collage” (Cantor and Valencia 389). Rendering different elements – such as color, shadows, or reflections – in layers and then combining them in a compositing stage allows for more precise control since each element can be adjusted individually. Compositing can save time on creating special effects because they can be made in a 2D program (instead of within the 3D animation package), and then those 2D effects layers can be composited with the rendered frames.
Compositing can also be used to combine different forms of media with 3D animation (such as live-action video footage or traditional paintings or illustrations) and to reduce final rendering times by simplifying the overall scene. For instance, a cityscape scene with many individually modeled and textured buildings would render much faster if a still image of the scene were rendered and then composited in the background of the main scene, in place of the 3D models (Cantor and Valencia 390).

Compositing is generally accomplished in passes, a way of grouping and distinguishing between the content that is added to the scene in each step. Examples of common compositing passes include a beauty pass (color information), specular pass (highlights), shadow pass (shadows), depth-map pass (effects affected by distance), reflection pass (reflections), and lighting pass (lights) (Cantor and Valencia 391-392). A scene can be divided into many different compositing passes to achieve the desired appearance.

The most important aspect of rendering for compositing is to “cleanly isolate” the elements on separate layers (Cantor and Valencia 393). There are variety of techniques that can accomplish this, among them using alpha channels and keying. An alpha channel is an invisible, black-and-white layer that separates the other elements of the scene, with white indicating opaqueness and black indicating transparency. Keying is a process by which a specific color is eliminated from the background of a layer and is replaced with the content of the layer beneath it. The specific color, or chroma key, is used to generate transparency to eliminate the background, a process known as green-screening since the color utilized is typically a specific shade of green (Cantor and Valencia 393-394).
Post-production

By the post-production stage, the majority of the work has been completed and all that remains are adding the audio tracks and finishing touches like filters, post-camera moves, and title and credits screens. Various filters can be added via compositing software to affect either individual compositing passes or the entire scene. Software like Adobe After Effects or Premiere Pro can add visual interest through lens flares, filters, color correction, or film grain effects, to name a few possibilities. Post-camera moves like shakes or rotations can also be added at this stage, so long as the frames were initially rendered larger than their final intended size so that they’ll still cover the entirety of the screen. It’s often easier to add certain camera moves in a two-dimensional compositing program than by trying to simulate them with the camera in a 3D environment (Cantor and Valencia 394-395).

Audio is divided into two major types: sound effects and music. Although audio is typically not added until post-production, in cases where the audio drives the narrative, it needs to be added as early on as possible, preferably when creating the animatic (see page 11-12). This keeps the piece cohesive and ensures that the audio and visuals precisely match up. Sound effects can be classified into three categories according to their purpose: visual accompaniments, visual substitutes, and ambient effects. Visual accompaniments emphasize an on-screen action, such as a character stomping his feet. Visual substitutions on the other hand, represent audibly something that is not seen on-screen, such as a distant crash or explosion. Ambient effects are sounds that set the overall mood of the
scene and can include environmental sounds such as rain, thunder, or highway traffic (Cantor and Valencia 397-398).

The sound effects for an animation can either be produced and recorded by the production team itself or purchased and downloaded. The audio files are then typically transferred to a computer in a .wav or .aiff format and cleaned up in audio-editing software like Adobe Audition. In addition to eliminating background noises and other imperfections, audio-editing software can also be used to vary pitch, speed, and volume of the original tracks. For greater precision, a long audio file that contains a series of sound effects should be broken up so that the different effects can be synched to the animation individually. One can also layer sounds to create a more realistic ambient effect. After editing, the audio is added to the animation in non-linear editing software being used to compose the movie, such as After Effects or Final Cut Pro. Visual accompaniments should be synched precisely to their on-screen actions, and slight delays should be added to indicate actions that occur at a great distance from the camera (Cantor and Valencia 400-401).

Adding music to an animation follows a very similar process, and should also be handled in a program specifically designed for non-linear editing. However, if the music determines the timing of different story points, it’s best to import the audio into the 3D program first so the audio and visuals will match up perfectly. Whether the music is applied before or after the visuals have been finalized, it might still be necessary to extend or reduce shot lengths by a couple of frames to better synch with the music. This is easily accomplished via frame handles, additional frames initially left at the beginning
and end of each shot that can be deleted or kept as the duration dictates (Cantor and Valencia 401, 404).

Although the title screen is among the last elements to be created, it’s the very first thing that viewers will see, so it requires careful thought. The title screen serves as the film’s “initial connection” to its audience and should effectively establish the mood and style of the piece to come (Cantor and Valencia 407). Title screens can be created using 2D or 3D graphics or a combination of both, and can be static or animated. Text should remain on the screen long enough to be easily read, but not so long that the viewer grows impatient waiting for it to disappear (Cantor and Valencia 407-408).

Text may also appear throughout the short film in the form of an introduction, subtitles, or an epilogue. Subtitles require several special considerations: the duration of time a subtitle remains on the screen should be roughly one-and-a-half times a normal reading pace; the text should be brightly colored and have a black outline to ensure legibility against any background; text should be presented in a simple, legible font like Times or Helvetica; and the text must remain within the title safe area of the screen or it may be cut off. This last point concerns differences in screen size and broadcast dimensions for television and ensures the text will be equally visible on a smaller, standard screen display and on a widescreen one (Cantor and Valencia 409).

Credits are generally added at the conclusion of a film, but the main contributors may also be listed on the title screen. Based on the number of contributors, multiple frames may be needed, with contributors grouped logically according to their roles in the project. Animation and/or static imagery may also accompany the credits, such as process
sketches or fictional ‘bloopers’ featuring the film’s characters (Cantor and Valencia 410-411).

**Problem Description**

As stated in the abstract, this project investigated how real-world animators from smaller studios use these techniques in the most effective and efficient ways. This project focused solely on the production cycle, with an emphasis on the overall pipeline and the modeling and animation processes, due to both my personal interest in these areas and the availability of prospective interviewees. A more long-term study could also incorporate all of the other aforementioned steps in the same amount of depth. Other relevant areas originally considered but not included in the final project are: asset organization (conventions for naming and organizing files), safeguarding (storage and backup methods for all the elements of a 3D animation), and comparisons between the 2D and 3D animation processes. These areas were ultimately not included in order to produce a more tightly focused, cohesive study on the animation production cycle, but they provide lead-ins to expand on this research in the future.

The people interviewed for this study included both an animation generalist and a modeler at Calabash Animation Studios, an animator/modeler at RTC and an animator at Phosphor Games, all Chicagoland locations. The interview with an animation generalist at Calabash Animation took place on-site, although due to licensing restrictions, no audio-visual recordings could be made; all other interviews occurred via email correspondence.
Design Methodology

Before considering questions to ask animators, I conducted background research on the animation process to become more familiar with the steps being investigated. I primarily relied on three main resources for this purpose: *Inspired 3D Short Film Production* by Jeremy Cantor and Pepe Valencia; *Ideas for the Animated Short: Finding and Building Stories* by Karen Sullivan, Gary Schumer, and Kate Alexander; and a series of Maya software training tutorials on lynda.com (see bibliography on page 73-74). After familiarizing myself with the information detailed in the previous “Background Information” section, I devised a series of questions for each area of the production process. Certain sections (such as texturing, rigging/binding, and lighting) were omitted entirely, as I ultimately chose to make my study more focused by going in-depth with storyboarding, modeling, and animation instead of attempting to cover the full range of production.

Storyboarding questions concerned the timeline of the storyboarding process (including what is added at each stage of storyboard production), the visuals of the boards, indicating movement, and camera cuts and angles. Modeling questions covered geometry types, character posing, and modeling techniques. The animation questions addressed use of reference material, overall workflow, motion tests, walk cycles, and facial animation. Questions regarding special effects covered types of effects, their implementation, and 2D versus 3D. Lastly, questions were included to inquire about scheduling methods.
For a complete list of the questions devised for this study, please see the Appendix beginning on page 74.

The next step after composing these questions was to search for small animation studios that would be willing to let me observe their facilities and see how the production team puts these techniques into practice. Through networking with college professors and mentors, I was able to get in touch with Calabash Animation Studios in Chicago and speak with Chris Blake, computer graphics producer and technical director at the studio. Although I was permitted a tour of the facilities and was able to observe employees in their work, I could not make audio or video recordings due to licensing agreements Calabash has with the companies it produces TV spots for. However, I was able to sit down and talk with Blake regarding preproduction elements, and was able to see storyboards, style frames, animatics, pencil tests, and the final product for several commercials. I also followed up via email after my visit and was able to receive more insight from Blake on post-production elements, as well as on modeling from Thomas Moore, a 3D modeler at Calabash.

I also interviewed two individuals exclusively via email: Eric Blomquist, a conceptual digital designer and 3D animator at RTC; and Alan Cruz, lead animator at Phosphor Games. Questions for them focused solely on the animation stage of the production cycle, which was not covered in detail during my visit at Calabash. The results of my interviews with all four of these individuals are detailed in the next section.
The second part of implementing this project was creating an original animated short film of my own. The first step was to develop a concise story idea that could be told visually in few minutes, without being too technically demanding. I already had plans to utilize a character I had developed previously: a ‘jingle lizard,’ or fictional species of lizard that has a bell growing out of its tail. The nonexistence of this creature in real life necessitated using animation to tell my story. After brainstorming and playing out various scenarios in my mind, I came up with the following premise: a jingle lizard is captured by a young human zoologist who’s dedicated his life thus far to discovering rare creatures in the footsteps of his father. The jingle lizard’s desire to escape and be free is put at odds with the human’s desire to keep the lizard captured and pursue his father’s work.

In developing my story, I considered the classic linear storytelling structure (see page 4) and modified it to fit my short film format. The exposition initially involved the human bringing the lizard home for the first time and admiring his captured specimen; I later changed it to the human returning home to the lizard he’d already caught, both making the time span more realistic given the story’s resolution and minimizing the necessary animation. Thus, the audience is introduced to the two characters and can quickly see the lizard does not want to be here where the human wants it. This exposition doubles as the inciting incident: the reintroduction of the human into the home as he rediscovers the lizard is unhappy to see him.

I ended up dramatically streamlining the rising conflict due to time and resource constraints, but it originally involved a series of short events in which it becomes
increasingly evident that the lizard is miserable: the lizard trying to escape through the cage bars, refusing to eat the food the human gives it, and not ringing its tail bell along with the human’s hand bell, which the human rings in an attempt to cheer it up. I reduced the rising conflict to only having the lizard refuse to look at its captor or ring its tail bell. The crisis/climax remained the same in both my original and abbreviated versions: the human looks, in detail, at the photographs on his corkboard for the first time, realizing that the lizards his father used to capture were equally miserable. The human is faced with the decision of whether to continue following in his father’s footsteps as a zoologist who collects and studies rare creates, or to release the lizard back into its natural habitat. The resolution is the human’s decision to put the lizard’s desires before his own and let the lizard go, a reflection of the theme/moral that one cannot always have exactly what he or she wants in life.

After developing the story, I planned to adhere to the following workflow in creating my short film: creating character sketches and model sheets, storyboarding, creating a 2D animatic, modeling, texturing, creating a 3D animatic, rigging, animating, lighting, rendering, adding any 2D special effects, compositing, adding audio, and adding post-production finishes like the title and end credits.

Data Collection

Visiting Calabash Animation enabled me to see firsthand the preproduction process in detail and I was given a walkthrough of the major stages of the production pipeline. Calabash uses a variety of visual styles to create animations for the commercial and entertainment industries, particularly television spots. Some of their clients have
included General Mills, McDonald’s, Hasbro, and the Walt Disney Company. The studio uses both 2D and 3D animation and combinations thereof. Although some of the software and specific sub-stages differed from my own project, the overall production process can be applied to both 2D and 3D works in general.

**Overall Production Pipeline – Calabash Animation**

At Calabash Animation, I spoke with Chris Blake, computer graphics producer and technical director at the studio. Blake is a generalist involved with pre-production and especially post-production work. The following details regarding Calabash’s production process were all gathered from my interview at the studio.

All of the required tasks for a given production are specified in production lists that state who is assigned to do what and when each task is due. The assets for the production, at least when done in 2D, are contained within a dope sheet in the program Harmony. The dope sheet lists the different layers in the animation in a vertical format, as opposed to the more traditional, horizontal display. This list of layers can also be written out on paper, to keep track of them in a non-screen format if desired.

The very first step of any project at Calabash is receiving an animatic from the agency that’s intermediating with the client. For instance, the agency might supply an animatic for a commercial that Calabash is producing for General Mills. From there, Calabash creates style frames and shootboards. The goal of the style frames is to determine what “each central part of the film looks like” (Blake). There’s no animation at this point, but the style frames allow the production team to “understand the color temperature of everything” and the overall look of the scene (Blake). While storyboards
map out a specific story action and its movements, style frames simulate the scene’s look and feel. “Oftentimes when you’re just doing one single style frame sheet, it will just be one frame for each scene … The smaller the project, the more all those things will just be in one document. The larger the project, the more it spans out” (Blake). Style frames can substitute for storyboards in Hollywood productions, whose length would make it difficult to create detailed storyboards on the same level as a studio like Calabash that produces significantly shorter works. Different film directors may utilize storyboards to various degrees, but what they generally use is more similar to the style frames I saw at Calabash.

The production team at Calabash uses the terms “shootboard” and “storyboard” synonymously. Technically, “a shootboard would be made on our end if we knew we were going to combine it with live action … You can use it in our pipeline as well in that it tells use what to do, how to shoot this commercial … The bigger, the more broad term is ‘storyboard.’ … The shootboard is just something specific that we give to somebody who’s going to shoot” (Blake). However, as there is not always live action in Calabash’s productions, the terms have become somewhat interchangeable. If a commercial has already been shot, the resulting boards would technically be called “boards of the rough live cut,” but might be referred to as a shootboard anyway (Blake).

The naming convention Calabash uses for its shootboards is the scene number followed by the panel number. “‘Scene’ and ‘shot’ are synonymous in the business,” and Calabash elects to use ‘scene,’ partially because it makes more sense to do so when everything keeps the same background (Blake). So for instance, a shootboard panel
labeled 2-1 would represent the first panel in the second scene. It’s crucial that “every important pose is there,” possibly “even down to the keyframes” (Blake). The shootboards may differ from those of other studios in terms of exactly how much is drawn out at this stage, but the overall process is the same. The level of completion of a given shootboard also depends on the animatic the agency provides for the project. For instance, one commercial for Trix yogurt was “an unusual project actually because it was laid out in After Effects, and in After Effects it was almost finished good enough. So in the animatic stage, they actually had done a framework for the whole commercial” (Blake). Also, Calabash may sometimes return to the shootboard after that stage has already been completed and add more finished images so the agency has a better idea of the studio’s approach.

Due to the costs of making changes later in the process, there are a number of things that must be finalized in the shootboard/storyboard stage. These things include the character’s exact position in the scene, facial expression, and dialogue. “You try language, music – or an idea of what the music might be, where the characters are placed, what is their motivation, what do they look like. … The background, and how they sit in that background. But the most important thing is the animation, so that’s the priority. What’s going to be animated and what can just be a still. Because then if they (the agency) want to change a still, that’s not a big deal” (Blake).

After the shootboard comes Calabash’s animatic, which the production team refers to as its ‘leica’ – a term for animatic used by northern animation companies, particularly in Canada. One of the reasons Calabash uses ‘leica’ is to differentiate from
the animatic that the agency produces, so when they refer to ‘animatic,’ they’re talking about what the agency has made. In terms of traditional animation terminology though, ‘leica’ and ‘animatic’ are synonymous. Because of the tight production schedule, sometimes the shootboard and leica are created simultaneously. Many changes are still made when putting together the leica. This is where the team experiments with different camera angles, and camera movements like pans are indicated via arrows. Blake showed me an example of both the agency animatic and the leica for a Trix yogurt commercial, and pointed out the differences between them. The leica had the appropriate timing, a more finished version of the music, some added 3D, dissolves, and more specific movements. For instance, this is where it would be specified whether the Trix rabbit would be standing still at a given moment or holding his ear, or perhaps tugging it instead.

The number of different shootboards or leicas that Calabash creates for an animation is based on agency approval. Ideally, they can be approved in one or two tries. However, “the agency might be fighting for the idea. So they are posing their idea to General Mills, and they really like the idea, so they’re not going to let it go” (Blake). Generally, if the shootboards or leica have not been approved by the fifth or sixth round, the commercial is not going to run. Once the agency approves of the leica, the elements in it are finalized and followed down to the last frame. Since the clients are creative themselves, Calabash has to be firm about this, or the cycle of going back and forth and making changes would go on endlessly.
Once the leica is approved, the production stage begins. Calabash does two pencil tests, which can also be called “work in progress one and two.” Other companies may do only one pencil test, or multiple tests. Calabash’s first pencil test is black-and-white and roughs out the basic movements. The second pencil test may or may not add color, but most importantly, it’s where the animation is entirely completed. It may be possible to leave off some of the lip-syncing, but everything else must be perfect. Following that, the production team creates a final work in progress to show the agency, typically two weeks before the final animation is due. Then final tweaks are added and the animation is rendered.

The software that each studio uses in the production process varies, but Blake walked me through the different software that has a place in Calabash’s pipeline. First, artists typically hand-draw the characters and scene elements. Then the hand-drawn images are scanned into a computer, and the 2D program Harmony (or Flash) is used to fill in and finalize the drawings. Adobe After Effects is then used for compositing throughout the rest of the process. NUKE, a higher-end compositer, is used later on to create effects that After Effects cannot. Finishing touches may be added in Adobe Premiere Pro, any 3D work is done in Maya, and digital painting is done in Photoshop. For rendering, Calabash uses “Smedge, which is render distributing software that’s (connected) to our network. (It) takes the files from Maya and renders them out” (Blake).

Modeling and Texturing – Calabash Animation

After conducting research on-site at Calabash, I followed up with Blake via email with more questions regarding specific stages of the production pipeline. Modeler
Thomas Moore was able to answer some of my questions via email, giving me insight into the modeling workflow used at Calabash. Although some of Moore’s responses reflect more individual preferences, they nonetheless exemplify professional modeling practices.

Moore uses a combination of NURBS and polygons for modeling (see page 15), but generally prefers polygons as he learned to model with that geometry and he feels it provides better control over edge flow. Edge flow describes how the edges of a model relate to the anatomy of the structure they make up, or in other words, how the edges match up with a character’s real muscle anatomy (Kittleson). Modeling with edge flow in mind requires one to conscientiously create flow zones – different parts of the body with different edge flows to each. All major body parts should have their own flow zones: head, chest, torso, arms, hands, fingers, legs, feet, toes, eyes, etc. (Kittleson) “Edge loops are important when it comes to animating organic objects and characters. With polygons you can go back and redirect the edge flow to something that will deform better” (Moore). Moore noted that it’s sometimes easier to begin a model using NURBS curves, and that automatically getting UVs (as opposed to needing to map them out manually) with NURBS is a plus. However, modeling with polygons feels more organic to him. “I like to be able to rough in a model without worrying too much about topology” (Moore).

The pose that a given character is modeled in depends on the character and what he or she will be expected to do. Generally, the character is modeled with consideration to the pose he or she will be in the majority of the time. Moore provided the following example:
“Recently, we were using a model of a body builder that was scanned from a real-life body builder as a base for a character. He was scanned in a T-pose – arms straight out, horizontally – and we ran into problems relaxing him into a more natural pose. His deltoids and back muscles were flexed because he was lifting his arms up and it did not look right when we lowered the arms back down” (Moore).

In this situation, it made more sense to keep the model in a more unnatural da Vinci pose instead of trying to maneuver the character into more of a relaxed bind pose (see pg. 20-21) that would not translate as well to the animation. For the most part though, Moore said modeling a character with arms out at a 45-degree angle to each side would be satisfactory.

Moore also deals with texture creation, so he detailed some of the workflow for that process as well. He uses a combination of methods to create textures, such as traditional media (although rarely), digital photos, digital painting, and procedural textures. For one project, Moore needed to make realistic textures for a hand, so he covered his own hand in Elmer’s glue, let it dry, peeled it off, and scanned it into the computer. He then brought the “resulting maps into Mudbox (a 3D sculpting and texturing program), where I could project them directly on the model as a bump map, or sculptural details that can later be converted into a bump, normal, or displacement map” (Moore). Sometimes scans and digital photographs may need to be edited in Photoshop first, but after that, they typically just need to be brought into Mudbox and applied to the appropriate model.
When textures do not have to be photorealistic, Moore prefers using procedural textures instead of creating maps (see pg. 18). Procedural textures can become too complicated when going for realism, but can work very well for less lifelike pieces. One benefit of using procedural textures is not having to keep track of textures files, which is particularly useful when the texture must be used repeatedly for a frequently used model (Moore). Additionally, “strategic UV layout can come in handy. For instance, if you have a vase that is darker on the bottom half than the top. You would want UVs laid out in a way where you can utilize a Ramp texture. Procedural textures can be very powerful when used correctly” (Moore).

Animation – Calabash Animation, RTC, Phosphor Games

Aside from investigating the overall production pipeline, the focus of my study was learning how small studios approach the animation process in particular. I was able to touch on animation practices with Blake during my time at Calabash, and then went into it in more detail during subsequent email interviews with Eric Blomquist, a conceptual digital designer and 3D animator at RTC, and Alan Cruz, a lead animator at Phosphor Games.

Blake said Calabash follows “traditional animation methodology” in that everything is initially situated in space during a layout stage. Calabash actually follows two separate layout stages: “the layout of the whole commercial – being the shootboards, the storyboards, and all that – and then the layout where you say, ‘okay it’s good, but let’s actually put it in a 3D scene and lay that out’” (Blake). Another way of conceptualizing it is first laying the scene out in a 2D medium and then translating that to
3D. Since Calabash focuses on character animation, the production team generally follows the pose-to-pose strategy (see pg. 27), although sometimes straight ahead animation is incorporated as well. It’s crucial to pay attention to keyframes in computer animation to avoid the more mechanical interpolations that computer software creates between poses. Whereas in traditional hand-drawn animation, the animator is in complete control of all a character’s in-between movements, software now automatically creates those movements and “it only knows to go from here to here in the most efficient way” (Blake). This makes going back and manually manipulating, and possibly adding, keyframes between poses a necessity.

After creating the layout, poses, and keyframes in a blocking stage, the final steps of the animation pipeline at Calabash are refining and polishing the animation. Full lip-syncs are added at this point, since up until now, the animators still aren’t certain about which moments the character’s face/mouth will be entirely visible, and it’s not worth animating a lip-sync that may not be used (Blake).

Since Blomquist of RTC and Cruz of Phosphor Games work more specifically in animation, I asked them detailed questions about the approaches they use for various steps from blocking to in-betweening and for tasks from creating walk cycles to animating facial expressions.

I first asked about how these animators create motion styles for a given character and what they reference when creating an animation. Blomquist’s approach is influenced by his background in theatre and acting; he tries to get into the character’s head and
understand his or her thought processes before animating. Some questions he asks himself include:

“What is the character (doing) a moment before? Motivation? How do they feel? What are their goals? What is the relationship with the people they are currently interacting with? How do they feel about the current environment they are in? It’s important to ask as many questions as possible and dig deep into the heart and soul of the character. Give each facial expression and gesture meaning!” (Blomquist)

Cruz mentioned following a reference guide created for each character that includes “a collection of videos, films, cartoons, reference drawings, and background content, character history, character guide, and any other story elements necessary for the overall movement of the character” (Cruz). The reference guide defines the character’s personality and the emotions that need to be conveyed in the animation. Poses are essential for showing personality, as “the posing brings the mood and feel of the character” (Cruz). This is similar to how the process works at Calabash, which needs to be particularly careful that the licensed characters it animates remain “on-model” with what the client has already determined. “On-model means drawn (to a) character spec sheet – the head is in a certain proportion to the chest, the legs” (Blake).

Both Blomquist and Cruz also record themselves performing the actions and speaking the dialogue they will be animating, as well as referencing online videos or animations that may be of assistance or inspiration. “I do a lot of takes, practicing different movements and poses. When I play back the movie I make sure to use
QuickTime because you can use the arrow keys while paused to scroll through frame by frame” (Blomquist).

Similar to Calabash, both of these animators combine different animation approaches. At Calabash where character-based animation is the focus, animators use a pose-to-pose strategy and occasionally incorporate a straight ahead approach. Blomquist does more of the opposite: “I have tried a few times to – and it makes complete sense – utilize a pose-to-pose method, but I prefer straight ahead, especially in 3D” (Blomquist). Blomquist admits that even his straight ahead approach is technically a combination of both methods, as he will “create the first pose I’m going for and then go back and animate the action to get to that pose until it is fleshed out” (Blomquist). Cruz combines pose-to-pose with layering, as he works on broader aspects like establishing position and orientation before moving onto details like in-betweening. “I create poses sequentially on a timeline. I then move the poses in space to the correct orientation. Then I retime the poses to get the overall timing. … Once timing feels good I create in-betweens to carry the motion through all the key poses” (Cruz).

Since both animators use a variation of the pose-to-pose method, they also create a series of different poses for a given character prior to animating, whether via drawings or 3D software. Blomquist prefers to experiment with drawing poses during the concept phase; Cruz uses the software to create a small library of stock poses “for emotional/body language reference” and creates a larger library while animating “to use later or for future reference” (Cruz). Another pre-animation step is testing out the rig to ensure it works properly. To do so, Cruz creates a “range of motion file” in which tries to “break down
the character’s joints and explore the limits of the rig” (Cruz). If the character is put in the most extreme poses he or she will be expected to be in, and those poses are achieved without a problem, then the rig should be fully functional for the task at hand. There are a number of typical poses the character may be positioned in for the rig test:

“The typical poses for the body are: arms up, sitting down, fetal position, a bridge the splits, and a squat. For fingers would be: a fist, pointing, and hang loose. For the face would be: smile, frown, angry, hold breath, stick tongue out, wide eyes, or any other set of facial expressions that will dictate who the character is. For example, a favorite saying or nervous tick that the character does repeatedly” (Cruz).

Another purpose of testing the rig is for the animator to gain familiarity with how it works. “We have to get to know our setup and become comfortable with it. Confidence is very important to production so I always create a test animation before I do any official work” (Blomquist).

My earlier research presented a specific workflow to be followed when actually beginning to animate a character (see pg. 32-34), and Cruz generally applied this same order to his work. Cruz focuses first on blocking the animation by creating and arranging the major poses on the timeline. Following that, he works on, in order: timing (especially synching the movements with any audio), in-betweening, smoothing timing and posing, and adding follow through, slow-ins and slow-outs, and secondary action (Cruz). “Blocking and timing is very fast and quick. I tend to spend more time on the last 10% of the animation accentuating the details” (Cruz). Although I wasn’t provided with the same
level of detail in the steps Calabash goes through, the studio uses the same general approach of moving from blocking and keyframing to in-betweening and refinement. Blomquist surely innately follows similar steps, but he says he relies more on the reference and his instincts when creating an animation. “If something does not look right, I’ll start to break it down further. But as long as you simplify the animation steps, it feels much more manageable” (Blomquist).

Blocking is about more than establishing the positions and timing of major poses. Aside from that necessary component, Cruz also considers “how the action will be followed by the camera. I also imagine how my eye will follow the motion” (Cruz). He blocks out the poses several times to test different ideas before settling on a final approach for a given shot. It’s recommended to have separate, lower-resolution character models for blocking and animating, and to save the full-resolution models for the final renders. This makes it easier for the animator to interact with the models without the software slowing down (Cantor and Valencia 267). For Cruz’s work, however, he’s generally able to use higher-resolution versions of the main characters and use basic geometry like cubes and spheres for the scene’s layout (Cruz). Blomquist typically uses the “production version models” of characters with the turbosmoothing feature off. He acknowledges though that this may not be the best approach: “The less resources the computer is using while you animate, the smoother and more manageable the process is” (Blomquist).

Cruz’s more regimented approach and Blomquist’s more instinctual approach in regards to the overall animation workflow are reflected in how they add secondary
motion and in-between movements. Blomquist said he follows “what feels right” whereas Cruz provided more specifics. He focuses on the character’s arms when adding secondary motion, and isolates individual body parts when in-betweening to create smooth follow-throughs and arcs. “Shift the body parts’ key poses and blend them accordingly to the action. You can get some nice subtle action” (Cruz). Blomquist added that it’s important to consider gravity, acceleration, deceleration, weight, and timing when in-betweening so that a movement looks realistic. “I believe that great eye, facial, and hand animation sells the realism” (Blomquist).

Other topics I interviewed Blomquist and Cruz about included using function curves, creating walk cycles, and animating facial expressions/dialogue. Function curves are displayed on a graph editor in the animation program and show a character or object’s movement over time. The curves are shown on a two-dimensional graph with two axes; the shape of the curves determines the subtlety or abruptness of the movement (Cantor and Valencia 330). Blomquist doesn’t really use function curves in his work, but Cruz uses them “to smooth or harden action.”

Both animators had different advice to offer regarding walk cycles. Blomquist said the walk “needs to fit the personality of the character.” Cruz recommended focusing on the upper portion of the character’s body, as that is what the eyes look to first. “The shifting of weight from the upper body to the lower is key. I also try to focus a lot on the shoulders and arms of a walk cycle” (Cruz). A walk cycle is an example of a continuous movement that generally needs to be repeated in an animation. Both animators noted the importance of making repetitive motions look as natural as possible by adding small
alterations to the cycle. Cruz creates a good, solid walk cycle, repeats it on the timeline, and adds minor – yet important – adjustments: “Based on the shot, I add more weight to the character’s limbs, create an overall pose to reflect the mood, change timings on the walk steps, shift weight differently, etc.” (Cruz) He also changes the character’s path based on the layout of the scene. Even following this sort of methodology, “cycles at the moment still feel a bit stiff. I’m sure at some point this will change using dynamic gravity and randomized movements” (Blomquist).

As for facial animation, I initially thought that using a skeleton/deformer-driven system would be preferable, since it seems to yield a far greater number of possibilities than a preset series of blend shapes (see page 17). It also appeared as if a skeletal system would save time by eliminating the need to create a library of blend shapes ahead of time. However, both animators actually preferred using blend shapes and found them to be a more effective way to work than skeleton-driven animation. Blomquist said blend shapes are “by far the most efficient,” but that “bone-driven manipulation is much more powerful for customized expressions and shapes. I choose by how much time I have and the amount of expression the character requires” (Blomquist). Cruz uses blend shapes (also called ‘facial targets’ or ‘morph shapes’) for the blocking stage, and then uses individualized controls for the more detailed movements (Cruz).

I gathered from my research that animating dialogue is one of the most time-consuming parts of animation, and Cruz and Blomquist’s experiences confirmed this. “Two seconds of generic dialogue should take about a couple of hours. More detailed dialogue in relation to a close-up should take longer” (Cruz). Blomquist said he could do
about 500-1,000 frames of facial animation during a regular day’s work using blend shapes.

Given the time-consuming nature of animation in general and my desire to streamline my own process as much as possible, I also asked about how animators handle scheduling. “(At Phosphor Games), we use a global shot schedule. Shots are initially handed out evenly, but as production continues, more qualified animators take on the harder shots, more visible shots” (Cruz) (see page 25). Cruz also said that in the event that production falls behind schedule, Phosphor either cuts scenes or hires experienced freelance animators to help. Blomquist seemed more focused on daily goals, which he adheres to by keeping a daily tracker for everything he hopes to accomplish. He will also “break down absolutely every aspect of what needs to be done and how to do it” (Blomquist). Of the three major schedules by which to complete shots (straight ahead, hero shot, or layering – see page 26), Phosphor Games favors a hero shot approach “to gauge the overall amount of work for shots later on … Hero shots require the most work up front, and it is easier to scale down on the secondary and tertiary shots” (Cruz). Blomquist recommends following the approach that works most effectively for a given animation and is most comfortable to the animator.

Lastly, I requested opinions on which are the most important animation principles to apply – not that any should be neglected, but which should be paid special attention (see page 26-31). Cruz included some of the most basic principles, such as squash and stretch and ease-in and ease-out, in his top five, along with anticipation, posing, and follow-through. He emphasized squash and stretch, follow-through, and ease-in/ease-out
for their subtlety and importance in replicating realistic motion. In regards to anticipation, “creating the ‘pre-action’ to sell the actual action is key. You can do so much with very little” (Cruz). In contrast, Blake of Calabash Animation considered principles as basic as squash and stretch and ease-in/ease-out to be so much of “a given” that they weren’t really principles, but were something that were “assumed” the animator would do. This is especially the case at a studio like Calabash, where “we do a lot of crazy animations, so squash and stretch is what we always do” (Blake). He instead highlighted principles that might be more overlooked: arcs, staging, and secondary action, as well as timing, appeal, and solid drawing:

“It’s from my point-of-view as both a person who’s involved a bit in pre-production and very much in post-production, timing and staging – if you don’t have that, you don’t have a commercial. And before I ever get it (the commercial), appeal and solid drawing have to be solved. If they don’t have a character that’s appealing, forget it” (Blake).

Blake’s focus on what are perhaps less ‘obvious’ animation principles is influenced both by the style of work Calabash produces and by his role as more of a generalist.

**Special Effects and Compositing – Calabash Animation**

I did not have the opportunity to interview Blake specifically about his role in post-production work while at Calabash, but I was able to follow up with him via email to have my questions answered (special effects and compositing can technically be either considered the end of shot production, or part of post-production; I elected to group these
steps with shot production as *Inspired 3D Short Film Production* did (see page 37), but Calabash groups them with post-production).

I inquired about whether 2D or 3D effects are favored in the studio’s animations, and why a given type of effect may be preferable. Calabash generally tries to find a two-dimensional solution to its effects, as even if a 3D solution is eventually implemented, the 2D solution can help lay out the framework for that. A 2D solution can be “better because it is not tied to the limitations of a particular software and really can involve the client early on, since a drawing can be shared much quicker than an elaborate 3D set-up. It is always a quicker solution in terms of rendering time” (Blake). As a studio that works with numerous different clients, turnaround time is an important consideration influencing Calabash’s preference for 2D effects. The decision is often based on whether the camera in the scene is moving, as a considerable amount of time and money can be saved by using 2D effects through a program like After Effects for a static shot (Blake). Examples of effects the studio may be more likely to add two-dimensionally during post-production – as opposed to three-dimensionally during shot production – include glows, sparkles, lens flares, and vignettes.

Another crucial step in Calabash’s post-production workflow is compositing separate layers into a fully rendered scene (see page 39). Calabash uses layers because, as mentioned in *Inspired 3D Short Film Production*, it allows different elements to be changed individually. This can save an incredible amount of time when the other option is to render the entire scene over again. “But if, for example, the shadow of a character on the floor needs to be lighter, you can simply make the layer more transparent” (Blake).
An example of how Calabash might divide different elements by layer would be having separate layers for the background, foreground, or character passes, such as highlights, shadows, and props. In order to place these elements on separate layers, they have to be cleanly isolated from everything else in the scene. Calabash accomplishes this by either keying using Keylight (an Adobe plug-in for keying in After Effects) or by rendering elements using the alpha channel in the 3D program Maya (see page 39).

**Results of the Study**

To create my own animated short film, I focused on the elements of the production pipeline that were emphasized through my preliminary research and personal interviews. Although generally no elements of the pipeline should be omitted, I learned which should be allotted the most time and I was better able to prioritize each stage of the process. The following recommendations apply particularly to individual animators, very small production teams, and 3D animation instructors.

Storyboarding and animating should be the two biggest considerations in the production of a small-scale animated short. Storyboarding is essential because the more decisions that are finalized in this step – such as camera angles, character and prop positioning, and overall movements – the quicker the process will be once 3D software is introduced. The actual creation of storyboards is not particularly time consuming since the drawings can be very crude and simple, but getting the staging down at this point will make laying out the scene three-dimensionally much more efficient. It’s important that even on a tight schedule, this step is not rushed in order to more quickly enter shot production.
Character and art design can occur before and/or during the storyboarding stage (since the characters do not have to look perfect in the actual boards), followed by the creation of animatics. Both a 2D and a 3D animatic do not have to be made, although the more preproduction materials that are created, the smoother the transition to shot production. It’s essential that some form of animatic be made to determine the timing of each shot before animating the characters. This way the timing can be altered when it is still relatively inexpensive time-wise to do so; changing the timing after a scene has been fully animated is much harder to implement and may result in long hours of animated work being scrapped or completely reworked.

Modeling, texturing, and rigging are important pre-production steps, but they should be completed with a focus on the upcoming animation stage. The models’ poses and structure (such as the placement of edges and vertices for polygonal models) must relate to the actions the character will be expected to perform when animated, and not determined arbitrarily. Similarly, the rig should be assembled in a manner that best facilitates the character’s anticipated movements so the animation stage is not hindered by an inability to move the character’s limbs as desired. This requires that special consideration be given to which limbs should be controlled via IK or FK controls, and which limbs should have switches that allow the animator to change between the two control types. Texturing, while a great way to introduce realism and style to a model, is technically a step that can be skipped or minimized in order to allow more time for the animation. In a large-scale production, one would always want to make all of the models as aesthetically pleasing as possible, but this may not be as important in smaller works.
The most time should be allotted to the actual animation, but even this step has many sub-steps that must be strategically prioritized. Blocking should be the quickest of these steps, but care must still be taken to ensure that poses are placed and keyframed along the timeline at accurate intervals. Accuracy is always paramount, but the movements at this point should be extremely simple – basically just moving a given model from point A to point B in the scene. Once the models are positioned and keyframed in the scene according to the timing indicated by the animatic(s), the next main step is to manually adjust the movements between the keyframed poses. The main goal of in-betweening is to make the movements look natural, instead of robotic and calculated like the software’s automatic in-betweens tend to appear. Some poses may need less work than others to achieve the desired look, and those that are most visible to the camera should always be prioritized. The final steps of the animation, such as smoothing out the in-betweens and overall movements and adding various forms of secondary action, should be the most time-intensive part of the animation stage. Even though the changes made in these steps are far more subtle than those made during blocking, these finer details are what really sell the animation and ultimately make it believable.

How long it takes to set up the lighting for a scene can be somewhat dependent upon the time available at this stage. Lighting setups can be incredibly sophisticated or rather simplistic, but a variety of approaches can be used to achieve the desired mood. It’s important to leave enough time to set up the renders and allow the software to calculate the final still image or movie files. Different types of rendering engines can be
used to achieve different effects (such as raytraced shadows, reflections, and refractions with the more time-consuming and powerful Mental Ray renderer), so which renderer will be required to accurately portray the scene must also be considered.

Lastly, special effects and other post-production processes can be streamlined or expanded upon based on the time remaining. What is essential is that any still image files are sequenced into a movie file for playback, and that any elements that were rendered separately (lights and shadows, for instance) are composited into the rest of the scene using compositing software like Adobe After Effects.

**Conclusions and Further Research**

Until conducting this study, my knowledge of the 3D animation process was based solely on secondary and educational sources: textbooks, online tutorials, and a collegiate level course. Investigating the workflows of professional animators provided a different perspective, and allowed me to see that many elements covered in my more traditional learning were reflected in these professionals’ work. The various parts of the production pipeline I investigated – such as straight ahead/pose-to-pose/layering approaches, animation principles, blocking, and in-betweening – were not just textbook concepts, but truly relevant to and used in professional-level productions. These animators follow references such as drawings, video recordings, and other animations, and even record themselves performing specific actions or speaking specific lines of dialogue. It was reassuring and encouraging to learn that professionals follow guides and seek inspirations the same as beginning artists do. While these animators’ work is clearly
on a different level than that of individuals just starting out, the process followed remains fairly consistent.

Although individual preferences influence each animator’s workflow, the overall animation process is generally the same from Calabash to RTC to Phosphor Games: blocking (including posing and timing), in-betweening movements, adding secondary action, and refining. The same holds true for the rest of the production pipeline from storyboarding to compositing. While different software programs and projects will inevitably require tweaks to this formula, being able to pare it down to a basic workflow helps the animator stay focused on the big picture and not become preoccupied with details, something all too easy to do when working on a multi-faceted task. For instance, during the animation stage step of adding secondary motion, there are various types of secondary motions to convey, different body parts to add these motions to, specific timing and placement for each, etc. Especially when working independently or in a small team, it is easy to become overwhelmed with the range of choices involved in this step alone. This is why being able to step back and see the entire production cycle from a simplified view can prove so beneficial. It can be difficult to generalize from a textbook what exactly are the most important parts of this process, but seeing the same elements repeated across multiple real-life studios makes the overall pipeline much clearer.

I also learned that despite the highly organized structure required for what is often a complex workflow, each animator seems to have freedom to work in the ways most comfortable to him- or herself. For instance, some of my preliminary research suggested following a very specific order for addressing animation elements such as position and
orientation, timing, center of gravity, weight, follow-through, secondary action, and moving holds. However, Blomquist prefers to follow his instincts and break down the animation when things don’t look right, instead of adhering to a strict, formulaic approach. Others such as Cruz may prefer following more ordered steps, but in the end, both animators produce high-quality work regardless of their exact methodology. When I asked Blomquist about how he handles shot scheduling, he had this to say: “There is no correct answer to this – the process is personal and all techniques should be explored to feel and see which is most effective and comfortable to the animator” (Blomquist). This can provide relief and reassurance to individuals or small teams who may be worried that they are not doing things in the ‘correct order’ or following the right approach. To be sure, there are certain steps that absolutely must precede others (the model must be created before it is rigged, and the model must be rigged before it is animated), but animators can take advantage of flexibility in the sub-steps to cater the workflow to their own personal style.

This study also reiterated some of the limitations of textbook-based learning, specifically in the area of animation principles. All of the animators I interviewed promoted reading and learning as much about the principles as possible, but it was clear from speaking with them that there is a whole other dimension of these principles that can only be realized through hands-on practice. For instance, some principles are used so often – such as squash and stretch by the character animators at Calabash – that they become second nature and no longer a principle that must be consciously considered. Additionally, the importance of correctly applying other principles, like follow-through
and ease-in and ease-out, is best emphasized by seeing them applied "incorrectly: “Adding extra realistic movement pulls the viewer in since it mimics actual reality and physics. Our brains are already hotwired for this and if done wrong, would be so noticeable. The subtlety for this is paramount” (Cruz).

The results of this study are particularly beneficial because they offer a look into a world – the small animation studio – that outsiders generally do not get to view, as the proprietary nature of most animated pursuits limits the information available to the public. Independent animators and small teams can use these findings to design their own production pipelines that utilize this basic, proven workflow and yet are personalized to reflect the given project and the individual’s or team’s personal style. They can also use these findings as a way to frame their workflow in the most general terms, so they are able to both view the process on a very detailed level and step back to see it more broadly. 3D animation instructors can also benefit from framing the animation workflow in this way, since it can be difficult to touch on the many facets of the discipline in a single course. Additionally, knowing about the specific practices and techniques that professional animators follow will guide educators in making their lesson plans as applicable to the actual industry as possible.

Areas for Further Research

This study provides several starting points for additional research into 3D animation practices. As previously mentioned, one way to take this study further would be to more thoroughly investigate other steps of the production pipeline, such as rigging, lighting, and rendering, or the following topics could be explored more in-depth: pre-
production, modeling, and animation. A subsequent study could reach out to a greater number of small studios and independent animators to provide a broader perspective on these processes. Such a study could also attempt to acquire permission to make video recordings or take photographs of production materials to illustrate the findings, something this study was not able to do. By conducting more long-term research, a greater amount of input could be gathered and synthesized, resulting in more widely generalizable conclusions.

Another approach would be to look at different types of animation work and the variations involved in the production processes for each. This study investigated animation very broadly, so the processes could apply equally to an animated short film, commercial, or video game character. A subsequent study could specifically look at the differences in modeling, rigging, and animating a character for a video game versus a film. A study could compare the special effects generated for a fully animated world – such as one found in a cartoon-style film or a video game – to the special effects used in live-action films. Future studies of this nature could examine how production processes differ based on the intended end product.

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Appendix

Research Study Interview Questions

**Storyboarding:**

• What are the steps in the storyboarding process and the order they generally proceed in?

• What are your conventions for labeling/numbering storyboards? Shots? Sequences?

• How much story planning/character design takes place before the creation of storyboards?
  
  o Must it all be nearly perfect before beginning work on the boards?
  
  o Is initial planning predominantly visual or verbal?
  
  o Are the storyboard artists ever the character designers/artists?

• Do you decide how to divide the story up into shots as you create the storyboards, or beforehand via the creation of a beat sheet, shot list or something similar?
• Are there different ‘rounds’ or ‘series’ of storyboards that you create while fleshing out the story and presentation?
  o If so, what’s the most important consideration in the first round of storyboards? (or when first starting work on the boards)

• What elements are added on subsequent rounds of storyboards?
  o When do things like lighting, camera focus, camera effects, cuts/transitions, etc. come into play?

• Are the first series of boards overly broad, representing whole sequences or acts instead of individual shots?
  o At what point do you start creating boards for individual shots?

• How many series or rounds of storyboards are created for an average film/game/production?
  o Why is this amount generally appropriate for your work?

• How significant are the variations between each series of boards? (Can you provide me with an example?)
  o How are decisions made as to which elements should be maintained for future storyboard versions and which should be discarded?

• At what point do the final storyboards begin to take shape?
  o Do multiple series of boards make it to the 2D animatic stage, and have timing and audio elements added?
If so, how much time is invested in developing animatics for each series of boards?

- How many types of cuts and camera moves are explored for each shot?
  - Do artists generally follow their gut instincts or always test many possible combinations for telling the story?
  - How do you determine when the best presentation has been achieved?

- Any philosophy/best practices for deciding on camera shots and angles, cuts, and transitions?
  - How about camera movement (the amount of movement, directions/angles)?

- What conventions do you use to indicate camera movements, cuts, transitions, etc. within a single board, or do you always make additional separate boards and show the effects using a program?

- What is your typical procedure for addressing continuity issues between shots?

- How much background scenery is generally needed to establish the setting and make the storyboards realistic?
  - As a general rule, is the focus typically on the foreground?

- Is it common to drastically change the ordering of shots, and why is such a decision made?
  - Can you provide me with an example where changing the order of the shots was beneficial?

- How do you determine which shots to cut/eliminate?
• Are cinematic storyboards interspersed with diagram panels, and if so, how?
  o How often are diagram panels included and why?

• At what stage are storyboards at when an idea is pitched, and why?

Modeling:

• What software do you generally use for modeling?
  o What are your conventions for naming models/parts of models?
  o How do you divide a typical model onto separate layers?

• Do you generally use polygons, NURBS, or another type of geometry for modeling, and why does this geometry type seem to work best for you?
  o Do you ever use different geometry types for different elements of a single character or prop? (Can you provide me with an example?)

• Do you use scanned 2D reference material to form the basic outlines of characters/props? Or do you model free hand, looking at 2D/3D references but not tracing anything?
  o Where do your references generally come from?

• Are characters generally modeled in a da Vinci pose, a relaxed bind pose, or some other type of pose?
  o Why does this pose seem to work best for you?
  o Does the pose vary based on character, and how so?

• What parts of a character model’s design are most impacted by the movements that the character is expected to perform?
• Can you provide me with some examples of how you might model a character differently based on what that character is expected to be able to do?

• Do you model a full set of blend shapes for all mouth movements (as in dialogue) or for the major different emotions/expressions the character is expected to have (morph targets)? Or is the mouth animation instead handled by rigging?
  o Why do you use the method you do?
  o Are different methods used based on the character/project at hand? If so, why? (When would morph targets be more beneficial than skeleton-driven animation and vice-versa?)

• What would you say are the top 5 most useful modeling techniques/tools in your everyday workflow? Why?

• How do you go about creating alternate, low-resolution models for layouts and animations? (Subdivision surfaces, replacing with crude lower-res versions, or some other technique?) Or is working with higher-resolution models not really a problem for you (and if so, why not)?

• Do you utilize deformers in your modeling workflow, and if so, how do you implement them (for overall modeling at the beginning, refinements at the end, or things in-between)?

• Do you ever use instances in your modeling?
  o If so, could you provide me with an example where using instances was beneficial?
• What techniques/tools are best for creating hair and fur, and are there any general recommendations or tips you would offer for working on these components?
  o Are they generally done by techniques other than modeling?

Animation:

• What type of animation style do you usually work in: realistic, cartoony, or something in-between?
  o What style do you prefer working in and why?

• How do you create a motion ‘style’ for a character?
  o How do you convey the character’s emotions/personality through the animation? How do you ‘bring the character to life’ and indicate his/his internal forces?

• Do you reference anything when creating an animation, and if so, what (acting it out yourself, watching someone else act it out, watching an animal, videos, something else)?
  o How about for animating dialogue?

• Do you utilize a “straight ahead” (manipulate most frames sequentially), “pose to pose” (first define the extremes and then fill in the spaces in between), or “layering” (establish position and orientation first and then hone in on details) approach to animating, or some combination of these?
  o Why does this approach work best for you?
• Do you create a library of ‘stock poses’ for a given character – based on what he/she is
going to be expected to do – before you begin the animation, or do you create the poses
as you go along? Why do you work this way?

• What kinds of motion tests do you typically put a character through to test the
functionality of the rig? Could you provide me with any examples?

• What would you say are the top 5 most useful animation principles that you apply to
your everyday workflow? Why?

• Is there a certain series of steps you work through when animating a given action?
(position and orientation, timing, anticipation, appropriate center of gravity and weight,
follow-through and secondary action, moving holds, etc.)
  o How did you develop this workflow?

• What things do you focus on animating during the blocking stage?
  o What types of models do you use for this stage – the final/near-final
    versions or crude low-resolution versions for approximation?
  o Why are these types of models used?

• Do you have a particular workflow for applying the various types of secondary motion
(overlap, follow through, drag, drift)?
  o In what order do you address these motions?

• Any tips on how to create realistic in-between movements between the main poses/how
to fine tune the automated in-betweening created when curves are released?

• Do you use function curves in your work, and if so, how? Could you provide an
example?
• What are the most important elements to a successful walk cycle?

• How do you animate continuous movements, like walks or runs?
  o Do you cycle the animation and make tweaks to it, or continually recreate the movements?
  o How do you make cycled motions seem realistic and not mechanical?

• Do you animate facial expressions/dialogue via morph shapes, skeleton/deformer-driven manipulations, or some other technique?
  o Why do you prefer this method? Does that preference change based on the particular project/character?

• How long does it typically take to animate a single line of dialogue of average length? Why?

• How is the process used for 3D animation different from the process used for 2D animation?
  o How are the processes similar?

• In many areas, 3D animation has replaced 2D animation; how do you see animation further changing in the future?

Special Effects/Post-production:

• For what types of animated elements do you use procedural effects instead of manual animation?
  o Why is it preferable to use procedural effects for these types of elements?
• Can you provide some examples of animated elements that use procedural effects and the types of effects you use for each (particle effects, motion dynamics, something else)?  
  o Why is a particular type of effect chosen for each situation?

• Can you provide an example of how you use particle effects?  
  o How you use motion dynamics?  
  o How you use any other main special effects technique?  
  o Why is a particular type of effect chosen for each situation?

• When using particle effects, are the particles typically points, trails, or simple objects?  
  Why?  
  o Do you ever use specialized particle objects, like sprites or instances? If so, could you provide me with an example?

• Are there any special rendering considerations that need to be taken with such special effects?  
  o If so, what are they, and what is their purpose?

• In what types of situations are 2D solutions used (for compositing) instead of 3D special effects? Why is 2D preferable in these particular situations?  
  o How is the choice between 2D and 3D effects made?

• Do you use compositing to combine separate layers in post-production, and if so, what types of elements does each layer typically consist of?  
  o Why are elements divided in this way?
• What technique(s) do you use for cleanly isolating and layering images/elements (alpha channels, masks, mattes, keying, etc.)? Why?

• What types of rendering passes are typically used (beauty, specular, shadow, depth-map, etc.), and why is the rendering divided in this way?

• Do you ever add post-camera moves/effects that might be difficult to create within the 3D program?
  o If so, what kinds of moves/effects do you add?

• At what stage are sound effects/audio added to the animation?
  o Why are they generally added at this time?

• What conceptual aspects of the film benefit or change the most as a result of post-production edits (lighting adjustments, special effects, synching issues, etc)?

**Scheduling:**

• How is scheduling for a project handled and tracked?
  o Do you use a global shot schedule and/or a shot progress chart? What are typical deadlines like for your department?
  o What do you do when production is falling behind schedule?

• What kind of schedule is used to create the final shots: a “straight ahead” approach (each shot completed sequentially from start to finish), a “hero shot” approach (completing crucial shots entirely before filling in the shots between them), or a “layering” approach (completing all shots in overall stages)?
  o Why is this type of schedule used?