

THE CREATIVE AND LEARNING PROCESS OF ARTISTS MAKING A
VIRTUAL ENVIRONMENT WORK OF ART

by

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In memory of Margaret Elizabeth Eber

who told me

Life is not about objects, but it is about the experiences we have in it. We make
our experiences what they are, and we assign their value.

All this is real.

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CHAPTER 1

INTRODUCTION

Introduction and Purpose

Art is a human activity consisting in this, that one man [or woman] consciously by means of certain external signs, hands on to others feelings he has lived through, and that others are infected by these feelings and also experience them.

Tolstoy, from *What is Art?*, 1897

A work of art, according to Tolstoy (1898/1960), is sincere, and it transmits information, feelings, and experiences through lines, colors, sound, or words. Actualization of the elements embedded in the imagery start with the creator and the creative process. The work may take varied forms, but to be art, the object, idea, or presentation goes beyond the physical and contains some aspect of human experience. Art may be created with any tool, as long as the artist can use that tool to put some of their true self into the art. In part because some do not believe the artist can put themselves in computer art, many have debated the validity of it as an art medium, especially virtual environments (VEs). A VE in general simulates some sort of environment, world, or space on a computer for a user to interact with. A VE work of art in particular is a form of computer art in which the artist designs the application to be an artistic work. This is in contrast to other applications of VE such as military war games and pilot training.

With the evolving tools necessary to create a VE, the artist will learn a new technology that may influence the nature of and how she reaches the creative level. To make a VE, the artist learns technology such as new software, some computer programming, a better understanding of the underlying hardware, new technological language, and the interaction of a complex system of computers and peripherals. Because the creative process is highly dependent on the individual and the surrounding circumstances, each new element acts as a layer in the molding of his or her learning and creative process. For example, the language surrounding computers alone may influence thoughts about the art. When a user wants to stop a process on a UNIX system, if all else fails they issue a “kill” command. Words such as this influence different people in different ways, but it is certainly present in the mind of people who must stop an unwanted computer process. The influence of new elements such as language and hardware is especially true when the technology, as with VEs, is in an underdeveloped state, one which requires the artist to learn new techniques and pay close attention to the impact of the tool.

In addition to the acquisition of new techniques such as programming, software, and language, the artist who chooses to work with VEs is faced with a new set of aesthetic considerations, as the final work of art is wholly different from that using any other medium. A VE work of art exists on a series of machines that are turned on, set up, and have a viewer (or user) interacting with it. The set up usually includes a way of surrounding the viewer with imagery, and sometimes sound. In this sense, a VE art work is like an art installation that is interactive, immersive, and adaptive, and only exists as a single experience of the viewer. Because the viewer’s interaction is unique to that moment and the VE changes based on that interaction, subsequent encounters with the work will also be unique, for that individual and other viewers. Even though a viewer may

have a different experience each time they view a particular a sculpture, for example, the physical sculpture remains the same, as does the environment it sits in, and the existence of it. Although there are variances to this generalization, they are not as unpredictable as a VE work of art. Depending on how it is constructed, the objects in a VE and their behaviors can be particular to the user's interaction. The interaction of the users and objects varies based on how the designer sets up the environment, which is not necessarily in concert with physical laws. Further, there is no physical entity behind what the viewer sees, as there is with sculpture, and that object or its environment may change or go away upon subsequent encounters.

The objects or structures in a VE are solely experiential, and the experience exists through the manifestation of computer code, hardware, and peripherals that simulate immersive sight and sound. Unlike a drawing, sculpture, or a painting, a VE isn't something to hang on a wall or set on a stand. In fact, the objects or structures involved in a VE cease to exist when the computer is turned off. Similar to conceptual and performance art, the entire art object is indeed the unique experience the viewer has with the VE installation.

Contrary to the concepts expounded in the popular media, a VE art installation can be more than a display arena for the art of others (Picasso, for example) or a "shoot 'em up" computer game. It can be a work of art in and of itself, one that requires of the artist a level of abstraction into the spirit of creativity that other traditional mediums demand. In "For the Sake of a Single Poem," Rilke describes how the spirit of creativity manifests itself for him, but in the medium of words. For Rilke, the content of a single word, in a single verse, in a single poem is not merely an emotion, but an experience, a life of experiences. The experiences are memories that no longer consume our

conscious minds, rather they become, over time, part of ourselves and our art.

Of these experiences he says:

Only when they [the memories] have changed into our very blood, into glance and gesture, and are nameless, no longer to be distinguished from ourselves--only then can it happen that in some very rare hour the first word of a poem arises in their midst and goes forth from them (Rilke, 1910/1982, p91).

The word in Rilke's poem is from the essence of his experience, an experience that has grown into who he is. It is the experience from his soul that becomes part of the poem, and when that memory resurfaces, it manifests itself in a word. A similar thing may be said for any art medium. How and at what point does the creative process occur for the artist working with the VE medium in a world of computer peripherals and code?

The creative process for a VE work of art is multifaceted, individual, and demands a way of thinking that in many ways is quite different from other art media. By the creative process for artists I mean the physical and mental actions that they experience prior to, during, and some would argue, after creating what they deem works of art. In the case of a VE that includes mental actions such as the artist's initial perception of what a VE is and learning the new tools to realize their perceptions. Examples of physical actions include using the computer and the peripherals and interacting with others and the machines in the computer environment. Rilke's creative process spanned a life time, and started with an experience that slowly, over time, became a part of him. Only after the experience grew into his soul did it manifested itself in a word, Rilke's art medium. This, for Rilke, was his creative domain.

Like Rilke, in what ways can artists reach the domain of creativity, what things must they first learn, and at what point does the tool become a vehicle of

expressive energy as powerful as Rilke's word? To explore this process, I devised a way for artists to convey their thoughts before, during, and after the creative stages of producing a VE work of art. Like Rilke described his process, the artists in this study tell the stories of their experience in the creative process with the VE art medium.

This study examined the creative process of the artist constructing a virtual environment work of art. By a VE, I mean a computerized simulation of a world, known as a scene, that a viewer experiences using various computer peripherals. The experience is interactive, stereoscopic (true three dimensional display), and immersive. In the last few years, computers in general have begun to make their mark in the world of art. Museums now show installations that include computers and other works that were created using them. Art departments in public schools and universities are slowly adding computer classes, majors, and concentrations to their curriculums. Despite all the attention computers have gained in the art world, there is little or no research on the creative processes employed by and their impact on artists using them. In fact, the computer is often thought of as an extension of traditional art processes rather than a stand alone medium. The computer art medium differs from traditional media in many ways, but most importantly, in the art object. The object or artifact in computer art is a digital file of 0's and 1's that the artist can manifest in infinitely different ways. That file can be displayed on the artist's screen, displayed on millions of other screens over the internet, written to video tape and displayed on a TV, published on a CD, printed to a wax printer in low resolution, printed to an Iris Inkjet printer in high resolution, written to slide film, written to negative film, etc. Furthermore, the art may be interactive, animated, or both. Every screen the imagery is displayed on and every printer the image is printed from is different, even the same screen and the same printer

will change over time. The old questions such as “What is the original?” and “What is the object?” take on new meaning.

In the case of an artistic VE, an extension of computer art, the ultimate product of the art process is the viewer’s experience with the VE. This is a new medium with new aesthetic, creative, and intellectual problems to solve and questions to ask. There is therefore a need to explore the new aesthetics, creative thinking, and learning approaches for an artist making a VE installation. This specific study on the creative process for an artist making a fine art VE reflects on perceptual and educational issues for students and artists making and learning about digital computer art during a time when the media and processes were (and still are) being defined. The purpose of this study is to describe the nature of the creative process for a digital artist creating a VE work of art.

Problem Statement

A virtual environment (VE), also known as virtual reality (VR), is a synthesized digital space, referred to as a *world* or an *environment*, generated by a computer and its peripherals. In this world, a user is immersed, or surrounded by sound and imagery through computer peripherals. This hardware may include a head mounted display (HMD) or an unencumbered CAVE environment, one that shows imagery and displays sound without peripherals (Kalawsky, 1993). Within this environment, the user interacts with and experiences three dimensional (3D) spacialized sound and stereoscopic imagery which are responsive, in many cases, to his head and hand movements. Thus, the imagery and sound change as the user alters both head orientation and physical position in the digital environment. The VE may instead, or in addition, track hand or other body movements, depending upon the peripherals. To be a true VE, this world is immersive, stereoscopic, interactive in real time, and

provides a multimodal interface (National Research Council, Committee on Virtual Reality Research and Development, report, August, 1995).

In the last few years, virtual environments (VE) have gained recognition as computer simulated worlds that can be used for diverse applications such as training pilots and soldiers for national defense, training workers in hazardous operations, visualizing complex information and scientific data, manufacturing products, educating students, computer games, marketing products, and providing a work environment for its users. These VEs are designed by computer scientists, engineers, game designers, and specialists such as psychologists, aircraft designers, educators, and marketing professionals.

Most recently, a handful of artists have used the idea of VEs to create computer based virtual environment art installations. An art installation is a work of art that goes beyond an object that exists on a wall or behind glass to encompass an infinite number of artistic possibilities that include alternative presentations, environmental constructions, multi-sensory stimulation, viewer interactivity, and theatrical performance. In short, an art installation is usually any art construction that is presented unique to its form. Most of these so called VE works of art are either not true VEs, or they lack aesthetic consideration and content. This confusion is understandable as a result of overzealous media attention and the unrealistic expectations of VE.

Although there are many applications for VEs, researchers in the field are not considering their use as fine art installations (National Research Council, Committee on Virtual Reality Research and Development, 1995). However, I believe such an environment will provide new aesthetics and experiences for both the artist creating the work and the viewer, also referred to as the user, interacting with the work. Despite the opportunity to create art in a new medium with new aesthetics, there are relatively few artists who are producing

VE works of art. At present, artists must wade through misconceptions, complex hardware and software in a culture designed for the military and commercial computer scientists and engineers. These factors, along with the new, evolving characteristics of VE, pose a fresh set of aesthetic challenges for the artist.

Because the thinking and acts of creating in this new medium of art will extend our ideas connected with the creative process, there is a need to explore the procedure that an artist goes through to produce the VE work of art. This process requires artists to explore and acquire the necessary hardware and software, learn to use them, consider content and formal elements, think about theirs' and the viewer's experience, define what a VE is for them, and ultimately go beyond the technology in order to express themselves through the work of art.

Research question

This study focused on the main research question:

What is the nature of the creative and learning process for a digital artist making a VE work of art?

Because the nature of my research necessitated data collection and analysis simultaneously, new questions (or sub-questions) emerged and were also addressed. Some of these questions related to the computer and VE art included:

What is the relationship between the technology and the creative process?

Do gender issues in computer technology and environments affect the creative process?

Does the nature of the computer culture (both with the machinery and the other people involved) disrupt, change, discourage, or enhance the creative process?

How (if at all) does the *aesthetic experience* (see Definition of terms) of the computer artist enter into the *creative* process?

How does the *learning* process influence the *creative* process?

How does the *creative* process influence the *learning* process?

How does the artist perceive the VE work of art (before and after creation)?

How do experienced computer artists rise above the technology to make the VE?

Is the computer artist more concerned with the technology or the art?

In what way does the computer artist translate artistic ideas into a VE?

What aesthetic considerations - old and new - does the computer artist employ?

Does the medium force the computer artist to consider the aesthetic experience of the viewer? If so, how do they think about the user.

How is the creative process for a computer artist constructing a VE similar to that of an artist creating a work of performance art?

How is the creative process for a computer artist constructing a VE similar to that of an artist creating other forms of computer art?

How is the creative process for a computer artist constructing a VE similar to that of an artist creating a drawing, painting, or photograph?

Definition of Terms

The following terms are used throughout this document and in the literature connected with art, computers, and virtual environments. Many of these words are ambiguous and have different meanings in different contexts. This list serves to clarify technical meanings of some words and for others, how I have used them.

1) *Aesthetic Experience* is when a viewer perceives in a work of art (or other things) something that focuses their mind and spirit in such a way that they experience an awesome and passionate feeling that is somehow connected with the piece. Although complex and multifaceted, the *aesthetic experience* for a viewer may be characterized by a heightened state of consciousness, or an experience in which the person is in awe, intensely focused, and in pure enjoyment (Dewey, 1934; Csikszentmihalyi & Robinson, 1990a). The viewer often experiences positive feelings, however this is not a necessary condition. Csikszentmihalyi also refers to this state as the *flow* experience (Csikszentmihalyi, 1990b). Although these definitions refer to the viewer experiencing the work of art, I believe the artist creating the work of art experiences the same kind of information flow between what they are creating and themselves. Thus I explore this experience in the creative process for the computer artist throughout this research.

2) *Art installation* is a work of art that goes beyond a two or three dimensional object that exists on a wall, behind glass, or in a room, but encompasses an infinite number of artistic possibilities including alternative presentations, environmental constructions, multi-sensory stimulation, viewer interactivity, and theatrical performance. A traditional work of art is usually presented by an artist or curator so the viewer will not notice the method of display and will focus on the art. On the other hand, an *art installation* is an art construction that exhibits some of the artists ideas in part from its display.

- 3) *Computer peripherals* are various devices attached to the VE system that allow the user to interact with it. This includes such items as a glove, mouse or an HMD.
- 4) *Computer code* is a language such as C that represents a set of instructions that are compiled to a lower level set of instructions and ultimately executed by the computer. This is different from a higher level interface that allows the user to transparently assign instructions to the computer. In the case of a higher level interface, the program automatically generates the code. Thus the user may assign instructions without having to write any computer code.
- 5) *Creative process* is a set of actions that make up the state in which, for this study, the artist feels that he or she is making art. Researchers define and describe this state in differing ways, for procedures ranging from making art to making dinner (see the Literature Review). This study is concerned with the description and definition of this state by the artist making a VE work of art.
- 6) *Head mounted display, HMD* is a computer device to which a VE system displays visual information. The information is sent by the system to two small screens, one for each eye. The two small screens are either a liquid crystal display (LCD) or a cathode ray transmitter (CRT). If the information in each channel is separate and skewed to represent the offset between the two eyes (the interocular distance), then the HMD is stereoscopic.
- 7) *Immersion* or *Presence* is the feeling for the user of a VE system that he or she is surrounded by the simulated space. This is usually accomplished through visual computer devices, although 3D sound and force feedback are powerful counterparts. Peripherals such as an HMD or a construct such as a CAVE environment provide the visual elements. This sensation is a whole feeling in that wherever the user looks, he or she sees a realistic (or logical) aspect of the simulated world which gives them the feeling that they are someplace inside. By

realistic I don't mean true to our physical world, rather a logical view of what the user may expect if he or she turns or tilts his or her head.

8) *Multi-modal* refers to more than one mode of interaction that the VE system provides for the user. Usually this means the use of peripherals for the head and hand such as an HMD and a glove.

9) *Real time* refers to the rate of display or interaction by a user with the computer that is fast enough for the user to perceive it as immediate. In the case of a graphical display, this means roughly 30 to 60 frames per second. Just as in traditional animation, computer animation is a series of frames that show slight changes from the previous frame. When a viewer watches them in sequence at a high rate, she perceives motion. Most computer animation is rendered off-line, or a series of rendered frames are created and saved over many hours. In some cases, each frame is recorded to video tape or film and played back on a VCR or projector. Other times the series of frames are played back on the computer display. On the other hand, with *real time* animation, the computer renders the frames "on the fly," or in sync with the user's actions. What takes off-line animation hours to do must be done in seconds with *real time* interaction. Thus, *real time* graphics must capitalize on optimization algorithms to make the graphics less complicated and run on computers that are fast enough to display the 30 to 60 frames per second. Usually, this kind of computer has special texturing hardware, multiple central processing units (CPU) with a high speed (200 MHz or higher). As of this date, certain PC's come close to this ability.

10) *Three dimensional sound* refers to a sound simulation of a three dimensional world. In other words, if a user hears a sound to his left and he turns his head left, then the VE will display the sound as if it were coming from in front. Thus, the user perceives the sound as if he were standing in a three dimensional space. If the user moves closer to the sound, it gets louder. Additionally, the sounds are

attached to objects in the VE. For example, a moving car could simulate the Doppler effect during the same time a static clock could simulate a stationary tick.

11) *Three dimensional graphics, 3D graphics* are computer images that simulate three dimensional space. The user makes geometric shapes, or wire frames, that are a series of lines, curves, and vertices that have x, y, and z points in space. The user additionally adds lighting and applies textures, such as marble and shaders, such phong so the images will appear realistic. Although three dimensional imagery may be simulated in two dimensional paint programs, the images are not defined by wire frames, but are defined by "painting" pixels, much in the same way an artist models three dimensional space on a piece of paper. One use for wire frames in a 3D modeling package is to calculate successive frames that represent different camera views and lighting. The geometric specifications enable the computer to interpolate the objects to represent the consecutive perspectives.

12) *True three dimensional graphics* are 3D graphics that are displayed to simulate a stereo view. This means there is a display for a left eye and one for a right eye, both skewed to represent the offset between two eyes. The distance of this offset, the interocular distance, is what creates the stereoscopic view. Because most computer graphics are a single view rather than two offset views, they are not true 3D graphics.

13) *True virtual environment* refers to a definition of a VE assigned by the National Research Council, Committee on Virtual Reality Research and Development in order to differentiate between the generic reference to virtual reality (VR) and their particular type of VR. They call their VR a virtual environment (VE), and it is an environment that is immersive, adaptive to the

user's actions, and reacts in real time. Additionally, this system provides true 3D imagery and is multimodal.

14) *User* or *Viewer* are both words that I use to refer to the person who experiences or receives the VE art. The person who receives a work of art is traditionally called a *viewer*, and the person who manipulates a computer is usually called a *user*. The term *viewer* in part implies a passive glance at an object, while the term *user* implies a level of interactivity with the computer. Whether that interactivity is a computer game or a word processor, the person *uses* the machine. I use the words interchangeably because I want to maintain the aspects of the term *viewer* that pertain to experiencing art, yet maintain a reference to interactivity and the operation of a computer.

15) *Virtual environment*, VE refers to a computer simulation of a space with objects. The simulation includes a way for the user to interact with three dimensional graphics in real time. The computer system refreshes the viewer's display when the person changes his position or orientation. The position is a coordinate representation of where the viewer is located in the world, and the orientation usually refers to the viewer's head posture. This real time refresh is ideally 30 frames per second, or faster. The position and orientation information is collected as input from the user through various peripherals. This input from the user allows the system to further respond to the user. This response may be the manipulation of objects or the space, but is dependent on the designers intentions. The response, whether simple orientational or positional changes, or more complex behaviors, make the system adaptive to the user. Some environments additionally provide three dimensional sound and force feedback.

16) *Virtual Reality*, VR is a term used to describe most interactive computer simulations. It is used freely in contemporary dialogue to refer to something not quite real. Virtual means the essence of the referent, but not quite the true item,

and reality means the quality of truth. Thus, the VR term results in an oxymoron. Reference to VR rightfully embodies the confusion surrounding 3D computer simulations. The specification of how our present culture uses the VR term is important to this study because it is used by the participants and in the literature, often in an attempt to describe or understand a VE.

17) *ASCII*, Stands for American Standard Code for Information Interchange and is the generic representation of alphanumeric characters in computer text files.

18) *CAVE*, or Computer-Assisted Virtual Environment, is a 10 X 10 X 9 foot room that provides an unencumbered VE experience with surround sound, interactivity, and 3D imagery that is projected on three walls and a floor. The room can hold a number of viewers at once, which make it feel more like a theater than a one person visualization tool.

CHAPTER 2

LITERATURE REVIEW

VE Technology

Virtual environments are synthetic sensory experiences that communicate physical and abstract components to a human operator or participant. The synthetic sensory experience is generated by a computer system that one day may present an interface to the human sensory systems that is indistinguishable from the real physical world (Kalawsky, 1993, p. 4).

In order to study the process of creation for an artist constructing a virtual environment work of art, I considered what researchers in the field of virtual environments define as such. According to Kalawsky (1993), a virtual environment (also VE, virtual reality, or VR) is a computer-simulated world in which a person interacts through some kind of interface. The world is made of three dimensional (3D) imagery and sound that change based on the user's *real-time* (30 frames per second) head, hand, or body motion. When the computer redraws (or refreshes) the viewing screen, it reflects the changes the user makes to the environment. In this way, the system adapts to their input.

The synthesized world gives the user a feeling of *presence* or *immersion*. This is the extent to which the viewer feels encompassed in the space provided by the VE, or "the level of personal presence within the synthetic or remote environment" (Kalawsky, 1993, p. 3). The immersion approach to computer interaction gives an entirely different sensation than the one provided by desktop VR, or interactive CDs from major art collections. As noted by people such as

Scott Fisher and Michael Naimark at the MIT Media Lab, "...something qualitatively different happens to you when your sensorium is surrounded than when you are simply gazing at (and listening to) a screen" (Laurel, 1992, p. 204). Unique from other art media, a VE intended as an art installation provides the viewer with a world that they can immerse themselves in.

VE designers base their interface design on how humans and computers interact. Laurel (1990) presents a volume of articles that addresses human computer interface, particularly in interactive multimedia design. Because VEs are a specific kind of interactive multi-media, the artist who makes them considers the viewer and how they will interact with the art. Because a VE is a group of machines and computer peripherals, human computer interface (HCI) design is an important issue for all VE designers. Questions such as *Will the user know what to do with this object?* or *Will the user understand how to navigate?* are examples of interface concerns. Much of this work stems from Don Norman's *The Psychology of Everyday Things* (1988). He has since addressed the issue of creating machines that fit our minds, rather than make us adapt to poorly designed interfaces (Norman, 1993). As with HCI research in general, Norman's work is specifically pertinent for an artist who wants to consider how the viewer will interact with the artistic VE.

True VE

According to researchers in VE technology, to be a true VE, the world must be immersive, interactive and adaptive in real time, stereoscopic with true 3D graphics, and provide a multimodal interface (Durlach, presentation August, 1995). By *presence* or *immersion* I mean the extent to which the viewer feels encompassed by the space provided by the VE, or "the level of personal presence within the synthetic or remote environment" (Kalawsky, 1993, p. 3). The

interactivity is defined by the human-computer interface that the user may manipulate to give information to the computer. A true VE provides some kind of tracking device that traces the head and hand movements of the user. The computer in turn responds, usually with a display screen refresh, to the user's input. One example is an environment that changes the display to reflect the orientation (or head location) and position (or spatial location) of the user's head and hand movements. In some environments, the user may interact with objects using the mouse, joysticks, spaceballs, and gloves. In this way the environment *adapts* or responds to user input. The changes happen in *real time*, or about 30 frames per second. This means viewers will see an instant response to their movements. Many computers can handle non-interactive 3D graphics that are rendered off line or simpler interactivity with 2-D graphics, but interactivity with true 3D graphics requires more processing power. 3D graphic objects are made of many polygons, all of which must be redrawn at 30 frames per second for every change the user makes in orientation or position. For each frame, the computer calculates the new display based on the original geometry of the object, and as a result of user input. With *stereoscopic* 3D graphics, the system must process twice as much information because there is a display for both the right and left eyes. This requires the computer to twice redraw millions of polygons per second, along with the associated textures and lighting.

Immersive environments are often associated with head mounted displays (HMD). The role of an HMD is to provide an uninterrupted stereo view of the virtual world to the user. This means the HMD provides a display through two small screens, one for each eye, and it is uninteruptable because the HMD shields the user from viewing the physical world. Because the user attaches the HMD to their head, it must be lightweight. A heavy HMD may hinder the user's feeling

of presence. To keep the weight down, the display electronics are encompassed in a separate system that processes the frames and projects them to the HMD.

The view the user gets in an HMD is redisplayed for every head tilt or pan (yaw, pitch, and roll). The user's head orientation in the VE is represented to the system as coordinates, and are usually tracked with an electromagnetic tracker attached to the HMD. If the tracker and processor are fast enough, the user will see the synthetic world updated in response to their head movements. This, along with position tracking (often with a mouse, a glove, or a joystick) are devices that help provide the user with a sense of presence in a "realistic" virtual environment.

The thrust of research in VEs is focused around industrial applications, hardware, and software development. Researchers are moving toward understanding the psychology of how humans act in the VE, but not within the arts. The National Committee on VR Research and Development lists this and other research (Durlach & Mavor, 1995), as does Carande (1993). Other applications in entertainment, training, hazardous operations, visualization, manufacturing, education, entertainment, marketing, medicine, and industry are described in Vince (1995), Loffler (1994), and Wexelblat (1993). These books present a series of articles on projects and ideas connected with them. Loffler and Wexelblat mention a few works of art made with the VE medium.

Kalawsky (1993) presents a computer scientist's view of VE concerns. In great technical detail he gives his definition of a VE and its associated terms, VE history, human physiology and perception in a VE, the interface of a VE to humans (through visual, auditory, and kinesthetic peripherals), software for construction, and limitations of the current technology. Another definition of a VE may be found in Durlach & Mavor (1995). This is a report, prepared by the national research council, committee on virtual reality research and

development, defines a true VE, associated terms, specific peripherals, applications, and recommendations for further research. A *true* VE, according to the committee, is immersive, interactive and adaptive in real time, stereoscopic with true 3D graphics, and provides an interface that works with more than one sense. This book does not recommend research in art or education. My research questions their definition of a VE in the world of art, and their view of pertinent applications for it.

Creative Process

The creative process for an artist making a work of art is complex, multifaceted, and often contradictory. Creativity, or the system of creativity is often broken into a four part system (the four *P*'s); product, process, person, and place. The four *P*'s are defined in many ways in many places, for example Sternberg & Tardif (1988c, pp. 429-440) and Simonton (1988, pp. 386-428). Simonton differs slightly from the conventional four *P*'s and calls the fourth *P* persuasion, a social phenomenon. I don't mean to imply that this four part system is exclusive or conclusive, however, it provides a frame from which to focus my concerns. Although my focus is on the creative process (the act of making art) and person (or the individual, or in my case, the artist), the product (or final work), the place (or the environment) are inherently and inexplicably intertwined. In a theoretical situation, all four parts to the system would be predictable, and imply an exact aspect of the other. In other words, a certain personality (person) would produce (process) creative objects (products) given a specific set of circumstances (place). Of course this simple interaction of elements is far from practice. It is actually much more elaborate than the definition of creativity alone, on which, incidentally, even researchers of creativity can't agree. I will therefore begin by illustrating a few definitions of

creativity, and end with how these definitions informed my exploration of the creative process. The other three *P*'s, person, place, and product, will naturally emerge as part of this illustration, and ultimately the thrust of my research.

According to Webster, creativity is an ability that includes artistic or intellectual inventiveness. This definition is close, however I believe artistic and intellectual abilities are not necessarily separate, and that IQ tests are not necessarily connected to intelligence. This distinction is important for my study because I interpreted creativity as an action in which a person may use intellect as an artistic tool towards an art work, much in the same way a person uses intellect as a problem solving tool in science. The creative ability that Webster states is in reference to humans, although I believe animals display this capability, as do machines (See examples in McCorduck, 1991 and Sims, 1994, pp. 28-39). For example, a computer may display creative "behavior" through intelligent code. By intelligent code I mean a computer program that produces original solutions to a problem or exhibits "behavior" that is based on simulation of intelligent systems in nature such as neural networks (see Wasserman, 1989) or genetic algorithms (see Goldberg, 1989). These are examples of the broader field of artificial intelligence (AI). In 1987, the first conference on artificial life (A-life), a most recent relative of AI, was held in Los Alamos, New Mexico. During this conference, researchers defined A-life as artificial organisms that mimic natural selection, "reproduce" based on inherent instructions, display highly complex (unpredictable) behaviors, and self organize their complexities (Turkle, 1995). These behaviors display artistic and intellectual inventiveness, but are they creative? If an artist creates a computer program that responds to environmental factors to produce a work of art, is the work of art created by the computer, the artist, or both. If a scientist creatively solves a problem by evolving her ideas in response to her observations of the physical world, did

nature solve the problem, did the scientist, or both. I'll leave the answer to this enigma up to the reader.

Morgan (1953) surveyed the literature on creativity and found 25 separate definitions, all with only one common element. He found that creativity, if nothing else, is the development (by a person) of something (a product) unique. Walberg (1988) questions the criteria of uniqueness and who determines what is unique. If an idea is a first encounter for an individual, is it creative for them? Or, should the world determine relative uniqueness. Should re-discoveries and variations on a theme be considered unique? Is anything ever new?

Some believe that nothing is ever new, that an apparently new idea is simply a recombination of existing elements (Lowes, 1927). This is a rejection of the *ex nihilo* problem, or the idea that something comes out of nothing. Perkins (1988) backs the idea of *ex nihilo* and argues that the recombination of found elements in and of itself, is creative. He also takes issue with ideas like Plato's that claim that creativity is *Deus ex Machina*, or the Machinery of the Gods. This term comes from a technique often used in theatrical productions in which the stage hands thrust gods, ghosts, or other spiritual entities on to stage via a web of pulleys, machines, and platforms, thus a machine that produces the gods. The play producers display an abstract idea like a god with an ad hoc mechanical device that the viewers never see. In terms of creativity, the abstract idea is the cause of creativity, and the device is, according to Plato, divine intervention. On speaking to him about his poetry, Plato (through Ion) told Socrates that his poetic creativity came directly from a god, and it was the role of Socrates to convey the divine words.

Socrates: ...and that the poets are nothing but interpreters of
the gods, each one possessed by the divinity to
whom he is in bondage. And to prove this, the

deity on purpose sang the loveliest of all lyrics
through the most miserable poet. Isn't it so, Ion?
Don't you think that I am right?

Ion: You are indeed, I VOW ! Socrates, your words in
some way touch my very soul, and it does seem to
me that by dispensation from above, good poets
convey to us these utterances of the gods (Plato,
1961, p. 221).

Plato stresses that the poet is possessed by a deity, and the words he produces are the words of the god. As Perkins (1988) points out, the *Deus ex Machina* answer to creativity gives credit to an outside force (environment, or place) and for Plato, the outside force is divine.

Aristotle's idea of creativity is polar opposite from that of Plato. For Aristotle, creativity is a purely rational act accomplished by the individual. It follows directly from the laws of nature, and it is often spontaneous, or by luck, and sometimes directly traceable from the natural product. In the case of art, the source of creation is the soul of the artist. "...but from art proceeds the things of which the form is in the soul of the artist. (By form I mean the essence of each thing and its primary substance)." (Aristotle, 1928, p. 792). The soul, for Aristotle, is the essence of the rational knowing self. The soul is not concerned with the spirit, which is the side of humans that is irrational, and does not need physical proof for an idea. Contrasting Plato's idea of the external and divine cause of creativity, Aristotle's idea of creativity is internal and rational.

In addition to the *non ex nihilo*, *Deus ex Machina*, and other "non-answers" to human creativity, Perkins (1988) presents his idea of creativity as a trait in a person and the characteristics we recognize in that person. The person continually (not once) produces novel "outcomes" (ideas, products, jokes, etc.)

that fit the given situation. Further, he says that creative individuals “tend to be autonomous, independent, and self-reliant, as one would expect. They value originality, tolerate ambiguity and uncertainty, and have an aesthetic appreciation for things rather than just a pragmatic mind set, and reveal strong intrinsic motivation in pursuing their projects.” (Perkins, 1988, p. 379). To support the idea of intrinsic motivation, Amabile (1983) termed the *intrinsic motivation principle of creativity*. She found that people are most creative when they are motivated from within about the work itself, and not from outside pressure, such as rewards. Amabile also found that the creative person has an intense love for the project or thought that they are involved with. Both Amabile and Perkins get to the question of creativity through the person, however Amabile connects the person to a larger system that interacts to mold the them.

Like Amabile, Csikszentmihalyi approaches creativity through a larger system whose factors are dependent on each other. In this sense, he looks more for the *Where* than the *What* (1988b). In other words, he is not interested in defining the creative person, or determining which product is creative, but he wants to know where the creativity comes from. He defines domain and field as determinants of the cause of creativity. The domain is the culture that preserves the idea, and the field are the gatekeepers, whom select the new variations worthy of preserving. Thus, creativity is inherently dynamic, and constantly dependent on a changing environment. As a result, the creative product and person is defined by the domain and field, a form of the place.

Other writers stress that the product is not a necessary element of creativity. They say that creativity is in the thought, and the thought may or may not produce a product. This view is often proposed by cognitive psychologists such as Newell, Shaw, and Simon. Their four part check list for creative thinking offers a useful measure for the creative idea.

1. The product of thought has novelty and value for the thinker or for the culture.
2. The thinking is unconventional in modifying or rejection previous ideas.
3. The thinking requires high motivation reflected in persistence and intensity.
4. The problem solved was initially vague and ill-defined, so as to require reformulation (Newell, Shaw, and Simon, 1963, p. 44).

Basically they say that the thought is the product, and the thinking is novel for the culture or the thinker. The new thought may update or deny an older idea, but it is the approach that is unique. If the thought branches from another idea, the original problem was not clear, and the solution required the thinker to reform the problem.

Whether the product is a thought or a painting, researchers most commonly attribute creativity to it if it is novel. Amabile & Hennessey (1988), Sternberg (1988b), and Weisberg (1988) assess novelty and other aspects of the creative product.

Especially pertinent to the moment of creation for the individual is her flow. Csikszentmihalyi defines the *flow* as an optimal experience, “when the information that keeps coming into awareness is congruent with goals, psychic energy flows effortlessly” (1990b, p. 39). The flow state is characterized by eight components that I see as partial conditions (not all sufficient, or even necessary) related to a successful work of VE art. The pertinent components for individuals in the flow state include a belief that their goal is reachable, their ability to concentrate, their goals are clear, they receive immediate feedback, they forget everyday worries, they have control over their actions, their sense of self

(hunger, for example) disappears, and their sense of time is altered. To examine the flow state, Feldman & Csikszentmihalyi (1994) present an approach to explore creativity in general from which I have culled elements to look at VE art construction in particular.

I reviewed a few (out of infinitely many) definitions of creativity, and in doing so, issues of place, person, product, and process emerged. The actual creative process then, is best stated in terms of the four *P*'s, however it is still a function of an action that exists at a point in time within an individual. In my research, the components of creativity manifested as forms of the person, process, place, and the product. My question surrounding the point in time of the creative process for the artist constructing a VE work of art touched on many of these ideas and raised questions such as: Did the hardware and work place (tools and environment) effect the ability to create in any way? Did it effect the product? My work explored how the theories of creativity presented here resonate with the experience of an artist creating a VE work of art.

Art Education

Because the artist who makes a VE constructs a setting, she will inadvertently create the context for the work. This set up is interactive and will inherently involve the viewer, thus the artist must consider how the viewer (or user) will perceive the work. For the artist creating the VE art, it is helpful to consider the viewer as someone trying to make sense of the new VE. People make sense in general through mental structures that they construct about the world. These structures create a context for stimuli that help the person understand it (Hochberg, 1977). This understanding is perception, or "the intentional formulation and testing of sensory expectations or mental structure" (Hochberg, 1977, p. 169). Cognitive theory says that we learn rapidly through

context, and we attach meaning to non-verbal symbols through this setting (Gombrich, 1982). This is slightly different from Gestalt theory, which states that we make visual sense of the world through the relation of figure and ground. Within that relationship we perceive the most discernible object. This is known as the “simplicity principle” (Hochberg, 1977, p. 156), and it differs from Arnheim’s “visual thinking” (1969) in that there is no memory component attached to the perception. In other words, the information we hold about an object is strictly formal (Hochberg, 1977). VEs in general help define conditions of learning visual meaning through the way in which the VE artist sets the world up. This forces the artist to consider human computer interface (HCI) research, or the context of elements for the viewer.

These perception theories may in part be traced to Piaget. His cognitive development theory is based on the human desire to make sense of their world (1971). He believed that people act on their biological instinct in order to comprehend their environment. In addition, he said that *maturation*, the accumulation of knowledge, forces people to make changes in their thinking process. He believed that the individual ultimately learns through *acting* on their environment. Because a viewer of a VE work of art experiences different motor and perceptual constraints from anything they have thus far learned, the VE artist must, whether consciously or not, give consideration to Piaget’s four stages of development; sensorimotor, preoperational, concrete operational, and formal operational. In fact, a VE does not necessarily have to be a logical world that mimics the physical world which we are already familiar with, but it actually goes beyond that. Not only is VE technology not presently capable of an exact replica of our physical world, an artist has license to completely redefine that world in his or her art. In her presentation for the panel that addressed spirituality in cyberspace, Char Davies, a VE artist, made a clear distinction

between the terms *virtual reality*, *virtual environment*, and what she calls *virtual space* (SIGGRAPH panel *The soul of the machine: The search for spirituality in cyberspace*, presentation, August, 1996). For Char Davies, *virtual space* more closely describes her art because it does not imitate the physical world that we already know, but a realm in which ground, sky, wall, time, up and down is ambiguous. Thus, on the surface, a VE is an opportunity for the artist to create environments that will tap the cognitive development of a target audience. Beyond that, however, I see a broader link to VE through these four stages of development. I do not see them as linear, all inclusive, or delineated by age categories, rather the individual who creates and experiences a VE will be forced re-visit these stages as they “navigate” the new sensations provided by the media. These stages will not be separate, ordered, or slow as in a child’s initial learning experiences. Instead, an adult viewer or artist in a space, such as one created by Char Davies, is forced to reconsider basic perceptions and motor abilities that were hitherto obvious.

The capability of the VE artist to create an uninterrupted, or engrossing experience is another way he or she considers the viewer. Because a VE is interactive and immersive, the VE designer must consider how the viewer will act. The viewer can’t passively absorb the art, rather she will be forced to interact at least on a basic level which alone adds to a higher level of immersion. Additionally, VEs with an HMD or another kind of surround imagery ensure an interruptable experience. The importance of this type of encounter is based on John Dewey's (1934) position that one learns through experience. The experience must be *whole* and include an interaction. When his experience is disrupted, the viewer’s encounter with the art may not be absorbed or it may become disjointed. In the disrupted case, the art is experienced by the viewer, but he does not have *an* experience with the art. By *an* experience, Dewey means one

that is complete and not interrupted, otherwise the experience becomes parts that are disjoint. In being disjoint the viewer misses an inexplicable quality that often only the whole may provide. Dewey explains the continuity of our experiences in living, and then contrasts them with one that is broken up:

Experience occurs continuously, because the interaction of live creature and environing conditions is involved in the very process of living...Often times, however, the experience had is inchoate. Things are experienced but not in such a way that they are composed into *an* experience. There is distraction and dispersion...(Dewey, 1934, p. 35).

In terms of the art encounter, for the viewer of a work of art to have *an* experience, it must be interactive and whole. For inanimate works such as paintings, the viewer may add the interactivity and create a whole and uninterrupted experience. Unfortunately, many people today do not know how to have this experience, they have grown up with a constant feed of animated commercials and sound bites. They have not learned many of the subtleties of visual communication. However, the immersive properties, or surround sound and imagery of VE works of art help facilitate the kind attention that is necessary to animate the work of art in the viewers mind. In accordance with Dewey's ideas, it provides a less distractible yet physically interactive work of art that not only holds the viewer's attention longer, but speaks a visual language that people today are familiar with. From the familiar an artist or educator can build a bridge to the unfamiliar, more subtle visual experience. The interactivity and immersive qualities, therefore, present new aesthetic considerations for the artist creating a VE work of art. My research on the creative process of an artist making a VE work of art explored some of these considerations.

In another part of my research I mentored both myself and two other participants, and for that, I considered different ways in which people learn.

Because I believe creativity can be nurtured, it was helpful for me to understand how to teach or nurture using different learning styles. Strong's *Questioning styles and strategies: procedures for increasing the depth of student thinking* (1986) is one book that outlines these basic styles. Strong looked at Jung's (1921) work on how people think, and compared the similarities and differences. He then presented the work of Myers (1980) who pinpointed a number of different learning styles. Strong finally pointed out why it is important for a teacher to acknowledge these styles and some methods of how to address them through teaching. Although I did not incorporate these methods as a recipe, the ideas informed my sensitivity to my participant's individual way of thinking.

The VE artist creates a world that is interactive and immersive, and through this, considers the viewer in a new way. For this reason, the artist must re-consider contemporary ideas about perception. In considering the viewer's perception of sound and imagery in a VE, I believe the artist re-lives an accelerated subset of Piaget's four stages of development. In navigating the final work, the viewer also partakes in this questioning of mental and physical perception. Another way the artist considers the viewer is through interactivity. Because the VE artist makes a space that the viewer at minimum must navigate through, she now must think about *how* the viewer can get around the digital space. This also leads the artist to reflect on providing an uninterrupted experience for the viewer. Finally, the research project required me to address the differing learning styles as I taught VE construction and nurtured creativity.

VE Art

Because VE is new, the variances of the creative process for VE works of art are mostly unknown, however there are a few artists and art centers that have created VE works of art. In order to inform my observations, I examined essays

about and by a few artists who have made VE works of art. The Banff Centre for the Arts recently completed a three year program that explored art and virtual environments. The artists that participated in the program developed the new skills necessary to create digital work. From these skills and a multi-disciplinary team, the artists created VE works of art. *Art and Virtual Environments* (Moser & Macleod, 1996) presents nine works produced for this project, along with essays and statements by the participating artists. Macleod points out the new relationship between the viewer and the viewed, and how the viewer becomes part of the performance of the work. This project in general focused on understanding VE as a new medium, not by itself, but as a part of contemporary culture. Rather than the melodramatic concept of VR that the media has conjured up, the artists in the Banff project were concerned with new perceptions and aesthetics in a “less sensational” VE (Moser & Macleod, 1996, p. xviii). In other words, they meant to look at the state of the technology and actually apply it to art, rather than make up hype akin to fantasy VE technology and delinquent human-like computers. One new aesthetic they considered is time. The viewer in a VE does not know of a duration or, like a movie, an amount of time it will take to view the work. Instead, the viewer is more of a user, and they interact in *real time*, where they consider and understand the piece as he both acts and interacts with it. Time thus takes on a new dimension.

Another new aesthetic considered during the Banff project was disembodiment, or the argument that the viewer leaves their awareness of physical self behind as they experience the VE. An essay in *Immersed in technology* (Hayles, 1996) challenges the notion that we leave our material self. In fact, Hayles argues that we are never disembodied, that we still have our material self in our physical world, and this informs and gives stability to our unnatural perceptions with a VE. She further mentions that the rejection of the

physical self in the VE experience represents the view that mind is higher than the body, a relationship that echoes masculinity over femininity. “The dualities line up as follows: mind is superior to body; silicon technology is superior to protein organism; man is superior to woman” (p. 4). She concludes that the VE experience is both of mind and body, even if we perceive physical interactions that are not natural to our physical world. This consideration, along with many others, such as creativity, are addressed by the Banff project through essays and the descriptions of the nine VE art works (Moser & Macleod, 1996).

Besides looking at the VE works of art from Banff, another way to understand the creative process of VE construction is to compare it to the process of performance art. Because a VE work of art is realized at the time the viewer approaches and acts with the work, the VE installation encompasses elements of performance art. In performance art, the exhibition becomes the creation, much in the same way the creator (and viewer for that matter) partake in the process of creation for a VE work of art. Phalen (1993) addresses the process of performance and its politics, and extends these issues to other art forms. Paley (1995) presents a series of works in which the creator performed in some way. Each work is presented by the descriptive voice of the artist, and by multiple views of others who experienced the work. The book itself is a performance, a text that may be explored as another layer of a dynamic creative system. This creative system is similar to that which the VE artist and viewer partake in, from the artist's inception, to the viewer's experience.

Char Davies and Rita Addison are two currently active and influential artists working with VE technology. Both work with a multi-disciplinary team of people, and both are working towards unencumbered, or wireless VEs. The team and collaborative nature of their work is key to its execution.

Char Davies is well known for *OSMOSE*, a virtual space that is meditative and based on full body immersion. Unlike other VEs, the work is solitary, or doesn't depend on the interactions of others for the experience. The work defies a sense of ground and sky and other such intuitive realities of our physical world, hence helps the viewer explore their own consciousness and truths. Char Davies is working on new projects with a small team of people in a lab at SoftImage in Canada.

Rita Addison is known for her CAVE experience *DETOUR: Brain deconstruction ahead*. This work was on display during the 1994 Association for Computing Machinery's SIGGRAPH (Special Interest Group, Graphics) convention in Orlando, FL. and is permanently installed at the Electronic Visualization Lab (EVL) at the University of Illinois in Chicago. This work explores Rita's reality of her mental capacities both before and after a car wreck. The presentation leaves the viewer with an understanding of such a transition that only an experience with the VE can explain. Rita is currently working on a new project with David Zeltzer at MIT.

Both Rita Addison and Char Davies are two of a handful of artists who have created and still create VE art works. Both artists have financial support for their art from major institutions and have other team members to work with the technical aspects. These artists epitomize the current state of VE art.

Both the performative aspects of VE presented by Paley (1995) and Phelan (1993), the few examples of VE art presented in *Immersed in technology* (1996) and contemporary work by Rita Addison and Char Davies inform aesthetic considerations for artists constructing a VE work.

CHAPTER 3

METHOD

General Method

My primary research question examined the ethereal process of artists creating a VE work of art. This study followed a *phenomenological* model in which the researcher attempts to understand the meaning of an event, person, or process to people in a given situation (Bogdan & Biklen, 1992). The specific instance of the phenomenon is a *case*. A *case study* is the analysis of a single case as it is embedded in a system (Denzin, 1989), and the case is the *bounded system*. The *bounded system* is a case that “is an examination of a specific phenomenon such as a ...process.” (Merriam, 1988, p. 9). For this study, the case was the experience of creativity for artists constructing an artistic VE. The experience was the bounded system, and it included myself and one other main participant and two secondary participants. The participants were purposefully sampled for their experience and maturity as computer artists. I acted as a mentor and teacher for both of the main participants and used a narrative method for collection, analysis, and presentation of the data. By mentor I mean a person the participant may share and reflect ideas with. Specifically, for data collection, I used *the personal experience narrative* (Denzin, 1989, p.43), which necessitated myself as the key data collection instrument. The many forms of narratives which were treated as data included pre-histories, daily reflections, and final reflections by the participants, and observations and interviews by the researcher. This qualitative method provided vivid descriptions of the artists’ process of creation.

On Narrative Data

Both my data collection and presentation are forms of a narrative. This provided rich insights to the internal nature of the creative process, or how it came about in the individual making a VE work of art. For the data collection, I used the *personal experience narrative*, a form of the *personal story*. A personal story is a narrative that people tell about themselves to others. As they do so, they construct and define themselves within the context of the interaction with their audience. Because they are tied to the self, I believe personal stories will provide information on the creative process that external stimuli cannot simulate. By external stimuli I mean a series of questions, or some such set-up by the researcher to prompt the participant to give information. Stories, on the other hand, are more natural to us, after all, “humans are storytelling organisms who, individually and socially, live storied lives” (Connelly & Clandinin, p. 2). The idea to have the participants expound their personal stories in addition to the researcher’s observations and analysis is *postmodern*, as it places meaning, thus power, within the knowing and telling of the participant’s world perceptions. A particular form of postmodernism, *poststructuralism*, embodies the notion that language and stories produce meaning and create reality as they are spoken or written (Richardson, 1994). As people live, they create a text based on experience, and as they tell of their experience, they reflect on themselves, construct, and retell their essence, and ultimately, define their experiences. According to Mishler (1986), this contrasts with short responses to narrow survey questions, which may suppress narration. Even when the survey question elicits a longer response, the analysis may ignore rich contextual information. I do not mean to denounce the survey, as it provides a wealth of information, but information framed by the researcher. The data generated from the personal

story was especially important for this study because the creative process is so individual and ethereal that it transcends tight categories. Instead, the data helped form an analysis that was an interaction of the researcher and the participant, which resulted in a document with many equal view points (Manning & Cullum-Swan, 1994).

Personal stories are forms of narratives, either written or told, that include the listener or reader. Some of the data generated for my study were written personal stories. When a story is written down, it becomes a text, which can then be studied. Once studied, the text takes form and meaning independent of the author and the person telling the story (Denzin, 1989, p. 41). This de-centers the author, as he or she is not fixed, but everywhere and nowhere within the text. Derrida (1981) argues that all the words of the text carry traces of other words, symbols, and signs, and their meanings are only apparent through the *difference* of the written word and all its traces. This implies that no work is ever final, as readers create the text and re-center the subject through interactions of the text, the author, and themselves. This is important for readers of the creative process description because they will be able to position themselves in the participant's frame of reference and contrast it with how they may apply it to their role as teacher, artist, or designer. As time moves forward, so will much of the meaning of the text. For example, the artist who makes digital art now must first hurdle technology that may be foreign, or even overwhelming. For many of the artists, it is their first exposure to the computer. Children today are born into a world of computers, and the concept of using the technology for numerous applications is comfortable. In fact, many kids grow up playing computer games and create comfortable and pleasant memories using computers. For this generation, the step to the computer art tool will not be so omniscient and the creative process for them will have a different form and meaning. This is one reason why the

creative process with the digital medium is an experience distinct to each person, one that the reader may cull applicable elements from. My desire to preserve this meaning and the importance of the artist's creative process for the reader helped motivate my display of some of the participant's unedited personal stories.

The form of the personal story that I used in this study was the *personal experience narrative*, a narrative in which the person told about her or his personal experiences with VE construction. According to Denzin (1989, p. 43-44), a personal experience narrative, like a story, has a beginning, middle, and end, and a set of events that happen outside of the telling. The pivotal experience is the center, and it optionally includes the self. The focus of this type of narrative is a common experience, like that of the creative and learning process. For my study, the narrative preserved whole meanings of the creative and learning process in which individual terms carried traces of other terms. The focus of the narratives in my study was the everyday experience of learning the construction of, and applying creativity to, a VE work of art. The pivotal event was the decision to make such a work of art.

Procedures of the Study

This study is a collection of narratives about the creativity and learning connected with building a VE work of art. Because the case under study was the *experience* the artists had with VE construction, both the researcher and the participant produced stories that took the form of personal experience narratives. Because the stories constantly reflected back on and were a product of the previous text, the narratives were the method of data collection, but also contained analysis. Based on how the telling of these stories defined meaning and how that meaning was constructed from other narrations, much of the

analysis was inherent in the story. This is similar to the *progressive-regressive* method of data collection and analysis, as it begins with a key pivotal event and works forward and backward from that event (Denzin, 1989, p. 67). Besides the pivotal event, this method includes a pivotal meaning structure, or something that defines the actions around the event. For my study, the key event was the decision to learn about and create a VE work of art, and the pivotal meaning structure was the everyday experience associated with learning and creating the VE. In the pivotal structure of learning and creating I discovered the descriptions of the creative and learning experience.

In addition to the major elements of the key event and the pivotal meaning structure, this method also provided the means for understanding how the event became important to the participant, how the meaning of the event changed over time, and what the event might mean to the society surrounding it. For my study, I examined how the VE form of art became important to the participants, what their preconceptions were, and what meaning work in this medium had for them. The study also looked at how the importance, conceptions, and meaning of the VE medium changed for the participants as they learned and created. Finally, this study attempted to make connections and see how these ideas may apply to the larger art community.

The first part of the exploration of the experiential phenomenon was the critical study of relevant aspects of myself as the computer artist. This necessitated my role as participant and researcher, using personal narratives as the data collection tool. These personal narratives served two purposes. First, they illuminated my perspective as the researcher for the reader. My perspective included the way I described the creative process, my background, and my learning process. The description of my background framed the meaning of my learning and creative process for the reader. Second, the self study helped me

understand the experience of learning and creating a VE. This gave me insight on how I served as a mentor to my other main participant, and gave me first hand experience with how it felt to go through the learning and creative process of VE construction. It also gave me insight into the processes of my two secondary participants and I was better able to frame questions and understand their stories. There are many ways to construct a VE, and many different tools to use. The self study helped me cull a subset of tools that I presented to the participant in order to make his learning more efficient and creativity most fruitful.

In using myself as a participant, I assumed the roles of researcher and participant. This was similar to a technique used by Juanita Johnson-Bailey (1994) in her study *Making a way out of no way: an analysis of the educational narratives of reentry black women with emphasis on issues of race, gender, class, and color*. Johnson-Bailey interviewed eight women for her study and used herself as the first study. Johnson-Bailey treated the interviews as oral histories, in story form. By telling her educational narrative first, she experienced her research procedure and illustrated her world view for the reader. For my study, I first wrote a pre-history of my art background, how I came to my decision to create a VE work of art, what new things I hoped to accomplish, and why I wanted to learn about and create VE art. Finally, I described what I thought my final work of art would be. This initial personal history served as a literal way of “looking back” and “looking forward” (Denzin, 1989, p. 67) from my point of entry into VE construction.

Next, I taught myself to select and use the necessary software, hardware, technical, and aesthetic elements necessary to realize a VE art installation. During this process, I wrote a daily reflection of items I learned and struggled with, how my artistic ideas manifested or died, and how my aesthetic concerns

developed. Like the pre-history, the daily writing provided another level of analysis through reflection backward and forward.

After my VE construction was complete, I wrote a final reflection, a form of the personal experience narrative, of the learning and creative process. The daily reflections and the personal history narrative served as the basis for this writing. The final reflection included a description of the art, my feelings about the VE art medium, my feelings of my artistic successes, new aesthetic concerns, new ideas for the future, and elements that emerged in the creation experience that I felt I wanted to elaborate on. This writing was a natural abstraction of the first two, the initial personal history, and the daily reflections. All three components of the self study portion, the pre-history, the daily reflections, and the final reflection, were participant documents in which I played the participant role. The final reflection document was an abstraction of the first two parts and hence it embeds part of this study's analysis, as I believe is the case with all participant documents. This is another major reason to display most of the pre-history and some of the final reflection in the analysis section.

The second exploration of the VE construction experience involved a study of another digital artist. The structure of this portion was like the one of myself. However, it differed in that I was the mentor and the digital artist was the participant. The data collection was mostly identical, however, I also took daily observational field notes. Also different was that the participant gave his final reflection in the form of a conversation rather than a written essay. The conversation was between myself and the participant and was not conducted like a formal interview. However, it was focused around a reflection of his VE work.

To teach the VE construction, I used the mentor and student model as opposed to that of the researcher and participant, and I analyzed that interaction through my daily observations and the participant's daily reflections. The

mentor model reflected how I supported and was a part of the participant's exploration. This was instead of providing him with a pre-defined tutorial for me to observe from the outside. The participant's daily reflection narratives, personal history, and final reflection narrative served as the artist's uninterrupted story of his learning and creative experience.

My choice to use this structure between myself and the participant in part two was two fold. First, I wanted the participant to feel as if he was in a natural learning and creative situation with the digital media. I felt this was the optimal way to encourage the telling of his experience. As Riessman (1993) points out, it is necessary for the researcher to facilitate the telling of the participant's story. Unlike a formal interview, my observations and our conversations were at the source of the creative process and a normal part of the mentor role. Because the participant's daily reflections, pre-history and final reflections were a natural part of the learning and creative process, I felt it was a rich source of data.

As a computer art educator, I encourage my novice computer art students to reflect on their history as mature artists in other media. After ten weeks, I ask them to reflect backwards on their new identity as computer artists. This requirement grew as I watched them struggle to define themselves in this new medium. I see a similar function for the pre-history and final reflection in this study.

Second, I wanted the participant to have a voice through his reflections (pre-study personal history, daily reflections, and post-study conversation), unencumbered by my agenda. Because I spent time with the participant as his mentor, I was able to make the essential observations within the process of our interaction. My intention was to observe the artist's creative process in its natural setting after having experienced a similar procedure myself.

The last part of this study was my research about the creative process of two VE artists that worked as a team to create and successfully exhibit a VE art installation. Through conversations in person and via email, I gathered an equivalent pre-history and final reflection from them. In addition, I gathered ideas about their daily processes in our conversations by comparing mine and my other main participant's daily thoughts with their stories. In addition, I physically experienced their VE art installation.

The data for these participants were field notes from my visit, email, and World Wide Web documents. The field notes for the first participant came from a presentation she gave to a conference audience and our casual interactions and conversations over a four day period. This included watching her present her VE art installation.

The field notes for the second participant were from observing him display the VE art work and from spending the following day casually speaking and interacting with him. For both secondary participants, I followed up with email correspondence.

The casual method of data collection was a way that I could establish a relationship of trust with the participants that was more like a conversation between artists rather than an interview conducted by a researcher. Because I experienced a similar process, I was able to share ideas with the participants that they often expanded and took far beyond any question I would have pre-defined.

In watching how they interacted with me I gathered more personal information about ways the artists worked from day to day. This was most evident when I compared my conversational notes with the notes from their video and the conference presentation. Both the presentation and the video were packaged for public consumption, whereas the conversational notes were more

reflective, personal, and detailed. This provided me with a better understanding of their entire creative process, from inception and daily workings to their final work and future aspirations. This information validated many of the results that I found in the first two parts of the study.

Final Presentation and Analysis

In the final layer of analysis, I reread all the text with the aim of making sense of the learning and creative experience with VE construction. I noted emerging themes and differences. After I immersed myself in the text, I created a final narrative that embodied the creative and learning process for myself and all the participants from my perspective. In her study on professional African American women, Etter-Lewis (1993) constructed a text based on oral narratives from nine women. Although the text was minimally reordered, it represented a form of interpretation necessary in all research. My final narrative was similar in that it was a construction based on my interpretation of the data. The interpretation was inescapably subjective, as I assumed meaning in light of my understanding. This is consistent with Barthes's ideas on the meaning of words. According to Barthes (1966/1987), words have multiple meanings based on contextual information, and the interpretation of a character (story, sentence, etc.) is constructed relative to the current society, intellect, and value system. My final summary is a level of abstraction above all the text, and will use the *progressive-regressive* method to reflect forward and backward from the entry into VE construction.

The final presentation of text is in two parts, Chapter four and five. Chapter four includes most of the two personal pre-histories presented in whole, with the daily reflections and the two *ipso facto* reflections woven into the researcher's final abstraction narrative, or summary. I used a similar format for

Chapter five, however, I culled results from the data for the secondary participants with the main participants in mind. In addition, I give a brief background on both artists, their VE art work, and the technology they used. In both chapters, I interpreted and described the data as themes, and presented them as a summary. My thematic analysis was informed by (but not restricted to) the idea of *coherence* (Mishler, 1986, p. 90). This is based on the way the narrator gives meanings to themes as they relate to each other in the text. Coherence exists on a local, global, and themal level. Every time the participant tells a story, the meaning of the words correspond within the particular text, but they also build on prior stories. The building elicits themes and patterns. I examined the text for all three levels, and my final layer of interpretation encompassed these narratives, much in the same way the artists incorporated global coherence in their narratives. In other words, analysis in the texts generated during data collection took shape in the telling and retelling of the artist's personal experience narratives. As they reflected on their work and their personal art history, the artists defined, and redefined their creative process. My intention in the final layer of abstraction was to make sense of the artist's experience using the idea of coherence.

In short, the final data presentation consists of two chapters. Chapter four is a summary of the two main participants and is interlaced with my observations, the participants' final reflections, and most of their pre-histories. The data consisted of both participant's pre and post reflections, their daily writings, and the researcher's daily observations. Chapter five is an analysis of how the secondary participants' data coincided with the main participants. I wrote the final narrative (chapter four and five) only after complete immersion in all the texts. The aim of the final document was to explicate the emerging themes that described the nature of the creative process in artistic VE construction. This

experience was particular to artistically mature artists working with the digital media. The presentation of my analysis (the final narrative) next to the earlier texts (the “raw data”) will give power to both the participant’s voice and the reader’s own ideas, questions, and conclusions.

CHAPTER 4

RESULTS AND DISCUSSION

Introduction

In this chapter I discuss the results of the learning and creative process of making a VE work of art for the two main participants in this study. The ideas presented are based on field notes, discussions, and writings by the participants. I have included most of the two personal pre-histories that each participant wrote. This provides an illustration of how the participants were thinking and what their background was prior to the study. The rest of the data, the daily reflections, final reflections, field notes, and conversations, are included as part of the final abstracted narrative.

I used a similar format for Chapter five, however, the data is slightly different. Rather than the participants providing me with their pre-histories, I constructed them based on their data. The data were mostly email messages and field notes from presentations and conversations. I culled results from the secondary participants' data that supported ideas from the main participants. In both chapters, I interpreted and described the data as themes, and presented them in the final text.

The nature of the creative and learning process for a digital artist making a VE work of art is complex and multifaceted. These elements together are unique to the VE construction process, however, most may be found as separate parts of other processes in the arts and sciences. Of these elements, some are unique compared to the way artists learn and work in contemporary art. Some of my general findings include descriptions of the artists' *flow* experience

(Csikszentmihalyi, 1990b), their technical learning curve, their need to work as a team, descriptions of their thought processes, and their consideration of the viewer in the final work. One of the more intriguing things I found in connection with the flow experience was the point at which the creative process and the aesthetic experience happen together, both for the viewer and the artist, thus blurring the line between the two.

To describe these and other findings, I've compared the creative and learning processes of two VE artists. These are my main participants who I describe in this chapter. In chapter five I present two well known VE artists and their installation. I compare some of my findings from the main participants with this team.

I present backgrounds of the two main participants to provide a frame from which to understand them and to provide a basis for discussion of observations gathered about the them, their work environment, and their art.

Backgrounds of the Main Participants

Although both Max and Margaret had experience in digital art, neither was an experienced VE artist. Margaret had some experience making VEs but had never exhibited one, while Max had no prior experience. They were both learning how to make and fully understand the implications and possibilities of a VE. Margaret spent time prior to this study researching and writing small scale VEs, so she was far from a novice. This was Max's first exposure to making a VE. The environment where they worked was a small room in a university computing support facility. The space was tight and filled with other work stations and people involved with other projects. They used an SGI ONYX with four MIPS R4400 CPUs, a RealityEngineII Graphics Pipe, 256MB of RAM and a large 21 inch monitor. This machine was capable of displaying textured 3D

geometry in real time. It didn't have the capabilities for stereoscopic 3D graphics. In order to make their VEs, they learned how to use a VE tool kit and its accompanying graphical user interface (GUI). The GUI, lynX, was used to set up the basic *fly through* environment and provided default functionality. Fly through refers to the basic ability to navigate through a 3D space in real time. This does not include more complex behaviors such as the ability for a user to pick up an object. Margaret used Vega, the tool kit, to program more complex behaviors and functionality with a library of functions accessible through a C program. They both brought with them prior knowledge about 3D modeling.

Max

Max's art background goes back to his childhood when he liked to draw but preferred building complicated structures with *Lego* blocks. His love of architecture is still with him today as the majority of his computer work is architectural. Max is not drawn to the computer for the sake of using the tool, rather, he uses the computer to facilitate the creation of his end product. In fact, Max considered himself computer illiterate and did not start using a computer until he was persuaded to do so at work.

Although Max had completed graduate and undergraduate courses in art, he never felt he was good at it. Despite this, he felt he was a good photographer. He didn't consider his photography to be art, but he thought his approach to it was artistic. With his digital art, whether 2D or 3D, he meant to portray imagery as realistically as possible, and he went to great lengths to draw attention away from the computer look. His 2D work was a mix of photography and printmaking, while his 3D work was more involved with visualizing spaces and flow in buildings. At first Max was frustrated with the 3D tools. He felt they were either insufficient or too complex. It wasn't until he found that the 3D tools

would apply to his architectural design work that he had the motivation to learn them. He used this same motivation to make a VE, a real time interactive 3D world. He was not interested in making games, but he wanted to make worlds that the user could fly through in order to experience the space. Max's history in his own words:

I always liked to draw when I was a child, but I preferred to build things with the multitude of building sets that I had. My favorites were *Lego* blocks and I constructed some rather complicated structures with the blocks. In high school I took several art classes, but I never felt like I was very good at anything. In college I discovered I had a strong interest in, and liking for, graphic design. Unfortunately the year I was taking my basic art classes was not a good one for me, and I dropped out of school without ever taking a graphic design class. That year also left me burned out on drawing and painting. I knew I wasn't very good at either of them. I should mention that all along photography had been my number one hobby. I felt like I was pretty good at it. I never really considered my photography "art," although I certainly approached it artistically. I have also always been a student of architecture and design. My passion is for furniture and decorative arts... which led me back to graduate school in Historic Preservation.

My Historic Preservation classmates laugh at me now, because when I started the program, I was basically computer illiterate. I had a typewriter at home, so why did I need to come to school to use a computer? One of my classmates took a class in digital photo manipulation, so I decided to give it a try. Just before I took my first computer art class, I had an internship with Athens-Clarke Planning Commission where we were looking at Prince Avenue as a corridor to the

city. My job for the project was to design a logo for the project and to manipulate some photographs in a “before and after” illustration of some of our proposed improvements. Thus began my computer art adventure.

My 2D computer art is sort of a mix of photography and printmaking, and generally I have attempted to mimic traditional media in the appearance of my finished artwork, specifically avoiding a “computer” look. Given my love of architecture it’s surprising I didn’t have a natural affinity for 3D design on the computer. Actually, the Macintosh based 3D programs left a lot to be desired, and I found that I was quickly frustrated by either the inability of the program to perform or my inability to figure out how to get what I wanted from the programs. Specifically, I wanted to avoid the “computer look.” When I was exposed to 3D on the Silicon Graphics Computer in the form of Alias Studio, I was overwhelmed by the sheer complexity of the program and the seemingly unfathomable learning curve. I was also turned off by many of the applications of the program, such as flying logos, character animation, etc. It wasn’t really until early this year that I found how I like to use Alias: for architectural construction and rendering. Creating interior spaces that are photo-realistic has been challenging.

My interest in a VR environment is rooted in my interest in architecture and partially based on game environments that I have interacted with. While I have no particular interest in playing games, I have an interest in the architectural environments that they create in which to play. More recently I have become interested in, and modeled in Alias, some architectural environments. These environments have been rather complicated from a wire data viewpoint, and the challenge will be

to simplify them enough to bring into a VR environment where a real-time interaction can take place.

Margaret

Much like Max, Margaret's art background started in her early childhood, but in the form of craft and cooking projects rather than *Lego* blocks. She, like Max, has had formal training in art and spent her early college years trying to avoid computers. Unlike Max, Margaret had formal training in Computer Science concurrent with her formal training in Art. Although at times the training coincided, they were, in her mind, unrelated. In fact, it wasn't until she finished graduate and industrial work in computer science that she resolved to leave the computer field to pursue her art. Margaret's art and science background in her own words:

It is hard to pinpoint the exact time I became interested in making a VE work of Art. This desire grew when I merged two seemingly disjoint portions of my life, Art and computers (or science). I've always made Art of some form, from candle dipping with my mom on rainy afternoons, to creative "pantry surprise" suppers I made with dad. Art was always there, and was always part of my everyday life, in some form.

In college, the most important courses for me were in Art, but my degree focus was in Mathematics and Computer Science. I chose Math over my first major when my engineering advisor laughed at my intention to take Art courses. Of them he said "You can certainly take such classes, of course, on your own time. They won't count towards your engineering degree, and they will prolong your graduation." I explained that the engineering curriculum had two electives, and I suggested that at least two of my Art courses could be counted in this way. He laughed and said

“No, an elective is a useful class to help round out your education.” I knew at that point I would not be an engineer. The Math professors were more forgiving. In fact, they seemed to me to be artists in their own right. Watching them write elegant proofs was like watching forces in nature create beauty from pure elements. This, I felt, was like a work of performance Art. These mentors encouraged my artistic drive, and additionally, turned me on to computers.

In 1983 I went scared, kicking and screaming to my first FORTRAN 77 class. I told myself that I was doing it for Dr. Taylor. It was my first exposure to computers, and I really didn't want to do it. We didn't have full screen editors then, we used something called Xedit, and our “dumb” terminals were all hooked to a Cyber 185 mainframe computer. This was my first experience with digital interactivity. I hit a key and a green character appeared on my black screen. In fact, I found that if my series of key strokes made a file of FORTRAN 77 code, and if I compiled and ran that file in batch mode, then I got output! I had to know why and how that little green character appeared on the screen, and how this innate object produced answers to calculations that took me days by hand. I was so driven to understand the computer that within two weeks I forgot my computer fears. After four weeks, I declared my minor in Computer Science.

Meanwhile, I was taking college level Art. I didn't know a life without Art, and it was only natural for me to work in photography, as I had since 1979. I had to fight hard for the spot in my first photography course, they did not take nicely (at first) to science geeks. During both semesters of my freshman year I started to more fully understand my commitment towards Art, and I kept my scientific mind out of it. Art was

extraordinarily comfortable for me, and in my sophomore year I declared my minor in Art. By now, work (or play) for my Art courses was my most cherished activity.

Despite its importance in my life, I never considered declaring an Art major. I was raised to believe that Art is something one does on the side. Even though I knew the importance of Art in my life then, I had not grown far enough away from my influences to forget them. Even so, I considered myself an artist, a science geek artist. I did my science on one end of campus, and lived my life in the other. People often told me that I had a future mixing computers and Art. They had all seen the early Macintoshes that booted up with a “happy Mac” face, and allowed the user to draw primitive black lines on the screen. This, my purest mind thought, was not Art. I thought science and computers were too square to be Art. Further, I felt that in my life I would not let the germs of science or computers corrupt my Art.

My roots were still at work when I decided to pursue my MS in Computer Science instead of an MFA. All through graduate school I took courses and independent studies in Art, I think in order to stay sane. After receiving my MS I worked as a computer specialist for a few years. I quickly saw that my commitment to Art required more of me than rainy Sunday afternoons. My job was unfulfilling, and I regretted every day that I had to sit in my cold, grey cubby hole.

In 1992, the roots that caged me finally died off, and I enrolled in an MFA program, with an emphasis in Photography. With my purest mind still at work, I thought computers and Art were separate.

Margaret explained that finally, in 1992, she combined her photographic aesthetic with computers and started to make digital imagery. From there, she

heard, read and experienced VEs, her first at SIGGRAPH in 1993. It was there that she saw the implications VE held for art, and it was at this point she decided to learn about and hopefully make one of her own. Since then, she has learned the magnitude of such a task, yet still maintains her original ideas to make a unique experience for each user and to make that experience whole and undivided. About her VE experience prior to the study she said:

The more I learn about VEs, the more I find I need to learn, and the more I see that researchers in the field still do not have many of the answers. I've also found that most artists that think they have created a VE work of Art have not, and that mostly, our culture at large is confused over what one is.

As I planned from the start, I still want to make a VE work of Art, an Art installation that is unique for every user from experience to experience, and one the viewer will explore much in the same way I explored to create the work. Since the spring of 1995 I have tried to learn on my own how to make a VE. I've written C code using Georgia Tech's SVE (simple virtual environments) tool kit, Performer code (an SGI VE tool kit), and most recently, Vega code (another tool kit). Thus far, I don't feel I have made that work of Art. People may "ooh" and "ahh" when they see what I have created, but it doesn't cross into the realm of experience that I have in mind. So far these are simple fly throughs, and I intend to add more actions and behaviors to my digital objects.

I want the experience that the viewer has with my objects in the VE to be the final product of Art. I see the VE as a work of Art in itself, much like any interactive installation, only this one is digital. I want the viewer to experience things that open their minds, and help them stop to look and think a bit longer. I believe the experience will be immersive and more

whole.¹ My world will be filled with 3D objects that will be textured with my 2D computer pictures. The objects will change based on user interaction, and the viewer will be able to navigate through the space with their object of choice. The world will be filled with my computer movies and 2D images, and the 3D objects will be my digital sculptures. Their experience will hopefully unfold as their unique story, one that above all, evokes a personal level of spirituality. The experience will be unique for all, thus the interpretation and product will belong only to the user that views the work.

It is from an informed mind that I lay out the elements of my future VE work of Art. I know what one is, I've tried to make one, I've looked at Art which the creator thought was a VE (but wasn't), I know how VEs work, I know how to code, and I've spent a long time trying to figure this all out. Even so, I have an enormous amount to learn, and I can't predict my final product completely, however I expect it to be as abstract as I've defined it here. At the very least I hope to realize some sort of artistic VE and to learn about what new creative experiences the VE medium can provide for me.

Analysis of the Artists

Both Max and Margaret are mature digital artists who have not only worked in art for many years, but have incorporated computers into the way they make art. Neither one limits the computer in their art to a few software packages, rather they both make works of art inspired by the computer and its tools, not directed by it. In other words, they start with their ideas and then find

¹ Margaret means whole in the sense of uninterrupted. The whole experience is similar to that described by John Dewey.

the digital tools necessary to manifest them. These two participants were committed to learn how to construct an artistic VE, even though they were not exactly sure of the possibilities and the outcome.

In the three years that I've known Max, I've noted certain things about his nature that pertain to how he works with VEs and computers in general. I've always seen Max as an exceptionally sharp and talented artist. Although he did not grow up with computers, I watched as he discovered them and taught himself how to use them in his art. As Max learned the complex digital tools, he demonstrated elegance and simplicity in his art. Even when his work became elaborate in technique or thought, the overall organization was always clear, accessible, and to the point. Like Max, Margaret did not grow up with computers and went through a similar discovery and learning process. Margaret, however, found computers during her undergraduate years and continued her exploration with graduate study in computer science.

Max was never afraid to admit when he didn't understand an aspect of the computer tool, a rare quality for people in the computer culture. I was reminded of this trait when a recent visiting computer artist told his audience that in order to make it in the computer industry, you should never let anyone know that you don't know a particular package or tool. He said that if you don't know how to use something, you should act as if you do, then be ready to learn fast when you are called on. He said he often found himself crying over the manuals, trying to figure out how to do what he said he could, but in reality had no experience doing (C. Wells, presentation to computer art class, January 16, 1997). Max was different in that he admitted what he didn't understand and this, it seemed, made it easier for him to seek help with the technical difficulties connected with his work.

This, among other characteristics, demonstrates Max's maturity, both towards his art and as a person. Max did not grow up obsessed with computers, another way he is not the "mainstream" computer type. Although now familiar with other platforms, I recall when Max first started using the Mac for his art. He bought the latest computer magazines in an attempt to educate himself on the basics. He did not spend his formative years of thinking about what he could use the computer for next, instead, he thought of it as another important aspect of his art. Although committed to using the computer in his art, he was balanced and able to talk about concerns beyond it.

Margaret, on the other hand, worked more like the visiting speaker, as she was involved with computers for a longer, more intense period of time. In perfect computer culture form, Margaret set off to teach herself how to make VEs on her own, as if she already knew how. Despite this, her motivation was internal, and she was first committed to her art and second, the computer tool. Like Max, she was committed to making a VE, but only as a vehicle for her art.

VE, Validity as an Art Medium

One of the most reputed myths about the artist who uses the computer for art is his or her inability to use the medium as an expressive tool. Proponents of this view argue that the computer makes the product and the artist simply pushes buttons. This, according to some, keeps the artist emotionally distant from his or her work, and is therefore never involved. Max's work is at least one bit of evidence that contradicts this idea. Apparent throughout Max's life was his love for architecture and design. Starting with his love for *Lego* blocks as a child, and continuing through his years of being a student of architecture, one of Max's artistic goals was to create imagery of buildings and space inside and out. He was concerned with the feeling of the space and how his rendition described

movement inside of it. It was no surprise that he carried this aesthetic into his 3D computer images. His work in Alias, a 3D modeling package, and again in making the VE was a reflection of this aesthetic. Despite Max's admitted intimidation by the computer, he was able to manifest the same concerns he had about architecture in his pre-digital work as he did with his digital work. In describing a VE, Max compared it to Alias.

When I'm doing Alias, I'm sort of thinking about a VE. It is the sort of mind set that I have when I'm working. In an architectural space I'm very aware of how things move, how things flow, doors, windows, floors steps. I guess that is how I see a VE.

It is clear that Max was inspired by his love for the space and layout of a building, how it works and how it feels. He carried this artistic concern into his work with VEs, and instead of his sense of design waning, the tools actually enhanced it. The real time interaction gave Max the sense of experience in a space that a static image couldn't portray.

Margaret's work is another piece of evidence that shows the computer, and VEs in particular, can be an expressive medium for the artist. Her artistic vision spelled out in her pre-history had more to do with the whole experience (Dewey, 1934) for the user, and her intention to evoke a personal story and spirituality for the viewer. In the following excerpt from her final reflection, Margaret explained her artistic accomplishments and some future goals for her VE project that also reflect the medium's expressive capabilities. [Portions of the participant's personal writings are indented as block quotes and noted with the initial of his or her name. Mg is for Margaret and Mx is for Max.]

Mg: In the final VE, I wanted the user to consider multiple realities through experiencing art in a way different from any of their other art experiences. Originally, I wanted to create a VE that revealed

multiple ways of viewing spirituality, creativity, and beliefs about existence. Through their choices and interaction with the art, I wanted the user to feel as if they had a role in the creative process by controlling and creating their own experience. My hope was that the users would be engaged enough to interpret the VE to find their own spirit and existence.

Although I started with a big idea about alternate experiences and dynamic interactivity, the objects, imagery, and motion I created were a reflection of my daily state of mind. For example, the spiritual nature of the work was in part a result of my need for balance with the overwhelming technical details. As I worked through the technical implementation of my ideas the VE changed, however, I was able to hold on to my theme of spirituality. I created objects with organic curves so my spiritually inspired pictures would change shape and perspective when I used them as image maps for the objects. My ideas remained even though I spent an inordinate amount of time with simple difficulties such as exporting the objects from Alias to Inventor and into lynX, and simple software difficulties such as flattened object hierarchies. Through all the technical nuances and my grand ideas, what I made came down to what I wanted to express on the day that I expressed it.

Although these problems with the objects made it difficult, I was determined to create movement for the user that was reminiscent of the flight of a spirit or angel. I created a floor that had many curves and was vast enough to feel like a sea of particles and imagery. I represented the user's motion with a fruit bowl, and

I constrained the fruit bowl to drive along the floor. I intended the user to experience ethereal motion through the curves and waves of the sea-like floor.

Either in spite of or because of the technology, she still maintained her ideas about her art and spirituality. Margaret also took advantage of the unique aspects of the VE medium. She intended for the user to interact with the VE to create their own experience and thus become part of the creative process. She also considered the viewer from the onset, one way in which the VE medium helped her think about her art.

Another way the tool added to Max and Margaret's artistic ideas was its ability to facilitate a sense of presence, which I see as a form of the aesthetic experience, for both the viewer and for themselves. In his interview, Max explained that one of his goals was to make a world for the viewers (or users) that was in some sense realistic, yet something that they knew didn't physically exist. With this new feeling, the users would perceive that they were in the space rather than outside. This sense of "being there" is known as *presence*, a contemporary topic of concern for those in the field of VE. Max talked about this idea during our conversation about the summary of his work. [Dialogue is noted by the speaker's initials, Mx for Max and D for Dena.]

Mx: My goal with VE was to create a more realistic environment, not necessarily something that exists, but something that if you were in it you would say, yeah, it exists, and the VE would help you be in it.

D: So, it would give you a sense of presence?

Mx: Oh, definitely, it would make you feel like you were there and give you a sense of place.

Max's ability to put the user in the work through his use of realistic 3D imagery in concert with real time interactivity extended his capability to provide an aesthetic experience for the viewer. The tool thus gave Max another mechanism to expand his ideas.

Margaret also wanted to provide an aesthetic experience for the user, and she wanted to use the interactive nature of the VE tool to provide it. She wanted the viewers to find their own spirituality through the way they interacted with the work. This interaction was in part a simulation of the viewers' motion that they experienced while navigating through the space of the VE. Margaret wrote of these intentions on a number of occasions, usually days when her thinking was non-linear, or not apparently stepwise. Sometimes she described her intentions and other times she described accomplishments. On one such day, Margaret explained how she wanted to use the dynamic nature of the VE to simulate the abstract and organic growth of a spirit and how the user would play a role. The following excerpt from Margaret's daily reflections illustrates this idea.

Mg: Oh, yes, the object. I just want something that is a 3D interpretation of what I've done in 2D. Then, I want that object to grow or change in the VE based on user interaction and it's own modification. Just like a spirit grows. Just like the spirit in me and from my Nana grows. I want to show that with my objects. They are spirits, and the viewer will find spirits within them when they interact. That is what I want.

On another day when her thinking was equally non-linear, Margaret explained how she intended the motion for her viewer in her VE to simulate that of a spirit, and how the images on her objects were manifestations of her personal

interaction with spirits. She expressed the hope that the user may find their own secular or non-secular spirits in her imagery and the motion.

Mg: See, the floor is my egg in a glass image, in black and white. An object representing the viewer will float around on the floor, close up to the imagery. The motion of the curves on the floor will simulate an ethereal motion and set them up for looking at the floor and wall images. The front wall will be my Nana "spirit" image, *I saw her spirit from the plane*. I want the viewer to feel as though he or she is with a spirit. Not necessarily my Nana, although that is who I will be with. On the left and right walls I will put two of the "eye of the water" images. These works for me are about dreams, staring into the eye of the water for my future and looking for my spirit, or a spirit, like Nana. The water is also the source of life, and the spill of womanhood. Which brings us back to the egg and the glass on the floor. Right now the object that floats on the floor is a fruit bowl. This is somewhat out of convenience, but I kind of like the idea. The fruit of the earth, our source of nourishment. Anyway, my hope is that the fruit bowl will follow the curves of the floor, thus provide the user with a different active way to feel physically and to experience the images emotionally.

Here Margaret wanted to use the ability of a VE to navigate the user through the space in a way to more fully experience the imagery. What she described was a sense of presence for the viewer, yet another way an artist may use the VE tools to create a work with the aesthetic experience of the user in mind. This ability for the artist to design an undivided or whole experience for the viewer adds to the uniqueness of the VE medium.

The Aesthetic Experience During the Creative Process

The same quality of presence that Max and Margaret used in their design for the user was also part of their creative experience. While Max created his work he was, at times, lost and engrossed in flying through the space he was working on. On one such day I noted evidence of this. Max had just loaded his building into the lynX GUI and ran a preview of it.

D: Once Max was in the model, it seemed he just wanted to drive through his building. He appeared engrossed and spent long stretches of time doing this. He then switched the motion model to UFO so he could “fly” instead of “drive.” I noticed his head tilting up and down, left and right as the motion model simulated the heading, pitch, and roll functions of flying.

He was so lost in his experience that he started making physical gestures that simulated the movement on the screen. Max did this sort of thing with his VE every time he launched it. Even a month later, I noted how Max was still ecstatic about moving through his world.

Just as before, he flew around his VE, his head tilted up in concert with the movements of the imagery on the screen, his jaw was open, and he was very engrossed. In the middle of this deep concentration he said, “I get the biggest kick going through my model.” Max was having an aesthetic experience in part because he felt present in his model. This rich experience was what he hoped the viewer would have. The aesthetic experience for both Max and the user are tied to their sense of what Max called “being there,” or presence, which *is* the aesthetic experience in a VE. This sense of presence was brought on through Max’s real time interaction with believable, not necessarily realistic, 3D geometry. Because the session was only a desktop simulation and not a display through an HMD, it illustrated the power of real time inactivity to facilitate the

aesthetic experience. Even when I reminded Max that he was not viewing his VE through immersive hardware, he still felt present and lost in pure aesthetic enjoyment. This was evident in a conversation we had during one of Max's VE sessions.

Mx: Ha ha, I get so turned upside down! Opps, look, no second floor!

Lets see...

[He went to the GUI to add it to the scene.]

Mx: There it is.

D: Imagine watching this through an HMD.

Mx: This makes me dizzy now! Man, look at that! I can get inside the wall! You know, this is just a sketch and look what it does for me. I can see that this will work good. When I go back and add textures and shading so it won't look so flat it will really work.

Max was involved with his new experience despite the lack of immersive hardware. Furthermore, because Max made the space believable instead of an exact replica of a building, and because navigation in the simulation was different from his usual understanding of movement in space, the total experience was new and he had a reason to explore in a way that he couldn't in the physical world. Without knowing of the academic term, presence, Max was familiar with the idea as a natural part of his and the viewer's process. This indicates that a good way to research presence in a VE is to look at the aesthetic experience for the artist and the viewer through a VE work of art.

In addition to its connection with presence, Max and Margaret's encounter with their VE included a point where their aesthetic experience and creative process were one and the same. I don't mean to say that this is always true, but this is certainly a place where they cross. When Max was aesthetically involved during his process of creating, he had a deeper level of involvement and a better

way to visualize the space. During one of the many times Max was engaged in his building, I noted that, as time passed, he got into his art and the experience of it. His engagement was a spring board for his design process.

Mx: HA HA HA

[He giggled as his excitement grew. His head was still moving with the motion of his flying.] Ha! I see the seams of the steps sticking up from the floor below, not good if this was a final.

D: Oh, so this helps you see where you messed up?

Mx: Yes, but I left those seams to stick through the wall so I could feel what the space was like. You see, I'm going to add another room, and I wanted to see where the stairs would go.

[This seems to give Max a good way to design his house. He goes back and forth between lynX and Alias, adding and taking away from his design.]

Mx: See, I'm going to stick a fire place here.

[He flew a bit more.]

Mx: Oh, and a chair here, yes, I want objects. I'm really getting a good sense of space. Oh, see, look, I'll put my dining room here, oh, and I think it needs a few windows, yes, some windows here.

Max was creating while completely engrossed in flying through the space. The experience gave him ideas for his work and places he wanted to edit it. The aesthetic experience, or his sense of presence while he was working was a mechanism for Max to focus and create.

When Margaret's aesthetic experience and creative process crossed, she was usually overwhelmed or excited and driven to solve a problem. She was often so lost in the work that she didn't think about anything but being with it. One day she was navigating through what she called her "world in progress"

when she got the idea about special motion for the user. Motion in a VE is a way the user navigates around the virtual space. Presently, many VEs display war scenes with fighter jets and tanks, thus they simulate the motion a user would feel driving over a battle field or flying and air diving into targets. Margaret didn't want the motion she created for the viewer to resemble anything like these functions, she wanted the movement to more meaningful.

During the session when she thought of this idea, she also envisioned a way to implement it, a creative solution to an art problem. In her daily reflections she wrote about her experience navigating through the VE.

Mg: OK, they will navigate using default drive, but I will add the ability to go up. So, they will drive forward with the left mouse, drive back with the right mouse, all three mouse buttons will reset, and the middle will break. This will be just like drive but, I will give them the ability to fly. The mouse buttons will be:
 left + middle = up and right + middle = down
 I will have to add this.

Then, on hitting my slide object, they will slide. On hitting the chair, they will sit and watch a picture. In both cases, the user will loose control. HA! Lets see, upon hitting the TV, they watch a movie? Or more pictures? If they touch the TV, the channel changes to another picture or movie. I guess I'll let them leave before it's over. Upon hitting the table, the fruit bowl will move towards them. They may pick up the bowl or cherries inside. Sounds good, a small burst of motivation, but this implementation may crash Ulysses, Oh, and all the code. I still feel overwhelmed.

Here, Margaret got new ideas about how her VE would work while she experienced the motion. Although she was overwhelmed by the enormity of the

task, she was so excited about her fly through that she was willing to take a risk and attempt her idea.

Thoughts of the Viewer

While both Max and Margaret were engrossed in flying through and creating their VEs, they expressed aspects of their design that included how the user would interact with it. In the above excerpt from Margaret's daily reflections, she was designing motion and interaction for the user of the space. Margaret had prior experience making VEs and had already confronted the idiosyncrasies of the end result for the user. In fact, almost all of her creative descriptions included the viewer. For Max, he often thought about his viewer without realizing it. A contemporary trend with many artists is to be more concerned with making their work for the sake of making without giving much thought to how the viewer will access it. I believe that most artists do not mean to be exclusive, rather I feel this is more a result of the artist being immersed in her or his creative process. Because the creation process for artists making a VE demands attention to the users' interactivity, immersion while making their art does not pull them away from the users, rather closer to them. Not only did I see evidence of this thinking in Margaret's intentional descriptions, but I noticed it while Max was designing his VE. As was often the case, Max made formal decisions that included the viewer while he was immersed in flying through his space. One time he noticed the emptiness of the rooms and described objects he wanted in them. However, the things he wanted in the space were objects, such as a chair, that the viewer could interact with. During one of our sessions Max told me how he was thinking of this idea.

Mx: I want objects

D: You want objects? Do you want objects that people interact with?

Mx: Yes, I want a chair.

D: A chair for people to sit in?

Mx: Oh, of course.

D: Well, how will they do that? I mean, if they intersect it, will their view change as they spin around to sit? Will they pick it up?

Mx: I didn't think that through, I mean I want them to sit in it, but how? I suppose I would have to program that. Yes of course I would want them to sit in it. I think that would be cool. I just don't know how to do that.

[He kept flying.]

D: It seems you are thinking of the viewer flying through and interacting with things.

Mx: Hm, at first I only thought of looking, but now I see you can do more. That is a good idea. Well, if I can make the viewer interact, why not do it!

A few things are key to the role of the viewer here. First, because Max is a novice at making VEs, he doesn't fully understand that things like sitting in a chair may be implemented. Even once he understands the possibilities, he hasn't thought about how that could be accomplished. Upon contemplation, he is forced to think of user's interaction and how the world would look for them, or how his display would simulate the act of sitting in a chair. Thinking of the viewer is an inherent part of the learning and creative process for an artist making a VE work of art.

Later, during his interview, when I asked Max about considering the viewer as part of his design, he confirmed my earlier notion. Not only did he admit that he unintentionally thought of the viewer, but he recognized that he

didn't think much of the viewer when he worked in other mediums, such as photography.

D: Do you think about your viewer when you are making a VE?

Mx: You know I'm not sure.

D: How about if you compare your work in photography and your work in making a VE. Are you thinking about the viewer in either case, and if you are, in what way?

Mx: I don't think I've actually thought about the viewer, but I guess I do, somehow, when I make a VE. I mean in photography, when you are shooting and take a picture, you are choosing a particular angle, a particular view, a particular lens, a particular subject like it is a document. It freezes the time of whatever you are doing, but I don't really know what the goal of that is. I think that is more for my own benefit. If other people like it, that is sort of an incidental thing. It isn't important to what I'm doing.

D: Is it important to a VE?

Mx: So, the VE. I think you have to think about the viewer. I don't think anyone creates a VE for themselves. I guess you could, but, what is the purpose?

D: Right, because you are constantly thinking about things like they should be able to move around this furniture, or maybe they should be able to open this door, or...

Mx: Or go through the wall, or not, or other things.

D: You know, I found that too. I mean that my art is very selfish. I usually don't care if anybody sees it, but when I make VE works of art I think about how the people are going to surf through it.

Mx: Yes!, it is a different way of thinking about things.

Max said that when he worked in photography he only thought of the moment, the slice of time that he was documenting. This was part of his creative process. With the VE, however, that same moment of creativity includes thinking about the interaction that will take place at a later time and for another person. As Max said, “it is a different way to think about things,” especially for the role the viewer has in the artist’s design.

Prior to asking Max about the viewer, I asked him to describe some of the ideas he wanted to implement in his ongoing VE project. His description inherently included user interaction, however he did not acknowledge this until I asked him about it in the above dialogue. In other words, he was thinking about the viewer without realizing it.

Mx: I still want to set the pivots on doors so they can open. You know, so they open and don’t just disappear when you walk through them, and I guess that kind of stuff.

D: So you want to set up how the doors open and close?

Mx: Right, and maybe you’d have to touch the handle or some sort of interaction so it doesn’t just open when you get to it. I want there to be some sort of interaction. Oh, of course all the walls, you wouldn’t be able to go through the walls, and at least one of the windows would open or something.

D: OK, so, collision detection on the wall, open and close all the windows.

Mx: Yes, and be able to go up and down the stairs.

D: So, you wouldn’t automatically go up the stairs when you got to them? Would you have to indicate it?

Mx: Yeah, you'd have to push into them. I'm not really sure how that works.

D: So you are maintaining control for the user?

Mx: Right. I've also been trying to figure out what to do with the furniture to make it interactive in some way. I mainly wanted objects that you can maneuver around and through, that's sort of the primary idea rather than another kind of interaction. I don't really know all the possibilities.

In his design, Max was thinking about all the functionalities and behaviors of his space and the things in it. He wanted the doors and windows to behave a certain way based on user interaction. He took this idea further and said he wants the user to be able to feel comfortable in the space and understand how to interact with it. Later in the interview he said of a VE that "nobody wants to sit there and try to figure it out." Max thinks that the interaction should be simple, clear, and accessible for the viewer so they may enter the work. For Max, this was the first time he thought through the viewer's actions. I predict that after this, Max's thoughts will transform, as Margaret's did, to thinking of the user in the initial design. In this way, VE artists can facilitate an aesthetic experience for the user, one similar to their own when they are in the process of creating.

Flow in the Creative Process

When Margaret and Max were involved in their creative process, they were at times, in a flow state. Csikszentmihalyi defined flow as an optimal experience, "when the information that keeps coming into awareness is congruent with goals, psychic energy flows effortlessly" (1990b, p. 39). He characterized the flow state by eight components that I see as partial conditions (not all sufficient or even necessary) related to a successful work of VE art. The

pertinent components for individuals in the flow state include a belief that their goals are reachable, they can concentrate, their goals are clear, they receive immediate feedback, they forget everyday worries, they have control over their actions, their sense of self (hunger, for example) disappears, and their sense of time is altered. Often, while Max was fortuitously tumbling around in his VE, he appeared so involved in his experience that his head tilted in the direction of the view on the screen, his jaw was ajar, and his mind seemed to be in deep concentration. It looked as if he had lost his sense of self and time. He experienced instant feedback about his model, which helped him see further changes to his design idea. Because the GUI was easy to use, once he found his ideas, they seemed simple and doable. These elements were evident when Max's ideas poured effortlessly.

Examples of Margaret's flow were slightly different and usually characterized by a stubborn attempt to manifest an idea that required many more iterations than she planned. Margaret seemed to have two kinds of flow, one very logical and usually connected with writing code, and the other non-linear and closely tied to her artistic ideas. Both states preoccupied her, both produced creative thinking, and one usually got in the way of the other. Halfway through her learning Vega and lynX, Margaret took a crash seminar on the software. At first, the environment of instruction and structure gave her a base of security that sent her off on a playful, non-linear tangent. After her first day of instruction, her writing in her daily notes reflected this ability to play given a small bit of guidance.

[This training session took place in Dallas, a week long intense crash course taught by Paradigm Simulation, the company that created lynX and Vega. She started this excerpt by describing how she transferred files

via the internet from the SGI computer (Ulysses) in Athens, Georgia to the one she was using in Dallas.]

Mg: Nothing creative with these guys. That was OK, I was so anxious that I FTPed [File Transfer Protocol] to Ulysses in Athens and yanked my “egg-in-hand” picture over as a warm up scene. I wish I had more of my pictures on Ulysses. Later I FTPed my geometry for my .obj [WaveFront file format extension] environments to plug in here--let the engineers help me figure out why the thing bombs--the same six files I sent Al. [Al was an interested computer scientist who wanted to learn how to code a VE using Margaret’s geometry.]

Once I had the pictures and geometry in Dallas, I jumped off and away from what the lecturer was showing. I was so excited that I lost myself in the possibilities. The lecturer laughed at me--I just want to play! I’m soaking it up like a sponge!!! Structured instruction! I’ve been hacking on my own for so long--it is nice to be taken by the hand. I feel confident with lynX. I feel now as though I want to re-read (at least skim) what we’ve done. I can’t wait to throw together a new environment.

I want a world about spirituality. One with my Nana series. One where I have spirit objects, some about life, others about death, experience. The objects will behave, morph, and change based on user interaction.

Yes!, I’ll play pixel movies on the objects. Yes. The movies will play differently based on interaction. I guess the movie can’t really change...INTERSECTION DETECTION...I just thought of a way! I know I can make the objects and the environment change. Behaviors, that is what I want!

In the first paragraph, Margaret was describing her plot to deviate from the instructor and go over the internet via File Transfer Protocol (FTP) and transfer her textures and geometry so she could start whipping up a spirit world. She was so lost in her excitement that the strange environment did not affect her, even after the instructor laughed at her. From this playful state her ideas poured freely, and her mind went off on her “spirit” artistic ventures. Margaret’s playfulness helped put her in a flow state that tapped non-linear thoughts about her art.

Other times, usually when she was fixed on writing code, Margaret’s flow was very logical. At these times she was set on resolving her programs and would often forget to go home, eat, and at times, even why she was writing the code. Although at these times Margaret was thinking of new ideas to make her code work, she was not thinking of the intention behind the code. Once, while stuck on how a user could “pick up” an object in the VE, she spent an entire day thinking about it, and the next making it work. The following is an excerpt from her daily notes that reflects this process.

Mg: I thought long and hard today about how a user could lift up an object. How basic, but it isn’t in lynX. How? Well, I thought of a number of ways. I had to first go back and push myself to think about players in relationship to objects, motion models, and observers. How confusing. BUT, I think you first attach a player to a dynamic object that acts as a hand. This doesn’t have to be a hand, but I will call it one for the sake of explanation. The hand represents the user-fly-through.

OK, the player is hooked to the object, and the player has an enabled motion model, like drive. I can offset the object from the player so I can see it. OK, I will attach an isector (an intersection

vector) to the player that will detect intersection with a static object, say a ball. Oh, or make the ball dynamic but attach a player with a motion model that is not enabled. Maybe.

From this initial idea, she wrote the pseudo-code, then the C code to make this work. This task took her well into the next night, far beyond what she would usually do. Although she solved the problem, she thought the resulting action on her example was basically stupid, and she didn't have a reason to use it. This logical portion of her flow was creative problem solving, however, not for her art, but for a technical idiosyncrasy.

There were many times when Margaret's logical state prevented her from thinking about the art, and other times in a non-linear flow state, when she was not able to concentrate fully on the technical aspects. On one occasion she sent 20 MBs worth of geometry and textures to a prospective collaborator, which ended up crashing his work station. It wasn't that Margaret didn't know that sending 20 MB worth of data would crash his mailer, but she was so lost at the time in her non-linear ideas about spirit-motion that she didn't think about it. Another time Margaret spent an entire week tracking down a bug in Vega that flattened the hierarchies of her geometry, thus preventing proper collision detection. As a result of the bug, her event callbacks in her code would not work, and she spent the week trying to get around the problem. After intense programming, she triumphantly emerged, however, she was unable to think about her art for another week. In this case, Margaret's logical flow actually hindered her artistic flow.

It was also clear when Max's flow was interrupted, often because of technical problems or loss of control over his work. In the beginning, Max had intense excitement over the possibilities of putting his *Bradburry* building in a VE. He had worked on this structure in *Alias* for roughly three months and he was

eager to realize it in lynX. His flow was focused and at one of his highest points. When he learned through many long hours of hard work that his Alias geometry was too large and too complex for real time graphics, he resolved to rebuild his *Bradburry* structure. Despite the work involved, Max was focused and in full throttle because he was excited and had a clear, reachable goal. It was only after repeated failures that Max started to lose motivation and flow. On that day I wrote how he didn't take to new material well and I sensed his loss of drive.

D: We didn't get too far today. All the new material I planned may have been too big of a cognitive leap. On top of that, Max is having the hardest time with his *Bradburry* model on the Alias side. It seems he has "thrown in the towel." I didn't want to lose him, so I didn't push too much. I did show him the motion models, Vega.c, and isectors. I also desperately tried to show the relationship between the observer, player, object, isector, and motion model. I'm not sure that I was clear.

I think it was the *Bradburry* model. I think Max needs to feel successful with a smaller, less complex model. *Bradburry* is just too big. He tried to simplify the building to one floor, but because of technical problems, it wasn't ready to put into lynX. We instead used some of the pre-made ModelGen objects so I could show him how to make a scene and add objects, very basic. He seemed very uninterested in using any objects but his own, perhaps because he felt a lack of control and ownership.

He is still very frustrated, and I don't think he is enjoying himself. There is a lot of technical stuff to get over before we can really do anything with lynX, not to mention the basics of going

back and forth between it and Alias. I think his creative drive sort of dried up over the difficulties.

It seems on this day that Max felt he lost a sense of control over his initial goals. At first they seemed simple enough, but the process of making a VE is so technologically laden that it shocked him. The shock, I believe, interrupted his flow. In his daily reflection, Max expressed his frustration.

Mx: I have spent almost an entire week simplifying my wire file and the textures of my *Bradburry* building in the hopes that I can get it small enough to run in the VR program. All the work seems to have been in vain, as I cannot get Alias to export an Inventor file for me. Finally understanding that Alias pix files used as textures must be converted to RGB SGI format, I quickly rebuilt the walls of the fifth floor of my building and applied the textures.

In order to place the geometry Max created with Alias into lynX he had to first export it in a format that lynX could read. One format is Inventor, however, for Alias to export to this format, the file can't be too complex, and the texture files must be in SGI's RGB format. There are a few things in this process that disrupted his flow. First, Max encountered difficulties with some of the preliminary steps of making a VE. When the small basic steps seemed daunting, Max's overall goal felt completely out of reach. Next, he had to accept that his geometry needed to be much simpler for real time interaction. He learned through actual experience that real time interaction meant his geometry was too complex, and he could not realize his initial intentions. Finally, to make his geometry ready for real time, he had to rebuild a structure that took him three months to make, and in doing so, eliminate some of the subtleties that he worked hard to accomplish. The technical problems demanded from Max a different way of thinking, one more logical and constrained. Even though Max found the

solution to his problem, the week of frustration and all its implications burnt him out. Max expressed this feeling during one of our sessions.

Mx: I'm trashing *Bradburry*. All the transparencies didn't work. It just isn't the same.

D: Oh but Max, you can fly through it, it think it looks great!

Mx: I don't know, I think I just can't look at it anymore.

I saw his flow dissipate. The building, even though it looked good, did not live up to his expectations. Even after we put his single simplified floor into lynX, he seemed as though he no longer cared about *Bradburry*.

This, among other technical difficulties often interrupted Max's flow and lowered his motivation. The difficulties with *Bradburry* were complications towards his said goal, but there were other parts of the process that bothered him. For example, the lynX GUI is not a software package meant to create a VE, but it is a convenience to set one up. It allows the user to specify the initial states of the environment, objects, and behaviors. Anything beyond that, such as opening a door when a user touches a knob, are based on collision detection and other functions that must be implemented in code. Max expressed frustration in trying to learn this, and even more when he realized that he couldn't immediately change the functionality of the defaults. For example, on one day he wrote about how he was unable to set the appropriate motion for the user.

Mx: The thing that I am most frustrated with is the "drive" interface. The defaults are no good. After I changed the "wheel" I seem to have a little more control over direction and speed. What I want is a smooth dolly around the room.

This lack of control over the drive motion model hindered his creative flow. He wrote this comment the same day he chose to "trash" his *Bradburry* model. This is precisely one reason why a task such as building a VE is best accomplished

with a multi-disciplinary team. With a team that included programmers, Max could have specified how he wanted the motion to a programmer. Max could then stay with his artistic idea and not get lost in frustration and lack of control over his project. In addition, if Max had someone to help him work through the difficulties of putting his geometry in the correct format for lynX, he may not have been discouraged during the basic steps, and he could thus feel secure with his larger goal. Without this support, Max's motivation was at a low.

Factors Affecting the Learning and Creative Process

There were aspects of the artist and the environment that affected their ability to learn and create. The idea of a team was an element that seemed to enhance Max's desire to learn and continue with his project. Despite his low motivation on the day he decided to abandon his *Bradburry* building, Max's interest was re-invigorated when I introduced the prospect of a team. The day that he seemed to not care about his work any longer was the same day I introduced Mike to a possible team. I had invited a professor and a student from the computer science department to sit in and take a part in Max's project. After they arrived I let Max watch in the background as I went over the basics of lynX and its associated tool kit, Vega. After this session, I wrote how Max's interest in the project seemed renewed.

D: It was good for Max to talk with Al and Wyatt, it seemed Max was more comfortable watching. In fact, it seemed that even though the talk was very technical and abstract (function calls, event driven callbacks), he seemed to be there with us somehow. Not that he now knows how to write event driven programs, but the lower level seemed to enlighten him on the higher creative level. It was a productive session.

Although he didn't fully follow every detail, Max seemed to follow the general idea. It seemed to me that the team process helped Max feel more in control of his work, and his goals, again, felt doable. The synergy of the group helped him forget about his *Bradburry* disaster and encouraged him to set a new group dependent goal. The following is an excerpt from Max's reflections when he wrote about this day.

Mx: Knowing that the *Bradburry* building project is behind me, perhaps I can look forward to a new project. I really appreciated the fact that Al and Wyatt and Margaret were there. It is actually starting to feel more like a group project. I think I could easily lose interest by myself, but our interaction made me more comfortable and encouraged me to create an environment that would allow us all to learn more about VR.

This was clearly a motivation for Max, which gave him the essentials for his next burst of motivation. At this point it was most clear to me that the optimal way to make a VE was as a team, individuals that share a creative process and work towards a common goal, much in the same way the individual parts of a jellyfish² work together.

Working as a team is not usually the way many visual artists work today. Most have their own studios filled with their own projects, and collaboration is something few attempt. This is nothing new for artists who create films or stage productions. Nobody makes a film or produces a stage drama without a team including actors, writers, stage technicians, camera technicians, and choreographers. In this sense, making a VE is much like producing a film or a play. As Max said in his interview, making a VE is a new way of thinking. To this I'll add that working as a team is part of that new way for visual artists.

² Thanks to Dr. Robert Nix for bringing to my attention just how a jellyfish functions.

Although the team seemed to motivate Max, he also showed periods of low motivation. In fact, Max's overall learning and creative process reflected a pattern of high and low motivation. As he encountered new difficulties or his learning curve became too steep Max's motivation would drop. After distance from his project, passage of time from new concepts, and a better understanding of VEs, Max was re-invigorated and in a prime state to work. Although his motivational and learning pattern was at times strong and at other times low, Max showed motivation to learn and create on a steady basis.

The low points of Max's work pattern were often a result of the large amount of technical information that is associated with VE technology. Making a VE demands a high level of commitment, a level that for some means blocking out other things in their lives in order to focus. This was the way Max worked best, however, he was unable to focus on the VE for a number of reasons. First, he kept trying to solve the problems with his *Bradburry* building, even after he said he "trashed" it. He also felt limited in his time on the Onyx both because of his other commitments and because of his limited access to the machine. He explained that it would have been easier to work if he had access when his motivation hit. Finally, he said because of these outside factors, he was unable to get the point of full immersion that he requires when he makes art. The following is an excerpt from Mike's exit conversation.

Mx: I think becoming obsessed with my art is the way I work, especially with something like the *Bradburry* building. I put everything else aside, and that is all I did. Because of my work on the *Bradburry* building I never really immersed myself totally in the whole VE thing. I also felt like there was a limited amount of time I could spend working over there. A problem with access. I mean, if I could have gone over every day and spent an hour...

D: So you think you had a problem with access to the Onyx?

Mx: Yeah, if I could have just gone over and done it whenever, that definitely would have changed the way I worked and I probably would have gotten a lot more accomplished.

D: So, to be able to work when it hits is part of your process in all medium?

Mx: Oh, definitely, and that didn't change at all with the VE.

Here Max explained that both other work and access time affected his creative process with the VE project. Access to the machine was not the only element of time that affected Max's work. He seemed to need a certain passage of time, both away from and involved with his project. Some of the new perceptual actions connected with the VE medium, like flying through space, and new technical aspects, like file formatting, take time to understand. When I asked him about this he recalled how he needed this kind of time before Alias made sense to him.

D: Do you think there needs to be a passage of time to fully understand a VE? I mean, sure, you can learn the techniques right away, but you don't really feel them until a certain amount of time passes.

Mx: Right! That is exactly the way Alias was for me. I mean, I sat around Denny's office and heard people ask questions and Denny would answer, and all that stuff sort of sank in, and then I would play for a while and get frustrated and finally this quarter it was like, "Oh, yeah, that makes sense" you know, I sort of understood after a passage of time. I think this is especially true with this VR stuff.

The passage of time is clearly part of Max's overall creative and learning process and fits his pattern of understanding, working a bit, getting frustrated, leaving the work, and then trying it again. Time for him included time for play, learning and collaboration with others.

Margaret's work also needed the passage of time to develop. This is true with most learning processes, but it is especially important with learning how to make a VE. The learning curve is especially steep because there are many technical aspects to master before the artist can manifest anything. Although practice over time increases the artist's skill in any medium, a VE is different because the feedback is not visually immediate. For example in painting, when artists apply pigment on to canvas, they get some kind of immediate representation of their work. In VE construction, not only does the technology demand learning a whole new tool set, but it demands a new cognition, a new way of thinking about the art before they can see it. For example, a painter may *represent* movement for a viewer through her brush strokes, but a VE *makes* movement for the viewer, and VE artists can't preview that movement right away. Furthermore, the movement is motion that is new for the artists and it requires them to rethink something that was up until now intuitive. How exactly does one "fly through" a "space?"

In addition, the artist must think about sequence, interaction, and whether there will be an order or a story. A film, for example, has a sequence, a pre-determined set of events. Even if the VE has a story or narrative, the sequence of events is up to the viewers and their interaction. The artist loses some control over the end product, something they are not used to. These things, among others, require an amount of time to get used to.

This transition in new thinking was evident when Margaret converted her way of working to consider the viewer in her VE design. This transition took

place over about one or two years while she thought, explored, and learned about VEs. Max, on the other hand, is just starting to think of the viewer. Thus time is more a factor in learning a vastly new medium, such as making a VE or other digital art, than it is in more intuitive mediums.

Even though Max's time with VE construction is small and he feels as if he is still learning, he is able to think about his artistic ideas, play with his art, and have short moments of immersion with it. With his VE work in particular, he said he needed an initial exposure, then he needed time to put the work down, maybe talk to others about it. This, for Max, was learning time. In his exit conversation he explained his creative process with his VE project up to this point.

Mx: So far I've got my initial exposure to VE and information about how it works. Also, I know how to prepare everything with my models in Alias so I can bring it in to lynX. I sort of played around initially. Then I went away and thought about it for a while, then I did some more, and each time I would go away and think about it. That is usually how I work, sort of build on things. Often I would think about introducing something else. Like our conversation tonight made me think about a lot of things that I hadn't thought about otherwise. I found that there are certain things that I work better with in a collaborative setting. I think this is one where a collaborative thing is necessary.

D: Yes, that is exactly the conclusion that I'm coming to with my work. Actually, all successful VE works that I have seen are collaborations. I have not met a person who has made a VE alone.

Mx: Yes, and basically with a VR it is like play, I think about it, play some more, think about it, I kind of think that I would like to spend

some more time now, I have to see how the quarter is going to go and just sort of start over. I mean, last quarter was almost a learning time. I can't imagine that somebody would sit down and just make a VE. I mean you start a project and work on it for a couple of weeks and then you realize there is a much simpler way to build this whole thing, but you had to go through it.

Max explained how this portion of his work procedure was also his learning process. It not only built his confidence, but it helped him understand the larger picture and gave him goals to set, to work towards, and concentrate on. Also key to his learning was understanding the capabilities of a VE. As he explained, he got new ideas from our conversation, ideas that were based on a better understanding of the possibilities and concerns of a VE. In our exit conversation, Max demonstrated this new thinking after I explained the dynamic VE and its capabilities.

D: If you had access to a CAVE set up, how would you design your VE?

Mx: I would still do the architectural stuff I started with, the stuff that would be easy to render. Maybe an interactive city, sort of like a street scene. Like a Disney main street (ha ha), well, not exactly. I would like it to be movie related in some way.

D: Wow, well one of the first relations to VE that I thought of was film. Rita Addison's VE, for example, has a beginning, middle, and end. But you could have an installation that doesn't depend on sequence, one where you don't know what is going to happen next.

Mx: I think that is sort of an interesting thing to put into a VE because I tend to think of it as static. But if you open a door, maybe that triggers something to happen. I sort of like the idea of this story

line that is going on. There could be things happening down there, and if you aren't down there, well you just didn't see it. But, maybe you are seeing something that is happening here. So, you know, if you had been down there, you would have missed this stuff. I like how the linear nature of time will figure into it instead of just an open space that you are wondering around in.

D: One where we don't always know what is happening.

Mx: Yeah.

Although still a novice VE designer, he was able to think novel thoughts as part of his learning process.

Also apparent during Max's learning portion of his project was his ability, in his own words, to play. Play is the way many creative people treat their "work." In other words, they can spend the time and become absorbed in their process because they enjoy what they do. When the "work" is play, they are internally motivated to excel. This is consistent with Amabile and Hennessey's internal motivation principle (1988).

Margaret's overall work pattern, like Max's, had hills and valleys, but continued on an upward climb. Like Max, play was an integral part of this pattern, which often provided motivation and increased her capacity to learn. Margaret's play mode was usually triggered by a feeling of confidence in her skill, usually as a result of solving a problem, or having something suddenly make sense, or what I call the "light switched on" experience. During one such experience, Margaret suddenly understood how she could give the vertices of her geometry new values through code during user interaction. This meant that she could make her objects and environment dynamic because they would change as a result of viewer interaction. She got so excited that the next day she deviated from the manual and started to "play" with other possibilities, such as

motion models. On the first day she scribbled some of the technical notes about the code necessary to change the geometry, and then she jumped off into new ideas. The very next day she explained how she launched into play. The following is an excerpt from those two days.

Mg: Lets see, I plowed through parts, players, and started motion models. I can add an isector to a part of an object (or an object for that matter) with `vgPartClass` or `vgObjClass` [`vgxxxx` refers to a Vega function call]. I want to try this, then change the part type from static to dynamic with `vgChangePartType`.

Wait! WOW, You can manipulate vertices! I can also manipulate players and control all dynamic entities! Yes, this is where I make things do something interesting, how exciting! I want to try it all, Oh, motion models. I can write my own, but I have to register it with `vgMotRegister`.

Still lots to learn. Tomorrow I want to start exercise 6, which means I must read up on motion models...

[Next Day]

Again, I feel good about my progress. I started off with the exercise on motion models, but I veered off from the text to play, I just had to code something so I could see what happens. See, for each object, I want to create an isector...

The excitement of the “light switching on” experience put her in a state to want to learn more, to explore what she thought was fascinating. For Margaret, this was playing, and that play actually taught her things about the Vega tool kit. As with Max, play was an integral part of her learning process, and that play was usually a happy state brought on by confidence. Another element of Margaret’s learning process was her environment. Although there were aspects

of this in Max's process, it seemed to affect Margaret more. The people around her and the machines she worked with often influenced how she learned, her creative flow, her confidence, and how she shaped her ideas. At times her point of view, upbringing, and possibly her gender clashed with her environment and tool set. This sometimes made her question herself, her ideas, and, mostly, her confidence. Because her confidence was so closely tied to her learning and creative process, this was an important concern for her. A clear illustration of a particular environment and her resulting thoughts was a reflection that she wrote after a week long lynX/Vega training session in Dallas. The following is an excerpt from her daily reflections about that training session.

Mg: Today, in my house surrounded by my art, my things, and my books that all represent my obscure thoughts, I am reminded of how un-mainstream and un-engineer I am. I see this in contrast to my week in Dallas at the lynX/Vega training. Despite my advanced degree and work as a math/computer scientist, my organic nature is growing outside the cracks of the box required by my engineer training. I was an item next to the other engineers in the class. They had never heard of using computers for art, let alone the idea of a VE as a work of art. I don't mean to say it was a negative experience, they all found me fascinating. I'm just reminded of how strange my work must seem to those around me. I feel strange.

The only reason this stuff matters is because it effects me as an artist, and my creative process. That environment was sterile and rule or "step" based. There was a right and wrong answer. There was an obsession, on the part of the trainers and the engineers, with getting things on the exact Cartesian coordinate,

and making things exactly as close to reality as possible. The application for 90% of this stuff is military (bombs, war games, missiles, explosions, fires) or gaming (bombs, war games, missiles, explosions, fires). The bomb stuff is far from the way that I want to use it. Vega was designed with bombs in mind, and bombing/explosion/fire capabilities and metaphors are the nature of my tool set. *This affects how I see, what I create, and how my creativity happens.* Exactly how, I don't know, it just gives me a tummy ache. I don't care about war games, and I don't know how to play them or how they work. Most little boys grow up playing cowboys and Indians, or nintendo games filled with explosions. They are used to the idea of a bomb, explosion, and a target. When the trainer mentioned the Vega target function, I got all confused and started thinking of a bumble bee looking for a flower. I was lost for a long while until I realized he was talking about a target for a gun or bomb or something. OOPPS. I'm not meaning to be sexist at all, no, that is not my intention. I'm only reacting to my tool set, and how it feels to use BOMBING functions.

One of the trainers was a woman, Teresa, who was the only other woman (except the secretary, introduced as someone to meet our "needs"this pissed me off....another can of worms...). I saw Teresa cringe once when she used the word "explosion." She stopped, stepped back, then said, "You know, I wasn't this violent until I started working here." She said this often. In talking with the other engineers, they didn't seem to understand what she meant. For example, over lunch I mentioned Teresa's comment. I said that I felt a similar way using "target" and "bombing"

functions, that it was a foreign concept for me to grasp, and that it felt violent. I got blank stares, and an uncomfortable silence. One of the engineers told me that the military has the money, and he went on to ask me what else I would use this for. I started talking about art, bumble bees, and flowers and I got more blank stares. I then realized how much the tool shapes how we use them and the way we think about their applications, just as language shapes our thoughts. Didn't Derrida or Denzin already say that? Anyway, one of the more sensitive engineers got my line of thinking, and rescued me by telling stories about his childhood and how he played cowboys and Indians. He recalled how his sisters were off doing something else, bumble bees and flowers.

I think this text mostly speaks for itself. Basically, Margaret said she felt like an outsider, not unwelcome, but somehow not normal. She went on to give examples of how she felt different because she didn't understand the war-like intentions and lingo of the software. Not only did this confuse her learning process and make her feel queasy, but when the others in her class didn't understand her discomfort, she lost a bit of confidence. She then realized that she would have to work hard to keep her "bumble bee and flower" idea despite the lingo connected with the tools. The tools, she surmised, shape our ideas. Because confidence was a dominant element in Margaret's creative and learning process, her level of comfort with her environment, whether a result of gender, socialization or otherwise, was essential to her positive progress.

Even though there are aspects of making and learning about VE construction that are unique, such as the war-like nature of the tools and the masculine nature of the environment, there are many general elements, such as the concept of play and how it is tied to motivation and learning, that make the

process similar to other art mediums. Besides play, there are other ways of thinking during the process of learning about and creating VEs that are similar to other art mediums. Like VEs, installation art is a kind of simulated environment that is three-dimensional and, in many cases, intended for a viewer to enter and interact with. As with making a VE, the artist thinks through how the viewer will enter the work, and how the environment will feel as a space. Max sees this connection and believes that a powerful VE is a growth from that. He connected this idea with a recent installation he saw. He spoke about this installation in our exit conversation.

Mx: When I went to New York, I went to the DIA center for the arts. It was the best thing that I did in NY. It is a four story tall building, each floor is an installation by an artist. It stays up for a whole year. You know, I'm not really big on installations, generally. I think I've sort of been burned by the "somebody collected junk from the salvation army and glued it all along a wall" syndrome, you know? That kind of stuff? That pisses me off, like why? What are you trying to say here? Why should I care? But, a couple of these spaces were really neat and I really liked them. I see a VE sort of mimicking that sort of thing. I think I'd like to see that in my work.

Max saw that an installation work is similar to a VE in that it is a space or construction of some sort that is not constrained to a frame meant for a wall. In addition, an installation is something that exists as a construct of many parts, often dependent on the space in which it was built. It is not usually something that somebody purchases and takes home, rather it only remains in the intended space for a determined amount of time. Although there is a product, the constructed space, it is usually not owned by anyone and exists mostly as an

experience for the viewer. A VE is similar in that it is a space that exists temporarily, but different in that it only appears when the computer and associated peripherals are running. Although the resulting VE is the product, it is one that can't be purchased as a physical entity.

The VE, like an installation, is the result of many smaller parts that are loaded into a space in order for it to exist. For example, an art installation designed for a room is realized only when all the parts are present and placed correctly in that room. The same parts piled in a corner in a different room is something else. Although the idea for all those parts may exist in the artist's mind, it isn't realized until it is installed.

A VE is made of many objects that are represented by geometric descriptions that are stored in a file. All the geometry must be loaded into a VE space and the computer must be turned on in order for the art to be realized. Like the artist's idea for an installation, the VE art may exist in the files of zeros and ones, but it is not realized until the computer is turned on and running the VE.

Like an installation, a VE session may be captured on video, but it remains only as a reproduction, many iterations from the synergistic first person experience. The art of VE work, like the installation, is the experience. For the artist creating both an installation or a VE, they are thinking of that experience for the viewer, and not usually how to reproduce and sell a product for mainstream consumption.

In thinking about the experience for the viewer, the artist who designs a VE is thinking of how they will interact. In this way the viewer becomes a part of the art work, a co-collaborator in a dynamic performance piece. As the viewer interacts, he or she creates the experience. Because for a VE work of art the product is mostly the experience for the user, they become part of a live

performance that, like performance art, only exists for the duration of the presentation. In his final discussion, Max agreed on this similarity.

D: I also see connections in VE with performance art.

Mx: Oh, yes.

D: Yeah, because the user or the viewer become a part of the live VE performance.

Mx: Oh, yeah, they can interact with stuff.

D: Yes! It isn't something passive that simply washes over you. I guess there has to be a change in thinking for both the artists and the viewer.

The similarities that VE has with performance art will, as Margaret said, require a new way to think about their product for the visual artist. No longer will they produce something that they can assume is finished when it is hung on the wall, instead they will have to think of how the viewer will complete the work. This is not to say that the viewer is not part of a static work, like a painting, or that the viewer doesn't complete this work when they view it, rather it is implied. A VE work of art demands this interaction to experience it at all.

In general, Max and Margaret's creative processes were both similar to other art mediums and unique to VE construction. Similarities with installations and performance art require the VE artist to think of the experience of the art, in particular, the experience for the viewer. However, because the VE and other computer tools are a new medium, the visual artist that is not used to performance or installation work is thinking about the viewer in a new, interactive way. In addition, the demands of VE construction require a team or a collaboration of sorts. This team is usually multi-disciplinary, a work environment that is new for artists and scientists alike. Also, the VE construction more clearly illustrates the point at which the aesthetic experience and creative

process cross for both the artist and the viewer. Finally, in looking at the creative process for Max and Margaret, I've shown how the artists are indeed able to put themselves in their work and think creatively, thus making VEs and computer art in general a viable art form.

CHAPTER 5

THE TEAM THAT MADE *DETOUR*

A Team, the Two Exhibited VE Artists

I visited Rita and Marcus in Chicago to experience their virtual environment work, *Detour*, *Brain Deconstruction Ahead*, and to explore how successful artists create a VE installation. There were many factors that enabled their success, however I focused on a few that I felt were directly related to the creative processes of Max and Margaret. First I will present a brief background on Rita and Marcus. Then I will explain their VE work of art and their unique hardware, followed by a description of the key factors of their creative process that led to their success.

Rita

When I first met with Rita, I was standing in the lobby of a large Chicago hotel in the midst of an American Psychological Association (APA) convention. My only contact with her up to this point was via email, and all she knew of me was my interest in her work. Despite our lack of history, she greeted me, in pure Rita form, with a big smile and a genuine hug. Rita's greeting held warmth, empathy, and compassion, qualities she carries in her work and in her art. I met her at the APA conference so I could see her give a talk about her VE art work *Detour*, *Brain Deconstruction Ahead*. After her talk I later took a trip with her and a group of conference attendees to the University of Illinois's (UIC) Electronic Visualization Lab (EVL) to experience *Detour*. Because psychology was her prior profession, she confessed to me how comfortable she felt at the conference,

almost as if she was still in the field. Fascinated by this, I had to know at what point her career took a turn. She replied “Oh, that was about five iterations ago.”

The most recent iteration was in 1993 when Rita started work on *Detour, Brain Deconstruction Ahead*, a VE work of art that addressed her experience with a 1992 car wreck and her ensuing closed head injury. This was Rita’s first VE work, one that she decided to pursue during the summer of 1993. The story that led to this choice is rich and powerful, power that only Rita can fully express. In short, she was suffering from the emotional pain that her injury left her with and was driven to make art about it. The turning point for Rita was a summer in Maine where she spent time in recovery, away from people, but with nature. She said the squirrels didn’t seem to mind her lack of focus as much as humans did. During this summer, her frustration peaked when she found, due to her perceptual anomalies, that she could no longer take pictures. Rita’s work in photography was two iterations ago. Prior to her accident, Rita was an active photographer. It was when she found she could no longer use the camera that she felt she had to tell her story. Like the accident and the injury she suffered, she wanted to express an experience in a way that went beyond pictures and words, one that would help the viewer feel what she and others with similar injuries were experiencing. VEs are about experience, the combination of sight, sound, and interactivity, an uninterrupted and focused encounter, the perfect medium for Rita’s idea.

When Rita decided to pursue this work of art, she didn’t know anything about VE technology, instead she had an idea and a drive to manifest it. Her ideas and drive, along with her warmth and compassion were Rita’s most pertinent qualities for making the VE work of art. Rita’s drive helped her pursue connections at MIT and UIC, and seek funding from Dr. Richard Satava at the Advanced Research Project Agency (ARPA). Rita’s ideas and old photographs

gave a concept and purpose to a mass of computer hardware and programming talent. Rita's warmth and compassion gave the art work a reason to be, a vehicle for outsiders to get closer with brain damage victims, and a way for victims to share their experience.

Rita's compassion and ideas live on in her present work, building artistic VEs that address more intuitive interfaces for the user. She and her collaborator, David Zeltzer, are calling the work "Tightly Coupled Interface Design for Responsive/Virtual Environments."

Marcus

I first met Marcus when I took the APA trip to see *Detour* at EVL on the UIC campus. Because Rita was no longer affiliated with EVL, Marcus, a graduate student at EVL, let us in. It was apparent when he started up Rita's installation that he was more than a custodian of off hour access to EVL, but in fact, the programmer behind *Detour*.

At the time, Marcus was pursuing two degrees, a Master of Fine Art (MFA) from the School of Art and Design, and a Master of Science (MS) from the School of Electrical Engineering and Computer Science (EECS). Although the MFA degree is through the School of Art and Design, the students in the Electronic Visualization program work at EVL. Professor of Art, Al Sandine, who coordinates an inter-disciplinary effort between the two schools, is a director of EVL and supervises the MFA candidates in Electronic Visualization. It is this MFA degree, in addition to his MS, that Marcus was working on. Both of these educational objectives reflected Marcus's interests and his role in *Detour*.

As it is evident in his course of study, Marcus is interested in the point where art and science meet. Because of this less traditional combination, I asked Marcus if he thought of himself as an artist. He said he didn't know, and went

on to explain that no matter what he does, he always thinks like a scientist. He said he was influenced greatly by his parents who are both in the sciences. However, he was equally influenced by his sisters who are both painters. This led our discussion to the concepts of “knowing” connected with science and “intuition” connected with art. If he couldn’t label himself as an artist, at least Marcus said he was always happier in his art classes because he felt they afforded the freedom to be intuitive. He felt that art didn’t have to be logical, but science did. He said in science you have to “know” something or “prove” it, the rules of the discipline are not satisfied if you have a gut feeling. I mentioned how there is logic and creative non-linear thinking in both art and science, however, science disciplines often discourage seemingly illogical thinking, just as art disciplines sometimes dissuade logical thinking. Marcus referred me to a recent article in *Scientific American* (Casti, 1996) that addresses the logical limits of science. In this article, Casti asserts that there are some seemingly unanswerable questions about the natural world, such as how a string of amino acids folds into a protein. These complex problems, according to Casti, may only be answerable if we loosen the constraints imposed by traditional scientific methods. Marcus and I agreed that one way to address these kinds of scientific questions may lie in the seemingly non-linear thinking of an artist. It is this belief that is a motivating factor for Marcus’s work in both art and computer science.

Since Marcus is doing work in both art and computer science, Rita’s *Detour* project was not his first exposure to making digital installations. Prior to this, Marcus was involved in numerous other digital visualizations through EVL that were exhibited nationally. He was already familiar with the CAVE, the hardware that ran it, and the programming necessary to run it. It was Rita’s idea that gave his technical talents a focus.

Marcus agreed to work with Rita in the spring of 1994, only months before *Detour's* scheduled summer exhibition at the annual SIGGRAPH (Special Interest Group, Graphics of the Association of Computing Machinery) conference. Up until this point, she and others at EVL were unable to manifest her idea in a VE. By the time Marcus started work with Rita, her ideas were focused down to a narrative. Marcus's role was to implement these ideas as an interactive real time CAVE experience.

Detour was successfully exhibited at SIGGRAPH in the summer of 1994, for Marcus, a product of one place where science and art join. Since then, Marcus has continued to explore the scientific side of art. During the summer of 1996, he was part of a team that released a 40-minute IMAX film for the Smithsonian Institution. *Cosmic Voyage* is a film that takes the viewers on a journey through the formation of our universe. Close to four minutes of this film are computer simulations of that formation. Part of this work was developed using the CAVE to simulate camera motion around various galactic explosions. According to Marcus, this film was a response to *Powers of Ten* (Morrison and Morrison, 1982), a book that explores our understanding of very large and very small numbers in terms of our relative size in the universe. Starting with 10^{25} and ending with 10^{-16} , the book gives scientific examples that represent the meaning of these abstract numbers. The book is a work of art, formally composed in imagery and content, it takes the reader on a symmetric ride from 10^{25} meters away (about 1 billion light years) down to 10^{-16} meters. To Marcus, this addressed our relative insignificance in the order of nature. As we sat eating lunch, he reminded me that if the checkered red Italian restaurant style table cloth was our universe, Jupiter wouldn't be a grain of salt, and Earth would be invisible to the naked eye. This interest with the scientific content in his art is seen in *Detour* and continues to be the thrust of his work today.

Detour: Brain Deconstruction Ahead

Detour: Brain Deconstruction Ahead, a virtual environment CAVE installation, is a manifestation of Rita Addison's experience with her brain injury. This work was created at EVL on the UIC campus primarily by Rita Addison and Marcus Thieboux, with limited consultation from David Zeltzer and various other people in the EVL and MIT community. As with any experience, the best way to understand *Detour* is to see and feel it first hand. *Detour* is a real time interactive display that surrounds a group of viewers with stereoscopic 3D imagery and sound.

Detour is a narrative that takes the viewers on a trip through a life before and after the car wreck that caused Rita's closed head injury. When *Detour* first starts, the viewers experience a walk down a peaceful hall-like gallery filled with Rita's photographs that she took before her accident. The viewers may walk up to and take time experiencing the soothing imagery and sound. The experience of the surround imagery and sound make the viewer feel as if they are in a gallery, and are really present with the work.

Although the CAVE room may be filled with a number of people at a time, one person "drives" the interactivity with a wand. At any point the navigator can stop and explore the imagery further. When the navigator hits the appropriate button on the wand, the experience changes from the gallery to a simulation of Rita's car wreck. At this point, the navigator loses control and must watch and listen. This portion of *Detour* is an animation of the car wreck, followed by a simulation of a tour through a damaged brain. Next, the viewers are sent back to Rita's photographs. However, this time, they are skewed to represent the view of someone who has brain damage. Through this distortion,

the artists represent thirteen perceptual anomalies that the viewer can experience.

In addition to the interactivity provided by the wand, the viewpoint of the imagery responds to the movements of a head tracker attached to one set of glasses. This also aids in the sense that the viewer is present with the work. The combination of head tracking and navigational control with the wand help the viewers *experience* rather than just *see* the perceptual anomalies, a unique element of the VE medium.

Detour was the first narrative CAVE installation, a work of art that had a beginning, middle and end. Up until this point, the CAVE was a scientific data visualization tool. For this presentation, the synergy of immersive 3D imagery, sound, and interactivity helped facilitate an undivided experience in the form of a story, a visualization of another kind of data, the artist's life.

The CAVE Technology

The CAVE setup is a 10 X 10 X 9 foot room that provides surround sound, interactivity, and 3D imagery that is projected on three walls and a floor. The room can hold a number of viewers at once, which make it feel more like a theater than a one person visualization tool. The name CAVE, or Computer-Assisted Virtual Environment, is a reference to Plato's *Allegory of the Cave*, a place to explore "reality, illusion, and, most importantly, education" (Luskin, 1996, p. 28).

The viewers experience high resolution imagery that is generated in real time by SGI Onyx computers. To make the viewers feel as if they are immersed in the experience, the computer stereoscopically projects the images on three walls and a floor. The viewers experience 3D imagery through glasses with liquid crystal shutters that merge the offset projections into a stereoscopic view.

This, along with the surround projections on three walls and the floor, visually immerses the viewer.

In addition to the visual immersion through 3D imagery, the viewers in a CAVE experience a sense of presence through physical interactivity. The viewers interact with work through head tracking and a 3D mouse (or “wand”). The viewpoint of the CAVE imagery is responsive to a viewer’s head movement. The movement is tracked in real time by an electromagnetic tracking device attached to one set of glasses. In other words, as the viewers move their head, they experience a change in perspective similar to what they would expect of a physical world view. They further interact with the application through a “wand,” also controlled through information from an electromagnetic tracker. The wand senses the viewer’s position in space, while the glasses sense orientation. The spatial data is also used for the simulation of surround sound, the final and often overlooked element of immersion.

Elements of Rita and Marcus’s Work

Unlike Max and Margaret, Rita and Marcus have worked together as a team to create and exhibit a virtual environment, *Detour, Brain Deconstruction Ahead*. These artists are not only different from Max and Margaret in that they have collaborated and exhibited their work, but they had an entirely different environment to work in, including dedicated hardware, the CAVE set up, and a dedicated facility, The Electronics Visualization Lab (EVL) at the University of Illinois in Chicago (UIC). This environment and its wider community was also a part of their “team.” For example, in a direct way, Rita and Marcus included as part of *Detour* a piece of animation created by a student at MIT. They also received consulting help from a research affiliate at MIT. In a less direct way, Rita and Marcus created *Detour* with a team that extended beyond themselves

simply because they made it at EVL, a lab set up and maintained by support personnel. In other less subtle ways, Rita and Marcus used drivers and functions that other people at EVL wrote and have left as available routines for anyone working with the CAVE. EVL is centered around the CAVE and its applications, so Rita and Marcus had an entire community of CAVE developers to consult with. Finally, because EVL is dedicated to showing applications created with their hardware, the *Detour* exhibition and subsequent permanent installation was enabled by the chartered purpose of the EVL community. In sum, Marcus and Rita's work was not only supported by their environment, a larger team, but was one necessary element in making it possible.

Although the work environment and team effort were elements of Margaret and Max's creative process, they weren't as developed as Rita's and Marcus's. What was similar, however, were the times that all the artists experienced an awesome and passionate intensity towards their work, one that focused their spirit and mind. When I asked Marcus to describe the sequence of events in the *Detour*, he couldn't help but get excited over how he made the car wreck simulation. He explained that while in the first part of the VE when the viewers are in Rita's pre-accident gallery, the person "driving" the VE could push a button on the wand and enter the accident scene. During this scene, the viewers experience shattered sharp and reflective broken glass from the car wreck. In describing how he made this glass, Marcus said he got so wound up in the shapes and realistic reflections that he would watch the animation time and again. In the following excerpt, I noted what he told me during one of our conversations. [In the excerpts from our dialogue, M stands for Marcus, R for Rita, and D for Dena].

M: Then, at any time the driver can push the first button, and BAMB!, you are in the accident scene. That was the first part I did. I really

got off on that, the breaking glass. The shapes and reflections were so realistic that I loved watching them break. I thought, Wow, this is going to be fun. That got me involved in it all.

Marcus also experienced intense pleasure with his work on an ASCII (American Standard Code for Information Interchange) level. According to him, much of his art was a conversation with the computer in ASCII, the standard text format. He meant he would write code, UNIX shell scripts or C programs, that the computer would then transform into works of art. During one of our conversations he described one of these ASCII conversations to me.

M: I've got a stream of ASCII text on the screen, am I making an image? I'm composing, writing, I'm not making imagery. I describe code to the computer, like a conversation. The machine then changes the ASCII into images. I'm not sure if I'm the artist or the computer is.

He said he often got so focused into the machine that he found himself talking to it when it didn't work. But the aesthetic experience came when he fixed the problem, when he would find a bug and then make it work. During the same conversation he told me about this experience for him.

M: I love to have ASCII conversations with the computer. I'll even yell "you stupid machine!" when it doesn't work, but when it works, it is beautiful. It is my drive to go on for hours without sleep or food. I love to find bugs, bugs of somebody else's. Then I can fix them and make them work, it is beautiful.

His ASCII conversations got so involved that he would ignore hunger and sleep signals.

While Marcus enjoyed the aesthetics of problem solving and formal qualities, Rita's aesthetic experiences were more emotional. In recalling how she

worked on *Detour*, she said it all started coming together when they synched the sound of the scream and the broken glass with the animation. When they finally got to the point when the sound matched the animation exactly, she could do no more than sit in the cave and cry. While synching the sound, Rita had to stand in the cave and watch the animation and hear the sound over and over again. In order to artistically simulate the experience of her wreck in the CAVE, Rita had to be emotionally focused on her feelings. Rita's aesthetic experience was more emotional and conceptual than formal. Even though this experience was not joyful, it was certainly passionate and awesome.

The aesthetic experiences for Marcus and Rita that I've illustrated are portions of their larger creative process. In other words, these aesthetic experiences, or the intense focus of their mind and spirit with the formal and conceptual parts of their art, were stages of their creative process. For Marcus, it was the pure satisfaction of problem solving and watching the simulation of shattered glass, and for Rita it was the emotional aspect of reliving the car wreck by watching and hearing the work over as it came together. This special slice of the creative process is consistent throughout many disciplines, but it contains unique elements particular to VE construction. VE is inherently immersive and experiential, thus it holds the attention of those viewing it. For those creating the VE installation, the medium requires that they view, listen to, and experience their work repeatedly while they make and design it. For the same reasons the VE medium provides an undivided experience for the viewer of the art, it also helps immerse the person creating the work. This phenomenon was apparent when Rita explained that since her accident she was unable to work in any other medium. She said that mostly she would lose her focus with other kinds of work, but with the VE, she kept experiencing her story time and again. When I asked Rita about times during her creative process that resembled an aesthetic

experience, she emphatically told me that they were one and the same. She doesn't create unless she is focused and feeling an awesome sense of emotional connection with her work. She said, for her, the aesthetic experience with a project is the only state in which she makes her art.

Not only is the aesthetic experience inadvertently evident in Marcus's and Rita's design process, but their decisions about their art consider this experience for the viewer as well. Both Marcus and Rita made comments about the power the CAVE holds for the viewer's aesthetic experience, mainly because it provides much more than imagery and sound. According to Marcus, the CAVE experience does not have much to do with images alone. The graphics just represent the complexity of the work. The whole of the sight, sound, immersion, and *adaptive* interactivity create an experience greater than any one of these things could. By adaptive interactivity I mean an experience that changes based on the user's input, either from the head tracker or the wand. Marcus wants to use this form of experience as a communication device for his art. He said that VEs advance a different way of communication that goes beyond words, pictures and sounds and puts the user in the realm of experience. He also said that a VE that uses CAVE technology is particularly good to put the viewer "in the shoes of" the artist, much like Rita's work.

About her work, Rita said that she used the immersive capabilities of the CAVE to hold the attention of the viewer and give them the feeling of the perceptual anomalies. The CAVE's capacity to provide an undivided moment for the viewer was one of the reasons she chose to use it. She said that VEs, in general, can focus people, much as they focused her. In this uninterrupted experience they can come closer to feeling passion or a connection with the work. She said she wanted to give the viewer a first-hand tour of her photographs before the crash, the crash experience, and the resulting perceptual anomalies

after the crash. Because the VE can provide the viewer with experience of the anomalies, she hoped they would then feel what it was like. In this way, Rita considered creating such an aesthetic experience for the user as part of the drive to make her own work.

In considering the aesthetic experience for the viewer, Rita and Marcus pointed out how a VE provides an undivided encounter with the art. When they showed *Detour* at SIGGRAPH 94, they noted the effect of the work on the viewer, proof that they in fact reached a point of awe with it. One viewer said “It’s a mixture of art, emotion and technology plus the medical aspect. It literally left me speechless” (Addison, 1997, p3). Ben Delaney expressed how he could experience the work much like he experiences a Picasso painting when he wrote

Addison’s work starts with the accident, then provides a view of the world as experienced through her modified sensorium. Images and sounds are fleeting, moving and often surreal. The experience, though rather beautiful, is frightening, as being trapped in a Picasso painting might be (Addison, 1997, p3).

This viewer described his aesthetic experience with *Detour* in terms of an extra element beyond what a painting could provide. For this viewer, *Detour* gave him a feeling akin to what he suspected being trapped in a painting might feel like. In other words, a sense of presence. This inherent aspect of a VE is one factor that facilitates the aesthetic experience for the viewer, thus making it a concern of the artist.

Much like the user who felt similar to being trapped in a Picasso painting, when a viewer interacts with art work they create their experience and take part in the creative process. This can happen with any kind of art, so long as the viewer is willing to interact on a conceptual level. With a VE, however, the only

way for the viewer to have an experience with the installation is if they physically interact with it. If a viewer's head is being tracked, a simple tilt of her head would force the display to match her view. In this sense, the viewer takes on a role similar to the artist's because they are, in fact, physically making the art. Both Margaret and Rita took this idea a step further when they spoke of their future plans for a dynamic VE. Margaret described a dynamic VE in her implementation of objects and environments that would organically grow based on user interaction, much in the same way she believes spirituality grows. Rita also spoke of a dynamic VE for the viewer in her presentation to the APA conference. The following is an excerpt from that presentation.

R: What if it was dynamic? In other words, you could construct your own space, say the user has a bucket of smells. She could construct a space that represented smells. Or what if the viewer could use his heart to create lighting in a thunderstorm. In this way, the viewer could co-create.

Similar to what Margaret expressed, the user adds and changes elements in the VE and thus becomes an artist on the extended VE team. Because viewers partake in both the creative process and the aesthetic experience, they too experience a point where they cross, as they did for the original artist. Given that user interactivity is a form of making the VE work of art, then, when a viewer reaches the aesthetic experience, he is also creating the work of art, thus the two elements cross. Margaret and Rita's future plans clarify this conceptual leap.

What is strikingly clear is how all four artists thought of the viewer's experience in some way. Max often thought of the user without realizing it, while Margaret intentionally listed things she hoped the user would experience. This level of thinking was tied to their experience with making VE works of art, works that inherently include the viewer. Margaret had some experience making prior

works of VE art and already found herself thinking of the user, whereas Max was just discovering the viewer's role. Marcus, on the other hand, had the most experience not only making VE works of art, but exhibiting them and watching the viewer's reaction. On the continuum of the importance of the viewer to the artist, Marcus had made the transition from self fulfilling art to consciously thinking of the viewer, as Margaret had. Marcus, however, took this a step further to make it his reason for creating the work. He asked me on a number of occasions if I thought VEs could ever surpass the glitzy "demos for conferences" or "shoot 'em up video games" phase, and if so, what would be the best application of them. He was concerned, after watching users at many exhibitions, if the true potential of VE was lost in the "glitz." Because of media coverage and their lack of understanding, most viewers expect to experience something outrageous, something that grabs them in the fast paced time frame (roughly 30 seconds) that they are used to. I call this the "wow" factor. Marcus felt that this was due to the viewer's lack of prior exposure with VE, and the short amount of time they had to see the present installation. For most, he witnessed their first VE experience. He recalled a VE exhibition that was lacking in glitz, and how many of the people who waited to see it felt let down. The following is from our discussion in which he talked about this exhibition.

M: People would wait in line for 3 hours and want the "wow." When they didn't get that, they were angry. So, now we [VE designers] are putting the "wow" back. I want people to get beyond the "wow" and into the experience. It is really a completely new experience for them to get used to. OK, say they have five minutes to go in the cave. Let's say they have two minutes to get over the "wow," short learning curve. Now, they have three minutes to have the experience. Right.

Most people, today, do not understand what a VE is or how their physical motions and cognition translate into a new space. Perhaps there is a necessary passage of time before they become used to this medium, much in the same way people got used to how they would speak to somebody on a telephone and how they are now learning how to communicate via email. A VE is a new way that a physical motion translates into visual information that a viewer first needs to understand, then learn to form into words and ideas. Until this becomes a common part of contemporary ideas and language, VE descriptions will seem somewhat surreal and fantastical.

Regardless of how many times the user has seen the VE, or how much time they have with it, Marcus's work is driven by the intention to help the user get past the "wow-factor" and into higher levels of thinking and interactivity. Due in part to his experience exhibiting VEs, Marcus's thinking is furthest on the continuum of how the viewer figures in his work. In his most recent project for his MS degree, Marcus designed a work with eight virtual spaces, each with the intention of engaging the viewer. While he was working on it, he wrote to me about it.

M: I'm finally getting this project together. I'm still short a space, and I'm putting too much other stuff in. Next week I have to start thinking about formal description and whatnot. I'm thinking of calling this part of the show "elements of interactivity." My notion is that by reducing glitzyness and engaging the person with tasks you can reinforce the presence of the virtual material. There is more to VEs than just fake images. There is live input data processing, and there is a real element to what is going on. The "wow" factor will drop rapidly with all the new home gaming devices. What will

be noticed is the difference between a silly game and a well developed VE session.

Marcus said it is his belief that you can engage the user or facilitate the aesthetic experience through providing them with actual tasks, thus increasing their presence. It is my view that presence in a VE is the aesthetic experience. This tasking provides a realness factor that is necessary to balance the unreal portions of the VE. Further, Marcus re-enforces my belief that after a sufficient amount of exposure through gaming devices, the viewers will get tired of the “wow” factor and perhaps understand how to use a VE better. They will then demand a VE with content. For this project, the role of the user is the thrust behind Marcus’s desire to create a VE. For visual artists in general, this is a transition in thinking from concern only about the art in the state it is while they are creating it, to thinking about its state while the viewer is viewing it, thus they consider the viewer during the creative process.

As much as his thoughts about the viewer were a part of Marcus’s creative process, so was his flow state. As I’ve already pointed out, the times when he was in flow, or his state of complete concentration of energy towards his work, often had elements of the aesthetic experience. However, his flow state also included times when his work seemed to effortlessly fall into place, and he would want to spend endless hours with it. During these times, he often suffered a deficiency of food and sleep, usually while settling differences with the computer. Marcus said, “I remember reconciling with the computer and I would lose total track of time.” While he explained this, he held his hands out in a typing position and started to quiver. He made his eyes wide, opened his mouth, and put off an intense stare as if in a trance. He reminded me of a junkie wanting a fix. He then said, still imitating this trance, “I remember sitting in front of the computer working, and I knew I needed food, I was shaking, but I

just couldn't leave." Here, Marcus was so involved with his conversation in ASCII with the computer that he cared more about it than basic bodily functions. This was part of Marcus's flow state.

Rita's flow state came when she felt she was working using the right side of her brain. She said that when she took her ideas straight from the source and saw them, a step at a time in the CAVE, she was in flow. Rita said of her best work experiences, "I would just enter the CAVE and create the program right here," pointing to the right side of her head. It was during these times that she could work many hours with Marcus. She said it was important to have Marcus there to work with because in order for her to make artistic decisions and think of creative ideas, she could not think of the technical implementation. She said this freed her ideas and helped her focus on her art and what she wanted to create. It was during these times when she came up with the appropriate CAVE representation of experiences that words and pictures alone could not explain. This observation is important for a VE in particular because it offers tools to make new representations of experiences. In addition, the complexity of the tools requires at minimum a small team, one where each member can offer or contribute what they do best. What Rita did best was create an idea and direct its manifestation. Anything other than that, she said, would get in her way of creating.

Just as the complex technology involved with making a VE interrupted Rita's artistic flow, it had the same affect on Marcus. Marcus told me that the complexity of implementing a VE kept him from feeling like he made art. He said he could never bring any of his artistic ideas into fruition because he got lost in his ASCII conversations with the computer. He had to design so much of the basic functionality that he lost his original ideas. To make a VE he said he had to write all of the code and design all of the buttons. He likened this to an artist

having to make his own pigments. The following is when Marcus told me about this metaphor during a discussion.

M: It would be like an artist who had to make his own pigment. I spend so much time making pigment that I lose my focus. I also lose a purpose to my work because I put so much energy into making the pigment that it becomes my reason. I mean, a painter picks up a canvas and a brush, squirts some paint on a palette, then goes at it. Making the pigment takes me far from my original focus. That and having to prepare for all these conferences!

He expressed that his focus became providing basic functionality to create in the cave rather than putting these functions to use. Certainly he was creatively solving technical problems, however, he lost his artistic motivation when he was immersed in the technology. Marcus saw nothing but ASCII until he solved all the technical glitches. Even though 3D digital artists must imagine what their texture will look like mapped onto a wire frame, and 2D artists must zoom in and out to imagine their entire composition, they at least work with models and visual representations, unlike the concepts Marcus must visualize. Marcus often replaced his focus on these concepts with technical concerns. When I asked him how Rita played a role in his flow, he said she provided the focus for his tools. Marcus got lost in his ASCII while Rita got lost in her ideas.

Marcus's method of making art in ASCII is similar in some ways to a painter's method of building up strokes. As Marcus must imagine the ultimate representation of his code, the painter must imagine how his or her pigment will ultimately render space. However, Marcus's method is slightly more primitive in that he can't see the build up of strokes, or the iterations along the way. He said that when he finished writing his code, he often felt that he didn't have to run it, as if the concept in ASCII was the end product for him. From here on, he

said, the computer makes the art and he would be satisfied if he never saw the manifestation of his ASCII. In this sense Marcus's process became his art, akin to both conceptual and performance art. It is conceptual in that the visual aspect is only one, perhaps unnecessary element of his work. This portion of Marcus's work is a universally autonomous form of performance art. It is his art work, performed in solo, and ending in solo, yet a product that represents the processes of others.

Certainly VEs have relations to other art forms besides performance and conceptual art, and I wanted to know what connections Marcus saw. He felt VEs were most like films because they usually told a story, a narrative. They are different because they provide an interactive experience and the exact order of events are unknown. In addition, he said that the VE medium is an extension of all other mediums that came before it, "Painting influenced photography, and photography, in turn, informed film. Now film, as well as games, inform VE art. It is the next logical step." As a medium, VE art is not that far removed from others. As a result, artists making VE works will experience some elements of their creative process that are similar to their process for other art forms.

VE is different from other mediums in many ways, but mostly in its inherent demand that the viewer participates in the art. That participation, according to Rita, is only twenty percent sound and imagery, with the other eighty percent being the combination of all the senses through interaction. It is a modern medium and it talks to a contemporary audience who themselves are reconciling with the computer in their lives. The newness of the medium requires the artist to think and create in novel ways. Rita and Marcus's work is one example of that process for a team that has successfully created and exhibited a VE work of art. Many elements of their process resonate with those of Margaret's and Max's. Some of these elements include their need for a team,

their recognition of the viewer, their aesthetic experience during the creative process, and their experience of an undivided focus that a VE provides through interactivity. As VEs become more main stream and more VE teams form that are geared towards making VE works of art, I believe more elements will surface and with that, an extended definition of a VE.

CHAPTER VI

SUMMARY, CONCLUSIONS AND IMPLICATIONS FOR FURTHER RESEARCH

In this study I examined the creative and learning processes of artists making a VE work of art. To do this I collected data on two main participants and two secondary participants. For the main participants, the data included pre-histories, daily reflections, a final conversation, and field notes. The data from the secondary participants were based on field notes from conversations, a presentation, and email. The main participants learned how to make and created a VE work of art. The secondary participants made and exhibited a VE work of art as a team. I culled elements of the creative and learning process from the two main participants that represented patterns for each artist and between them. I used elements of the secondary participants that elucidated the findings for the main participants.

Although humans continue to create new technology such as VEs, human potential has not changed. However, we build on the effects and lessons of earlier human experience. For example, we no longer have to think about physically cutting and pasting text when preparing a document, we use a word processor to do it digitally. Editing changes are now easy, which frees us to spend more time with the thought behind our words. Here we have used our invention of the word processor to take our same potential to a new level.

Still, it is often hard for those that didn't grow up with these technical innovations to comprehend them. Not that they can't, but their life experiences have taught them to think differently. My father still keeps his patient's files in a file cabinet, and will not transfer them to a computer. I, on the other hand, don't own a file cabinet. New tools in any discipline result in new ways of thinking

and new products. The VE medium is one of those new tool sets that can produce a new form of art. These new tools seem like a natural way to make art to those who grew up with computer games and other childhood computer experiences. After all, as Rilke reminds us, every word, or in this case, every art work is based on a life of experiences. It makes sense for an artist whose life experiences include new technologies to use the computer for art.

The VE medium seems appropriate to speak to people who are used to thinking and feeling with a computer. Just as it is natural to experience art through a painting for previous generations, it is natural for younger generations to experience art through a computer. It is a medium and language they understand.

In looking at the creative and learning process for digital artists making VE works of art, this study uncovered elements that inform specific and general areas in art, art education, and VE research. Above all, this study shows how artists indeed experience creative processes with the VE tool similar to those of other mediums, thus making it a valid form of art. In addition to the similarities, however, the process of making a VE has unique elements that give the artist and viewer novel experiences. Although the list of similarities and differences is quite long, the key unique element of a VE is interactivity, which is both similar and different from traditional mediums.

Summary of Findings and Implications

Validity and Uniqueness of the VE Medium

As it is fundamental to any art tool, the VE tool set is a mechanism for expression and communication for the artist. To be an expressive tool set, the artist must be able to show his or her ideas despite the medium. This is often

seen when artists work consistently with the same ideas as they change mediums. This study shows how Max was able to carry his concerns for architecture from his childhood and other art media into the VE tool set.

The VE medium affords more than a valid art tool and offers elements that make it different from others. One such element is the interactive nature of the medium and how artists making a VE are able to view, experience, and edit their work. In Max's case, he used this aspect to get a better sense of the movement or flow of one room in his building into the next. The interactive nature of a VE aided his design process and encouraged Max to spend more time exploring his ideas. In this way the VE tool is unique because the design process requires the artist to run the environment, experience it, and make further changes. It is true that an artist interacts with her painting as she builds layers of brush strokes, but she doesn't physically interact with the result that a viewer will see. VE artists experience a physical interactivity as they build their strokes by running and interacting with the installation they intend to exhibit. The interaction forces the artist to spend time, get a sense of the sequence of events in their work, and gives them tasks to experience. Navigation through the space is one of the most basic tasks, and it engages the artist's attention to the design and the feeling of the VE installation. Not only did the VE tool set provide a mechanism for expression, as other media, but this kind of interactivity during the design process aided Max's experience making his art.

Margaret and Rita were also able to use the interactivity of the VE medium as a palette for expression, however their communication was more emotional. As Rita built her VE with Marcus, she experienced the work one iteration at a time. The two added new geometry, movement, and sound much in the same way a painter builds strokes. Between each iteration, Rita stood in the CAVE and experienced the work in progress. When she did this, the

emotional content of the work tapped her visceral chords of expression, and through this, Rita was better able to represent her experience. Margaret did the same when she designed the ethereal motion of the bowl through her space. Margaret wanted to create a world of spirituality facilitated in part by the motion of the user through the space. While she designed her work, she was able to interact with the objects and imagery in the space to experience the motion she wanted to portray. As did Max, Rita and Margaret used the unique element of interactivity during their design process to experience what they wanted to express and communicate.

The Aesthetic Experience for the Artist

In addition to aiding the artists in expression during their design process, the interactivity of the VE also facilitated an aesthetic experience for them. When the artist has an aesthetic experience during his or her creative process they become engaged with their work and are often at peak productivity. Margaret was at her best when she was able to fly thorough her virtual space and experience the motion she just created. She often became so much involved with the motion that she lost her sense of anything else. The aesthetics of the simulated motion in her VE pulled Margaret in and gave her motivation to work through the details of how she wanted to display it.

Max's aesthetic experience was evident through his physical body movements. He was so involved with the interactivity of his work that he tilted his head and tensed the muscles in his face and body in concert with the physical tasks of his VE. At these times he didn't even recognize that others were around him.

Rita's involvement while she was creating was characterized by her outpouring of emotions. At such times she was involved with the experience of

her work at such a high emotional level that she uncovered feelings within herself that she was then able to incorporate into her VE. Although not within the scope of this study, this is an interesting finding for those involved with clinical psychology.

Marcus's aesthetic encounters were when he had conversations with the computer in the form of ASCII code. Marcus was most absorbed in his work when he found and solved bugs in the code. For Marcus, the aesthetics of his art were often ASCII manifestations.

In all the cases, the interactivity of the creative process intensified the artists' ability to reach a point of complete engrossment with their work, in some cases pure enjoyment and, others, sheer sadness. This high level of involvement enhanced their ability to take their art to higher levels of accomplishment.

The Confluence of the Aesthetic Experience and the Creative Process

Spurred by interactivity, this intense involvement with their work was a point where the creative process and the aesthetic experience were one and the same for the artists. This aesthetic level of engrossment was usually the impetus for novel ideas about their work. Margaret came up with and solved the implementation of the subtle motion she wanted as part of her VE experience. It was when she was physically interacting with the motion herself that she became focused enough to think of the experience she wanted to portray. This level of involvement also gave her the motivation to overcome the idiosyncrasies of its implementation.

Max's aesthetic experience provided an involvement with his building that aided his sense of space and movement within that space. The crossing point of the aesthetic experience in his creative process helped him envision novel ways to give the smooth feeling of movement from room to room.

In Rita's case, her emotional aesthetic experience gave her a focus that her brain injury usually hindered. She was then able to translate the same experience she was feeling into her CAVE installation. When Marcus was aesthetically absorbed in his creative process he was able to creatively solve implementation problems and bugs associated with realizing Rita's ideas.

In all instances, the physical interactivity with the work in progress inherent in making a VE facilitated an aesthetic experience for the artists that was part of their creative process. This state is important because each artist was at peak performance and able to think of novel ideas associated with their art. In other words, it motivated the artists to create and solve problems because they were highly involved with their art.

Thinking of the Aesthetic Experience for the Viewer

In the same way the interactivity of a VE facilitates the aesthetic experience for the artist, it does so for the viewer of the installation. Both Marcus and Rita commented on the power of the experiential nature of the CAVE, and how the interactivity aided in providing something that went beyond surround imagery or surround sound alone. It is these immersive elements together with interactivity that make the experience unique. This unique experience facilitates a level of involvement, or presence, on the part of the viewer that is the aesthetic experience. This element is so ingrained in the medium that VE artists think about it for the user in their design.

The viewer is often left out of the minds of the artists while they are making their art. I believe this is more a result of the artists being involved with their work than their lack of concern for the viewer. Often artists are so much consumed with their present aesthetic experience that their thoughts don't include the state of their work for the viewer. When the product the artists are

making is about providing a physical interaction for the viewer, the artists can't help but think of the future state of their work. A VE is a product for which the artist automatically considers the aesthetic experience for the viewer.

Thinking about the viewer is a new idea for many artists and, as with any new idea, it matures and is refined with time. This study shows the continuum of that maturity from the novice who first experiences that idea to the expert who fully embraces it.

Max, who is a novice, described elements of his VE that included the viewer without even realizing it. Max doesn't think of the viewer when he works in other mediums, such as photography, but he couldn't help but include them in his thoughts for a VE. He credited this to the interactive nature of a VE and said the user is the motivation for the work.

Margaret, who had made a VE before this study, already knew about the viewers and outwardly expressed concern for how they would experience her imagery. She wanted to add to their experience by the way they navigated through her space, or what she called motion. Marcus, who had expert experience making and exhibiting VEs, was most sensitive to the viewer of the art. This seasoning influenced Marcus to not only have concern for the viewer, as Margaret did, but to make it the drive behind his work.

The progression of thoughts concerning the viewer in the artist's creative process is clearly something that the interactive nature of the VE shaped. An art educator may use this potential of the VE medium to teach artists to think about their work for the viewer and to think about their work in a future state.

The Aesthetic Experience as Presence

The aesthetic experience for artists and viewers describes a level of involvement with the work of art that makes them feel as if they are inside the

work of art, or present. This sense of presence can happen with any kind of art work, but the physical interactivity of a VE work of art helps the viewers sense that they are mentally and physically within the space of the installation.

This sense of presence is also aided by the adaptive nature of a VE system. By adaptive I mean that the VE changes with input from the user. At a most basic level this could be how the VE re-displays the view in concert with how the user navigates through the system or, if her head is tracked, how she tilts her head. This adaptability is something the system displays as the user interacts. The adaptive mechanism is real time interactivity and it helps the user, the artist or the viewer, sense and believe they are present in the work.

It is important in art and art education for artists to reach a level at which they are able to create new thoughts and solve new problems in connection with their art. The aesthetic experience for the artists is one way to do that, and presence in a VE can provide that experience.

Also important for art educators is to help artists think about the state of their art after it becomes a product for a viewer. It is easier for artists to think about the viewer when they are in a state of presence with their work. The feeling of presence for the artist while they are creating is a sample of the aesthetic experience the viewer will feel.

In museum education, it is a goal of the educator to facilitate the aesthetic experience for the viewer of the work of art. When a VE provides a higher sense of presence for viewers, they become more involved with the work and are more likely to have an aesthetic experience. Presence in a VE is a gauge for museum and art educators to understand and advance the aesthetic experience for both the artist and the viewer.

Because the aesthetic experience with a VE art installation is a result of a high level of presence, I suggest that the sense of presence in a VE is a form of the

aesthetic experience. Researchers who are concerned with exploring the best way to make the users of general VEs feel this sense may find rich answers observing the aesthetic experience of artists making, and the viewers experiencing, VE art works.

The Newness of the Aesthetic Experience as Motivation

In addition to aiding in the sense of presence, the aesthetic experience in a VE encompasses new cognitive elements which serve as motivation for both the artist to work and the viewer to become involved with the VE. By cognitive elements I mean aspects of the VE that require the users to re-think visual and physical perceptions.

Throughout this study, the artists used the concept of flying through a virtual space to mean navigating through a visual simulation. This concept is one example that is foreign to those who have never experienced a VE. Another is how the user's physical movements are translated into visual stimuli that are different from what they would expect in the physical world. Because what the viewer sees and hears in the VE is adaptive and interactive in real time, it is believable. The viewer knows the environment is not physically real, but they can believe it, much like they can believe a movie. These are examples of new cognitive elements that the artist and viewer must reconcile.

For the artist, this reconciliation is a large chunk to understand and it takes time for them to see its specific implications. These new perceptions may at times be frustrating, but are also exciting because they give artists something new to explore. The excitement helps feed their aesthetic experience, which leads to novel thinking. For example, Max, although frustrated by the new perceptions at times, was interested enough to explore them. This exploration

tended to heighten his aesthetic experience and give him motivation to add new ideas to his VE.

These new cognitive elements are stimulating for both the artists and viewers, and are part of their aesthetic experience. While having that experience, the artists and viewers spend more time with the work. For artists, this passage of time helps them understand and become more involved with their work. For the viewer, this encourages them to spend more time experiencing the art. In both cases, these new cognitive elements provide a motivation for the user and the artist to explore and spend meaningful time with the work.

General Flow Patterns

The optimal flow state for the artists were usually those times when they were having an aesthetic experience with their work. This was often characterized by their lack of desire to eat, sleep, or stop working. During these times they experienced an intense focus with their work in such a way that other life difficulties seemed unimportant. The artists were in their optimal flow states when they felt a balance between their goal and control over getting to it.

Max felt in control of his work when he kept the tools simple and ignored the plethora of overwhelming possibilities. He kept an outside eye on further possibilities, but left them for later implementations. It was in this state that his flow pattern was optimal.

Margaret also experienced flow best when she felt in control of her environment and her goals. This was most visible when her flow was interrupted and she let the technical information or other environmental factors drown out her artistic endeavors. Margaret was particularly affected by her environment, especially the violent implications of the lingo of some of the tools in her set. VEs were developed by the military for training purposes and then

mainstreamed by the gaming industry to simulate battle situations in computer games. As a result, the tools to design aVE and some individuals attracted to making one reflect this nature. There were times when the violent nature of the VE tools, along with the difficult technology and the masculine work environment negatively effected her flow. It was when she could grasp the technical aspects and feel secure in a friendly environment that her flow was prime.

In general, both Max and Margaret experienced highs and lows in their flow pattern, but the pattern continued on an overall steady incline. The highs occurred when they felt in control of their work, and they usually included an element of play. The playfulness often spurred creative ideas about their art and ways to solve problems. The lows were often a result of the steep learning curve associated with VE construction both on a cognitive and technological level. They often required an amount of time away from the art to let the new information slowly make sense. This time segment was a necessary part of their learning process.

The importance of the time element is often overlooked by educators in all disciplines. It is one thing for the student to know about a tool and how to use it, but it is quite another for the student to have an intuition about it. This intuition only comes after a period of time when the student can make connections with the tool and concerns in their lives. In other words, the student must learn to “feel” the tool, and this feeling, like aging a wine, can’t be rushed. As their flow patterns suggest, Margaret and Max returned from their lows with a better feel for the VE tool set. This better intuition led to more flow states, each more productive than the last.

The Flow of a Team as a Jellyfish

The flow for both Margaret and Max was greatly influenced by who else was involved with their work. When Max's work with his *Bradburry* building felt irreconcilable, he hit a low and wanted to forget further efforts with it. When Max was at the furthest depth of this low, I introduced him to a potential team. Max instantly showed a renewed enthusiasm for his future work as a member of a team. The dynamics of the team and the promise of a distributed work load gave Max energy that led him into another flow state. A similar thing happened when Margaret experienced the promise of collaborators with her work.

Because the VE medium is laden with new technology and cognitive possibilities, it is hard for one person to fully visualize and bring the VE work into fruition. Both Margaret and Marcus were able to think on a technical and an artistic level, however, they were proficient in only one at any given moment. The optimal flow state for making a VE happens when different ways of thinking are present at one moment. The demands of VE construction require various kinds of thinking which may be best implemented by a team of people.

When Marcus and Rita worked together they, along with their extended team, displayed the synergy of the different work styles. The unique workings of a VE team are similar to how the individual parts of a jellyfish work together to propel the fish forward. According to Perry, "It is difficult to determine whether the large jellyfish are single animals or societies of individuals concerned, respectively, with propulsion, protection, fishing, feeding and reproduction. Perhaps...they are of some higher individuality beyond our comprehension" (1972, p. 133). As Perry suggests, the single entities of the jellyfish are concerned with one larger goal and a new kind of individuality.

In much the same way as the jellyfish, the members of a VE team play important individual roles that are imperative to the larger VE goal. They are at

optimal productivity when they share a flow that taps different thinking modes at one time. On their immediate team, Marcus creatively solved problems, while Rita was creatively generating ideas. Marcus provided as much focus for Rita as she provided for him. Both of their energies were directed by the other which allowed Rita to concentrate on her non-linear artistic ideas, while Marcus could focus on the logic of programming.

The success of Rita and Marcus's work together supports the idea that team work is essential to tap the varied abilities necessary to make a VE. It also explains the comfort that led to increased flow for Max and Margaret when they felt the potential for team involvement. Be it artistic, industrial, military, or educational applications, VE construction requires a team of individuals that can each think in a variety of ways.

A New Way of Working for Visual Artists

Although many other disciplines have used the dynamics of team work to reach optimal flow and productivity, this way of working is new for some contemporary visual artists. There are some efforts to collaborate in the visual arts, but they are not common, and most of them are recent. Traditionally, most artists work in their individual studios and reach their respective flow states in a world unto themselves. They usually have solitary control over their work and the direction it takes.

I have yet to find examples of VE works of art that were made by one individual. In fact, what I've found suggests that the artist who chooses to work with the VE medium will have the most success reaching their flow state on a team. This working situation could be a teaching tool for educators to teach about creating collaborative works of any sort. This is important in a broad sense because the demands of our increasingly complex, technologically driven society

may well call for team strategy in many situations in order to survive. This will help the students learn to work on multi-disciplinary teams and tap into the productivity of a shared flow state. The members of the team benefit from other kinds of thinkers from various disciplines. This way of working is reflective of some recent trends in industrial work environments, especially in computer graphics.

I believe there is non-linear artistic thinking and stepwise logical thinking in both the arts and the sciences, however the respective disciplines are sometimes unfortunately cut off from one another. A multi-disciplinary team such as I have suggested will help link the different methods of thinking to each other.

Implications for Further Research

Because the VE medium is new, VE trainers, designers, and artists still need to understand at what point and how to get the user and the artist to a place where they have an intuitive feel for the medium. A VE trainer needs to help those who design VE applications understand the implications of the tool. What are the best ways of teaching this? VE designers and artists need to have an intuitive feel for the tools so they may better understand how to make VE applications. Exploring this transition period for VE artists may also shed light on the cognitive and psychomotor development of children, adults, the disabled, and other populations.

Also intriguing about VE construction is how it demands the work of a team. Some of the questions this raises include "What is the optimal way to set up that team, who should be on it, how should the individuals work together, and who gets recognized?" Studies that ask questions such as these may start with research in art, yet have implications for teams in industry, education, the community and government.

I believe the VE art medium will become mainstream. When it does, art educators will need new curriculum and training in order to address the new technical, cognitive, and team work aspects of the media that I have presented in this study. These concerns are similar to those that computer educators now face. The VE art curriculum in particular should include how to use the inherent interactivity of a VE to facilitate the aesthetic experience for the artist and the user so they may have a more mature understanding of the art work.

In this study I found that interactivity is a key difference of the VE medium from other art mediums. Adaptive interactivity, or engaging the user in tasks, is the element of a VE that helps the viewer and the artist feel a sense of presence with the art. In addition to adaptive interactivity, surround images and sound through constructs such as the CAVE and peripherals such as a head mounted display aid in that sense of presence. Which is more important, the surround images and sound or the adaptive interactivity? Peripherals are quite expensive, and there is a plethora of rich experiences a low end system can provide with adaptive interactivity.

Also connected with adaptive interactivity is concern for the efficiency of the display and the resulting low resolution graphics. In a VE, there is always a trade off between using CPU cycles to render high resolution graphics slowly or render low resolution graphics quickly. The faster the computer responds to input, the less lag time the user feels between her motion and the resulting visual representation of it. The effect of lag hinders the user's sense of presence. Because presence and the aesthetic experience are equivalent for a VE work of art, researchers concerned with presence will benefit from noting how a viewer's aesthetic experience is altered when efficient interactivity is substituted for higher resolution graphics. In other words, which is more important for the user to feel the sense of presence, immediate interactivity or high resolution graphics.

Connected with high resolution graphics is the importance of stereoscopic graphics. Like high resolution imagery, stereoscopic graphics also require more processing power and as a result, may slow down interactivity. Which is more important for presence, the stereoscopic graphics or interactivity. Researchers may observe the aesthetic experience of viewers using stereo and non-stereo VE works of art to test this trade off.

Also related to the aesthetic experience was how, in this study, it usually coincided with the artists' optimal flow state. During these times, the artists felt an intense focus with their work in such a way that other life difficulties seemed unimportant. The artists felt this state when there was a balance between their goals and control over getting to them. Researches in art may observe how the balance of goals, the aesthetic experience, and the optimal flow state are related, and a VE medium would be an appropriate research instrument.

Also crucial to reaching the flow state is the passage of time. Time is a particularly important element for educators teaching ideas that demand the high amount of new cognition and technological mastery that VEs do. In this study, the artists learning about VE construction often required an amount of time away from the project to let the new information slowly make sense. This time segment was a necessary part of their learning process. The importance of the time element is often overlooked by educators in all disciplines. There needs to be research on the effect of time on the learning process, especially in highly technical areas such as VE construction.

Finally, there needs to be curriculum concerning the many ways an art educator may use the interactive quality of VEs. Because interactivity forces the artist to think about the viewer, the art educator may use VE construction as a mechanism to teach them about the communication component of the creative process and art. Recall Max didn't think of the viewer when he worked in other

mediums, such as photography, but he couldn't help but include them in his thoughts for a VE. He credited this to the interactive nature of a VE and said the user is the motivation for the work.

The interactive component also makes it easier for artists to think about the viewer because they can more easily reach a state of presence with their work. The feeling of presence for the artist while they are creating is a sample of the aesthetic experience the viewer will feel. A VE exists to be interacted with, and an educator may use this tool to help students understand yet another way to communicate ideas. The curriculum for teaching about this technology still needs to be developed and incorporated into other disciplines within the field of art.

REFERENCES

- Addison, R. (1997). *Rita Addison* [On-Line]. Available: <http://manray.mit.edu/www/rka/rka.html>
- Amabile, T. (1983). *The social psychology of creativity*. New York: Springer-Verlag.
- Amabile, T. M. and Hennessey, B. (1988). The conditions of creativity. In Robert Sternberg (Ed.), *The nature of creativity, contemporary psychological perspectives* (pp. 11-42). Cambridge: Cambridge University Press.
- Aristotle. (1928). *Metaphysics*. In W. D. Ross. (Trans and Ed.), *The Oxford translation of Aristotle* (Vol. 8, pp. 791-795). Oxford: Oxford University Press.
- Arnheim, Rudolf. (1969). *Visual thinking*. Berkeley: University of California Press.
- Barthes, R. (1987). *Criticism and truth*. Minneapolis: University of Minnesota Press. (Original work published 1966).
- Bailey, Juanita J. (1994). *Making a way out of no way: An analysis of the educational narratives of reentry black women with emphasis on issues of race, gender, class, and color*. (Doctoral dissertation, University of GA, 1994).
- Bogdan, R. C., Biklen, S. K. (1992). *Qualitative research for education*. Boston: Allyn and Bacon.
- Casti, J. L. (1996, October). Confronting science's logical limits. *Scientific American*, 102-105.
- Csikszentmihalyi, M. (1988b). Systems view of creativity. In Robert Sternberg (Ed.), *The nature of creativity, contemporary psychological perspectives* (pp. 325-339). Cambridge: Cambridge University Press.
- Csikszentmihalyi, M. and Robinson, R. (1990a). *The art of seeing*. Malibu: Paul Getty Museum.
- Csikszentmihalyi, M. (1990b) *Flow : The psychology of optimal experience*. New York: Harper & Row.

Connelly, M, and Clandinin, J. (1990, June-July). Stories of experience and narrative inquiry. *Educational Researcher*, 19, 2-14.

Carande, R. (1993). *Information sources for virtual reality : A research Guide* . Westport, Conn.: Greenwood Press.

Davies, Char (1996, August). *The soul of the machine: The search for spirituality in cyberspace*. Panel at the meeting of the Special Interest Group, Graphics of the Association of Computing Machinery.

Denzin, Norman K. (1989). *Interpretive biography*. Newbury Park: Sage Publications.

Derrida, J. (1981). *Positions*. Chicago: University of Chicago Press.

Dewey, John. (1934). *Art as experience*. New York: Minton, Balch & CO.

Durlach, N. & Mavor, A. S. (Eds.). (1995). National Research Council, Committee on Virtual Reality Research and Development. *Virtual reality: Scientific and technological challenges*. Washington, DC: National Academy Press.

Durlach, N. & The National Research Council, Committee on Virtual Reality Research and Development (1995, August). *National research agenda for virtual reality*. Report presented at the meeting of the Special Interest Group, Graphics of the Association of Computing Machinery.

Etter-Lewis, G. (1993). *My soul is my own*. New York: Routledge.

Feldman, David . & Csikszentmihalyi, M. (1994). *Changing the world : a framework for the study of creativity*. Westport, Conn.: Praeger.

Goldberg, D. E. (1989) *Genetic algorithms in search, optimization, and machine learning*. Reading, Ma: Addison-Wesley Publishing Company.

Gombrich, E. H. (1982). *The image and the eye, further studies in the psychology of pictorial representation*. Ithaca: Cornell University Press.

Hayles, K. N. (1996). In Moser, A. & Macleod, D. (Eds.). *Immersed in technology, art and virtual environments* (pp. 1-28). Cambridge: MIT Press.

Hochberg, Julian. (1977). Visual art and the structures of the mind. In ? (Eds.). *book title* (pp. 151-172). New York: Pub???

Jung, C.G. (1921). *Psychological types*. Princeton: Princeton University Press.

Kalawsky, Roy S. (1993). *The science of virtual reality and virtual environments*. Wokingham, England: Addison-Wesley Publishing Company.

Laurel, B. (Ed.). (1990). *The art of human computer interface*. Reading: Addison-Wesley.

Laurel, B. (1992). *Computers as theater*. New York: Addison-Wesely.

Loeffler, C. & Anderson, T. (Eds.). (1994). *Virtual reality casebook*. New York: Van Nostrand Reinhold.

Lowes, J. L. (1927). *The Road to xanadu*. Boston: Houghton Mifflin.

Luskin, J. (1996, Spring). The universe in a CAVE. *Iris Universe*, 35, 28-32.

Manning, P. & Cullum-Swan, B. (1994). Narrative, content, and semiotic analysis. In Denzin & Lincoln (Eds.), *Handbook of qualitative research* (pp. 463-477). Thousand Oaks: Sage Productions.

McCorduck, P. (1991). *Arron's code, meta-art, artificial intelligence, and the work of Harold Cohen*. New York: Freeman and Company.

Merriam, Sharon B. (1988). *Case study research in education, a qualitative approach*. San Francisco: Jossey-Bass Inc.

Mishler, Elliot G. (1986). *Research interviewing: context and narrative*. Cambridge: Harvard University Press.

Morgan, D. N. (1953). Creativity today. *Journal of Aesthetics*, 12, 1-24.

Morrison, P. and Morrison, P. (1982). *Powers of ten*. New York: Scientific American Books, Inc.

Moser, A. & Macleod, D. (Eds.). (1996). *Immersed in technology, art and virtual environments*. Cambridge: MIT Press.

Myers, I.B. (1980). *Gifts differing*. Palo Alto: Consulting Psychologists Press.

Newell, Shaw, and Simon. (1963). The Process of creative thinking. In H. E. Gruber (Ed.), *Contemporary approaches to creative thinking* (pp. 43-62). New York: Atherton.

Norman, D. A. (1988). *The psychology of everyday things*. New York: Basic Books.

Norman, D. A. (1993). *Things that make us smart : defending human attributes in the age of the machine*. Reading, Mass.: Addison-Wesley Pub. Co.

Paley, Nicholas. (1995). *Finding art's place : experiments in contemporary education and culture*. New York: Routledge.

Perkins, D. N. (1988). The possibility of invention. In Robert Sternberg (Ed.), *The nature of creativity, contemporary psychological perspectives* (pp. 362-385). Cambridge: Cambridge University Press.

Perry, R. (1972). *The unknown ocean*. Newton Abbot, England: David & Charles Limited.

Phelan, Peggy. (1993). *Unmarked: the politics of performance*. New York: Routledge.

Piaget, J. (1971). *Biology and knowledge*. Chicago: University of Chicago Press.

Plato. (1961). The ion. In L. Cooper, E. Hamilton, and H. Cairns (Eds.), *Plato, the collected dialogues* (p 218-221). New York: Pantheon Books. (Reprinted from *Phaedrus, ion, gorgias and symposium*, (L. Cooper Trans.). 1938, Ithaca: Cornell University Press

Richardson, L. (1994). Writing, a method of inquiry. In Denzin & Lincoln (Eds.), *handbook of qualitative research* (pp. 516-529). Thousand Oaks: Sage Productions.

Riessman, C. K. (1993). *Narrative analysis: Vol. 30. qualitative research methods* Peter K. Manning, John Van Maanen, and Marc L. Miller (Eds.) Newbury Park: SagePublications.

Rilke, Rainer M. (1982). For the sake of a single poem. In Mitchell S. (Ed. and Trans.), *The selected poetry of rilke*. New York: Vintage International. (Original work written 1910)

- Sims, K. (1995). Evolving 3D morphology and behavior by competition. In R. Brooks and P. Maes (Eds.), *Artificial life IV proceedings* (pp. 28-39). Boston: MIT Press.
- Simonton, D. K. (1988). Creativity, leadership, and chance. In Robert Sternberg (Ed.), *The nature of creativity, contemporary psychological perspectives* (pp. 386-428). Cambridge: Cambridge University Press.
- Sternberg, R., (1988b). A three-facet model of creativity. In Robert Sternberg (Ed.), *The nature of creativity, contemporary psychological perspectives* (pp. 125-148). Cambridge: Cambridge University Press.
- Sternberg R. & Tardif. (1988c). What do we know about creativity? In Robert Sternberg (Ed.), *The nature of creativity, contemporary psychological perspectives* (pp. 429-440). Cambridge: Cambridge University Press.
- Strong, Richard W. (1986). *Questioning styles and strategies : Procedures for increasing the depth of student thinking*. Moorestown: Hanson, Silver, Strong & Associates.
- Tolstoy, L. (1960). Extracts from *What is art?* In E. Simmons, *Leo Tolstoy, VII* (p. 239). New York: Vintage Books. (Reprinted from *What is art?*, (Aylmer Maude Trans.) by L. Tolstoy, 1898, Oxford: Oxford University Press)
- Turkle, Sherry. (1995). *Life on the screen, identity in the age of the internet*. New York: Simon and Schuster.
- Vince, J. (1995). *Virtual reality systems*. Wokingham, England: Addison.
- Walberg, H.J. (1988). Creativity and talent as learning. In Robert Sternberg (Ed.), *The nature of creativity, contemporary psychological perspectives* (pp. 340-361). Cambridge: Cambridge University Press.
- Wasserman, P. D. (1989). *Neural computing, theory and practice*. New York: Van Nostrand Reinhold.
- Weisberg, R. (1988). Problem solving and creativity. In Robert Sternberg (Ed.), *The nature of creativity, contemporary psychological perspectives* (pp. 148-176). Cambridge: Cambridge University Press.
- Wexelblat, A. (Ed.). (1993). *Virtual reality : applications and explorations*. Boston: Academic Publishers Professional.
- Wolf, M. (1992). *A thrice told tale*. Stanford: Stanford University Press.

APPENDIX A

SAMPLE DATA

In the following data samples, Mg stands for Margaret, Mx stands for Max, D stands for Dena, R stands for Rita, and M stands for Marcus.

Pre-histories

Both main participants were asked to write their own pre-histories. I have included both of these, in full, at the beginning of chapter four. For the two secondary participants, I wrote the backgrounds from my field notes and have included them in chapter 6.

Sample of the Daily Reflections from Max and Margaret

A sample of Margaret's daily reflection.

Mg: I thought long and hard today about how a user could lift up an object. How basic, but it isn't in lynX. How? Well, I thought of a number of ways. I had to first go back and push myself to think about players in relationship to objects, motion models, and observers. How confusing. BUT, I think you first attach a player to a dynamic object that acts as a hand. This doesn't have to be a hand, but I will call it one for the sake of explanation. The hand represents the user-fly-through.

OK, the player is hooked to the object, and the player has an enabled motion model, like drive. I can offset the object from the player so I can see it. OK, I will attach an isector (an intersection vector) to the player that will detect intersection with a static object, say a ball. Oh, or make the ball dynamic but attach a player with a motion model that is not enabled. Maybe.

A sample of Max's daily reflection.

Mx: I have spent almost an entire week simplifying my wire file and the textures of my *Bradburry* building in the hopes that I can get it small enough to run in the VR program. All the work seems to have been in vain, as I cannot get Alias to export an Inventor file for me. Finally understanding that Alias pix files used as textures must be converted to RGB SGI format, I quickly rebuilt the walls of the fifth floor of my building and applied the textures.

Sample Final Reflections

Max's final reflection was in the form of a dialogue. The following is an excerpt from that conversation.

Mx: My goal with VE was to create a more realistic environment, not necessarily something that exists, but something that if you were in it you would say, yeah, it exists, and the VE would help you be in it.

D: So, it would give you a sense of presence?

Mx: Oh, definitely, it would make you feel like you were there and give you a sense of place.

Margaret's final reflection was in the form of an essay. The following is an excerpt from that writing.

Mg: In the final VE, I wanted the user to consider multiple realities through experiencing art in a way different from any of their other art experiences. Originally, I wanted to create a VE that revealed multiple ways of viewing spirituality, creativity, and beliefs about

existence. Through their choices and interaction with the art, I wanted the user to feel as if they had a role in the creative process by controlling and creating their own experience. My hope was that the users would be engaged enough to interpret the VE to find their own spirit and existence.

Sample Field Notes on Max, Rita, and Marcus

Field notes on an observation of Max.

Mx: Ha ha, I get so turned upside down! Opps, look, no second floor!

Lets see...

[He went to the GUI to add it to the scene.]

Mx: There it is.

D: Imagine watching this through an HMD.

Mx: This makes me dizzy now! Man, look at that! I can get inside the wall! You know, this is just a sketch and look what it does for me. I can see that this will work good. When I go back and add textures and shading so it won't look so flat it will really work.

Field notes on an observation of Rita.

R: What if it was dynamic? In other words, you could construct your own space, say the user has a bucket of smells. She could construct a space that represented smells. Or what if the viewer could use their heart to create lighting in a thunderstorm. In this way, the viewer could co-create.

Field notes on an observation of Marcus.

M: I've got a stream of ASCII text on the screen, am I making an image? I'm composing, writing, I'm not making imagery. I describe code to the computer, like a conversation. The machine then changes the ASCII into images. I'm not sure if I'm the artist or the computer is.

Sample Email Correspondence

The following is an excerpt from Marcus's email.

M: People would wait in line for 3 hours and want the "wow." When they didn't get that, they were angry. So, now we [VE designers] are putting the "wow" back. I want people to get beyond the "wow" and into the experience. It is really a completely new experience for them to get used to. OK, say they have five minutes to go in the cave. Let's say they have two minutes to get over the "wow," short learning curve. Now, they have three minutes to have the experience. Right.

The following is an excerpt from Rita's email.

R: I, too, am very interested in creating artistic virtual spaces. I've checked out just about every display device there is and none seems to measure up to the experience-creating ability of the CAVE.

However, there isn't one here at MIT, where I've come recently. I'm writing a few articles on the subject of just HOW to do it, i.e., how does "presence" arise? What is the critical mass of visual/auditory/haptic, etc. stimuli and content needed to bring

the users to a threshold over which they cross and enter
“undivided moments” of sublime concentration?