COMBINING PERFORMANCE ANIMATION AND VIRTUAL REALITY FOR EARLY CHILDHOOD EDUCATION ROLE-PLAY

THESIS

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By

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ABSTRACT

Role-playing is an essential component to social skills training in early childhood education. However, current programs are either not interactive enough in role-playing, or through the process of interaction with adults, become confrontational and frightening. A combination of virtual reality and performance animation can provide an environment for a child to learn through role-playing that is non-threatening, yet interactive enough for authentic and constructive interaction, as well as facilitating communication between the teacher and student.

This study begins with a review of literature and contemporary applications of early childhood education, performance animation, and virtual reality. The question of how performance animation and virtual reality can contribute to a lesson that uses role-play is explored through prototyping components of an immersive environment for role-play with digital characters. This prototype was then demonstrated to early childhood educators. A focus study was conducted to evaluate the prototype and its implications in the field of early childhood education.

The findings from the focus group are presented and analyzed. Conclusions are drawn based on the focus group feedback and designer's experience in combining these fields. Future work in combining performance animation and virtual reality to benefit early childhood education is proposed.

Dedicated to Mom, Dad, and Alexander

And to the memory of Fred Rogers

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CHAPTER 1

INTRODUCTION

1.1 Introduction to research

Role-play often takes the form of two or more people acting and improvising the parts of imagined people or characters in a scene. The emotions experienced by the people playing these parts can feel real, creating a valuable process for memorable and meaningful learning experiences. This practice can often be seen in programs where a participant needs to practice actions and reactions. Role-playing is helpful while teaching a lesson and allowing a child to apply what the lesson has taught him. The practice of role-play benefits the learning process by allowing the participants to explore and repeat new behaviors all while within a safe environment. By successfully and unsuccessfully repeating and practicing the new information, it becomes knowledge through the memorable experiences of success and failure. The safe environment in which the practice takes place is crucial because the child should feel free to explore the new behaviors without fear of the negative consequences of failure. The positive aspects of role-play have been explored in academe and are used in classrooms and numerous children's programs.

When a teacher is the role-play partner to a child, the child is role-playing with a knowledgeable other: Lev Vygotsky's term for one who knows the material to be learned.

The teacher can model, or act out, the behavior and create a scenario in which the child can attempt this behavior himself. The relationship of the teacher and student allows the teacher to construct the role-play with the appropriate level of challenge for the student. The human component of the instructor also allows her to provide the improvisation and flexibility beneficial to a role-play.

Despite the many advantages of a learner role-playing with a live knowledgeable other that has a pre-existing relationship with him, this knowledgeable other has a disadvantage. The knowledgeable other in a classroom learning situation is quite often an adult. Role-playing with an adult can be frightening or uncomfortable as most adults are much larger than most children and are usually in positions of authority. If a child is frightened or uncomfortable, he or she cannot learn. If a children's program attempts to meet the need of comfort by sacrificing role-playing, the lesson is not effective. The question then is, how can a lesson in children's conflict resolution be created that allows the child to role-play interactively in a comfortable environment, yet provides the participant with a role-play partner that does not frighten the child?

One solution of the past has been to use traditional puppetry. Children have responded well to puppets in both therapeutic and role-playing applications (Carter & Mason, 1998). However, traditional puppetry has several shortcomings including a lack of sense of scale, a sense of immersion, and a possible growing lack of acceptance with contemporary children who are raised watching animation and three-dimensional graphics. Allowing the child to role-play against a partner his or her size could be advantageous in learning to identify the experience with later real-world events. However, providing the child with a role-playing partner that is his or her height through

the use of traditional puppetry would be an impractical solution. Traditional puppetry also cannot provide a sense of immersion for the participant. Being immersed in an appropriate simulated environment helps a role-play feel real, while still allowing the participant to remember that he or she is in a safe environment. While some traditional puppeteers build sets for their shows, these sets, in general, do not reach the sense of immersion that can be helpful for role-playing.

Several children's programs have attempted to provide lessons using computer-based interactive applications. Such applications can benefit from lower-cost production and distribution, but often sacrifice the advantages of real-time human interaction and personalization of lessons for specific learners. An academic relationship, developed from real-time interactions between the teacher and student allows the teacher to rely on her experience with that student for challenging the student appropriately and contributing to the student's growth. Depending on a lesson's material, this real-time interaction is essential for the successful exchange of knowledge. This real-time human component in instruction is exceptionally helpful in role-playing, but often not allowed for by computer-based learning objects for children.

The use of a live early childhood educator driving digital puppetry could not only address the shortcomings of preprogrammed responses, but also benefit from the usefulness of the opportunities offered by technology. The early childhood educator could employ her expertise in role-playing with children and conflict resolution curricula while providing the immediate feedback, intervention, and facilitation that effective role-play requires. Allowing this expert in role-play to drive the animation of a child-friendly and appropriately scaled role-playing partner would address the disadvantages of the

expert's physical presence in the role-play, and embrace the advantages of having such a character replace her with the character's digital presence. The live actor can provide the immediate and specific feedback that is helpful to the participant, while in the form of a non-threatening digital puppet.

Performance animation has a history and practice that could inform this process. With roots in traditional puppetry, performance animation embraces advances in technology to create new and interesting applications of traditional puppetry practices to real-time animation of digital characters. Some performance animation groups have created live interactions between a digital character and a human. An educator with expertise in role-playing could drive the animation of a digital character much like he or she may have done with a traditional puppet, while benefiting from the opportunities afforded by a digital character. By providing several animations from which to choose and allowing the educator to select them appropriately, a live role-play exchange can take place between a digital projected character and a child.

Creating an appropriate and safe environment is another essential component to a successful role-play. Immersion in an environment appropriate to the learning material has helped children construct knowledge in the past (McComas, MacKay & Pivik, 2002). Placing a child in a peaceful environment can contribute to a peaceful resolution to conflict (Lamm, Groulx, Hansen, Patton, & Slaton, 2006); placing a child in a violent environment can contribute to a dysfunctional approach to conflict resolution (Vestal & Jones, 2004). This implies that the provided environment's design will have an impact on how a role-play is approached by the participants and how the child constructs knowledge from the experience. The creation of an appropriate virtual environment for

the lessons could be a helpful component of role-play scenarios. This would embrace the advantages of immersion as well as the advantages of a safe environment to learning. Virtual reality environments could provide the means to create an immersive environment that can also serve as a safe place.

1.2 Research Question

What advantages would performance animation and virtual reality bring to teaching a lesson that uses role-play with children?

1.3 Hypothesis

Combining performance animation with virtual reality can offer a unique solution to the problem facing children's programs. Based on a pre-existing relationship with the child and her expertise, the early childhood educator could provide the interactivity, feedback, and repetition that are important to role-playing, while an immersive virtual reality environment can provide a sense of immersion and a safe environment.

1.4 Methodology

The proposed study will approach this unique combination by reviewing historical and contemporary studies in early childhood education conflict resolution curricula, performance animation and virtual reality, and using these studies to inform decisions made in creating a prototype of a teaching and learning tool that can be used by early childhood educators for role-playing lessons of conflict resolution with children.

Investigation in applied role-play methodology will be used to inform the educator-child interaction design in this prototype. Research on performance animation and traditional puppetry will inform the design of the digital characters and the interface provided to the educator for puppeteering. Research on virtual reality, simulation, and immersion will inform the development of a virtual environment that draws from a sense of safety in a virtual space, responsiveness, and desired approach to conflict resolution. Current works in digital role-play will be explored to inform the design process of the project.

This project, named *Eegan's Aquarium Challenge*, will attempt to facilitate opening a channel of communication between the adult teacher and child learner during a role-play. The teacher will be a digital puppeteer of child-sized, non-threatening digital characters in a virtual environment. The teacher will be given an input device that will allow her control of an introductory narrative. This same device will allow her to choose the appropriate digital role-play partner for the child and choose the digital character's responses to the child from a list of pre-programmed animation and verbal responses. The child will role-play with the characters chosen by the knowledgeable other and will be able to ask his live and present teacher for help during the role-plays.

The project will be evaluated by a selection of teachers of children aged four to seven. They will observe how the system works and watch a demonstrated role-play from initiation to completion. They will then be asked questions concerning advantages and disadvantages of the system. Their responses will be used to evaluate and modify the final product.

CHAPTER 2

BACKGROUND INFORMATION

2.1 Role-playing in Education

In order to discus role-playing in education, one must first situate these ideas within a theoretical framework of learning. This paper draws from the theories of Lev Vygotsky, an educational psychologist, and from Elizabeth Wood's and Jane Attfield's interpretations of Vygotsky's work. Vygotsky held a constructivist approach to childhood learning: the child constructs new understanding and capacities (Wood & Attfield, 2005). A social interaction and relationship between the child and the knowledgeable other helps create the foundation for this learning. The role of the knowledgeable other is to guide the child towards the ability to function cognitively on increasing levels. She does this by scaffolding the learning experience. Scaffolding can be described as a process through which the knowledgeable other encourages and assists the learner as necessary, and gradually lessons the amount of assistance as the learner becomes more adept at the task involved in the instruction. The child is not passive in this construction. Rather, he and the knowledgeable other actively work together to develop the child's knowledge and abilities. The knowledgeable other provides assistance by scaffolding a constructive learning experience for the child. The knowledgeable other does this by placing the child in his zone of proximal development. To do this is to understand what the learner's

current capabilities are, and predict what the learner can usefully and feasibly do next. When in his zone of proximal development, the child may tolerate some frustration with the challenge of the task before him, but the task should not be so far beyond his abilities that he becomes discouraged and de-motivated.

The scaffolding experience that the knowledgeable other creates can be in the form of play. Play is an empowering experience for children, for in play a child can pretend to be braver than he thinks he is in reality. Vygotsky saw great potential for learning in role-play, especially for pre-school children. He defined role-play as including imaginary situations, subordination to rules, liberation from situational constraints, and definition of roles. This is to say that in role-play, children experiment with behaviors, rules, boundaries, and their own limitations in a pretend environment in an attempt to understand reality.

2.1.1 Role-Playing Overview

Role-playing is a widely used practice for teaching children social skills and allowing them to experiment with what they have learned. While there are many possible ways to role-play, the bare essentials of a role-play include two participants acting out a scene in real-time. The scene may be partially scripted or completely improvised, and the participants may play the roles of themselves or others. Generally, the purpose is to allow the participants to try out new behaviors in multiple scenarios all while in a safe environment. The important components of role-play discussed in this section include acting out a scenario in the first person, acting out a scenario from the view point of another, acting out a scenario with a knowledgeable other, and using a character to speak for the participant.

2.1.2 First-person point of view

Acting out a scenario from the first-person point of view allows a participant to act out a scenario from the viewpoint from which they are most accustomed to thinking and acting. Role-play from the first-person point of view is the most widely used method for developing interpersonal skills (Holsbrink-Engels, 2001). A new problem-solving skill is taught to a learner, and the learner practices the skill with another person in a role-play. While the axiom, “Practice makes perfect” may be commonly accepted, it is also important to the learning process that the learner be presented with variations on the theme of the basic scenario and skill. As an example, a child may be taught to ask for permission to use the restroom. The child can learn this behavior best when practicing in a role-play form with a teacher. To truly understand the skill, the teacher should present different scenarios in which the child can practice the skill. Perhaps the teacher is busy, how would the child get her attention? Does the child need to ask, if it is truly an emergency? What would happen if two children ask at the same time? Lisa Galarneau’s article on authentic learning through play, games, and simulation suggests that allowing a role-play participant to practice many scenarios encourages him to push his learning of the skill further (2005) and makes the learner more confident to try this new behavior in the real world. While the first-person point of view is perhaps the most used in daily life, role-playing from the point of view of another has distinct advantages as well.

2.1.3 Taking on the viewpoint of another

Some children, and even fully developed adults, struggle with seeing a situation from the viewpoint of another. This can lead to misunderstandings, hurt feelings, and conflict. Acting out a scenario from the point of view of another can help decentralize, or

teach empathy to, the participant and lead to understanding and conflict resolution (Jeweler & Barnes-Robinson, 1999). For example, a teacher has a student with a habit of cutting in line in front of other students. The child can be told many times not to cut in line, but may have trouble understanding why this action is undesirable. He gets the reward of the line sooner if he cuts in; the only negative consequence is being occasionally disciplined by the teacher for the action. The teacher could set up a role-play for the student in which he is waiting in line for some reason, and another child cuts in front of him. This exercise can help explain to the child through experience why the action is inappropriate by allowing him or her to experience the point of view of the injured party. Role-playing through the point of view of another can help a participant understand how his actions affect others.

2.1.4 Role-playing with a knowledgeable other

To ensure that a lesson is guided so that the appropriate skills are practiced, it can be helpful to role-play against a partner who is knowledgeable in the area of the skill being taught. A knowledgeable other can be a desirable role-playing partner because she can direct the scenarios to strengthen weaknesses and adjust the level of difficulty to match the learner's needs. A teacher can coach a child toward the resolution while making sure the child feels safe and satisfied with the solution (Lamm et al., 2006). A teacher or similar knowledgeable other can better facilitate the role-play than a partner who is not familiar with the skill being taught. While a teacher has the option of having two children role-play with each other and intervening when problems arise, it is more effective to guide the role-play to a constructive resolution from within the interaction. As a role-play partner, the teacher also has the ability to model the behavior for the child,

and then let the child practice it. Children have been shown to have the aptitude to model behaviors of knowledgeable others, be they adults or peers, and then use the modeled strategies themselves (Vestal & Jones, 2004). A role-play partner that can both model behavior and choose which scenarios are appropriate for the child would then seem to be the ideal role-play partner.

2.1.5 Past solutions in traditional Puppetry

The very strength of this seemingly ideal role-play partner, however, often is coupled with a weakness: the physical appearance of the partner. Adults are most often larger than young children and hold immense power and authority over the children. The adult may also remind the child of a past or present perpetrator. All of these factors can result in the physical presence of the desired knowledgeable other creating unsatisfactory results. A traditional solution to this problem has been for the child or teacher to use puppets in place of their physical presence; they speak and act through the puppet on the puppet's scale, and not through the human body or on the human scale. Once using the puppets in the puppet world, the children can often express feelings and work through conflicts that they cannot in the physical world (Lamm et al., 2006). The child can project his feelings onto the puppet and deal with events too anxiety-laden to deal with in the physical world (Carter & Mason, 1998). Once removed from his physical body, the child's emotions are safe in the imagined "puppet world". The teacher or counselor can use the puppet as well, with promising results. Replacing the counselors physical presence with that of a puppet has been shown to be effective in working with children, especially in establishing trust and rapport or when non-threatening communication is required (Carter & Mason, 1998). Puppets are most successful when they are easy for the

counselor to use (ibid.); marionettes may have the advantage of human scale for a role-play, but take carefully honed expertise to learn to use effectively. The puppets should appear to be "soft and cuddly" and stay alive even while not speaking (ibid.). The puppet that replaces the role-play partner should appear alive at all times, or the illusion of the replacement of the teacher's physical body is broken. This practice has been proven to be successful for teachers and counselors to use in role-playing with children, but the practical necessity of keeping this interaction on the puppet scale keeps the children from expressing their new skills with their physical bodies on the human scale, which is much more akin to a situation in which they will need to use the social skills being taught them; the experience is perhaps not real enough to be memorable.

2.1.6 The benefits of failure in a safe place

Humans learn from memories; we remember strong emotions that we experience. A role-play must evoke real emotions and feelings to be memorable, but maintain the balance of taking place in a safe place so that the learner is secure that he can experiment with new behaviors without fear of negative consequences. The feeling needs to be maintained that the scenario being acted out is not happening in the real, physical world; however, the role-play needs to be realistic enough that the participant can experience and learn from failure and success. Teachers are cautioned to create a safe environment for role-play where the children know their bodies and feelings are safe (Lamm et al., 2006). This safety allows for the children to repetitively practice the new behaviors being taught to them without experiencing the fullness of the negative consequences that might occur in real life if a practiced skill is not successful. The child must be given the opportunity to fail so that he can learn these consequences in the safe environment, rather

than in a place were failure has real consequences. The opportunity to fail is important to learning (Galarneau, 2005); to know success one must know the opposite and what it feels like. Failure in a safe environment, however, still evokes real emotions that become real memories from which the participant can learn (ibid.). These memories will become knowledge and inform the child's decisions in using the new skill once in the real world where the consequences are more permanent than during the role-play. Too much failure, however, creates an unsafe environment. An important component of a safe environment for role-play is a supportive teacher that provides guidance so that the child does not get discouraged and de-motivated. Vygotsky theorized that the child needs to have an active role in his learning (Wood & Attfield, 2005). If the child is de-motivated due to too much failure or being placed outside his proximal zone of development, he will be discouraged from taking an active role. The safety of an environment depends partly on the teacher's ability to make the environment feel safe and constructive by giving the child appropriate tasks and guiding him when he struggles. Role-playing in a safe environment allows the child to take risks that he could only take when feeling safe, so that he can experience and learn from failure and success.

2.2 Performance Animation and Digital puppetry

2.2.1 Terms and Definitions

The term "performance animation" has various definitions given it by private sector entrepreneurs, non-profit organizations, researchers, and performance groups. Performance animation "combines the qualities of puppetry, live action, stop motion animation, game intelligence and other forms into an entirely new medium" (deGraf &

Yilmaz, 1999). While separately the words seem easy to define, the combination of the two sometimes creates controversy (ibid.). Recurring words in different definitions include, “motion capture,” “digital puppetry,” “interactive characters,” and “real-time.” Although the scope of performance animation is broad and ever expanding, this paper will focus on the aspect of an interactive character controlled as a digital puppet.

The digital puppetry aspect of performance animation harkens back to the roots of traditional puppetry; talented puppeteers control a character’s motions and voice. This is not entirely dissimilar from the control of a character found in video games: the player chooses when the avatar runs, turns, uses a tool, or turns his head. Pre-programmed animations can be provided to a puppeteer, and a computational algorithm can interpolate between key motions and a waiting motion. The digitally controlled character can do things that traditional puppets cannot. A digital puppet can have blinking, tail wagging, breathing, and other secondary animation behaviors programmed to play automatically while the character is being given explicit instruction on primary animations. This can help the character seem more “alive” than a traditional puppet. Good digital puppetry relies on good puppeteers, but can explore new opportunities that traditional puppetry cannot easily accomplish. Digital puppetry also makes high quality puppetry more accessible to people who do not study puppetry, but need it only for certain aspects of their job.

2.2.2 Varying forms

Common types of creation media for performance animations include virtual reality environments and other gaming engines. Gaming engines allow for accepting input from a person to direct the actions of a character, lending themselves nicely to

creating a real-time interactive character. Digital input can be received from many different devices with the purpose of influencing output, or animation, in this case. Common input types for performance animation and digital puppetry include joysticks, game controllers, Shape Tape, data gloves, microphones, and full-body optical motion capture systems. The input gathered from these sources can be used to directly control movement, or spontaneously select pre-programmed animation. An audio signal input can be analyzed and used to control opening or closing a character's mouth. Displays for the output of digital puppetry can include television monitors, projection screens, and headset displays. Because the output is digital information, it can be displayed in any format that can display digital images; the choice is dependent on what is appropriate for the audience. A large auditorium of people would prefer a projection to taking turns using a head set; a participant wanting to interact with a character on a human scale might prefer a life-size projection. The various inputs and outputs afford many choices for a designer to use for a particular application.

2.2.3 Significant Historical Contributions

The current state of performance animation has developed through a past rich in experimentation. In the early 1960s, Lee Harrison III created one of the first forms of motion capture and digital puppetry: ANIMAC. He fabricated a body suit equipped with potentiometers that communicated their position to a computer. The computer would then visualize this information in the form of a moving, simplified, three-dimensional digital character. An actor would wear the body suit and control this digital character in real-time, viewing the results as she would move. Harrison made short films with this technique, and later advertisements with an evolved form of ANIMAC.

Silicon Graphics and deGraf-Wahrman Inc worked together to produce a more complex visualization of a digital puppet. "Mike the Talking Head" performed live at SIGGRAPH in 1988 (Sturman, 1994). Mike Gribble's face was digitized and scanned while mouthing important phonemes (Hall, n.d.). During the performance, a puppeteer could control different parameters of "Mike's" face: expressions, head positions, mouth, and eyes (Sturman, 1994). The impressive "Silicon Graphics hardware provided real-time interpolation between facial expressions and head geometry as controlled by the performer" (ibid.). While the eventual goal of this project was to create a tool for recorded-time animation, the reception and spectacle at SIGGRAPH in 1988 qualifies this demonstration as a significant work of performance animation and especially digital puppetry. Brad deGraf later went on to form and guide the research of the performance animation group Protozoa.

Shortly after the animated performance of "Mike the Talking Head," Waldo C. Graphic was introduced to the public. While Jim Henson Productions had been attempting performance animation in the form of digital puppetry since 1985, the collaborative effort between Pacific Data Images and Jim Henson Productions was shown at SIGGRAPH in 1988 (deGraf & Yilmaz, 1999). Their effort, Waldo C. Graphic, was controlled by a mechanical arm with upper and lower limb controls (Sturman, 1994). The puppeteer was able to control the motion of a low-resolution character in real-time. This allowed the puppeteer to control Waldo C. Graphic in concert with physical puppets. The success of this performance animation lead to Waldo C. Graphic's appearance on the *Jim Henson Hour* (deGraf & Yilmaz, 1999). This collaborative effort brings to the forefront the importance of both technology and talent necessary for successful performance animation. While a technologically talented company can create an amazing real-time

human-motion driven system, the performance aspect of performance animation cannot exist without puppetry talent and engaging content.

2.2.4 Futuristic Visions

Neal Stephenson's book, *The Diamond Age* (1995), details one possible application of performance animation and digital puppetry in the future. In his book, Stevenson predicts that all entertainment will eventually become real-time streamed performance animation and interaction. Stephenson describes a motion capture system where performers have thousands of trackable markers embedded in their skin. They are then presented with a digital script when someone opens a book, turns on the television, or otherwise activates a performance animation module. The performer reads the script and physically acts out the scene. His or her animation is then mapped onto whatever type of character's or animal's part he or she is acting, and the digital puppet is displayed to the person that opened the request for a performance. The human actors drive the real-time motion of characters ranging from humanoid dolls to mice, dinosaurs, and more. The actor and participant engage in intense interactivity such as a conversation, lesson, or other role-play; the participant rarely passively observes a scene, but rather actively engages with the digital character. While a very interesting idea, Stephenson assumes that the many challenges of performance animation retargeting algorithms, or mapping human data onto non-human forms, have been solved in this version of the future.

Digital puppetry is still in a relatively early stage of development, but people like Stephenson see its potential to solve real world problems by creating an environment to practice these problems in a digital world with non-threatening characters. With a plethora of inputs and outputs from which to choose, a designer has almost no limit to the

combinations that she can use to create a digital puppet interface that is accessible and usable for the appropriate audience. However, the world in which the audience receives the digital puppet plays an important role in how the interaction with the digital character is perceived.

2.3 Virtual Reality and Simulation

2.3.1 Terms and definitions

The words “virtual” and “reality” each have commonly accepted meanings. Virtual can be defined as being “almost”, “not actually”, or “as though.” Reality is complex to define, but can be considered as meaning the quality or state of being real, true, or actual. When combined, however, the two words form a term that has diverse meanings attributed to it. Using the accepted definitions of virtual and reality, it can be said that virtual reality is that which in a state of being close to reality, but not actually real. The created works labeled “virtual reality” are incredibly diverse and embrace all different aspects of being close to real. The community that creates and applies virtual reality is comprised of researchers, authors, artists, military organizations, and others for motives including exploration, education, entertainment, profit, and more. Members of this community often attempt to more clearly define their use of virtual reality. Michael Heim, the author of Virtual Realism, calls virtual reality “a technology that convinces the participant that he or she is actually in another place by substituting the primary sensory input with data received produced by a computer” (Heim, 1998, p. 221). Dr. Denise Reid, a researcher at the University of Ontario asserts, “Virtual Reality is defined as an immersive and interactive three-dimensional computer experience

occurring in real time" (2002, p. 559). Howard Rheingold purports that the two foundations of virtual reality are immersion and navigation (Rheingold, 1991). Common components in definitions of virtual reality include the ideas of immersion and interactivity, or navigation, in a computer-generated environment with real time results.

To be immersed is to be completely surrounded, enfolded, encompassed. A man is immersed in the sights, sounds, tactile feedback, and smells of reality from the moment he wakes until the moment he sleeps. This reality can be taken for granted as the norm, until he is immersed in another multimodal reality. He dives into a pool of water and the information he receives from his sensory inputs is different from the information he was receiving above the surface. Briefly, he is in another world. Immersion in water changes the way humans perceive sensory input: sound is muffled, light is bent, and pressure is increased. While still existing in reality, this multimodal sensory change resulting from immersion in water results in a virtual transportation to a different world. To create immersion in virtual reality is to use technology to create an alternate world and submerge the user in this world. Heim (1998) states of immersion,

> The virtual environment submerges the user in the sights and sounds and tactility specific to that environment. Immersion creates the sense of being present in a virtual world, a sense that goes beyond physical input and output. Immersion clearly has psychological components, but it involves sensory input in ways that surpass purely mental imagination. (p. 215)

By enfolding the participant in the virtual world, and providing sufficient visual and audio cues, the goal is to replace the participant's reality with the virtual reality. This world, much like the participant's reality, must allow the participant a chance to interact, or navigate within it. This can be in the form of allowing the user to navigate through a space, in the traditional sense, or of allowing the participant to interact with objects or

representations within the environment. Reid asserts that this navigation or interactivity contributes to the feeling of immersion (2002). Heim agrees that part of the potential in virtual reality is to allow the participant to make his or her own discovery (1998). In order to allow the participant to actively participate, rather than being a passive observer, an interface must be provided for the user to become the participant.

2.3.2 Input and Output

An input for a virtual environment can be overt or implicit, and should be chosen based on the type of interaction with the environment desired by the designer of the virtual world. Heim defines an interface as the "connection point between human and digital machine" (1998, p. 216). This connection can take the form of a head tracking device, a data glove, various sensors, a joystick, or any other digital input used for performance animation. The interpretation of the input can be obvious to the user, such as pressing a joystick button upwards, and the machine interpreting this motion by moving her forward in the virtual environment. The interpretation can also be subtle and less overt: sensors can detect when a participant's blood temperature changes and decrease the level of difficulty of a task in a virtual environment. The designer should chose the input device and use based the virtual environment and desired interaction between the participant and the virtual world.

The display types available for those designing virtual environments are numerous and each contribute to a different type of immersive. A desktop virtual reality display provides a diminished sense of immersion (Reid, 2002). This display has advantages in that it is less costly than most display options, but provides a limited field of view. A head-mounted display has the advantage of providing around one hundred

twenty degrees of view versus the six degrees provided by a conventional monitor (Rheingold, 1991). The head-mounted display equipped with headphones is an effective display for immersion because it can essentially isolate the participant from her surroundings and only provide her with the sights and sounds of the virtual world (Heim, 1998). This sensory replacement contributes to the sense of immersion because it provides the participant only with the virtual world through isolation from reality. This isolation, however, can be a disadvantage in virtual environments where social behavior is necessary. Other disadvantages of the head-mounted displays include discomfort with the physical device and motion sickness for some users. A CAVE™ is a display that solves some of these issues. The CAVE™ is a system of projection for walls of a room (ibid.). A CAVE™ allows for multiple participants simultaneously, which can lead to a social virtual reality experience, as opposed to an experience of isolation. Heim claims that a CAVE™'s advantages over a head-mounted display include collaborative group viewing possibilities, concurrent higher resolution and field of view, the lack of uncomfortable headgear, lower viewer fatigue, increased mobility, and a "collaborative sense of presence" (ibid., p. 221). The ability to observe one's real body in their virtual environment decreases the vague sense of disembodiment created by some head-mounted displays. The possibility of collaboration of people who have not been disembodied creates the possibility of a social environment for relationship building. This would seem to indicate that a CAVE™ or other form of projection might be a more appropriate choice of display for enabling role-playing lessons.

2.3.3 Virtual reality and immersive simulation towards provision of a safe and participatory environment

Virtual reality and simulations taking place in an immersive environment allow a participant to act out a scenario in the first person while in a safe place, which has been shown to be important in the process of role-playing, while adding the benefits of immersion to enhance the participant's experience. If the environment plays a part in the lessons to be learned, an immersive environment can make a role-play or simulation seem more real and memorable than a role-play in a vacuum. If a police officer practices making arrests in a calm forest through role-play, she will not be prepared to make arrests in a seething riot. Providing her the opportunity to role-play the proper arrest procedures in the correct environment will prepare her better for the real-world scenario. It is, however, difficult to ensure safety for practice in an actual riot, so if this environment can be simulated, she can get the practice she needs in an environment that seems dangerous, and is memorable, but that is actually safe. Making the experience more memorable and real can help the participant learn better from the role-play or simulation. Instead of hiring thousands of actors and renting out a street for the simulation, this environment can be created in a computer. A virtual environment has the added benefit that, while it may seem real, it is still a fabricated, and thus a safe environment, which can be crucial component to successful role-play.

While in the appropriately designed immersive environment, the role-play or simulation that takes place will seem more real and thus be more memorable. The simulation or role-play should allow the participant to experience various possibilities that might be encountered in the real world to boost the participant's confidence in her

capabilities (Galarneau, 2005). The simulation allows the designer to create an authentic learning experience when it is not practical to have these experiences in the physical world (ibid.). This could include surgeries that cannot be performed on real patients during practice, but it can also include experiences that are too dangerous to have in the real world. Allowing a timid participant to simulate a role-play with a behaviorally aggressive partner that takes on a form of a non-threatening character could decrease the fright and allow the participant to practice and gain confidence in her abilities to use assertiveness skills in the real world against an aggressive person. Role-play in a simulated virtual environment allows the participant to practice skills in an environment that simulates reality and makes the experience more memorable, but is not actually real, so it feels like a safe environment.

2.3.4 Using game level design to inform the design of a virtual environment

This virtual environment should be deigned with the learning advantages of memorability in mind, and can also be informed by game level design theory. In his article for an on-line gaming magazine, Tito Pagán discusses the success of using basic design and architectural principles to inform good level design for games (2001). He notes that staying attentive to user interaction, user navigation, how the space directs the player, and the impact of the sound, space, lighting, pace, and scale creates a well-designed level. In order to address these concerns, he recommends looking to design and architecture principles. Because there are pre-existing proven and commonly accepted rules of form and navigation in architecture to convey meaning, intended traffic flow, and mood, he argues that these rules be applied to the design of virtual worlds for the benefit of the users and the designers. These preexisting rules can be seen as a common language

that designers and building users share in the real world, and, as a result, naturally in a virtual world. Some of the rules include the shape of windows and walls expressing weight and direction to the user. A long low wall can encourage the user to walk along it; a concave wall can beckon the user to approach it. Pagán purports that the increasing power of computers results in the play's expectation of increasing believability and ability to engage with the level. He says that to achieve this believability and engagement, level design should address the game's needs and apply commonly accepted and basic design principles as necessary. These factors of good design should include making conscious choices with balance, scale, proportion, unity, emphasis, rhythm, harmony, color, pattern, texture, and style. He claims that if the designer uses these tools properly, the player will feel more comfortable. Earlier in this paper, the advantage of the participant's comfort was linked to increased potential for learning. Using basic architecture principles can help the participant decipher the purpose of the level, while still allowing him to explore and navigate through the virtual world. Using basic design principles can help increase the participant's comfort level in the virtual environment.

2.3.5 The virtual environment in *Eegan's Aquarium Challenge*

Eegan's Aquarium Challenge has an environment that is static during the role-plays and allows limited navigation at the end of the role-plays. The environment is designed to make the participants feel like the screen is the fourth wall to the room in which they are viewing this environment. The feeling is achieved partially through the display: a life-sized room projected on a flat screen. Much like the technique of a CAVE™, a wall and its reality are effectively replaced with a screen and its projected

virtual reality. This projection creates a point of interface for the real world and the world in which Eegan lives.

The participant is to feel that they are standing at the back of this room looking forward. To achieve this, the room presented to the viewer does not move, until the end where the participant is asked, “Would you like to come closer to see the fish?” The child’s answer of “yes” makes the environment move forward to the participant computationally; the goal is to create the sense that the child is moving through the environment toward the fish. An answer of “no” results in no movement. Much like in reality, the room around us does not move until we make an intentional decision to move ourselves through it.

The fish tank is recessed into the wall and appears through a diagonally cut opening. Pagán suggests that the diagonally cut opening is “less accessible and protected within the wall itself” (2001) as opposed to a right-angle-cut. This seems an appropriate choice for a habitat for small living creatures on display that are meant to be protected and observed, but not touched. This fish tank also serves as a point of emphasis to attract the participant’s attention. It is central to the projection of the environment and lit to draw attention to itself. This visual choice is meant to attract the participant’s visual attention and convey to him that the fish tank is special, alluring, and a goal. This visual communication reinforces Eegan’s instructions and narrative. The participant views the fish tank as the goal, so when he is asked if he would like to move closer, he knows what he is moving closer to see. The emphasis and diagonal-cut draw and focus attention in a way that intentionally creates interest around this point and not others on the screen. The desired result is that when the participant can move forward, he will not want to navigate

around the other walls and informational displays; he will want to see the goal. The environment design contributes to the participant's understanding of the purpose of navigation in this environment.

2.4 Specific Background on conflict resolution

To explore the research question proposed by this paper, it was necessary to choose a subject matter and age group that benefits from role-play in the lesson.

2.4.1 Why choosing this scenario

While several children's social skills and safety lessons were considered, an early childhood education conflict resolution lesson was chosen because the learner is commonly accepted to benefit from role-play in this lesson and this lesson is a part of many schools' curricula. Several articles containing the benefits and methods of teaching conflict resolution to young children have been reviewed to inform the design process of *Eegan's Aquarium Challenge*.

2.4.2 Brief background of teaching and learning Conflict Resolution in Early Childhood Education

Although, varying opinions exist on whether children should be raised to handle conflicts with diplomacy or with force, in this paper, diplomacy and peaceful conflict resolution will be considered as a desirable result. Anita Vestal and Nancy Aaron Jones write that when a child grows up exposed to violence and aggression in the form of media, familial relationships, or other forms, the child begins to model this behavior (2004). The exposure to violent and aggressive environments promotes dysfunctional social skills in children (Vestal & Jones, 2004). A teacher wishing to counter-act the

effects of the violent environment needs to provide an alterative to this violent immersion. “To break the cycle of violence, new ways of handling anger and resolving conflict must be introduced to young children” (ibid.). Parents, relatives, child advocates, and teachers can accomplish this. By placing the children in a peaceful environment, one can replace the immersion in violence. Once in this peaceful environment, the teacher can promote peaceful ways of dealing with conflict. The consequence of not teaching children how to resolve conflicts peacefully can result in the children’s inability to peacefully engage in learning and play (Lamm et al., 2006). Young children have been shown to have the ability to learn and use peaceful conflict resolution skills when taught by a teacher that has undergone the proper training and uses the proper methods (Vestal & Jones, 2004). If the success of teaching conflict resolution relies on the expertise of the early childhood educator, a designer of a teaching tool for conflict resolution role-play should rely the expertise of an educator for the success of a role-play in her creation.

2.4.3. Teaching style

The most successful teaching styles for conflict resolution focus on empowering the children to resolve conflicts peacefully by giving the children the necessary knowledge and tools, and allowing them to practice. In the teaching publication, *Young Children*, Sandra Lamm writes with other authors about teaching conflict resolution to preschoolers in a peaceful environment. She notes that successful conflict resolution programs place emphasis on “guidance rather than intervention” (Lamm et al., 2006). During a role-play, should a teacher see a problem, instead of stopping and correcting, the teacher should artfully guide the role-play back to a constructive outcome. This project needed to allow an avenue for guidance, rather than a dead end, should the role-

play begin migrating towards a non-constructive solution. This guidance, rather than intervention, will empower the children to practice conflict resolution skills in their own lives (Church, 2001). Although this guidance generally comes from an adult teacher, Dr. Deborah DeBates and Julie Bell suggest peer education in some cases (2006). They argue that people often identify more with others who have similar characteristics as themselves (DeBates & Bell, 2006). They also support this suggestion by saying that, in some cases, peer education is less threatening than adult-led education (ibid.). By uniting these guidance and peer education ideas, a designer could create a tool that benefits from both empowering the child and providing him with a knowledgeable other with which he can more easily identify and feel comfortable.

2.4.4 Specific Curricula and Methodology for Teaching Conflict Resolution

While approaches to teaching children peaceful conflict resolution vary slightly, most lists of steps and methodologies contain significant overlap. Sue Jeweler and Linda Barnes-Robinson report the tools for conflict resolution as including brainstorming, questions, active listening, conceptual thinking, role-playing, triggering, and problem solving (1999). Lamm and her co-writers expand on this set off necessary skills by recommending that children need to be able to recognize and name their feelings, as well as know appropriate ways to express them (2006). To utilize this toolbox in a conflict resolution, Ellen Booth Church, from *Early Childhood Today*, suggests a three-step solution: encourage the child to use his words, imagine solutions, and act them out (2001). Lamm and her co-writers' process is similar: help the child state the problem, brainstorm ideas, discuss how these ideas might work, have the child agree on one possible solution, try it out in a role-play, then review to see how the process worked

(2006). Common components of conflict resolution education include talking out the problem, trying it out with role-play, and reviewing success and learning from failure.

2.4.5 Environment

As discussed earlier, role-playing in a safe and peaceful environment is an important part of the success of this learning process. Lamm and her co-writer suggest applying these steps in a peaceful classroom environment that, in turn, promotes peaceful conflict resolution (2006). Components of this environment can include relaxing music, puppets for role-playing, but most importantly, peace: the lack of aggression and violence. The peace in this environment is suggested to be maintained by interactions between teachers and parents both at school and at home (Lamm et al., 2006). As immersion in a violent environment promotes and models violent behavior, immersion in a peaceful environment promotes peaceful conflict resolution and behavior.

2.4.6 How can these suggestions inform the design of *Eegan's Aquarium Challenge*?

The teacher using *Eegan's Aquarium Challenge* to open a channel of communication with a child during a role-play should be educated and practiced in teaching peaceful conflict resolution to children. This teacher should guide the role-play to empower the child in learning, rather than stopping the role-play to intervene. Therefore, the tools provided to the educator should facilitate this guidance. DeBates and Bell's findings concerning peer education indicate that providing the child with a child-like coach may be conducive to non-threatening communication and the child's ability to identify with the coach (2006). Lamm and her co-authors' suggestions about peaceful environments indicate that the more peaceful the environment of *Eegan's Aquarium Challenge*, the more conducive it will be to a peaceful conflict resolution.

CHAPTER 3:

CURRENT DIGITAL ROLE-PLAY APPLICATIONS

To inform the visual project design process, a survey of contemporary applications of role-play on a digital platform was performed. This survey covers a broad spectrum of applications from conventional software to large-scale interactive virtual environments. The groups creating the application range from non-profit organizations to researchers and profitable entertainment companies. Each application was chosen for discussion because it contains components that can inform the design process of *Eegan's Aquarium Challenge*. These components will be elaborated and their implications for the visual project will be discussed.

3.1 *Ditto's Keep Safe Adventure*: Conventional Software with Human role-play

Ditto's Keep Safe Adventure appeared in a compilation of games presented at the Serious Games Conference in 2004. The CD-ROM was purchased and played and the parents' companion guide was read to evaluate how *Ditto's Keep Safe Adventure* (2003) could inform the design process of *Eegan's Aquarium Challenge.* Bravehearts Inc., a non-profit organization whose goal is to end child abuse through education, developed *Ditto's Keep Safe Adventure* to focus on child assault prevention through a series of lessons and games. While *Ditto's Keep Safe Adventure* has not yet been formally evaluated for

effectiveness in education at the time of this writing, it may be in the future. The character design of the coach of *Ditto's Keep Safe Adventure* and the human-to-human involvement in this project are of particular interest to informing the design process of *Eegan's Aquarium Challenge*.

In the software component of *Ditto's Keep Safe Adventure*, Ditto teaches children lessons aimed at empowering children to protect themselves from abuse. Ditto acts as a coach, giving instruction and automated feedback throughout the lessons and the comprehension checks at the end of the lessons. The character design of Ditto can inform the process of creating a non-threatening character with which children can identify. While a gender of the character is not easily, or perhaps possibly, discernable, in the interest of readability, Ditto shall be referred to as a "he" in this paper.

Ditto is a lion cub: a furry mammal. Carter and Mason suggest that when presenting a puppet to a child for therapy, that puppet be furry and look as though it would be nice to touch or hug (1998). It stands to reason that the guidelines for choosing puppets for children's therapy would carry over to digital puppetry, avatars, and digital coaches for children's instruction. Ditto is drawn as a furry character, adhering to Carter and Mason's suggestion. Lions are traditionally associated with bravery. When using puppets with children for therapy purposes, Carter and Mason recommend providing children with symbolic puppets: lions for bravery, sheep for timidity, and so forth (1998). By choosing to make Ditto a lion, Bravehearts utilizes the symbolic properties of the lion to inform the audience of the character's personality. This analogy is further continued with the visual design of Ditto's tail. Instead of a usual lion tail, Ditto has a purple heart

at the end of his tail. The choice of the symbolic animal character and the visual design of the tail leads the audience to the conclusion that he has a brave heart.

As a brave character, he acts a model for the lessons taught. This constructivist approach to teaching, discussed earlier, utilizes a knowledgeable other going through situations and scenarios to model the behavior for the learner. He shows the learner what he would do when confronted with certain situations. In the Bravehearts Help Plan section, Ditto explains the process of creating a helper plan, demonstrates his process, and instructs the child to do the same. In examples such as these, he acts out a behavior so that a child can learn to do the same thing from his example. His age is never disclosed, but from his physical form as a cub rather than a grown lion, the audience can assume that he is young in his species. Catherine Garvey sites a study resulting in the conclusion "adult-directed games are less favored that those learned directly from children" (1990, p. 104). It may make the child feel more comfortable when another child is in control of the lesson. Adults are often in a position of regulation, control, and authority in the life of a child (MacNaughton, 2000). This may contribute to the child's preference and comfort with games and interactions lead by children. As discussed earlier, when the child is more comfortable, they are likely to learn better. The age of the knowledgeable other matching the age of the child may also make this character easier for children to identify with. Ditto's age and modeling behavior makes him a preferable model from which a child can learn.

Ditto's positive feedback after comprehension checks may also make the child more comfortable and aid in their learning of the subject matter. Ditto's character design

is non-threatening, follows puppetry guidelines for work with children, and makes it possible for children to identify with him and learn from his modeled behavior.

The design process of Eegan from *Eegan's Aquarium Challenge* can be informed by the design of Ditto from *Ditto's Keep Safe Adventure.* Like Ditto, Eegan will be fury and aim to look like he would be nice to touch. Like, Ditto, Eegan will also be a juvenile of his species to help children identify with Eegan. Also, like Ditto, Eegan will not have an easily discernable gender in hopes that children of all genders will be able to easily identify with Eegan. However, for readability, Eegan will also be referred to as a "he" in this paper.

The human-to-human interaction component of *Ditto's Keep Safe Adventure* is of interest to this thesis in that the software component's success is dependent on human-to-human interaction. Upon opening the case for *Ditto's Keep Safe Adventure*, one finds a CD-ROM on the right and a printed parents' guide on the left. The printed guides starts of by advising the parents:

> "It is important that you join your child on '*Ditto's Keep Safe Adventure*.' It is designed for you and your child to play and will not achieve the desired results without your involvement." (Ditto's Keep Safe Adventure, 2003, p. 1)

This section highlights the importance of human involvement in successful learning from electronic components. The word "involvement" in the disclaimer means interaction, not just attention; the parents or guardians must interact, talk, discuss, and answer questions. At other points in the booklet, Bravehearts recommends role-play to reinforce the lessons taught by the electronic media. "It is a good idea to practice empowering you child with 'what if' scenarios/games" (Ditto's Keep Safe Adventure, 2003, p. 1). While this

instruction does not use the phrases, “role-playing,” it is describing a role-play with the words “empower,” “practice,” and “what if scenarios.” A “what if” scenario is the platform for a role-play: if you were in a given situation, and you had to follow certain social or safety rules, how would resolve this challenge? By practicing “what if” and scenarios, the parents will be teaching their child through role-play. Following these suggestions counts as involvement. The booklet conveys that teaching a child lesson about social skills is not enough; the child must have the opportunity to role-play and use the information from these lessons to construct knowledge from them. This also conveys that the CD-ROM is not enough; these lessons of social skills and safety cannot be learnt without the advantages of a human role-play partner. In this case, the human role-play partner would have a pre-existing relationship with the child. This could also be helpful in placing them in the right zone of proximal development, as discussed earlier. The booklet continually highlights the importance and advantages of the integration of a live human to reinforce the lessons of the digital medium.

A researcher can learn from this example by ensuring that any created digital learning devices integrate the advantages of having a live knowledgeable other present. *Eegan’s Aquarium Challenge* borrows from this by allowing the teacher, parent, or other adult to be visible and present during the role-play. At any point in the role-play, the child may interact with the adult. *Eegan’s Aquarium Challenge* also allows the adult to tailor the role-play to the needs of a particular learner through providing the knowledgeable other with the ability to control the digital role-playing partner.

3.2 *Turtle Talk with Crush*: Performance animation in a virtual environment

An exhibit in Disney's California Adventure Park, named *Turtle Talk with Crush,* is an example of performance animation and role-playing for entertainment. This attraction is also an example of digital puppetry for profit where children and their parents are seated in an auditorium and interact, as a group, with the character named Crush from Pixar Animation Studio's film *Finding Nemo*. The virtual environment, output method, and interaction between the audience and a digital character are of particular interest to informing the design process of *Eegan's Aquarium Challenge*.

The virtual environment in which this interaction takes place is a point of interest in the development of a virtual environment for *Eegan's Aquarium Challenge*. The environment is designed to match the seascapes in *Finding Nemo,* where most viewers are first introduced to the character Crush. The virtual environment is aesthetically pleasing in part because of the "harmony" of the scene. Pagàn refers to harmony as a common element that brings together the parts of a scene through similar colors, patters, or other details (Pagàn, 2001). The colors in the environment are all closely related and contribute to the aesthetic success of the piece. The environment creates interest by remaining active during the piece. The seaweed in the background undulates slightly, as though it were moving in water during the performance. Schools of fish swim across the background, contributing to the feeling of the audience observing an undersea scene. The sound design of the scene is addressed by occasional, yet unobtrusive, ambient sounds associated with being under the sea. This attention to visual and audio cues helps contribute to informing the audience of the location of the scene and the mood.

The output of this piece is also a point of interest in the development of a virtual environment for *Eegan's Aquarium Challenge*. This underwater scene is presented to the seated audience through a large-scale rectilinear projection. This shape creates the sense that the underwater world and human world are interfacing in a commonly experienced and accepted way: through a wall of glass. Humans often encounter sea creatures and large-scale seascapes at aquariums though a rectangular wall of glass. The large-scale projection of the tank consumes an entire wall from floor to ceiling. This projection allows Crush to appear as large as he would in the physical world, and for the audience to observe him in the scale of reality. In previous encounters with Crush, humans have seen him three times larger than themselves in theaters, and five times smaller than themselves on personal video players, like iPods. This projected encounter is reflective of the actual size of sea turtles and may help the audience feel more immersed in the environment because the tank is projected in the scale of reality.

The comfortable interaction between the digital puppet and the audience is also a point of interest for *Eegan's Aquarium Challenge*. This work qualifies as role-play because, presumably, a live performer acts the part of the main character, Crush. While no existing writings outline the way that Crush is controlled, he reacts to different audience questions and situations as only a human can. No existing artificial intelligence could adapt to the human interaction with the audience the way that Crush does. Upon multiple viewings of different shows, one can conclude that the audience members enjoy and feel comfortable to contribute to this interaction. The audience members ask questions and answer questions as though they are engaging in natural, and sometimes exciting, conversation. While the character sometimes engages with adults, he focuses

most of the interactive portion of the show conversing with children. The children seem comfortable asking the character questions about the movie in which he previously appeared and about living in the ocean. The children also seem happy to answer his questions about being human. The observed comfort level of the children in their interaction with this digital puppet suggests that this could be a good way to communicate with children in order to keep them comfortable and engaged in a conversation. While the performance does not address material that demands a non-threatening coach specifically, the success of the project suggests that this use of digital puppetry could be especially helpful in conversing comfortably with children about sensitive subjects.

A designer can learn from this example by paying attention to aesthetics and environmental components when designing a virtual environment. *Eegan's Aquarium Challenge* borrows from this by trying to keep the environment harmonious by using a closely related color palette in the environment. The environment also includes visual cues, such as automated seaweed and fish, and static display areas, and audio cues, such as crowd noises and bubbling. A designer can also learn from the display. *Eegan's Aquarium Challenge* borrows from this display by presenting the participant with a large-scale rectilinear projection that is meant to convey that the participant is at the back of a room. The comfortable interaction is also a point of interest for a designer. *Eegan's Aquarium Challenge* will benefit from the example of a live performer controlling a digital puppet. In this case, the live performer will be a teacher with a pre-existing relationship with the child participant. *Eegan's Aquarium Challenge* will aspire to reach the comfortable interaction the children enjoyed with Crush.

3.3 Simulating Graded Levels of Difficulty and Immersion for Therapy

Collaborating researchers from University College Cork and St. Stephen's Hospital in Cork, Ireland conducted a study investigating the effectiveness of computer-generated environments in exposure therapy to treat driving phobia as the result of a motor vehicle accident. This study in virtual reality exposure therapy shows the advantages of repeatedly role-playing a situation of graded levels of difficulty in a memorable immersive environment. In this study, selected participants experienced computer generated driving simulations of increasing difficulty in the first person during twelve one-hour sessions. The resulting success of the increasing level of difficulty of the scenarios and of the memorable immersion in this project are of particular interest to informing the design process of *Eegan's Aquarium Challenge*.

The researchers of this study hypothesized that virtual reality and gaming reality could be effective in inducing a sense of immersion in participants (Walshe, Lewis, Sun, O'Sullivan, & Wiederhold, 2003). They predicted that twelve sessions of immersion would result in a decrease of driving anxiety in the real world for their patients (ibid.). In this study, the researchers measured "immersion" through an anxiety response resulting in an increased heart rate (ibid.). They found that not all the people screened for the study, however, could experience their definition of "immersion." They explain this by postulating that virtual reality "requires a willingness to enter into an alternate reality with a 'suspension of disbelief'" (ibid.). For those that could allow themselves to enter this alternate reality, they found that some patients developed a strong enough sense of immersion that they went into a panic when confronted with simulated operation of a motor vehicle (ibid.). These findings can lead one to the conclusion that while the

population for whom virtual reality can be accepted may be limited, their experience in this virtual reality can be limitless.

Because the purpose of this therapy was to decrease driving anxiety, a memorable environment and a sense of immersion in that environment was essential. However, because the danger of driving is very real, these simulations needed to take place in a safe, simulated environment. After establishing a physiological measurement of immersion, the group worked to create a memorable immersive experience for the selected participants. A heart rate monitor was used to record the participant's heart rate to measure the success of the immersive experience. The simulation took place in a darkened room (Walshe et al., 2003). This step decreases the subject's natural immersion in physical reality. The darkness dampens attention to the trashcan in the corner, the posters on the wall, and the physical presence of existing in immobile environment. The subject's visual reality was then replaced with a monitor or head mounted display, depending on the subject. Audio from the environment was played on stereo speakers and a subwoofer. Each subject was seated in a physical car seat with a steering wheel and accelerator petal, to address the subject's tactile sensory perception (ibid.). For some subjects force feedback was available during the simulation (ibid.). By addressing multiple sensory inputs, the researchers constructed a memorable experience and sense of immersion. By learning positive adaptive strategies during repeated exposure to challenging immersive environments, the subjects showed reduction in avoiding travel and travel distress (ibid). The experience and memories of coping effectively while in this simulated environment lead to the success of coping effectively while in similar environments in reality.

While within this immersive environment, the subjects role-played scenarios of increasing difficulty. By allowing a student to start with simple tasks and work up to more difficult tasks, the scenarios can place the student in their zone of proximal development, or the level of challenge most conducive to learning (Wood & Attfield, 2005). Once a task is complete and knowledge gained, a slightly more difficult task can challenge a student to grow, but not frustrate them into inaction, or in this case maladaptive panic. The scenarios presented to the participants included urban and rural environments of varying traffic density, weather, and lighting conditions (Walshe et al., 2003). The subjects first were placed in simulations were they drove on empty rural roads, and then eventually increased traffic density and speeds (ibid.). Once a participant was comfortable and coped appropriately in a given environment, they were given tasks of increasing difficulty, such as overtaking other cars, dealing with skids, and eventually entering accident situations (ibid.). The patients could see their own heart rate and were coached in breathing techniques to control their breathing and cope effectively under duress (ibid.). The study repeatedly exposed the patients to scenarios of graded difficulty. As discussed earlier, repetition and trying out new behaviors is an important component of learning. By allowing the subjects to learn effective coping behaviors in low-stress situations and allowing them to gradually experience increasingly stressful situations, the researchers created the supportive, yet challenging structure, in which the subjects' learning could take place. In this study, the knowledge the subjects constructed in the simulations translated into real-world driving skills. In addition to improved driving and coping skills, the researchers found a significant decrease in the subject's driving anxiety, posttraumatic stress disorder ratings, heart rate increases, and depression. Through

exposure to a memorable immersive environment and tasks of graded difficulty, the researchers created an opportunity for significant therapeutic improvement. Through perseverance and repetition, the subjects of this study were able to improve their real world experiences.

A researcher can learn from the example of the creation of tasks of graded difficulty while within a truly immersive environment. By addressing audio, visual, and tactile components, these researchers were able to create a convincing immersive driving experience within the safety of an immobile room. *Eegan's Aquarium Challenge* borrows from this by placing the role-play in a darkened room and presenting visual and audio cues as a substitute for the participants' reality. *Eegan's Aquarium Challenge* also presents three levels of difficulty for the participant in the form of three role-play partners. Each will present a different challenge and are meant to be provided to the child in order from most easily resolved to most difficult to resolve. The teacher, however, will use her relationship with the student to select the correct role-play partner that places the child in his zone of proximal development.

CHAPTER 4

PROJECT DOCUMENTATION

4.1 Project Overview and Goals

The proposed project attempts to satisfy the need for live human interaction between teacher and child, while utilizing the benefits of digital puppetry and virtual reality to facilitate a role-play that teaches peaceful conflict resolution to children. This project, named *Eegan's Aquarium Challenge*, provides a peaceful and safe environment in which a child role-plays an assertiveness scenario under the guidance and expertise of a live early childhood educator. This environment is projected on a wall or screen to exceed the height of the child with stereo speakers for the digital puppet's voices. The objective for the child participant is to wait in line to view a fish tank. The child has his teacher by his side for guidance, and a digital character acting as a coach on the screen. Different characters cut into the line in front of the child. The child is then challenged to use words, body language, and help from his teacher to make the characters go to the back of the line. The reward for successfully asking the three characters to move out of the way is to be invited to come forward and see the fish up close.

4.2 Evolution of pre-rendered animation approaches to real-time animation

Originally, this project was proposed as a rendered animation that would allow a child to choose between several proposed courses of action with a mouse or keyboard, and then play an ending to the animation that might be the result of this choice. This idea would have allowed the child to see the selected behavior modeled and allow the scenario to take place in a safe environment, as it would all happen on a screen. However, because it would be pre-rendered and automated, this idea would limit interaction in the role-play. This idea evolved after reading several theorists' ideas about learning from role-play. Vygotsky places emphasis on playing, or trying out the idea to construct knowledge (Wood & Attfield, 2005). This research indicated that a better choice would be to allow the child to role-play during the entirety of the experience, as opposed to during limited portions. Additionally, time spent researching at The Ohio State University's daycare center for Education Teaching and Learning 848, taught by Dr. Laurie Katz, indicated that preschool children often ask unexpected questions and think of unexpected answers to adults' questions. This observation supported the idea that a solely computer-driven, or automated, role-play would likely not be able to accommodate the interaction of the target audience to the extent that would benefit the construction of knowledge. A machine alone cannot guide a child through a role-play with the expertise of an experienced educator.

4.3 Character Design

Four characters were created for *Eegan's Aquarium Challenge*: one coach and three role-play partners. The three role-play partners were created to serve as three

different situations of graded difficulty from which the child could learn. The benefits of graded difficulty demonstrated in the virtual driving therapy (Walshe et al., 2003) informed the process of incorporating graded levels of difficulty in *Eegan's Aquarium Challenge*. The three levels of difficulty, were, in this case, presented as scenarios with characters of differing personalities. The personalities, in order of increasing difficulty were non-confrontational, passive aggressive, and aggressive.

4.3.1 Personality profiles of the role-playing partners

The least challenging personality to role-play against is the non-confrontational role-playing partner Montag. She is meant to be the feline equivalent of a human 4-year-old. She has a name that contains soft sounds, to communicate her soft personae. She is not exceptionally verbose, and cannot say complex things. She is kind and does not wish to offend anyone.

The intermediately challenging personality to role-play against is the passive-aggressive role-playing partner Berrette. Berrette's name sounds a bit more nasal than Montag's as well as requiring a hard "t". This helps the name sound a bit more sassy and conceited. She is meant to be the feline equivalent of a 5-year old. Berrette does not mean the child harm, but does not feel the need to wait her turn. She has successfully been passive aggressive in the past, and plans to use this technique again with the child to avoid waiting in line. She has trouble seeing conflicts from the point of view of another.

The most challenging personality to role-play against is the aggressive role-playing partner Garth. His name has a hard "are" sound, so that it's easy to snarl. He is the feline equivalent of a 7-year-old human and does not easily see situations from others' point of view. He is a verbally aggressive foe and minimizes, or puts down, his

child role-playing partner when the child tries to resolve the conflict. He does not respect other children, only authority figures. He is larger than the other foes and proportioned more similarly to a teenager.

4.3.2 Eegan's role and design

Eegan was created to introduce and guide the child through *Eegan's Aquarium Challenge*, facilitate the communication between the educator and student, and contribute to the child's sense of immersion. Eegan is the first part of *Eegan's Aquarium Challenge* that the child experiences. This interaction is pivotal in the child's acceptance of *Eegan's Aquarium Challenge*. Eegan stands waiting for the child to enter and begins to build a relationship with the child by asking the child's name, sharing his own name, and talking to him about aquariums and lines. Eegan is kind and friendly with the child. After developing a relationship with the child, Eegan gives preliminary directions and goals to the participant. Why are we here? What is the task? How can we accomplish this? Eegan sets the stage for the role-play interactions that are about to take place, and establishes himself as a friendly resource during the role-plays.

During the role-play Eegan serves as a coach to help guide the child towards a constructive resolution to the conflict. He provides positive and encouraging feedback to the child. During the role-play, Eegan serves as a digital voice of the teacher. The teacher can prompt Eegan to encourage the child, listen to the teacher, or keep trying. This facilitates the teacher's ability to guide the role-play, instead of stopping and intervening.

The child's interaction with Eegan also contributes to the immersive environment of *Eegan's Aquarium Challenge*. The child interacts naturally with Eegan: he can use his words and body to participate instead of a controller or other symbolic input device.

Eegan provides the option of moving forward in the space once the role-play is complete. By asking the child if he would like to come forward and then allowing the child to come forward and see the fish, Eegan effectively *is* the perceived interface for the child's navigation through this world. The natural interaction the child has with Eegan helps the environment feel more like reality, but the friendly coach helps remind the child that the environment is imaginary and that the child is safe. The safety and comfort experienced with Eegan helps the role-play provide an effective and constructive learning experience.

Eegan was designed to appeal to the child and been seen by the child as an ally. He speaks in a chipper tone to encourage and guide the child. His proportions are designed to be a feline equivalent of a six-year-old child: the average age of the intended participants. His name was chosen to sound like a name the children had heard before: Ethan. This name was then caricatured to remind the participants that while he is a peer, he is still a safe cartoon. His positive reinforcement and friendly attitude exist to help the child feel comfortable during *Eegan's Aquarium Challenge*.

4.3.3 Visual Design

To address acceptance by the target audience of four to seven year olds, the characters were to be young, furry, and animated. Drawing from DeBates and Bell's theory that peer to peer education can make a child more comfortable (2006), the characters were designed to be the ages and sizes of children participating in the lesson. Carter and Mason's suggestion to use furry puppets (1998) informed the decision to make the characters look furry. A content analysis of current children's programming on PBS reveals that a disproportionate number of children's shows use animated cartoon characters rather than humans controlling puppets. The media's migration toward digital

characters may decrease children's acceptance of traditional puppetry and increase acceptance of digital animated characters. This observation supported the decision to make the characters three-dimensional animated characters. Also contributing to the decision to make the characters three-dimensional was the desire to create a certain level of visual realism to enhance the sense of immersion in the virtual environment.

The characters in this project are four anthropomorphic kittens. The domestic house cat was chosen because cats are quite often familiar to children as approachable house pets. The decision to make the characters young cats, or kittens, was made to help the children participants feel comfortable in the role-play, informed by DeBates and Bell's theories about peer-to-peer education (2006). They are anthropomorphized in hopes of promoting child acceptance of the characters. They stand upright, move like children, talk like children, and act like children. While the characters are furry, they act and look quite like the children's peers to make them familiar to the children. This blend of furry animals and human behavior, and similarity to peers is an attempt to synthesize the components that Carter with Mason and DeBates with Bell recommend for child acceptance.

During the project, the characters have evolved from their initial sketches. The most accurate representations of their final appearance are in the surfacing section. Eegan was drawn to have the proportions of a six-year-old child. The character was meant to look appealing and non-threatening (see Figure 1). Montag was drawn to have the proportions of a four-year-old child. Her visual design includes large eyes and ears with the intention of making her appear small, approachable, and cute (see Figure 2). Berrette was drawn to have the proportions of a five-year-old child. She has a slightly more pointy

snout to make her appear less approachable (see Figure 3). Garth was drawn to have the features of a seven-year-old child. His fur is very plain compared to his peers. He has the most pointed snout, the smallest eyes, and the sharpest ears to make him look the least approachable. He is also rather tall compared to the other characters to help him appear more intimidating (see Figure 4).

4.3.4 Modeling

With the goal of eventually placing these characters in a virtual three-dimensional environment, the topology is minimal so as not to overload the real-time rendering system with too many polygons (see Figure 5). The characters are modeled to mimic the human proportions of their human ages: the youngest has a larger head and is shorter; the oldest is proportioned more like a teenager and is taller.

4.3.5 Surfacing

Originally the colors were chosen that would exist on cats in nature. This coincidentally resulted in some of the kittens having flesh tone colors for their fur. Flesh tones were then consciously avoided in order to avoid unintentionally inferring that any of the attitudes of the cats are reflective of human racial groups. This change invited the use of vibrant and diverse colors, which may help the children differentiate the characters (see Figure 6).

The characters are each surfaced with real-rime fur of different colors. Montag is baby blue, Berrette is light fuscia, Garth is orange, and Eegan is mint green. Montag has a white belly, paws, and ears. Berrette has a tiny white patch. Garth has no variation. The choice to make Garth's fur without variation was made to contribute to his back-story of jealously over cats with fur variation. Eegan has a white heart on his chest partly as

homage to the Braveheart's character Ditto, who has a heart at the end of his tail, and partly to communicate the child that he is a loving and friendly character.

4.3.6 Rigging

The control skeletons of each character are the same. The joints all use forward kinematics, with the exception of the tail. Graduate student, George Gantzer, created a tail rig that would allow the animator to choose end position of the tail and interpolate the other joints in the tail accordingly. The skin geometry is bound to the skeleton using a smooth bind and with a small amount of adjustment to the deformation weighting. The skin deformations were not belabored because the skin was to be covered in fur, which visually obscures the skin deformations.

4.3.7 Acting

Initially, the design for the educator interface involved the educator having complete control over Eegan by having her physically perform his animations and voice. This was to be accomplished by using full-body motion capture as an input for Eegan's digital puppet: the teacher's motions would be directly reflected onto Eegan in real-time. She would interact with the student in real-time in the form of Eegan. This process to allow the educator complete control of Eegan through full-body real-time motion capture proved too technically challenging to resolve in the scope and timeline of this project. A compromise needed to be made to maintain the technical accessibility of Eegan's Aquarium Challenge for the educator, while still providing her enough control of the characters to create a constructive interaction between the characters and the child.

The resulting solution was to provide the educator with several pre-programmed animations that could be chosen in real-time. This created the need to author pre-

programmed animations that could be started and stopped in accordance with the interaction between the characters and child. Although the teacher would not be physically acting the part of Eegan, the result would still be a form of performance animation because the teacher would remain the digital puppeteer. She would choose when the digital characters would execute their pre-programmed animation and trigger this command at the appropriate time during the interaction between the child and character. This particular form of performance animation was seen as acceptable for this application because it would continue to provide the benefits of real-time interaction between the digital characters and child through puppeteering by the teacher.

The power of performance animation was also put to use in the creation of the preprogrammed animations. Because the characters are anthropomorphized, full-body motion capture leant itself well as a means of generating the base animations for the characters. An actress would perform the motions of each character, and her performance was recorded and mapped onto the characters. Drawing on expertise from a background in dance and acting, the actress would assume the identity of the appropriate character and transform her physical motion into the way the character would move. A set of cameras would track points on her body and interpret the recorded data into a set of control points to animate the characters. Her captured performance becomes part of the characters' animation.

Each character's actions are slightly caricatured, or exaggerated with the purpose of expressing that character's personality. Montag was performed so as to appear very young: her knees were locked as she moved and she was not yet graceful. The way Montag moves her body is meant to convey a kitten that is not yet sure of how to

gracefully move her body, nor is grace a concern. Her motion is a very emotionally transparent performance: she does not at all conceal the way she feels. Berrette was performed so as to convey that she is conceited and sneaky. She slinks into the scene and swishes her hips while watching the fish. The manner or her motions are meant to convey that she is snooty and annoyed when the child begins to confront her. Garth was performed so as to convey his obnoxious and aggressive nature. He deliberately jumps in front of the child participant. He then wags his rear when the child confronts him. When he leaves, he waves the participant away in a dismissive manner. Eegan's animations were performed so as to seem encouraging and positive. Eegan has a very strong and self-assured posture. The motions for Eegan were acted to reflect Eegan's joy in helping the child participant's succeed and grow.

The resulting captured performances were mapped onto the digital characters to produce a basic set of animations for the characters. Some of these animations were then augmented to further the feeling of caricature. These animations were then applied as preprogrammed animations to the characters, but more work lay ahead to purpose preprogrammed animation into a non-linear animation.

4.3.8 Blending of animations

The characters in *Eegan's Aquarium Challenge* were animated with a mix of pre-programmed and real-time animations. The characters would sometimes need to move from one animation to the next immediately, and at other times would wait for their next set of instructions after completing an animation. Character movement continuity was very important to maintain for the sake of perpetuating the sense of immersion. A character suddenly popping from one pose to another with no motion in between would

be jarring and likely to shock the audience out of the experience. The continuity of motion maintained in *Crush's Turtle Talk Adventure* informed the desired continuity of the animation in *Eegan's Aquarium Challenge*.

At certain points during Eegan's introduction and during the role-play, the educator could provide input that selected certain animations. The animations for each character were constructed with the non-linear nature of this experience in mind. At the beginning and end of each pre-programmed animation, the character assumed roughly the same pose. This pose was chosen to reflect the character's personality. Garth's pose has his elbows bent and paws slightly above the waist, as though he could quickly assume a more aggressive stance. Berrette's pose has her paws on her hips as though she is impatient. Montag's pose has her arms out in wonderment. Eegan assumes a neutral pose with his arms slightly outward. If every animation were allowed to start and complete without interruption, these poses would satisfy the need for continuity of motion. However, some animations needed to be interrupted at unpredictable times. If the child had to wait for a response until the character had finished an animation, this may have detracted from the sense of immersion.

This created the need for natural-looking and short-notice blending between animations. Most of the programming of *Eegan's Aquarium Challenge* was constructed in VirTools, a virtual reality engine adept at rapidly prototyping games or simulations. Because many existing video games require an avatar to change motions immediately depending on input from a participant, VirTools has a built-in behavior created to do just this. The "unlimited controller" building block allows a designer to provide rules for blending each animation. For example, the animation where Garth cuts in front of the

child can only start at the beginning and cannot be interrupted; however, the animation where Garth shifts his weight from side to side while he waits for a selected animation can be interrupted at any point in time and can start from whatever pose is closest to the one he's in when the command is received for him to switch. Transition times between animations were also specified. These rules and transition times were decided upon after testing multiple possibilities, adjusting the rules, experiencing the results, and refining the parameters. This time-intensive process was given priority to avoid unnatural blending between motions, and consequently interrupting the sense of immersion experienced by the participant.

4.3.9 Programmed autonomy

There was time between the pre-preprogrammed, selected animations where the character would wait for it's next set of directions from the educator. Carter and Mason suggested that when using puppets to communicate with children, puppets should always look alive, even when not talking or directly being the center of attention (1998). This suggestion informed the scripting of autonomy, or "wait states," for the characters between selected animations. It was important that the wait states be "in character," or congruent with the other actions of the character, to avoid detracting from a sense of immersion. This meant that each character needed a unique and appropriate wait state, or set of autonomous behaviors. Between animations, Eegan shifts his weight from side to side and swishes his tail occasionally. After Montag has cut in front of the child participant, she bats at the glass, and looks around the tank in wonder until interrupted. Berrette shifts her weight from side to side in between animations, but in a manner sassier than Eegan. Garth shifts his weight, looks around, and swishes his tail aggressively. Care

was taken to randomize several possible waiting animations for each character to minimize repeating patterns.

In some cases, primary and secondary animations were layered to decrease the perception of repetition in the wait states. Eegan had primary animations for shifting his weight from side to side, but tail swishing and eye darting was controlled separately. While one time that he was on his left foot, his might swish his tail rapidly; the next time he might swish it more slowly. The increasing possibilities of combinations of motions resulted in an increasing diversity of waiting animations.

4.3.10 Eye control

In an attempt to simulate Eegan making eye contact with the child participant, the educator was given control of the height of Eegan's gaze. This control would set the position to which Eegan's eyes were constrained with some random movement applied. The resulting appearance is that Eegan's gaze is at eye-level of the participant, but his eyes appear as though they are moving slightly about the participant's face. This effect was desired, as it is more natural and comfortable than having a character directly stare at the participant.

4.3.11 Mouth animation

The role-playing partners had relatively little speech when facing the participant. Because the location of the viewer was static, this meant the mouths of the role-playing partners did not need to be animated in synchronization with the words. Because Eegan played the part of a narrator and coach, he had to look directly at the participant while he spoke. Eegan's large amount of spoken lines required much lip synchronization work. However, in an attempt to save time, the lips were animated independently of the body

and applied as a secondary animation. This meant that Eegan could have several key animations, such as leaning forward, holding up his hands, and nodding his head, that could be repeated as necessary as primary animations, and have line-specific mouth animation layered on top of his body motions. This was to result in saving time, as animating five key poses is less time-intensive than animating fifteen motions dependent on spoken lines.

However, an unexpected problem was encountered when animating in Maya and using VirTools to play the animations. The mouth was originally designed to move with Set Driven Keys: on a specified node, an animated variable would exist that would control the rotation of both the lower and upper lip joints. The resulting animation from a Set Driven Key in Maya, however, is not directly supported by VirTools, as no explicit keys are generated on the lip joints. The options to remedy the situation were to bake this set driven key animation onto the lip joints, which would result in explicit keyed animation, or to animate the mouth dynamically in VirTools based on volume input. The later was chosen because of its possibility of versatility.

Although the work to create the volume-driven lip joints would take a non-trivial amount of time, it would be more efficient than hand-animating Eegan's words, should his script change. Eegan's mouth was rigged in VirTools to analyze the volume of a specified audio clip and rotate the lip joints in response within a specified range. The programmed result is that any audio clip could be loaded into VirTools, and Eegan would be able to "speak" it without time-intensive lip synchronization animation. The visual result is that when Eegan speaks, his mouth opens and closes in time with the words.

4.4 Environment Design

The setting of the role-play is a public aquarium. This location was chosen because it is a public place where peaceful conflict resolution is sometimes necessary. A fish tank was chosen to exist at the child participant's eye-level so that a character could obstruct the child's view when cutting in a line. The public nature of the aquarium implies that public social skills are necessary, as opposed to the different set of social skills used with close friends and family. The location of the aquarium also implies that an adult may be present in the form of a docent, teacher, or guardian.

4.4.1 Visual Design

The design of the environment is meant to mimic an informational kiosk and display of two rare fish. Reference for this environment came from informational displays at the Columbus Zoo Reptile House. The displays give information about the animal; it's natural habitat, eating habits, and level of scarcity in nature. The informational displays created for this project are meant to contribute to the sense of being in a public aquarium, where public social norms apply, as opposed to a private home where conflict between siblings and close friends has more complex variables and may be addressed in different ways in different households. The visual design of the aquarium itself came from personal observation through owning aquariums. Seaweed, rocks, and a lamp were added to the environment for visual interest and to convey from a distance that the participant is viewing an aquarium. The fish were designed as a slight abstraction of a beta fish. They were chosen to be complimentary colors for visual interest. When a participant gets close to these fish, he can see color variation in the fins and body. Lighting references were gathered from pictures of aquariums (see Figure 7).

The most prominent theme in these reference photographs was the blue light emanating from the fish tank. This effect has been incorporated into the virtual environment. The blue light contributes to a sense of harmony by tightening the color palette. Lamm and her co-authors recommend that peaceful conflict resolution be taught in a peaceful environment (2006). The blue hues and chromatic harmony are meant to contribute to the peaceful feeling of the environment, in an effort to promote peaceful conflict resolution.

4.4.2 Modeling, Surfacing, and Lighting

The environment was modeled in as few polygons as possible to avoid taxing the real-time rendering. Flat planes with images attached were used wherever possible to limit geometry. These images have a transparency channel to convey contours of more complex shapes. The texture maps on the architectural geometry have lighting characteristics incorporated into them to avoid the expense of real-time lighting. Lights were created and positioned in Maya and rendered to a texture map. This map is then brought over to VirTools. The tank and fish use real-time lighting because the fish are animated and a static light effect on the surface would be confusing to the viewer (see Figures 8 and 9).

4.4.3 Animation of the environment

The seaweed, fish, and bubbles are the animated components of the environment. The seaweed was animated with a wave deformer cycling from 1 to -1 to visually achieve undulation as the result of moving water. This animation was then baked into the mesh and exported to VirTools where it is cycled continuously and without variation. The fish bodies were animated in the same fashion as the seaweed. Their position and direction, however, are scripted in VirTools. During the role-play, the fish follow a predefined

curve. When the child is rewarded and gets to see the fish up close, they seek random locations, move to reach these locations, and then turn to face forward. Once these actions have been achieved, and a new random position is defined as a goal, the fish continue this process. The fish, however, do not interact with each other in this automated process. The bubbles are particle systems that are emitted from a point at the bottom of the tank. Adjusting parameters in VirTools, such as gravity, lifetime, and rotation was necessary to achieve the effect of bubble jets.

4.4.4 Sound

To add to the sense of being in a public place, there are ambient crowd noises in the space recorded at the Columbus Zoo Discovery Reef. The lack of a visual presence of crowds calls for an auditory presence to convey that these scenarios are happening in a public place. Although most informational displays have auditory components, a conscious choice was made to leave this component absent as not to complete with the attention of the participant for the audio of the role-plays. When the child comes forward to see the fish, there is a soft bubbling sound in the background to accompany the visual bubble jets.

4.5 Interface design for the early childhood educator

Two interfaces needed to be created for *Eegan's Aquarium Challenge*: one for the child participant and one for the early childhood educator. An early childhood educator was chosen to guide the role-play because of Vestal and Jones's suggestions that successful conflict resolution teaching relies on the expertise of a properly trained educator (2004). This project endeavored to facilitate opening a channel of

communication between the educator and the child. Upon creating this facilitation, it was important not to add unnecessary complexity to the role of the educator. The creation of an interface for the early childhood educator endeavored to balance the educator's ability to control the role-play and tailor it to the child's needs with the simplicity of an input device. In order to achieve this, much work was done to present the educator with a simple input device that would control a complex system of selecting animations at the appropriate time. To maintain the simplicity of the experience for the early childhood educator, a choice was made to encapsulate the software driving this system by hiding the complex programming controlling *Eegan's Aquarium Challenge* and presenting a simplified selection of buttons to the educator. This interface will be discussed in terms of what was visible to the educator, and what computation was taking place as a result of the input.

4.5.1 Scenario Scripting

The first step in creating the software of *Eegan's Aquarium Challenge* was to storyboard an ideal progression of the role-play. Eegan's ideal script was to ask the children questions to build a relationship with them. Ideally, the child would answer him the first time with the requested information: name, familiarity with lines and aquariums, and preparedness to start the role-play. A different script was written out for the conflict with each role-play character. Because Montag inadvertently cuts in line, as soon as the child would say anything to catch her attention, Montag would apologize and move immediately. The ideal conflict with Berrette and Garth required the child to ask several times for the character to move, and the characters eventually doing so after the child used his voice and help from his teacher effectively.

While this was a good starting point for designing the role-play interactions, allowances had to be made because different children would react in unique ways to conflict. If the child strayed from the ideal script, in accordance with the suggestion by Lamm and her co-authors, the teacher needed to be given the ability to guide the role-play back to a constructive outcome rather than stopping and intervening (2006). Effective guidance is a complex component of an educator's expertise. However, the relative simplicity of the device needed to be maintained. How does a designer allow for an appropriately tailored, and guided experience conducive to learning while maintaining simplicity in the decision maker's input device?

The answer for this problem was solved with logic trees based on conflict resolution theories that conflict can be escalated or de-escalated through the use of words, body language, and other non-verbal communication (Maiese, 2004). This discovery highlighted a progressive construct of escalation and de-escalation. This construct seemed to be a possible solution for controlling complex decisions in a simple interface. In the ideal scenarios, Berrette and Garth both respond with escalation and de-escalation at different points in the role-play. Berrette escalates by taunting the child passive aggressively and de-escalates by starting to back down: "Just gimme another minute." Garth escalates by increasing his taunting of the child and de-escalates by saying aloud that the fish are getting boring, justifying his reason for leaving. By adding additional and graded levels of escalation and de-escalation to Garth and Berrette's possible responses, a teacher would be able to have the digital partners respond in real time with appropriate escalating or de-escalating words and actions based on the child's performance in the

role-play. To simplify these choices for the teacher, an escalation button was provided, as well as a de-escalation button.

4.5.2 Educator Input Device

The educator input device is a Logitech Precision Game Pad. A game pad was chosen with the intention that its fewer buttons than a keyboard would maintain the desired simplicity for the educator. This decrease in buttons meant that some of the buttons had to serve dual purposes at different points during the role-play. This led to the development of the narrative mode and the role-play mode. When the scene was in the narrative mode, the each button on the controller performed a specific function; when the scene was in role-play mode, each button on the controller performed a different function. This slight increase in complexity necessitated the development of a chart for the early childhood educator (see Figure 10).

The educator input has visual feedback on the screen in the top left-hand corner that was not obtrusive to the scene. When the controller is in narrative mode, the educator could advance the plot, control the height of Eegan's gaze, and choose a character for a role-play. The educator is provided with one button to raise the height of the gaze and one button to lower the gaze. When pressed, these buttons produce a mostly transparent pyramid as a marker for the height that disappears shortly after the instructor releases the control. The controller was mapped so that the role-play characters could be selected with one of the four number buttons for each character. These buttons were painted to correspond with the color of the cat selected. A visual cue also appeared on the screen echoing the selected color. Once the teacher was sure of her selection, she could then

press a button to intentionally proceed with the selected character. The controller would then go into role-playing mode.

In role-playing mode, the educator uses a button to bring the selected character into the scene. The educator then can escalate the situation with the red button. One tap produces a slightly escalated response, two taps a medium response, three taps produces a highly escalated response, four taps or more resets this selection and waits for another initiation of input. The de-escalation button is green, and works in the same manner. Visual feedback is provided for these choices in the form of a red bar for escalation and green bar for de-escalation, increasing in size as the number of taps increases. After three taps, the bar disappears to show the educator that the system has reset tap counting. During the role-play, the educator has the choice to having Eegan say encouraging and instructive phrases such as, “Keep trying!”, “Great Job!”, and “Listen to your teacher.” When the educator thinks that the child has successfully resolved the conflict, she presses a button for the role-play partner to leave. After the child is finished for the day, the educator may choose to have Eegan congratulate the child and allow the child the choice to see the reward screen, a close up view of the fish the child has been waiting to see.

4.6 Interface Design for Child

The digital characters, virtual environment, teacher’s use of the input device, and projection method all culminate in the child’s “interface” with *Eegan’s Aquarium Challenge*: an immersive experience in an interactive world. This interactive world exists for the purposes of his safe and effective learning. In this world the child can use his words, body language, and actions to interact with digital characters the same way he

would with other peers. He has a coach to guide and support him and digital characters with which to role-play and from which to learn. He is immersed in a virtual environment that is a safe place for his learning to take place.

Eegan encourages and establishes a rapport with the child. The child feels comfortable with Eegan and knows that Eegan is a friendly resource during the role-plays. This makes the environment that much more safe to the child. When the child role-plays against the digital characters, he can use his words, just like he would in real life, to interact with the characters. The characters, in turn, react in realistic ways and levels of escalation and de-escalation appropriate to the child's actions.

The immersive environment transports the child to a place where it is safe to experiment with social skills. The sights and sounds of the environment let the child know that he is in a public aquarium, but the cartoon cats let the child know that he is in an imaginary place. This imaginary place is blue, and peaceful, promoting a peaceful resolution to the conflict. This safe environment exists only for him, for the purpose of ensuring that he feels comfortable trying new things without the negative consequences of failure.

The environment is projected at life size for the child: Eegan should be around the child's height and stands roughly on the floor as the child does (see Figure 11). This is achieved by large-scale rear projection on a screen that touches the floor. The intention of the life-sized projection is to make the experience more immersive, and more memorable. While experiencing a situation in the correct scale, the child can use his body in the role-play as he would naturally.

The educator herself is also part of the experience for the child. The educator is there to guide the child and place him in his zone of proximal development. If the child has trouble with the role-play, the live knowledgeable other that he knows and trusts is there to help him. The child can, and is encouraged to, ask the teacher for help during the role-plays. This creates a teaching moment for the educator. She can guide the role-play towards a constructive learning moment for the student. The educator pays attention to the child's words and actions in the role-play and decides whether the situation is working towards resolution and directs the characters accordingly.

With her expertise as an educator and relationship that she has with the child, the teacher helps guide the child through his experiences in this immersive environment. Eegan helps coach and support the child during his time at *Eegan's Aquarium Challenge*, and the set of digital role-playing partners provide an active and effective learning experience. The environment immerses him in a new world in which he can explore how to peacefully resolve a conflict. *Eegan's Aquarium Challenge* creates a memorable immersive experience for the child that will help him resolve conflicts in the real world.

CHAPTER 5

DISCUSSION

5.1 Results

This section of the paper describes the evaluation process for *Eegan's Aquarium Challenge* as well as the feedback gathered from the focus group.

5.1.1 Focus Group Evaluation

For *Eegan's Aquarium Challenge* teachers were used as the evaluators because of their expertise on the subject of teaching conflict resolution to children and their ability to predict how their students would react to *Eegan's Aquarium Challenge*. The selection of evaluators was originally set to include only practicing teachers of first grade and kindergarten as well as graduate students in the field of early childhood education. After recruiting from this target group, other interested parties involved with early childhood education were welcomed. The final group was composed of members of various levels of experience with early childhood education, including several practicing teachers of kindergarten and first grade, an English as a Second Language and Special Needs teacher of kindergarten and first graders, an administrator from the Education Teaching and Learning department at The Ohio State University, an Early Childhood Education graduate student, an Education and Human Ecology undergraduate student, and a multimedia designer.

The evaluation format was a demonstration of the project followed by a focus group session. The participants passively viewed a demonstration of *Eegan's Aquarium Challenge*. I demonstrated the role of the teacher and the role of the child was demonstrated by Mary Twohig. After the demonstration, questions were fielded from the participants. This was followed by a focus group in which questions were asked of the participants as a group. The participants were then welcome to use the educator interface if they so chose.

After viewing the demonstration, the participants discussed several questions posed by the researcher. This list of questions included:

- What are some of the advantages you see as a result of this teaching tool?
- What are some challenges you see?
- In what other applications might this tool be effective? Why?
- In what other applications would you discourage the use of this tool? Why?
- What about this tool would you change to make it more effective?
- What about the interface for the early childhood educator would you change?
- What about the interface for the child would you change?
- How would you compare this tool to other types of existing teaching tools, such as linear animations, CD-ROMs, or traditional puppets?
- In what setting would you like to see this tool used?

The questions of the highest priority to the researcher included the advantages and disadvantages of this tool. An inferred question of great interest was whether the added complexity of the controller and set-up outweighed the advantages of the benefits for the role-play. Another inferred topic was child acceptance: would children feel comfortable

and be interested in this type of system and these animated characters for role-play? The listed questions led the educators to discus these inferred areas of interest.

5.1.2 Summary

Overall, the technical requirements involved with *Eegan's Aquarium Challenge* seemed accessible to the teachers since it allowed for increased educator control, facilitation of guidance, increased interactivity, and increased possibilities for social learning. *Eegan's Aquarium Challenge* was created with the goal of facilitating a channel of communication between the teacher and student. The educator feedback seems to indicate that this goal was met and that the teacher's role as a guide is also made easier. The advantages that *Eegan's Aquarium Challenge* offers to the teacher and student, and the educator feedback, supports that virtual reality and performance animation can facilitate role-playing social situations with children.

5.1.3 Character design feedback

The focus group discussion revealed several aspects in which *Eegan's Aquarium Challenge* could be helpful for the children participants such as the way it makes the role-play partners and coach acceptable to the child. One teacher commented that the digital characters would be less frightening to role-play against than an adult, which is a problem she observes in her school's current anti-bullying program. Her remarks indicated that the children would feel more comfortable role-playing against this cartoon than an adult. A common interpretation of Maslow's Hierarchy of Needs supports that a child learns better when safe, or comfortable (Simons, Irwin, & Drinnien, 1987). This would indicate that role-playing against the presented digital characters is more conducive to learning than role-playing against adults. Another participant pointed out that the cartoon nature of

Eegan and the role-playing partners would make her students feel more like they were "playing" than "learning." She indicated that increasing their enjoyment of the situation would increase their desire to participate. This comment indicates that children would accept Eegan. In the event that the child did not, however, feel comfortable, an additional puppet was recommended for use by the child. This puppet could talk for the child, a technique traditionally used in children's therapy when children have trouble expressing themselves (Carter & Mason, 1998). Increasing the child's comfort with and acceptance of the role-playing partner was one of the goals of creating child-like cartoon characters. The educator feedback would seem to indicate that this goal has been accomplished.

5.1.4 A safe environment

The educators felt that *Eegan's Aquarium Challenge* provided a safe environment in which the role-play takes place. One teacher said that *Eegan's Aquarium Challenge* causes one to experience a different environment while looking at the screen. This would be helpful in a classroom because it provides an alternate, safe environment where the children are free to take risks. The perception of being in a safe environment is essential for the success of role-play, where the negative consequences of failure are not real (Galarneau, 2005). Creating a safe and peaceful immersive environment for this role-play was another goal of this project. This educator's input seems in indicate that this goal has also been met.

5.1.5 Interactivity and motivation

In comparison with CD-ROMs and linear animations, a teacher preferred *Eegan's Aquarium Challenge* because of the level of interactivity offered. This interactivity, she felt, would interest the child more than passive or moderately interactive media. The idea

of maintaining the child's interest over multiple role-plays was important and helpful because of the importance of repeatedly practicing social situations. Teachers are not always available to students on the playground, so the children need to be able to use these skills in the real world without the intervention of an adult.

Another positively reviewed component of *Eegan's Aquarium Challenge* is the reward at the end of the role-play. A teacher indicated that this would make her students feel good about themselves. While learning from failure is helpful, one can also learn from and be motivated by positive reinforcement. Maintaining the child's interest with interactivity and motivation can lead to successful repeated practice and finally to empowering the child to use what he has learned in the real world. Empowering the child to use these social skills independently and in the real world is the ultimate goal of social skills training.

5.1.6 Increased control and resulting facilitation of guidance

A participant observed that allowing the teacher to become a third party in the role-play would change her point of view and help her assess the situation better. Generally, to achieve this third-person perspective, an educator has two children role-play each other. One participant noted that having two children role-play each other is sometimes difficult to steer toward a constructive solution because the children experiencing the role-play do not necessarily have the expertise to guide it constructively. She noted that by allowing the teacher control of one of the characters, it would increase her ability to guide the role-play towards a constructive learning experience. The combination of the third-person perspective and the educator control over one of the role-play partners facilitates the teacher's role of guiding the role-play. This resulting increase

in ability to guide the role-play is compatible with the recommended role of the teacher during a role-play (Lamm et al., 2006).

5.1.7 Possibilities of social learning

While several teachers said they would use *Eegan's Aquarium Challenge* individually with a child who has problems being assertive or a child who cuts in line, the possibilities of social learning also seemed to be of great interest to the educators. When compared to traditional puppetry, *Eegan's Aquarium Challenge* was preferred, as the large-scale projection would be better for classroom-sized groups rather than small groups. Several teachers agreed that they could use a laptop and SMART Board to project *Eegan's Aquarium Challenge* onto a wall in their classrooms, have the entire class gather around to watch, and have one child interact with the digital role-play. A teacher elaborated by saying she would then ask the children what courses of action the role-player could pursue, and have the children in the audience offer suggestions. By suggesting solutions and influencing the role-player's response, the children would effectively make this student their avatar in experiencing the role-play, and in turn, this student would model the agreed upon behavior for his peers. This social learning experience harkens back to Heim's description of the positive possibilities of a CAVE™, as opposed to a HMD or desktop display for virtual reality (1998). Allowing the children to have a social experience during this learning moment helps the class learn this social lesson as a group. This could be particularly helpful if the lesson was one with which the group struggled. This collaborative learning environment that was exciting and interesting to the teachers seems to be better supported by *Eegan's Aquarium Challenge* than traditional puppetry and other existing electronic media.

5.1.8 Educator interface discussion

The possible perceived disadvantages of *Eegan's Aquarium Challenge* included concern about the educator interface and set up. The participant group was divided on whether or not the use of a game controller as an input device was comfortable or acceptable. The younger participants, the two students and a younger teacher, seemed to accept the game controller, but the older participants mentioned preferring a more familiar device, such as a keypad or full keyboard. However, one of the older teachers mentioned that if she could master the use of the game controller, she might increase her acceptance among some of her students. One teacher that was concerned about her ability to use the game controller preferred the ease of use of the game controller to animate four characters versus the difficulty of manually and vocally controlling four puppets. She mentioned that it is a common misconception that every teacher can adequately control a puppet. While the start-up of the software was not overtly a part of the presentation, some of the teachers recalled past negative experiences with initializing programs and having technical difficulties. These participants felt that they might need someone to show them how to set it up, and would need to ability to call for help if the system or the user malfunctioned. When weighing this feedback against the advantages that the technology provides, the participants' positive feedback indicates that dealing with the technology is worth the advantages gained by *Eegan's Aquarium Challenge*.

5.1.9 Opportunities for autism intervention

A possible application for *Eegan's Aquarium Challenge*, mentioned several times, involved teaching children with autism. According to the teachers, their students with autism struggle to interact with people, but excel in interacting with screens and digital

media. Several of the teachers thought that *Eegan's Aquarium Challenge* would be helpful in teaching and practicing social skills with autistic children because of the children's great difficulty with interacting with other children. One participant mentioned that teachers are responsible for tracking the development of special needs children in their classrooms. She added that if *Eegan's Aquarium Challenge* were equipped with a recording device that monitored how many times a child escalated and de-escalated the situation after playing *Eegan's Aquarium Challenge* over a period of months, it might facilitate the teachers in documenting the child's progress in social skills. The teachers agreed that while *Eegan's Aquarium Challenge* is age appropriate for typically-developing four to seven year-olds, it would also work well for developmentally delayed, specifically autistic children, well into middle school.

5.1.10 A possible model for distribution

The educators proposed a subscription-based web-accessible system with multiple versions of Eegan's Challenges targeting a range of social skills training. Teachers could then select and download skills with which their classroom most needed practice. They seemed to agree that all social skills require role-playing, but that certain classrooms need more practice with some social skills than others. The ability to request or select role-plays for issues affecting their classrooms was a point of interest for the teachers. The teachers recommended that these Eegan's Challenges include role-plays to teach skills such as asking a group if the child can join them, asking for help, knowing when it's OK to say no, making friends, and others situations where there is risk in reality, but not in the simulated environment. One teacher also mentioned the advantages of adding the ability to have input over what the characters would say. She said that in her classroom,

when a child has a problem with a particular social skill, the child writes a script with the teacher, acts it out, and then reviews it for success and failure. This method is consistent with Church's recommendation for role-playing: form a plan, act it out, review the outcome (2001). The teacher said that the ability to tailor the characters' speech to the child's "social story" would help the child in learning.

5.1.11 Recommended Revision to *Eegan's Aquarium Challenge*

Areas of interest for improvement of *Eegan's Aquarium Challenge* include relationship building with Eegan and child user testing. Relationship building with Eegan was an area of great interest to the evaluators. One evaluator recommended a storybook to introduce Eegan to the child participant. Several other teacher's agreed that plush Eegan toys or puppets would also help strengthen this familiarity and further develop the relationship between the child and Eegan. This relationship would increase the child's acceptance of Eegan, and ultimately make the child feel more comfortable with Eegan. This comfortable and friendly relationship with Eegan might help the role-play become a more memorable learning experience. This idea of familiarity and a previously existing relationship increasing comfort can be seen in *Crush's Turtle Talk Adventure.* Most of the children in the room already know and like Crush from *Finding Nemo*, so they are excited to talk with him. If Eegan had a similar introduction device, such as a video, storybook, or plush toy, this would help children like and feel more comfortable with Eegan as a coach.

Given time to facilitate this relationship building between Eegan and children, child user testing is also a recommended future goal. Having children participants evaluate *Eegan's Aquarium Challenge* would help provide a more complete

understanding of the effectiveness of the role-play environment and level of comfort for the child participant.

5.2 Conclusions from the designer's perspective

My undergraduate education centered my studies around designing animation and video for educating college-aged students. I created print media and two-dimensional animations concerning global warming, videos about common psychological disorders, and three-dimensional models for teaching biology and astronomy. The theoretical research and practical applications on which I spent most of my time gave me experience as an animation and film designer. After earning my undergraduate degree, I became interested in finding new ways that technology and education could interact to provide new synergies and opportunities for mutual advancement.

Through my research, education, and experience, as a hospital advocate for survivors of domestic violence and sexual assault, I learned that much of the violence in society can be prevented through education in the early years of a child's life. Seeing a possibility to address the human suffering that I saw in a preventative fashion, I began to focus my graduate career on ways to use technology to aid early childhood education. Drawing on my experience as an animator, I considered creating an animation to teach children about assertiveness, a skill that can prevent violence. Given the dwindling use of traditional puppetry on PBS in comparison to the rise of animation in children's programming, I saw the possibility to reach children through animation.

After exposure to virtual reality and performance animation, I began to think that they too would have a valuable contribution to make in early childhood education.

Personally experiencing and watching others experience a virtual environment seemed to create very powerful memories of active experience, rather than passive observation. Working with performance animation through the form of motion capture created the opportunity for an interesting exploration of instructive animations. Seeing performance animation in the form of real-time digital puppetry influenced the idea of the possibilities for real-time animated characters that could be acceptable and exciting to children.

These experiences lead me to explore combining virtual reality with performance animation to open a new channel for communication between teachers and children. This combination seemed to have the potential to redress the predominance of violent behavior models in video games, decrease the fear children can experience from role-playing with an adult, and increase child acceptance of digital role-playing partners. However, to combine performance animation, virtual reality, early childhood education, and my experience as an animation designer, I realized I would need to learn much more about these other disciplines.

In order to create a learning role-play that would be helpful, I needed to learn about teaching children. Taking classes, and interacting with children and teachers through these classes, gave me a better idea of my target audience, but I realized that it was not possible for me to gain the knowledge of an experienced teacher by taking a few classes. To understand virtual reality, I read articles and books on the subject and learned about the historical and current applications in the military, art, and therapy. I soon realized that this was another field in which one needed much more experience than I could gain over three years to understand all the facets of this complicated field. The same was true of performance animation. When attempting an interdisciplinary project, it

is important to understand that it is improbable for an individual to achieve the level of "expert" in all of the disciplines.

This led me to find mentors in each field that were experienced and active in their fields. Dr. Laurie Katz, an Education Teaching and Learning department faculty member was able to lend great expertise to the development of my project and understanding of early childhood education in the context of role-playing, puppetry, and technology. Susan Metros was able to guide me in the art form of successfully combining technology and education for a meaningful and engaging learning experience. Brian Windsor, who works with real-time digital puppetry to entertain and teach children, was very helpful to my understanding of effective methods of using digital puppetry and performance animation with a young audience. Alan Price was a mentor for virtual reality and immersive environments and the value and power of social experiences in these environments. These mentors were critical to the success of my understanding of these fields and of how to successfully combine them.

I also came to the conclusion that when combining multiple disciplines, one must learn the theories behind the most commonly held values for each discipline. The writings and work of Vygotsky in early childhood education and the work of Heim in virtual reality influenced many of the decisions made during the design process of the project, and developed my understanding of their fields. In addition to researching the founding values of these fields, it was also important to look for applications that strived to combine these fields and learn from the success and failures of each.

The next step to learning how to combine several fields is to attempt to combine them, and learn from one's own success and failure. It is important to ask oneself, am I

using these specific techniques together because I think this might be a good idea, or because I have tested this in some form and can validate that this is a good idea? Am I using the right advantages a certain technology may afford for a specifically and warranted reason? It is also import to ask oneself during the design process, are these fields that I am combining benefiting to the fullest from each other? What could I do to improve this combination and interaction?

From my research and experience, I can conclude that virtual reality and performance animation have much to offer each other. A performance of a virtual character can be so much more powerful when it is also an experience where the viewer feels as though they are part of the environment in which the performance is taking place. The experience of immersion draws the participant into the work beyond a visual or even emotional connection. As an artist, I have found that it can be exciting to see ways in which I can use as many senses as effectively as possible to truly reach someone and make a memorable and moving experience. Once the participant is in the virtual environment, their imagination starts actively participating to complete the immersion in this world. The participant begins to listen to the audio cues, and explore their virtual surroundings. Once a participant is immersed, this experience of discovery is so powerful that the mind blocks out the mundane concrete floor, computer creating the projection, or other aspects of reality that are not a part of the virtual world. Once the participant is involved in constructing his reality from the virtual world in which he has been placed, he is actively paying attention to what the designer is telling him. He is captivated and actively engaged for a performance, simulation, or lesson.

After creating this sense of immersion and gaining the full attention of one's audience, one can use digital puppetry or real-time animation to enhance the experience. The participant's actions can interact with real-time results, effectively making him the performance artist. Allowing the participant to control the actions of characters or objects within the environment empowers the participant further to feel like an active part of the experience. This combination of virtual reality and performance animation can lead to more constructive learning experiences through creating an immersive and memorable situation and allowing social interaction while in this environment.

As children, my generation was greatly influenced by television shows that artfully used traditional puppetry, painted sets, live action videos, and songs. The next generation of children, however, is growing up watching different television, playing video games, and interacting with content offered over the Internet. They live in a world of screens that provide this media in the car, at home, even on phones. They are inundated by and learning a visual language of animation, three dimensional forms, and interactivity. We understand lessons better when they are taught to us in the language we understand. Early childhood education could benefit from learning this visual and interactive language the children are acquiring and use it to reach and teach the children of this generation.

Early childhood education can use performance animation to communicate in this language. Digital characters offer unique opportunities for communicating with children who grow up watching computer animation and playing video games. Maslow's Hierarchy of Needs supports that a child cannot learn well when scared or uncomfortable. During this study, several factors determined that role-playing against digital characters is

more conducive to learning than role-playing against adults. The introduction of performance animation and its precedents to inform the design of the digital characters and the means for their interaction has served to bridge the communication gap commonly attributed to human interaction versus conventional forms of computer-based media. CD-ROMs and interactive websites often do not know or cannot responsively determine the level of knowledge of the participant and the possible areas for growth. By allowing a teacher control of a digital character, this ensures that the knowledgeable other is able to guide the learner into his zone of proximal development where learning can best take place.

An increase in social learning and relationship building can be beneficial for the children who encounter much isolation as a result of video games. The video games that children are growing up playing acclimates them to a highly active, yet reclusive experience. Early childhood education can use a combination of performance animation and virtual reality to turn the same technology that generally results in isolation to open a channel of communication between teacher and student by creating an immersive and highly interactive world and communicating with the child through digital characters, visually similar to the ones they see in their media. By repurposing this technology, the opportunity is created to author social and relationship building experiences for the teacher and student. New worlds can be created that the teacher and student can explore together, and through this journey strengthen their relationship. New characters can be created to mediate interactions between teacher and student, and bring them together. By strengthening the relationship between teacher and student, both can realize that they have much to learn from each other and the motivation to do so can be inspired.

The teachers with which I have developed close relationships have been critical in my development academically, spiritually, and emotionally. I owe much of my identity to their combined effort, guidance, and patience. Without these relationships, I could not be who I am, or be where I am today. These relationships were developed through scholastic and non-scholastic social interactions and exchanges between the teachers and I: through collaboration, conversations, challenges of skill, mutual moments of frustration, and shared joy when new skills are developed. One of the problems facing early childhood education today is the risk of losing the opportunity to create these teacher and student relationships because of the growing dependency on technology-based media that promotes independent and isolative learning above social learning, and the growing gap between the visual and interactive language that the child has learned from his media and the traditional method in which many teachers prefer to communicate. The same technology that results in isolation can be repurposed to create an opportunity for the teacher to use the computer's capabilities to open a channel to reach the child and provide guidance and mediation while this channel is open. Virtual reality and performance animation can help facilitate the communication that is critical in the development of the precious relationship between teacher and student that can be mutually beneficial for both of their lives.

5.3 Future Work

The opportunity to create a channel of communication for guidance and relationship building between the student and teacher was a significant outcome resulting from the combination of virtual reality and performance animation to facilitate role-play.

However, the teacher's ability to have total control over the content provided by the system could increase her ability to mediate the situation and provide guidance. In order to make this technology accessible to educators, however, the flexibility associated with performance animation was compromised. Future work could include putting more effort towards increasing the control the educator has over digital characters to facilitate the channel of communication with the child, by restoring the fullness of what performance animation can provide to this interaction. This could result in the experience being tailored more specifically to the child's needs, as determined by the teacher. To reach this goal, work would need to be done to enable the educator's capability for authoring the content provided by the system and restore the flexibility associated with performance animation, while ensuring that the end result is still accessible to the educator.

The possibility of reaching children with special needs was also a significant outcome resulting from combining of virtual reality and performance animation for role-play. While autism was specifically mentioned, children with diverse social development needs could benefit from early intervention and repeated social training with a digital character in order to prepare them for interacting with peers. Further work should endeavor to discover in what ways certain populations of special needs children could be reached by this combination.

APPENDIX

FIGURES

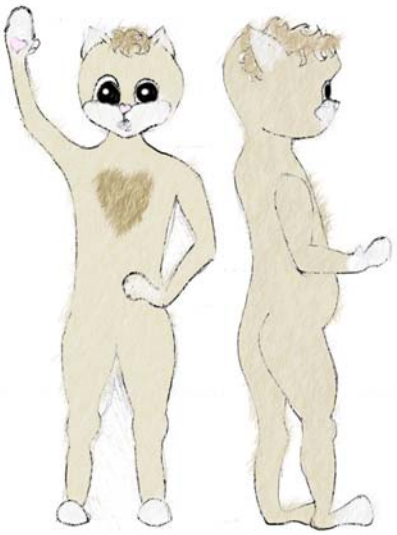

Figure 1: A sketch of Eegan.

Figure 2: A sketch of Montag.

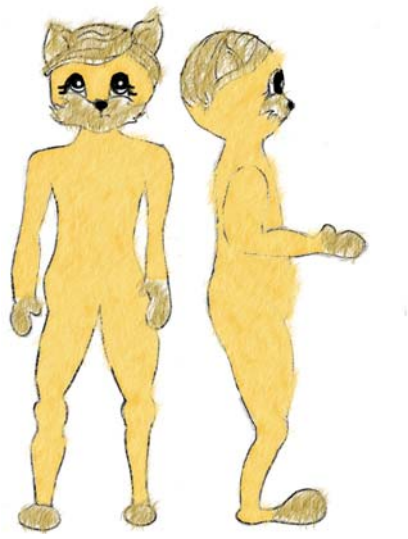

Figure 3: A sketch of Berrette.

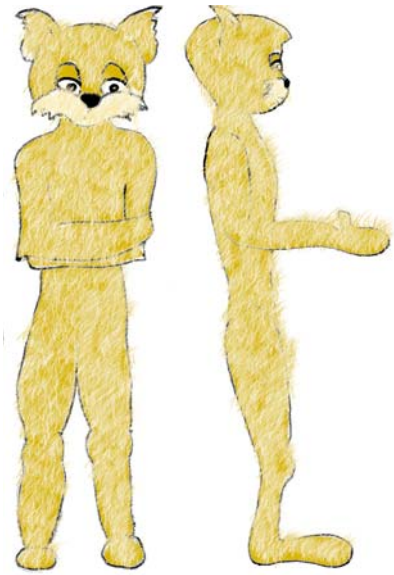

Figure 4: A sketch of Garth.

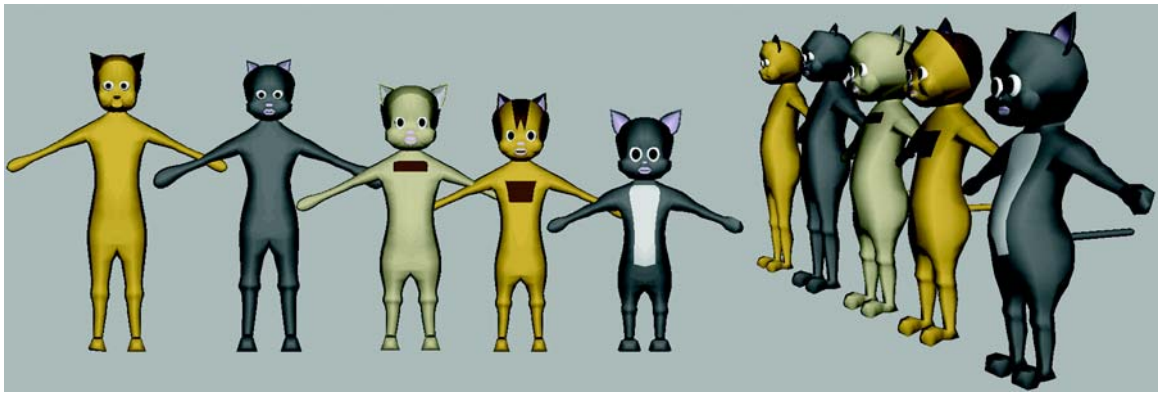

Figure 5: Geometric models of the characters. The extra cat was phased out when his personality proved too similar to Garth's to make a meaningful distinction in role-playing for the participant.

Figure 6: All four characters with real-time fur and final coloration.

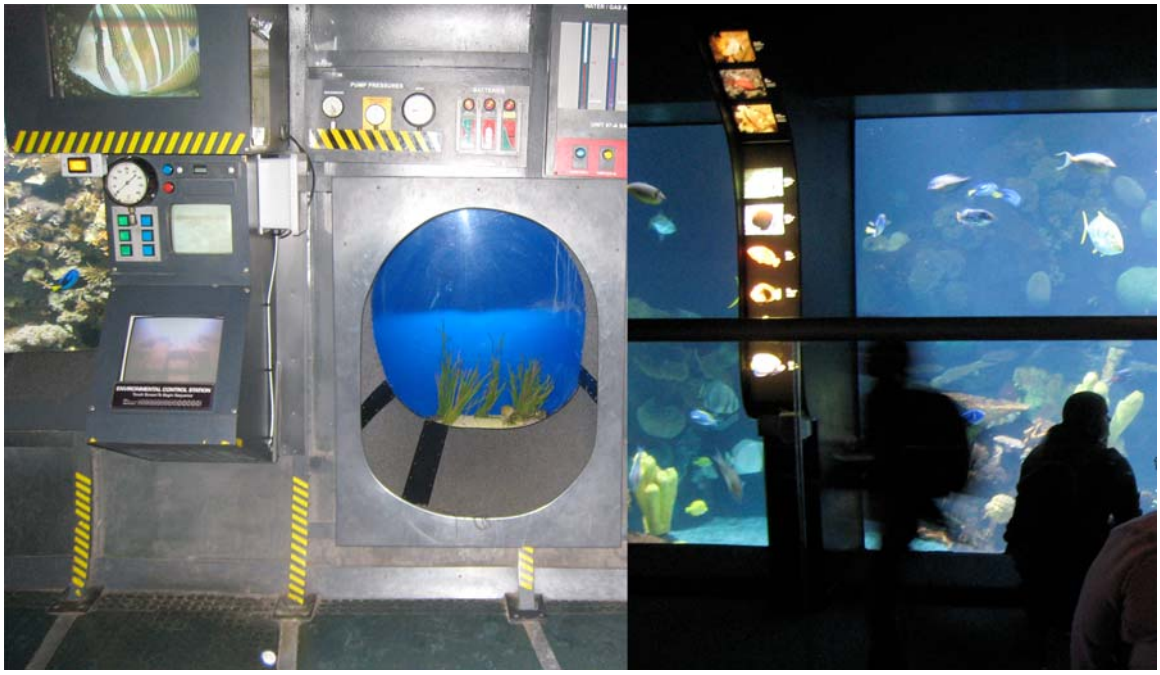

Figure 7: Photographic references take at the Columbus Zoo Discovery Reef.

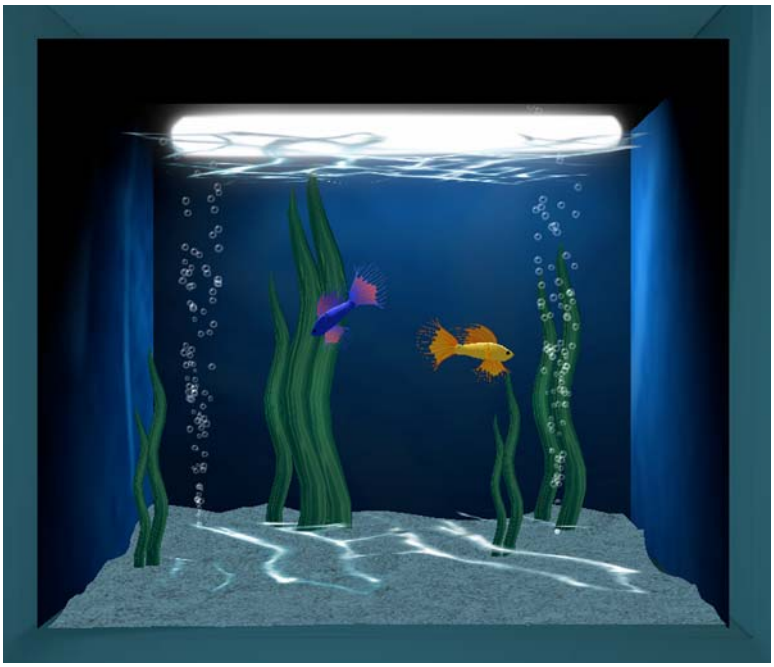

Figure 8: The fish tank and reward screen.

Figure 9: The modeled environment complete with Eegan.

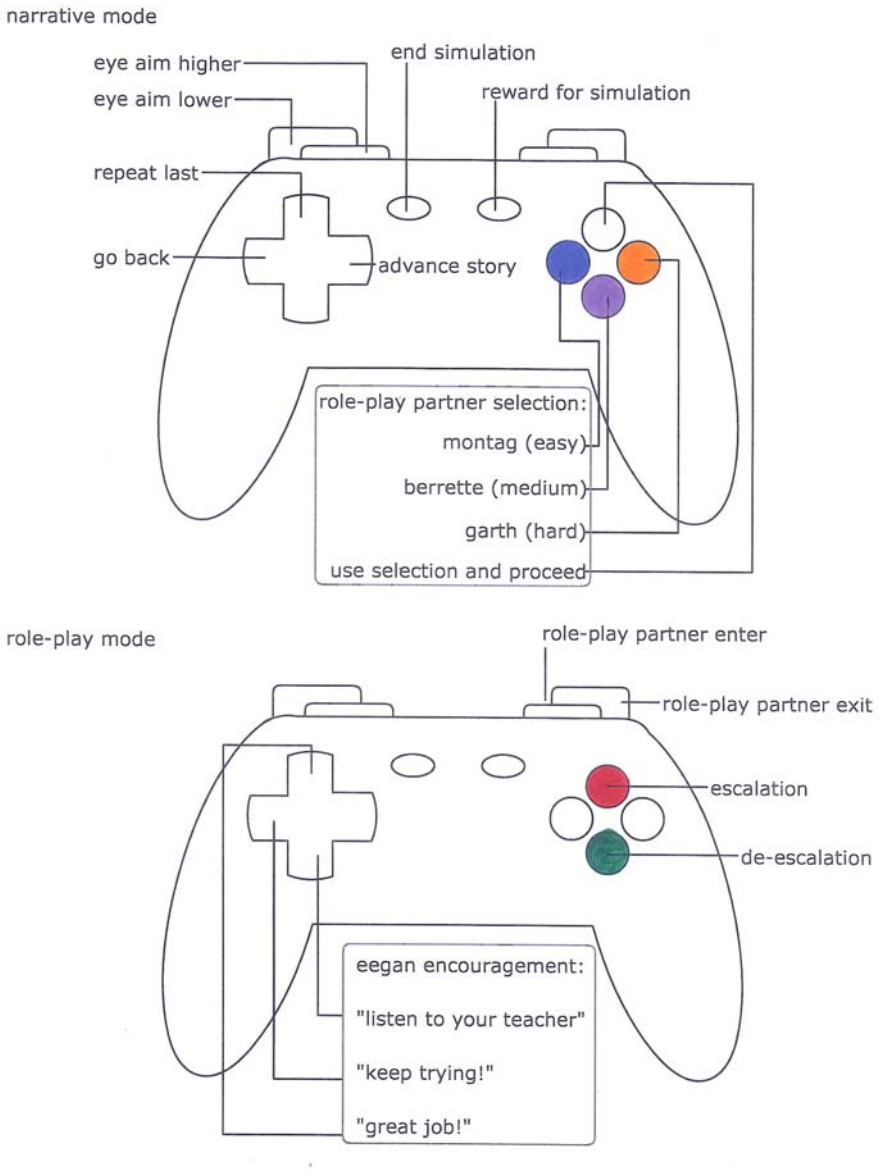

Figure 10: A diagram of the educator input device.

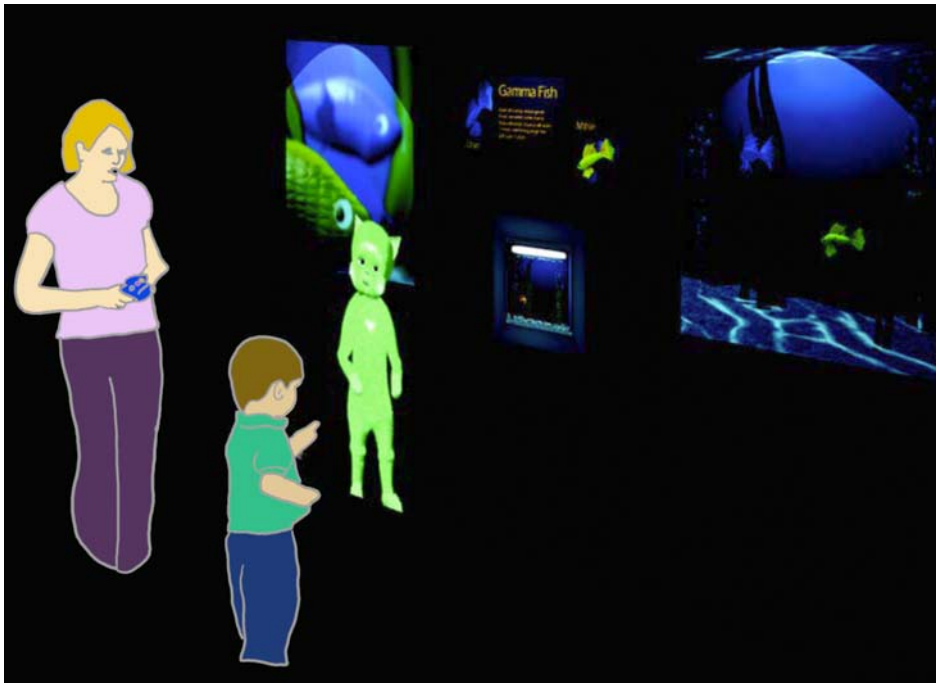

Figure 11: An illustration of the final environment created for the child: teacher holding game controller and guiding the role-play.

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