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INFORMAL COMPUTER-ART EDUCATION: A FOCUS ON THE ART AND HISTORICAL IMPACT OF COMPUTER GENERATED SPECIAL VISUAL EFFECTS AND THE PEDAGOGY OF THE ARTISTS WHO CREATE THEM PROFESSIONALLY IN THE SAN FRANCISCO BAY AREA PRODUCTION COMPANIES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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* * * * *

The Ohio State University
1995

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ACKNOWLEDGMENTS

It is with my greatest and most sincere pleasure that I welcome this opportunity to extend my gratitude to those who have made this document a reality. Primarily, I would like to extend my deepest appreciation to Dr. Noel Mayo for his encouragement, motivation, and support throughout my most difficult times at The Ohio State University and for guiding me through the process. I am deeply indebted.

Gratitude is also due to the Department of Art Education faculty. Dr. Anthony Scott co-advised and offered his guidance, knowledge, and criticism throughout the entire preparation of this document. Dr. Don Krug offered his insights into the area of nonacademic art education and provided the key concepts for the foundation and design development of the research methodology. Drs. Arthur Efland and E. Louis Lankford contributed through their lectures and advice. The Department of Art faculty member, Dr. Midori Kitagawa-DeLeon provided technical expertise in the practical areas of computer graphics. I also thank former instructor Reudy Leeman for his dedication to teaching throughout his year at The Ohio State University's Advanced Computing Center for the Arts and Design.

Thanks are also due to Professor Charles Csuri for his overwhelming support and suggestions and to the other pioneers and educators whose contributions have added significantly to the body of this document. To the many corporate trainers, training practitioners, and practitioners of the San
Francisco Bay Area digital effects production company, who contributed generously as my needs arose, thanks for responding to my numerous requests for additional information. Thanks to the marketing staff at these companies who assisted in arranging the initial appointments and interviews with the effects artists.

To my former professors Susan Morrison and Jane Veeder, thanks for their knowledge and direction.

To my countryman Kurt Shade and the Caribbean Students Association; Nicholas Banks and the Office of the Eminent Scholar of Art and Design Technology; my friends and colleagues at the Department of Art Education and the Advanced Computing Center for the Arts and Design, thank you all for the support and words of wisdom.

My appreciation to my many assistants, Mauva B., Jennifer M., Christtina P., Rina, Linda H., Barbara W., and Muge, for taking the time out of their busy schedules to ensure that this document met the various deadlines in the stages of its preparation.

To my brother Gary and best friend Michelle, thank you both for your continued love, support, and advice.

To my father—my former boy scout commissioner, high school woodwork teacher, current chief advisor—and to the rest of my family, I offer my love and gratitude.

To all of these people and to the others who have gone unnamed I express my deep appreciation.
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CHAPTER I
INTRODUCTION

PROBLEM

Background of the Problem

My interest in visual effects stems directly from my experiences with computer animation. While studying computer graphics and animation at San Francisco State University between 1990 and 1993, I became increasingly interested in the ways in which computer animators work in a production environment. I always believed that computer animation was at the heart of the special effects industry and that all effects producers had to understand computers to successfully achieve extraordinary effects in their films. I believed that there was a school that instructed them on the various styles and techniques of special effects until my illusion was dispelled by a class visit to Colossal Pictures in the summer of 1993. I was amazed by the interdisciplinary animation environment—an environment in which computers were only one of the tools used in production. Even as a major special effects and animation production company, Colossal at that time was only at the beginning stages of incorporating high-end computer technologies into their productions on a permanent basis. Surprised to discover that Macintosches were the computers most commonly used by Colossal at that time, I was later informed that other, more powerful computers such as Silicon Graphics Iris and Sun workstations were rented only if they were
needed for a project. In addition to using the Macintoshes, Colossal also
developed proprietary software. This software was being developed by a team
of computer scientists.

Colossal has worked closely with advertising agencies for commercial
clients including Levi Strauss, Nike, Honda, Kellogg's, Xerox, Anheuser-
Busch, McDonald's, General Foods, General Mills, and Coca Cola. Colossal
also designed and produced stylized industrial designs and signature logos for
The Disney Channel, Nickelodeon, MTV, Showtime/The Movie Channel,
HBO, Quantum Media, NBC, ABC, CBS, PBS, FOX, ESPN, and numerous
network affiliates. Colossal also created and supervised the special effects for
films such as The Right Stuff, Top Gun, Running Man, The Serpent, and The
Rainbow. Most Colossal productions are done through the use of special
effects techniques, from classic cel animation through photo and stop-motion,
motion control, clay animation, puppet, and traditional cel animation
(Colossal, 1994).

This visit to Colossal caused me to question computer graphics as my
academic choice. I wondered whether it was worth a major course of
academic study, if artists were being trained on the job to use a company's
particular software and hardware configurations. Further research showed
that Colossal was not the only production company that wrote and produced
its own software. In fact, that was the general trend established by these
production companies in the San Francisco Bay Area at that time. During
that summer, I began to look into a computer-based animation company
called Pixar. In contrast to that of Colossal, Pixar's work environment was
highly focused on computer animation. Pixar was mainly interested in the
production of high-end computer animation shorts\(^1\) and 30-second television commercials. There were several computer artists in the production environment at Pixar. Pixar's work force also comprised computer scientists and programmers, whose primary interest lay in the development of proprietary animation software (i.e., animation programs written for a specific company for computer effects development). I became curious about the interaction that took place between computer artists and computer scientists and their roles in this interdisciplinary art environment. I also became interested in the informal art training that commonly appeared to be taking place in that environment, because of the constant evolution and changes in computer programs. Informal science training was also evident in the induction of new formally trained employees, whose entrance into this formal training had helped to equip them to deal with the companies' proprietary software.

Later, I began to investigate the works of other companies in the Bay Area that were interested in the production of visual effects. I looked into major production companies such as Xaos, Industrial Light and Magic, and Pacific Data Images. I found that the San Francisco Bay area holds one of the largest concentrations of special effects companies in the United States. From stop-motion effects to computer visual effects, the Bay area is also the home of the nation's largest special effects company, Industrial Light and Magic. This company and many others in this field are subcontracted primarily by the Hollywood film industry to add a unique and exciting quality to feature films. These San Francisco Bay area companies are also employed by

\(^1\)Short films or videos in the computer effects field are usually under 15 minutes long and are based on a short story that is told through the use of, in this case, computer animation.
marketing directors of large corporations to assist with the pre-visualization and the production of computer effects for television commercials. Pacific Data Image is one of the pioneering effects houses, with offices in Silicon Valley and Hollywood. The company's president, Carl Rosendahl, recalled, "the way that digital technology got into Hollywood was really as a replacement technology for traditional optical composition" ("Hollywood...," July 1994, p. 37).

In my view, the computer effects culture grew as a means to complement the skills of the film and conventional effects practitioners. Although many stop-motion jobs are going to computer animation studios in the Bay Area, some stop-motion studios are integrating animation effects techniques into their conventional effects environment. Such is the case for Danger Productions, a San Francisco-based conventional effects company that has made the transition to experimenting with computer animation for an ABC children's television series, *Bump in the Night*. In this series, computer animation is incorporated as a means of achieving secondary motion to add to and exaggerate the motions of the main stop-motion character. Such a mixture between conventional and digital effects is also done by such special effects companies as Colossal Pictures.

The visual effects industry is constantly dividing, as practitioners leave companies to form smaller companies. The large number of these smaller companies, coupled with the more established effects houses, made it difficult to identify the companies that specialized in the production of computer effects for particular films. In the mid-1980s, Industrial Light and Magic founder George Lucas decided that computer animation was costing too much to produce. The tools the artists and scientists required for their
creative (and the company's competitive) edge carried enormous price tags. As a result, a smaller company, Pixar, was established to deal with the demand for computer-generated animation. Similarly, some effects directors are following ILM founder George Lucas' lead and starting their own effects houses. James Cameron, of *Aliens* and *Terminator 2* fame, co-founded Digital Domain in Venice, California.

Smaller companies such as Foundation Imaging also brought a new problem to hand. Foundation Imaging is known for the computer effects on the television series *Babylon 5*. This company uses low-end computer graphic tools and is able to achieve high quality effects. But through their existence and that of other companies like them, it became difficult to outline which production houses were too unsophisticated, or too inexperienced, to be considered for the research. It was difficult at times to distinguish the work of these larger and more technically sophisticated production companies from the "souped-up" home computer users. While conducting this preliminary investigation, I realized that the term "special effects" was, in fact, a broad term used to describe a vast interdisciplinary environment. I became increasingly curious about this field, its history, and the impact of computers in this area.

Historically, I wanted to learn more about the various inventions in this industry such as optics, film, camera, and other devices that had been appropriated earlier by magicians and artists alike (Fry and Fourzon, 1977). How did these various inventions affect the art process and outcome of visual effects? I was interested in the industrial transition that made it possible to progress from *King Kong* (1933) to *Jurassic Park* (1993), the major developments in technology, and the various professional and academic
pedagogical issues that were involved. The movie industry, special effects departments in particular, can be viewed as a school, and the effects practitioners can, therefore, be viewed as students who are constantly learning and learning how to learn the new technologies that have always impacted their field. To create these effects, artists must first learn and develop a practical understanding of the tools and develop a mastery beyond this basic knowledge. The advent of the computer has presented a new challenge to the visual effects industry and its practitioners. As the newest tool in the field of visual effects, the computer, with its associated software, is the single most rapidly evolving tool in the history of film art.

Statement of the Problem/Research Question

In this research, I plan to investigate the relationship between the training of computer graphics special effects practitioners and traditional special effects practitioners in the film industry. I will examine the similarities in the structure and computer effects training programs at three Bay Area production companies. Historically, what impact has technology had on the traditional effects companies? How have computers influenced the curriculum of traditional art programs?

As far back as the late 1800s, film producers created avenues for incorporating visual effects in their productions. During this period, special effects techniques, such as the ones created in 1900 by a professional magician named George Méliès, were beginning to fascinate theater audiences. Méliès discovered that more than one image could be photographed on the same length of film. He astounded viewers by having people appear and disappear before their eyes with the first dissolve (Madsen, 1990). Today, visual effects
and animation companies such as PDI, Xaos, and Pixar are at the cutting edge of research and development in the area of special effects. Far removed from the works of Méliès, these companies have redefined visual effects. Computers are just one of the contemporary tools used in visual effects, in addition to the many new tools created since the late 1800s. Unlike in the 1800s, when special effects were essentially a craft requiring a knowledge of clever carpentry and cabinet making in order to make ladies vanish and rabbits leap from a silk hat (Hutchison, 1987), today's viewers are bombarded with numerous visual special effects that are common in a large number of contemporary feature films. The abundance of visual effects and the naivété of the viewers regarding how they are created seem to be two the main reasons why visual effects are not widely accepted as a form of art. Visual effects such as computer effects incorporate an array of different traditional art techniques; however, the process of creating computer visual effects is not often explained to the viewer. Research in this area will give me the opportunity to investigate the origins of visual effects, examine the impact computers have made on visual effects productions, survey the people involved in computer effects, and make a case study of some of the people who create this art form.

Every special effects project begins with a story written by a writer or producer of visual effects. The information is translated into a storyboard, which sometimes "resembles a huge comic strip. A series of one-panel pencil sketches showing the action are [usually] pinned up in sequence on a huge board" (Cawley and Korkis, 1990, p. 12). The actions of the camera and actors are normally described in dialogue boxes at the bases of the individual panels.
Although the writer and the storyboard artist play crucial parts in the creation of visual effects, they are rarely mentioned in most visual effects literature.

A confusing variety of terms has been employed throughout the industry with reference to optical effects cinematography; however, it was not until 1963 that the Academy of Motion Picture Arts and Sciences formally designated a separate award category for visual effects. Before this time, optical effects were grouped together with mechanical and sound effects, under the general heading of special effects. Today, an overwhelming number of terms are used to describe special effects. Such terms as "visual effects" or "visual special effects" are used equally to describe a general interdisciplinary art category of film effects. Since its introduction as a film effects tool, the computer has formed a contemporary branch of visual effects commonly referred to as digital effects or computer effects. Traditionally, visual effects were called "optical effects cinematography." Today, however, optical effects, like digital effects, fall under the broad umbrella of film effects.

According to Azarmi (1973),

The following terms are used synonymously in the industry. The terms "optical effects" and "optics" are synonymous with "special optical effects." The term "special visual effects" is used synonymously with "photographic effects" or simply "photo effects." Depending on the establishment, any of them are used with reference to the "optical effects cinematography". (p. 7)

According to Fielding (1985), "broadly speaking, special effects work falls into two categories—photographic effects (sometimes termed 'visual effects,' 'optical effects,' or 'process cinematography') and mechanical...or physical effects" (p. 1). Photographic effects are as old as the motion picture
itself. In fact, the principles that govern photographic effects were invented centuries before the advent of the motion picture. In the early days of motion picture, the cameraman himself (using only a camera and ingenuity) was responsible for a crude vision of these effects, but it was the optical printer of the early 1930s, a single device, that was able to produce the same effects and an astonishing number of others (Fry and Fourzon, 1977, p. 3). Optical effects include such visual devices as fades, dissolves, superimposition, all the various matte work, rear projection, front projection, and so on (Brosnan, 1974, p. 9). The term "visual effects" can be viewed as an umbrella that originally referred to the combination of the visual elements of two or more scenes into one single scene. As mentioned, Madsen (1990) indicated that the visual effects industry comprises four specialists: storyboard artists, director of art, director of effects cinematography, and the effects artisan and animator.

Optical effects are usually created by these specialists through the use of special cameras, optical printers, animation, rotoscoping, or motion control, and cannot be done live in front of the camera. Optical effects can be as subtle as a red glow superimposed over a vampire's eyes or as spectacular as a dozen X-wing fighters attacking an imperial death star in outer space (Baur, 1993; Madsen, 1990).

Stop-motion is a photographic visual effects technique that can be applied to both two-dimensional (2-D) and three-dimensional (3-D) environments. To achieve stop-motion, the artist splits up the motion of a film sequence into a series of still frames. Each still, which represents a frame of motion, is shot as a separate photograph in the motion sequence. The frames are then played on a film projector in sequence and the motion appears to be continuous. This technique of stop-motion is used in several
methods of film animation, namely, claymation, paper manipulation, pixilation, and cel animation. Pascall (1977) explained that "when the film is run at normal speed, the arm appears to move. This is due to a phenomenon of the human eye called **persistence of vision** and it is proof that the camera not only can but does lie to us, with the collusion of our minds" (p. 18).

Mechanical effects are produced "live" in front of the camera. These effects are essentially a continuation of stage techniques--trap doors, wires, explosions, etc.--used for decades in live theater (Fry and Fourzon, 1977, p. 3). In addition, Madsen (1990) described mechanical effects as "a machine or mechanical device filled with hinges and wires and covered with hair to become **King Kong** grabbing at airplanes or a (big) life size model of a great white shark designed to masticate its way through hapless bathers in **Jaws**" (p. 326). Mechanical effects can be defined as effects that incorporate the use of miniatures, or a puppet that, when operated mechanically, can simulate the motions of a creature, object, or human. This simulated motion can be either filmed simultaneously with the actors and actresses in the scene or shot separately by a camera crew and combined with the other action in post production. This technique of mechanical effects depends not only on skilled and innovative mechanics, but also on expert sculptors who can model convincing life forms, cast them into foam rubber and polyurethane forms, and finish them with colors and textures that will withstand the scrutiny of a close-up on a wide screen.

Photographic effects and mechanical effects make up the visual special effects industry. They are not often viewed as separate industries; instead, they complement each other. An example can be seen in stunt acts, which, when viewed independently, may be labeled mechanical effects, but the wires
used to enable the stunt person to achieve these effects may be removed later through a technique known as "wire removal," a photographic effects technique. The intent is to convey the thought, mood, and the imagination of the film writer or director. It is used as a seamless craft that blends fact and fiction and that may go unnoticed by the film audience. According to Imes Jr. (1984), this is the best visual effects (p. 1).

An art form that predates film, special effects were once used by magicians to trick their viewers. However, present-day visual effects are not mainly produced to trick the public into thinking that a particular creature as enormous as *King Kong* exists or that a cybernetic organism is possible in the years ahead; rather, they are meant to convince its viewers of an illusion of reality on film. In definition, "a special effect in a motion picture is any technique or device that is used to create an illusion of reality in a situation where it is not possible, economical, or safe to use the real thing" (Culhane, 1981, p. 4). Culhane explained,

it is not possible to make a person defy the laws of gravity and fly, so we create the illusion of flight. It is not possible to order up natural rain or snow on cue, so we simulate these conditions. It is not economical to transport a company to a distant location if the scene can be successfully simulated by composite photography on the studio lot. It is not economical to build a complete set, if most of it can be done with a matte painting. It is not safe to have an actor jump through a plate-glass window, so harmless breaking resin is used. It is not safe to photograph your leading actor on a ledge forty stories above the street when the scene can be duplicated by trick photography on a studio set with absolute safety.

Visual special effects are often aided by motion control devices. A motion control system is an automatic camera system that usually consists of
a mounted camera whose movement is electronically controlled. The camera is usually connected to a model stand, which stabilizes it and allows for vibration-free photography. The camera can be moved through a complete continuous or stop-motion shot. The exact repeatability of this lineage allows original-negative, multiple-exposure photography, with some shots lasting twelve to fourteen hours over several days. In some cases, the camera, automated in a model mount, is attached to motorized gimbals at the end of a long boom arm assembly. The boom, in turn, is usually attached to a motorized camera pedestal that rides on a precision track. The camera has eight axes of motion control to do in-camera streak, slit-scan, and single frame stop action cinematography (Culhane, 1981; Imes Jr., 1984). Sometimes called electronic motion, this technique was used in some of the scenes in the 1967 feature film, *2001: A Space Odyssey*, in which a computer-controlled electronic motion device was used to move a camera in seven different directions to allow special effects to repeat every move with perfect harmony (Cosner, 1985). This device is neither a photographic nor mechanical effect; instead, it is a computerized mechanical tool that aids in the production of photographic effects.

Besides their use in the production of 3-D environments, traditional special effects are also used to produce 2-D characters and environments alike. Such methods as cel animation and paper manipulation are categorized as methods of 2-D effects that are produced through stop-motion techniques. Both methods of 2-D effects are produced solely through the use of photographic effects techniques; however, if combined with a 3-D environment, traditional effects may inherit the various qualities of mechanical effects or 3-D photographic effects, as in the case of *Who Framed*
Roger Rabbit. In this feature film both 2-D and 3-D effects techniques were combined. According to Madsen (1990), it is a process known as "tone passes," produced through the use of the optical printer, which is crucial for providing animated cartoons with the roundness and form that make them credible as being interactive with live action characters (plate 18).

Whether 2-D or 3-D, photographic or mechanical, visual effects techniques that precede digital effects are broadly referred to as having a conventional or traditional approach. These terms are used synonymously to describe and identify a style of visual effects that were done before the invention of digital effects, or effects that are done in the present-day but do not involve the use of computer graphics applications or programs. More specifically, the term "traditional special effects" is most commonly used in the literature and various discourses to describe the general field; however, the term "conventional special effects" is seldom used. In this discourse, "conventional special effects" is used to describe a group of workers who are involved in the production of "traditional special effects"—the field in which they work.

Since 1950, computers have been incorporated into the arts, and in 1967 computer graphics made its debut as a new form of visual effects used in the film industry. This new form of visual effects as a whole will be referred to as "contemporary effects." "Computer effects" or "digital effects" will be used to describe specific areas of visual effects that are concerned mainly with the incorporation of computer-aided effects in motion pictures. These effects are not limited to, but include morphing (the transformation or computer interpolation from a 2-D or 3-D computer data to another over a particular number of frames) of live action figures, modeling (building or displaying 3-D
computer data) of 3-D environments, and textural mapping (2-D digital information used to form the surface quality of a 3-D computer data). "Live action" will be used in this study to describe the photographed action of living things, as distinguished from action created by animation.

Within the computer effects industry, there are various titles for the effects practitioners whose work may focus on the areas of computer animation, digital lighting, and art directing. As Carlos Arguello (1994) explained, special effects directors at effects production houses may take on the title of "art director" if they are directing effects for a feature film. They are called the effects directors only if they are directing smaller projects such as animation short films, commercials, or music video projects. There can be only one effects director on a special effects feature film; that title goes to the person who guides all the effects in a film, not just computer effects.

PURPOSE OF THE STUDY

The purpose of this study is to fill the informational gaps on visual effects, the people who create them, what it takes to work in the industry, and how knowledge is passed on to the next generation of visual effects artists. I will focus on transferring knowledge amongst artists in the area of computer effects. Computer effects are only one of the visual special effects disciplines. My goal is to explore the history of visual effects in movies and focus on selected computer art makers who have been instrumental in the creative and teaching aspects of this art form. Additionally, I will study this art form to learn more about the interdisciplinary approach adapted by those in the profession to the creative process. This study will also address questions pertaining to the techniques and process of visual effects, the favorable
procedures for using computers to creating effects, and the factors that have influenced visual effects production.

This research will examine a problem that does not arise from the literature, but instead from a lack of literature. Several publications deal with the subject of special effects in films, but few address in detail the history of visual effects. Furthermore, I have not located any specialized publications that investigate the history and use of computer graphics in visual effects nor any that have studied the work of computer artists and the informal computer-art education that takes place when creating computer-generated images for visual effects.

An animation publication called *Cinefex* published its first monthly issue in March 1980. With a mission to report on the various visual effects in films, *Cinefex* will be one of the publications I use to establish a time sequence for visual effects beyond 1980. In *Working Cinema: Learning from the Masters*, author Roy Paul Madsen (1990) details the work of George Lucas and his company, Industrial Light and Magic. The book investigates the early works of George Lucas; however, little attention is given to the role of computers in visual effects. Madsen (1990) described the visual effects industry as having four specialized departments that are involved in the production of visual effects. These departments include storyboarding; art directing; the directing of visual effects cinematography; and computer animating and modeling. I will adapt Madsen's four categories for discussing the field of visual effects in the historical content of this study.
LITERATURE REVIEW

On the subject of the history of visual effects in film, I have found various views. Fry and Fourzon (1977) studied the film effects pioneers and detailed the works of Méliès and many others, including the history of Eastman and Edison. Hutchison (1987) wrote on the topic of film magic and magicians and provided a general overview of the creative uses of early film effects (miniatures, puppets, etc.). Barnouw (1981) provided an overview of the uses of visual effects in the pre-film era—an era when magicians held the key to visual effects. Cawley and Korkis (1990) are extremely generous in presenting the information on film animation. They interviewed some of the animators involved in the making of traditional film animation. Additionally, information on the history of visual special effects can be accessed through The Ohio State University's Journalism Library and the video archive at the University's Advanced Computing Center for the Arts and Design (ACCAD).

Overall, the publications used, on the basis of their theoretical content, can be classified into several types: animation (Solomon, 1989; Halas, 1990); animation history (Russett and Starr, 1988; Heraldson, 1975); visual effects (Madsen, 1990); computer effects education and training (Leeman, 1985; McDevitt, 1986); and non-academic art education (Krug, 1993).

METHODOLOGY

The information related to this dissertation was compiled through the survey of pertinent published and unpublished literature, as well as discussions and interviews with practitioners, pioneers, and trainers (art educators) in both the academic and professional environments of visual
effects. A substantial portion of the literature is derived from my empirical experiences as a student, artist, and graduate teaching associate in the area of computer-generated imagery (Azarmi, 1973). My study was thoroughly grounded in the oral description of the work environments and training of computer visual effects artists at production houses in the San Francisco Bay Area. The methods used to interpret the collected information had empirical, theoretical, and interpretive dimensions. The conceptual and theoretical framework on which the methodology was constructed was based on the various literature reviewed in the previous section. It was the theoretical aspects of these works and others that stimulated the origin of this research.

I used case studies to gather a rounded description and explanation of the informal relationship that exists between the educators and student trainees in the production environment, together with the pioneers. These "cases" will help me to arrive at a comprehensive understanding of a special effects practitioner and to develop a general theoretical statement about regularities in the social structure of the field and in the process by which the artists are trained and educated (Merrian, 1988).

Besides case study methods of inquiry, historical methods were also used to conduct the research. The case study was used as an empirical inquiry to investigate the contemporary phenomenon of computer effects artists within their real-life context. The abundance of "how" and "why" questions, coupled with the limited control over the events, made this the most appropriate method for the accumulation of information on how artists are trained and educated in the production environment. The most important sources of the case study information were several interviews. Respondents were interviewed for short periods, which varied from forty-five minutes to
an hour. Some of the questions asked in the interviews were open ended in nature and varied slightly from one practitioner to another (Yin, 1984). The majority of the questions focused on the central theme of education and training. This methodology combines both observation and interviews. Patton (1990) wrote,

We interview people to find out from them those things we cannot directly observe. The issue is not whether observation data is more desirable, valid, or meaningful than self-report data. The fact of the matter is that we cannot observe everything. We cannot observe behaviors that took place at some previous point in time. We cannot observe situations that preclude the presence of an observer. We cannot observe how people have organized the world. We have to ask people questions about those things. (pp. 288-289)

The interviews with the practitioners were a blend of four types: structured, semi-formal, informal, and retrospective; these were combined and merged into one interview type. The structured and semi-formal portions of the interviews consisted of a series of questions that were designed to elicit specific answers on the part of the respondents. This type was used to obtain source information that could later be compared and contrasted with other sources. I used the informal and retrospective portions to collect both contemporary and historical information through casual conversations. The retrospective segments of the interviews combined structured, semi-formal, and informal methods. Larger segments of this method were used primarily with the pioneers to gain an understanding of their recollections of events in the history of computer-generated effects (Fraenkel and Wallen, 1993).
The case studies were conducted primarily through interviews with the practitioners and were used to gather information from computer graphic teachers and computer graphic pioneers. These interviews generally lasted from sixty minutes to eighty minutes. In constructing these interviews I combined six different types of interview questions, as indicated by Patton (1990): background or demographic questions; knowledge questions for factual information; experience or behavior questions, to elicit descriptions of past and current experiences; opinion or values questions to call attention to the respondents' goals, attitudes, beliefs, or values; feeling questions; and sensory questions to find out what the respondents have seen or done (see Appendix C). In most cases, the teachers and pioneers were less confined to time constraints. This factor made it possible to conduct a more semi-formal and informal interview, whereby, although the questions were prepared ahead of time, other questions were spontaneous and were derived in response to a particular answer or an abstract term.

Overall, in this qualitative approach to research, the paramount objective was to understand the structure and training methods used in effects production houses. Merriam (1988) wrote that qualitative research assumes that there are multiple realities—that the world is not an objective thing out there but a function of personal interaction and perception. It is a highly subjective phenomenon in need of interpreting rather than measuring. Beliefs rather than facts form the basis of perception. Research is exploratory, inductive, and emphasizes processes rather than ends. In this paradigm, there are no predetermined hypotheses, no treatments, and no restrictions on the end product. One does not manipulate variables or administer treatment. What one "does" do is observe, intuit, sense what is occurring in a natural setting... (p. 17)
Qualitative inquiry is inductive and focuses on the process, understanding, and interpretation. The present research is built on abstractions, concepts, hypotheses, and theories. Several characteristics of qualitative research were used for the case study: process, meaning, and field work. The process dealt with the steps that were necessary for conducting the case studies. The meaning looked at how the artists and trainers (educators) made sense of what they were doing, especially professional art educators. The research was collected by the actual physical pursuit of the researcher in the field (Marriam, 1988).

Rationale

The rationale for the case study methodology in this research is to probe the minds of the practitioners who create visual effects via the use of computers; to examine the training and education process and methods that are used in this creative art setting; to make inquiries as to how artists and animators adapt to the changes in technology; to examine the relationship between artists and scientists in the research and development of computer-generated imagery; to examine the relationship that exists between animators of computer visual effects and the trainer and or educators in this informal computer art education environment; and to gather a general knowledge as to how the computer is used as an art-mediated tool for the advancement of the field of conventional visual effects. Overall, the methodology was aimed chiefly at inquiring how the digital effects specialists are able to work collaboratively to produce primarily 3-D graphics and animation—works that appear to have height, width, and depth, and lifelike attributes like texture, shading, and photo-realistic qualities, such as the shiny chrome of the
Carolco, 1991, *Terminator 2* to the flying logos and graphics at the beginning of a movie or news broadcast. Moreover, the methodology is meant to illuminate the transition artists made from their prior positions as university or college students to creating sophisticated animation that allowed the artists the freedom to describe the parts of the picture or scene as separate objects, move the objects across the screen, and control how they interact with each other (Jacobson, 1992).

This methodology was chosen to examine the informal pedagogy of the artists in their advancement in the field of computer effects at specific production houses in the San Francisco Bay Area. It combined fieldwork with the collection of documentary sources, ranging from the most "informal" to the most "formal," or "official." Case study methodology was used in congruence with historical methodology (Hammersky and Atkinson, 1991).

The theoretical historical methodology helped in gathering background information about the field and its workers. These methodologies worked together to solve "the foreshadowed problems," which, as explained by Malinowski (1922), are a problem or set of issues that begin the research. They are the main endowment of scientific thinkers, and, through critical studies, these problems are revealed to the observers. In fact, the methodologies support each other. For example, the case study interviews with the pioneers of computer graphics and visual effects were used as a primary source of information for the historical inquiry. This "triangulation is not a combination of different kinds of data per se, but rather an attempt to relate different sorts of data in such a way as to counteract various possible threats to the validity of our analysis" (Hammersky and Atkinson, 1991, p. 199). The
data-source triangulation, as used in this research, involves the comparison of data relating to the same phenomenon.

Assumption

The design of this research relies on the basic assumption that the art of computer effects is, in some way, connected to the area of conventional special effects and, as a result, has impacted the field of special effects as a whole. Further, it is also assumed that the computer effects area is a separate branch of visual effects. These assumptions find substance in the literature of the various effects publication and reviews of various "Making of..."² videos and films.

The Design

I believe that it is important to make the distinction between these two levels of technical operations because the training and education are not consistent between these levels of companies. Although this methodology for the case study seeks to identify the various methods of training and education within the Bay Area effects companies, I was interested only in the larger companies; thus, smaller companies (1-2 practitioners) will make the variables extraneous (Wallen and Fraekel, 1991). My final selection was made from a list of companies established in the San Francisco Bay Area that have been working in the field for more than five years.

As I started my search to identify the computer effects artists and trainers, I found that the number of computer practitioners, including trainers, in the production companies of the Bay Area was overwhelming.

²Films, usually in the video format, that illustrate how a particular effect was accomplished.
There were more than 350 practitioners at Industrial Light and Magic (ILM) alone, and other companies such as Pacific Data Image (PDI) and Colossal Pictures had well over 100 practitioners. I had telephoned other companies such as Xaos and Pixar and had inquired about their sizes. These companies were smaller and more manageable. Between these companies, I felt that I had covered the Bay Area. Their projects are well represented in the periodical literature concerned with the computer effects industry.

I reviewed several books, videos, and periodicals before contacting these companies. They suggested that these companies, ILM, PDI, Xaos, Pixar, and Colossal, were among the best production houses in the Bay Area. "Commercials that Stand Apart" and "Vanguard Design, Animation, and Effects" are two sections in Millimeter, the magazine of motion picture and television production that was useful in my selection process of production companies. The monthly magazine showcases the television commercial and feature film that contain the most creative or innovative effects for a particular month. In addition, the magazine showcases the production company, creative director, and animator who were involved in the effects creation. Over a period of several months I was able to identify the Bay Area companies that were heavily involved in the creation of visual effects.

The information I received from Millimeter was then cross-referenced with Special Effects and Stunt Guide (1989). This book provided a list of special effects companies, along with their productions and their locations. The fact that the book was published in 1989 meant that the most recently established companies were not listed. But if these companies were working on or had worked on interesting projects, the work and the companies' names would be listed in the sections of Millimeter. For a more detailed look
at a particular project, I reviewed the literature in *Cinefex*, a publication that focuses on the making of Hollywood feature visual effects films. This magazine provided not only an in-depth look at the companies involved in the making of an effects movie, but it also helped to identify exactly how much a particular company was involved in the creation of special effects for a movie. This periodical detailed the various types of conventional and computer effects currently used in the industry. Most important, I learned the names of the companies that were subcontracted for, and who were specialists in, particular styles of computer effects. This information was cross-referenced with what I had received from *Millimeter* and special effects and stunt guides.

For the purposes of this methodology, I was interested mainly in the effects by artisans and animators who did computer-generated effects. Solomon (1989) provided a short section of computers in traditional animation for the production of computer effects.

Through these various books and periodicals, I came up with a list of effects companies in the Bay Area that either specialized in computer effects or had a computer effects department (see Appendix A). In August 1994, I contacted all of the companies on the list and requested a marketing and information packet along with a videotape of the most recent projects on which the company had worked, if possible. At the time of the initial call, I spoke with the marketing persons or publicists at the companies. Upon receiving the information packages, I contacted some friends and acquaintances who were presently employees at these companies. I needed suggestions as to the most appropriate way to come up with a list of practitioners who were ideal for the research. The field comprises many
practitioners who are "Jacks of all Trades" within the area of special effects and computer effects. In addition, the job titles of these practitioners changed, depending on the projects with which they were involved.

I reviewed the promotion packages and found that most companies included information on their top computer effects artists. This information provided me with the names of individuals who worked at these companies. Their names were then cross-referenced with the suggestions made by my friends and acquaintances. I looked for consistency in the articles distributed by the companies. For example, in a simple text analysis, I counted the number of times particular practitioners' names were mentioned alongside "computer" and/or "effects" (see Appendix A). The list of names continued to grow, and it became obvious that some individuals had been in the field of special effects for a considerable time and were no longer "students," but rather "pioneers" in the field.

I needed a way to categorize individuals into the three distinct headings of teachers, students, and pioneers. Krug (1993) suggested a list of criteria for identifying non-academically art-educated "makers of art." Based on the knowledge I gained from the review of literature of periodicals and books that addressed issues in the field of visual effects and the advice from friends, acquaintances, and other practitioners, I established the following list of criteria to help identify the ideal practitioners for this case study methodology:

Teacher
• Must have directed computer effects for at least two feature films and/or television commercials.
• Should be familiar with the computer programs used at the production company.
• Should have worked in the field of computer effects for at least four years.
• Must formally or informally train new practitioners to work with computer graphics and animation programs.

Student
• Must have had a formal (college) education in the area of computer graphics or related field.
• Must have worked in the field of computer graphics for at least six months to one year.
• Should have worked with an effects director on, or have directed, computer effects for a television commercial at this company.
• Must be primarily interested in computer effects but must have an interest in other areas of visual effects.

Pioneer
• Must be known as one of the pioneers of computer graphics at the company.
• Must be considered a leader of special effects in feature films and/or television commercials.
• Must be not necessarily the president, but must have helped to found the company.

These criteria were formulated based on a summary of the general responses that were accumulated through my informal conversations with the practitioners and personnel staff at the various Bay Area companies. In addition, the derivation of the list of criteria that pertain to the pioneers was the basis of a review of the history of computer effects.
I made a second telephone call to the companies on the list (see Appendix A). At this time I confirmed that the companies were interested in participating in the research. I then put together an information package that consisted of a shortened version of the research proposal, the list of criteria, and a cover letter (see Appendix B). The list of criteria was included to help the marketing specialists or publicists to better understand the methodology and to help identify the people at the company who might qualify for one of the three categories. The companies were given two weeks to read and respond to the research project. If the companies did not respond within that time frame, I called to confirm their approval.

I traveled to the Bay Area in December 1994 to conduct the field research and had already made several necessary arrangements to meet with some of the practitioners. Upon arrival, I contacted the publicists at the companies and began to arrange interviews with the practitioners. In most cases, I contacted the practitioners by telephone and arranged possible meetings (see Appendix C). Given the time of the year, it was difficult to contact or arrange possible meeting times with some of the practitioners because of projects and productions that were in progress, not to mention their commitments to their families. I had mapped out a strategic plan and an economical way of getting around to all the production companies from my base in Silicon Valley (see Appendix A).

Cawley and Korkis (1990) had written about the field of animation, and the review of this book provided me with interview questions, which I modified to form a basic pool of questions for the case study methodology (see Appendix C). I formatted similar questions for interviewing the students and teachers. The appointment usually took place at the practitioner's place of
work. In the majority of case studies, the interviews took place in conference rooms in the companies and usually lasted forty-five minutes to an hour. The information-gathering procedure combined several different instruments of data collection, i.e., direct observations, formal interviews, and informal conversations (Krug, 1993, p. 24). With the permission of the practitioners, I used a microcassette recorder to document the actual dialogue in the interviews. Any conversation before and after the interviews was not recorded, and I assured the interviewees before the interview that any confidential information concerning proprietary software would be edited out. This assurance provided them an opportunity to answer the questions and respond liberally about the field and the training aspects of the company.

The criteria for the consideration of teachers and students remained the same throughout the research. When I made the second calls to the companies, I learned that one of the companies was just celebrating its fifth-year anniversary. Hoping to gather pioneer source information from at least one practitioner from the various companies, I was concerned that the company may have been too young to assist in this area. I had developed a good rapport with the company, so I adjusted the criteria and eliminated the category of "pioneer" from the criteria list for this company only.

In California, I interviewed eight practitioners and one university professor. The practitioners comprised two trainers, three students, and three pioneers. Practitioners were not chosen by any form of elimination process; rather, they were the ones recommended or selected by other practitioners who had already been interviewed. Luckily, they all qualified for one of the three categories in the criteria list. The practitioners who were interviewed
came from three computer effects companies in the Bay Area, and the data collection included

- Motivation of trainee/student,
- Historical background on trainee/student,
- Environment for training and educating students,
- Relationship and links of production, and
- Role of older practitioners or pioneers in the production environment.

Upon arrival at the production companies, I was usually greeted by receptionists who announced my arrival and appointment. I remained in a waiting area until the practitioners came out to greet me, at which time we moved to the part of the building where the interviews were to be held. At times, the locations for the interviews were outside the buildings on the practitioners' lunch hours. The interviews were usually preceded by tours of the complexes with the interviewees, and at times I received permission to briefly observe the practitioners at work.

An Exemplary Study to Present the Various Methodological Dimensions

The methodological dimensions that were used in this research are empirical, theoretical, and interpretive. The empirical dimension was significant to this research because it allowed me to use the data collected through observations of the practitioners' work environments. The interpretive method allowed me to explore explicitly the preconceptions and to add personal biases. According to Heidegger (Manen 1990, p. 25), "the meaning of phenomenological description (as pure description of lived experience) as a method lies in interpretation and hermeneutics (as
interpretation of experience via some 'text')." Both empirical and interpretive dimensions are grounded in the theoretical dimension of the methodology. In this section I provide an example of the backgrounds of two computer effects practitioners in an effort to illustrate the model for the analytic and interpretive dimensions of the case study data. In addition, this section will show how the experiences of both the practitioner Alexei and the educator Brandao are similar, and how the information collected from the pioneers will be used in the case-study methodology.

Before entering this work environment, Alexei Tylevich of Xaos explained, his background and prior knowledge of computer-mediated art were minimal. Now a student practitioner, Tylevich (personal communication, December 1994) said,

I didn't go specifically to computer graphics. I went to Minneapolis College of Art and Design and they don't have a specific degree in computer animation. They do have very extensive computer lab facilities. I studied illustration and graphic design. My degree is in graphic design. I've been taking courses parallel to my degree in computer graphics. I started from the Macintosh which is used for graphic design; that's what most graphic designers use right now. From the Macintosh I got more into 3-D and computer animation. So I started with the Mac 3-D software and that was real limited. I started to move towards the SGI. Then I took maybe one year more worth of classes and Wavefront before coming here.

Alexei is now working with Roberta Brandao (a trainer at Xaos), who was educated in a similar way to Alexei:

My previous training was in design, graphic and industrial design. I kind of got into computer graphics while doing design, but I didn't have any formal education then. I had a few courses
like programming. Then I came to The Ohio State University, and that's when I got some formal education in computer graphics. So I went through a Masters program that taught the basic principals of animation, but applied in computer graphics. I took lots of courses in the more technical departments at Ohio State like Computer Science and Math. I did not take courses in any of the visual arts related programs when I was there, so I didn't get any training in visual effects. (personal communication, December 1994)

An Interpretation

As indicated from their interviews, these two practitioners came into the field of computer graphics via graphic design. The lack of established programs in computer graphics at universities often is the main reason given. Even today, effects practitioners are still being trained in the work place and are self taught via microcomputer applications. But computer graphics, as explained by C. Csuri (1994),

is being integrated into the culture at every level where because of the combination of microcomputer technology and its power and because of commercial software, more and more people have access to being able to create visual techniques and to use the technology in such a wide variety of ways for page layout, for newspaper, for magazine layout or simple graphics let's say for a newsletter and that because of the software and because the technology is becoming easier to use, more people are simply using it. It is almost going to become like a telephone in terms of communication. (personal communication, December 1994)

This integration of microcomputers into computer graphic application is both good and bad, Csuri added. "I think it is good that people have access to the technology. On the other hand, without speaking primarily to the relationship with the Fine Arts, without some sort of education and training that helps one acquire culture sensibility, we're going to see some very very
bad art." Regardless of the tool used to create the art, the art of good computer effects still depends basically on the individual's imagination, creative insight, and sensitivity toward relevant aesthetic issues (Russett and Starr, 1988).

As modern technology develops, its image-making potential is being examined and explored by a new breed of animators who are technicians as well as artists. Like Alexei, many current practitioners studied art at a college and later put together a program that allowed them to gather practical knowledge in the area of computer effects. These students most times are not able to acquire a grounded education in the field. They get caught up in the study of computer applications, and the art principles of the animation software are not emphasized. Brandao, on the other hand, did receive a more general college education in the field. The fact that she attended The Ohio State University within the past six years means that she could have studied at the Advanced Computing Center for the Arts and Design. This university facility is structured like a corporate effects environment, where artists and scientists work together on projects.

Documentation

The recorded interviews were transcribed and filed on disk and on a computer database. While I was revising the transcript, more questions emerged, and I contacted the practitioners several times via telephone to clear up any incoherence in the initial transcribed interviews. As the researcher, I wanted to gather more information from the afterthoughts of the practitioners. I felt that this process would help to avoid misrepresenting the practitioners or their companies. In addition, there were several words that
were said in the interview that were inaudible. This process also helped to correct these non-transcribed words.

Limitations

Although there is a vast amount of literature to be explored regarding visual effects, I have limited my methodology to the consideration of computer effects practitioners, educators, and pioneers. The education of computer effects practitioners in the production environment of the San Francisco Bay Area has been my major concern. I have focused on the different methods and techniques used to educate these new practitioners in the changes and reconstruction of their tools use in production. My main concern, however, has been the investigation of pioneers of computer graphics. I have examined their influences on contemporary users; reviewed the similarities that exist between the academic model of computer graphic art education as used in the university environment of The Ohio State University; and compared the academic model to the training model used by the computer production environments of Pacific Data Image, Xaos, Inc., and Pixar. Historically, the concept of special effects began during the 1600s; therefore, in this research I have examined the methods and techniques used to achieve visual effects from that time to the present. Further, I looked at the development of the computer as a special effects tool in comparison to how it is used by contemporary artists in the effects industry.

The methodology I used was limited in several ways because of the environments in which the case study interviews were conducted and because of the companies' rules by which the practitioners were governed. When I initially telephoned the production companies, most were reluctant
to participate in the research for fear that the methodology used may force their employees to reveal the companies' trade secrets. Others felt that this methodology would simply cajole practitioners to speak specifically about productions that were in progress. Therefore, the methodology was designed to keep within the companies' regulations. This constraint meant that I was unable to have free reign in the production house; thus, I was always accompanied by the educators or the practitioners. At one production house in particular, I was not even allowed to go beyond the reception desk because the entire company's interior space was being used for production on their first computer animation feature film; I was not allowed to ask questions.

The times and lengths of the interviews were also gauged by the practitioners and educators, who at times were allowed to converse with me for only thirty minutes, after which they had to return to the routine of production. During the interviews, the practitioners were first given a brief description of the methodology and the research. Failed attempts to properly route a mailed copy of the proposal meant that sometimes it did not get to the practitioners before the interview appointments. Usually, the practitioners were given a brief description of the methodology by telephone calls preceding agreed-upon appointments.

**SIGNIFICANCE OF THE STUDY**

There is evidence that special effects have been incorporated into the motion picture industry since 1900. Computers are the newest addition to the special effects industry and bring a new set of fascinating and unique techniques. As a viewer, I am intrigued by how these computer-based visual effects are achieved; as an artist, I am curious as to the process of making this
new art form; as a computer animator, I am curious as to how new animators are trained to adapt to contemporary changes in the programs and software.

After completing an ERIC search of the Dissertation Abstracts International and a national library search, I concluded that little in-depth material has been written on the subject of computers in visual effects. Research in this area has explored the field of special effects in general. This study will document the history of computer effects in the context of special effects. Apart from providing the historical context, this study will also indicate some of the key players of computer-based visual effects and events that have influenced the direction of visual special effects since the late 1800s. This historical and case study document will allow for a better understanding of present-day use of visual special effects and the role of computer graphics and animation in this area. This study will help to assess the effectiveness and to determine the future direction of computer effects. Additionally, this study will add to the body of knowledge concerned with computer graphics, animation, and visual special effects. Art educators, art historians, film historians, and college students interested in this area will be able to draw upon this body of knowledge to understand the art of visual effects, the creative force behind the scenes and development of computer effects, and the pioneers of this industry. Art Educators in particular can draw references from the body of this document to help them develop and design a curriculum for pioneering a computer graphics courses at the university level that will educate and prepare graduates for the field.

Chapter two will provide a background and historical origin of traditional visual effects as used by early film makers and animators. The
chapter also focuses on the relationship between scientists and artists in the development of the technologies.
CHAPTER II
THE EARLY YEARS

Antecedents

The intellectual heritage behind the theory of visual effects as used by artists over the years is complex and wide ranging. Unfortunately, the origins of visual effects are not well known, and most literature has neglected to mention the names of many of the artists and scientists who contributed to its birth (Spellerberg, 1980). In this chapter I will highlight some of the artists and scientists who were pioneers in the early art of visual effects.

Birth and Development of Traditional Visual Effects

Visual effects involves both art and science. Its artistic roots can be traced to the court magician, who created wondrous illusions to astound and entertain. Its scientific aspect was developed by engineers with a good understanding of practical physics (Hutchison 1987). However, it is my belief that scientists and artists drive each other’s creativity and that this is seen in the history of visual effects. According to Cawley and Korkis (1990), "early audiences were less demanding and just the novelty of movement was sufficient to provide entertainment" (p. 22).

Fry and Fourson (1977) wrote, "the story of motion pictures starts with 'A'--Aristotle developed the basic theory of optics, Archimedes began experiments with lens and mirrors, and an Arab named Alhazen pioneered
the study of the human eye" (p. 5). A German priest and a mathematics professor named Athanasius Kircher has been credited with the invention of the first crude slide projector in 1644. As a result of his numerous impressive inventions, Kircher earned the title of "Doctor of a Hundred Arts" (Fry and Fourzon 1977).

Kircher was born in Germany in 1602. In 1633, he was summoned to Rome by Francesco Cardinal Barberini (nephew of Pope Urban VIII). Kircher was delighted to move to Rome, the intellectual center of Europe. He was a man of boundless energy, and once he became interested in a problem, he was never content until he knew all the facts, from personal investigation if possible, and had written exhaustively on the subject. Kircher's work with magic lanterns, projections and his observations on the major shadow-art science were related in his book, *The Great Art of Light and Shadow*, published in Rome, 1646. The first nine chapters of this book included such diverse topics such as "light, reflection, images, the speaking tube, the structure of the eye, sketching devices, the art of painting, geometrical patterns, clocks, the nature of reflected light, refraction and means of measuring the earth" (Quigley, Jr. 1948 p.52). The tenth section of this book is divided into three sections where he discussed the story of Magic Shadow and explained the use of mirrors and reflections. This section also detailed the various types of mirrors such as convex, concave, and spherical. An explanation of a variety of mirrors was necessary for understanding the Catoptric Theatre—a large cabinet in which many mirrors were concealed" (Quigley, Jr. 1948 p. 53). Kircher's Catoptric theatre was an example of an early peep-show device, which would later be developed by Edison (Quigley, Jr. 1948).
Suspected of being in league with the devil on account of his power with mirrors, lenses, and amazing projected images, Kircher's name as "The Doctor of a Hundred Arts" spread throughout the European world. People began to understand and appreciate his magic projection through the use of mirrors. In the months following its announcement, the magic lantern was distributed widely by vagabonds and impostors, all claiming it as their own invention. Among these impostors was a Dane, Thomas Walgenstein, a man who claimed to have invented a better form of the lantern, which had, according to Kircher, been described in his book. According to Quigley (1948), based on statements made in Kircher's book, "Walgenstein should be hailed as the first commercializer of the projector and the first traveling picture showman or 'road-showman'" (p. 58). In his lifetime, Kircher wrote about Walgenstein, "a Dane, Thomas Walgenstein, not a little known as a mathematician, who, recalling my invention, produced a better form of the lantern which I had described. These he sold, with great profits to himself, to many of the prominent people of Italy" (p. 58).

As a result, Kircher received a new patent in 1670 and revised and enlarged his book, *The Great Art of Light and Shadow* in 1671. In this new edition, two new plates were introduced, one illustrating the room and box-type projections, and another demonstrating his use of the lantern idea to tell a story through the use of various techniques such as the revolving disc. Kircher died in 1680. By this time, his lantern was widely used in Europe for scientific and entertainment purposes, as in the art of deception.

Through the use of optics, the magician became the king of entertainment between the middle of the seventeenth century to the late
nineteenth century and beyond. Special magic theaters and grand tours were arenas for family entertainment.

He (the magician) turned a man into a skeleton, then back into a man. A woman disappeared in a puff of smoke, or she was burned alive on the stage, to arise presently from her ashes. The shows included robots who could play the violin or read people's minds. There were fantastic illusions like rocket trips to the moon, descents into hell and visits to mermaids under the sea. The magician let you know it was all skill, aided by science, nothing supernatural, no sorcery— but you could believe what you like. (Barnouw, 1981, p.3)

Through their zestful appetite for science, nineteenth-century magicians were, according to Barnouw (1981), pioneers of film.

Throughout the nineteenth century, the magicians made it their job to stay ahead of the public. To achieve this, they were constantly inventing new tricks to substitute for the old and maintain a high level of audience interest. Optics played a central role in the magic performances. A significant factor of optical magic was found in the extraordinary magic lantern, a device that was scarcely known by the general public because it was used covertly by magicians for spectacular effects (Barnouw, 1981). The lantern was a direct result of Kircher's contribution to optics in the seventeenth century.

Although Kircher has been credited for the invention of the magic lantern, an instrument created in the middle 1600s, there is evidence that the magic lantern was constantly being improved. Evidence has also shown that the original design of the lantern was used by magicians up to the late nineteenth century. Barnouw (1981) wrote, "its role was not a recognized one... until its use by lecturers in the late decades of the nineteenth century,
when it came to be used visibly. Long before that, magicians were using it covertly for spectacular effects" (p. 16).

Apart from Kircher himself, four other men made the magic lantern projector principle and construction widely known. These men were Gaspar Schott, Claude Milliet de Chales, Johann Zahn, and William Molyneux. Gaspar Schott, a protégé of Kircher, was known for his book, *Wonders of Universal Nature and Art*, published in 1658, with a second edition in 1674. In this book, Schott described the various types of lanterns that were created by Kircher. Schott described lanterns with and without lenses and covered points of practical use as well as the theory that was used in creating them. The second of these four men, Claude Milliet de Chales, was best known through his monumental work, *The Mathematical World*, a book he wrote in 1674. He devoted one section of this book to optics. He studied the eye and knew that the image was upside down on the retina. Before his demise in 1678, he investigated various vision problems, including angular vision and vision at long range and devised lenses and spectacles for both far- and near-sighted persons. He experimented with light- and dark-colored objects and discovered that the eyes actually see color and light and not objects and movement. This was the primary basis for the motion picture process. De Chales even attempted 3-D projection, without the use of special viewing glasses, a concept that is still to be fully developed. Although de Chales had devised a simple searchlight that improved the projection of images in Kircher's design of the magic lantern, now allowing it to project text that was bright enough to read, his most important refinement was the introduction of a two-lens projection system. The lens allowed the optics to be projected ten to twelve feet and enlarged the color image to about four feet in diameter.
Although he kept the original design of the concave mirror used as the light collector on most of Kircher's projectors, de Chales' double lenses made it possible to project a fairly focused image that not only helped to popularize the magic lantern but also extended the art and science of light and shadow. Johann Zahn in 1658 published *The Artificial Telescopie Eye or Telescope*. This book outlined a better lens system for the magic lantern, describing many applications including false representations to create wonder and fear. Zahn developed some ingenious improvements, including a table-top model projector, which set the pattern for the projectors developed in 1851 with the capability of showing a motion picture from hand-drawn slides. All that was added to the projectors of the nineteenth century was improved ways of creating the light sources. As a showman, Zahn demonstrated for his theatre show how images could be projected under water. William Molyneux, an acclaimed scientist and teacher, further developed the lantern by adding focusing lenses. In his book *Dioptrica Nova*, of 1690, Molyneux devoted a section to describing the magic lantern projectors system, detailing such parts as the focusing lenses, glass and concave mirrors, and adjustments in the picture focus (Quigley, Jr., 1969).

Written contributions from scientists and developers such as Schott, Milliet, de Chales, Zahn, and Molyneux were important for enhancing the public's understanding for this new art tool and its uses. The lantern served as an entertainment tool and as a magician's tool for creating visual effects. "By the early part of the eighteenth century, the magic lantern was commonplace and men were skilled in its use" (Quigley, Jr., 1969, p. 69).

The use of the magic lantern through the nineteenth century remained a mystery. Magicians wanting to keep their art a secret were not willing to
admit that the extraordinary magic lantern played a central role in the production of optical effects. In 1845 French magician Jean Eugene Robert-Houdin, "the father of modern magic," founded a theatre in Paris that produced magic shows for more than seventy years. The theatre workshops produced a continual series of new illusions, including optical effects using multiple magic lanterns. The optical creations became an especially important part of Theatre Robert-Houdin in 1888, when the theatre was owned and managed by George Méliès (Barnouw, 1981). Although the lantern was not the only optical effects tool used by early magicians, it was certainly one of the primary tools used in the performance of magic tricks through the 16th and 17th centuries. Its concepts and principles made way for much more complicated experiments with the use of optics in the production of film effects.

Traditional Visual Effects in Film: The Development of the Tools and Techniques

Brosnan (1974) wrote,

the beginning of the story of special effects is to be found at the beginning of the film industry itself. Not long after the first image had been successfully projected onto a screen, trick photography, the creating of illusions through the manipulation of camera and film, was born. But one of the most exasperating things about any investigation into the development of the film industry is the difficulty of attempting to determine just who was first with any particular technique or device. This is because so many of the early pioneers were working independently, separated by both natural boundaries and business competition... it is more or less impossible to state with any certainty just who invented trick photography, but we can at least group together those who were among the first....(p.15)
Despite Kircher's attempts to develop the science of optics, Thomas Edison and his assistant William Dickson put together and applied these theories of optics. The two began working on these problems in 1887, and shortly after, they discovered that film was the way to reproduce moving images. Although Edison and his assistant had the right concept for reproducing moving images, they were unable to develop the right photographic emulsion to make it work. The problem faced by Edison was similar to that which George Eastman faced, who at that time was working on the production of a simple snapshot camera for the amateur photographer.

Eastman's interest in photography began at age 24, when he made plans for a vacation to Santo Domingo. When a co-worker suggested that he make a record of the trip, Eastman bought a photographic outfit with all the paraphernalia of the wet plate. This equipment included the camera (which was the size of today's microwave oven) and a heavy tripod and other paraphernalia that completed the outfit, along with a $5 cost to learn how to use it.

Eastman did not make the trip to Santo Domingo, but he became completely absorbed in photography and sought to simplify the complicated process. He began reading British magazines in which photographers were publishing their findings upon making their own gelatin emulsions. He read that plates were being developed that, when coated with emulsion, remained sensitive after they were dry and could be exposed at leisure. Using a formula taken from one of these British journals, Eastman began making gelatin emulsions. This concept led to three years of photographic experiments by Eastman. At the end of the third year, Eastman had a formula that worked.
By 1880, he had invented and patented not only the dry plate, but also a machine for preparing large numbers of plates. He quickly recognized the opportunities for making dry plates for sale to other photographers. In 1885 Eastman developed a thin, flexible base film emulsion (Kodak).

Although Eastman developed many of the photographic raw materials, the development of film required the assistance of a scientist who helped him to expand the technologies far beyond the other pioneers in this field. "In 1886, Eastman became the first American industrialist to employ a full-time research scientist [anonymous] to aid in the commercialization of his flexible transparent film base" (From..., 1992, p. 26). However, Eastman had only concluded the work of his predecessors such as photographic pioneer Nicephore Niepce of 1826, the creator of the world's first photograph (Azarmi, 1973).

The development of the flexible transparent film base solved both Edison's and Eastman's problems. It was the opportunity Edison was waiting for to patent the kinetograph motion picture camera and a separate viewing device called the kinetoscope (Fry and Fourzon, 1977). Eastman and Edison collaborated to make motion picture possible. According to Barnouw (1981), the kinetoscope, a product of Thomas Edison and his co-workers, particularly William Kennedy Laurie Dickson, made its debut in 1894--the year before the debut of cinematography. These devices were closely related, and the kinetoscope made "viewing pictures" a reality for peepshow visitors. The failure of Edison to patent the kinetoscope internationally meant that it would be fabricated by Robert W. Paul. Barnouw (1987) wrote,
during 1894-95 Paul fabricated more than sixty peepshow machines, adding some improvements of his own. Meanwhile he began experiments towards the next step, a "projected kinetoscope." Edison, though he had not patented his kinetoscope, was copyrighting films he made for use on the machines. Paul tried to obtain Edison films to show on his own unauthorized machines, but was rebuffed by Edison. To pursue his work meant that Paul had to go into the making of film and he developed a camera for the purpose. (pp. 41-42)

In efforts to learn the latest in technology and visual effects, the early magicians attended conferences and meetings. These meetings often were advertised to a few selected individuals who had an interest in special effects or merchandising the technical devices. At the end of 1895, twenty Cinematographe machines were developed as a result of various contributions and the combined efforts of the pioneers. These machines were projectors that could also serve as cameras or printing machines. The invention of the Cinematographe was given its historic premiere at the Grand Café in Paris. "This became the signal for a chaotic scramble, a rush for wealth and glory, in which numerous magicians took part" (p. 43).

According to Brosnan (1974), G.A. Smith, an Englishman, was also experimenting with photography during this time. Like most other developers, he built his own camera and began to make films. Soon he was experimenting with trick photography, and in 1897 he took out a patent for double exposure, which he used in his film, The Corsican Brothers. It is possible that he preceded both R.W. Paul and Georges Méliès in the use of trick photography. Paul was an engineer rather than an artist, and his ability to design better and more efficient projectors made him one of the chief developers of the kinemotograph. Both Paul and Smith have lapsed into relative obscurity, and it is the name of Georges Méliès that is always
mentioned when the subject of trick photography arises. Although Méliès was not the only pioneer of film effects, it can be said without a doubt that his films had the greatest influence on other film-makers in the field of special effects.

Georges Méliès, a renowned stage magician and director, got his start in 1888. When his father retired and decided to pass on the business to his three sons, Georges promptly sold his share to his brothers. That year the Theatre Robert-Houdin was offered for sale, and the 27-year-old magic addict was able to buy it, thanks to the revenue from the sale of his share. With his established theatre in France, Méliès was now referred to as a theatre manager rather than an artist. In 1895, he attended the Lumière brothers' demonstration of their cinematography machine and decided it would make a marvelous added attraction in his theatre. The brothers refused his offer to purchase the machine. Méliès later obtained a film stock and a projector from Robert Paul for a fraction of the price after making a trip to London. The trip to London not only gave him ownership of a projector but also enabled him to make living pictures a regular part of the Robert-Houdin programs. Meanwhile, studying the projectors, Méliès was able to design a motion picture camera and have it fabricated by a mechanic. A few months after the debut of the cinematograph, Méliès succeeded in plunging into a film-making career that eventually accounted for some 500 short films. From the start of his film-making efforts, Méliès used film as a magic item to enrich the programs of the Theatre (Brosnan, 1974; Barnouw, 1981; Fry and Fourzon, 1977).

Fry and Fourzon (1977) wrote,
Méliès accidentally discovered stop-motion, the same effects Edison used in Mary, Queen of Scots and when bored audiences rebelled against the travelogues and faked documentaries that were still the staple of international cinema, Méliès brought the public dramas, comedies, vaudeville operas and operettas, visual tricks and fantastic voyages. (p. 8)

According to Brosnan (1974), the accident that caused Méliès to open his eyes to trick photography occurred when he was filming the Place de L'Opera in Paris. While filming this project, Méliès' camera jammed. It took Méliès a few moments to clear the obstruction and begin filming. "After he had developed the film and was screening it at home, he observed the startling transition that the jammed camera had caused with the scene that he had been filming" (p. 17). In the screen process, legend has it that he had the experience of seeing an omnibus turn into a hearse. This experience opened up his mind to the possibilities of what effects could be achieved through the use of the movie camera. Not long after this incident, Méliès began to experiment with fast and slow motion, double exposure, multiple exposures, stop-motion, the dissolve, and the fade.

Méliès' most successful period was between 1897 and 1902. He used numerous mechanical and film techniques to achieve effects in his films. Fry and Fourzon (1977) wrote that in his theatre "he built a glass studio incorporating every conceivable stage facility, from wires and trapdoors to scrim curtains, and became filmdom's first director, actually planning his films in advance and shooting them in logical order" (p. 8). Méliès utilized these techniques to create such successful films as Cinderella (1899) and A Trip to the Moon (1902) during this five-year period. Although Méliès' films consisted of four main divisions, he pioneered the art of using deceptively simple means to achieve striking results in his films. In his earliest fantasy,
films were simple examples of the complex wonders to come. In *Cinderella* (1899) Méliès used stop-motion to turn a pumpkin into a coach and grimy rags into a glittering ball gown. Slow motion allowed dancers to hang suspended in mid-air for a longer period of time as they drifted easily towards the earth. Fast and reverse action added touches of slapstick to a still genteel medium. This film saved his theatre from a slow death by boredom and became the sensation of the day and almost single-handedly pulled the business out of a two-year depression. In another film, *A Trip to the Moon* (1902), Méliès used his usual camera tricks, plus close-up, zoom, and the like (Fry and Fourzon 1977; Brosnan, 1974).

Over the five-year period Méliès was known as an international superstar of the cinema, but this fame would soon come to an end. According to Fry and Fourzon (1977), the public adored his realistic documentaries, outrageous fantasies, and ever-present camera tricks. His finished production of more than 75 films a year established the standard of quality in film that undoubtedly inspired a substantial segment of film's second generation for whom his movies were the only "school" available. Although another pioneer, such as R. W. Paul, was a film genius whose innovations earned him the title of father of the British film industry, it is the name of Georges Méliès that is best remembered as the pioneer of film effects. Brosnan (1974) wrote,

unfortunately Méliès never really developed as a film maker and despite all his photographic innovations, his films were never more than filmed stage shows. This lack of vision led to an early curtailment of his career. Even by 1904 audiences were looking for something more; it was time for the motion picture to stop being a novelty and grow up. Often film workers took the hint but even in 1912 Méliès was still making films in his
customary fashion. By 1913 he was bankrupt, having been crushed by the large scale business operations that had been formed with the rapid growth. (p. 19)

Artists began using visual effects to solve problems in film as used by film pioneers in America. Unlike those used by Méliès, Paul, and others who had experimented with early effects, visual effects in the early 1900s took on a more practical use in the film industry. By the turn of the century, the novelty of trick film had begun to evaporate. The short story lines and simple trick photography were no longer enough for the paying public; to them, the effects by Méliès and other pioneers had become trite. As the product of an internationally known cinema superstar, even Méliès' seventy-five minutes of finished, undoubtedly inspiring film-a-year was not enough. Before the turn of the century, the trick photographer was seen as the real star of the movie. Little attention was given to the actors or to the story; instead, the story was nothing more than an excuse to trot out a bunch of showy effects. However, in the Great Train Robbery, American film maker and story pioneer Edwin S. Porter illustrated a more practical side to the use of trick effects. In this film, the use of visual effects was extremely subtle and "for the first time in the movies visual effects were used not as a form of spectacle, but as a way of making scenes in a film look natural and lifelike" (Schechter and Everitt, 1980, pp. 32-33).

Schechter and Everitt (1980) explain the practical uses of special effects used by Porter in the production of The Great Train Robbery.

The first scene takes place inside a telegraph office. Through a window we see a train arrive outside. Though some film historians have claimed that the scene was filmed on the location, the truth is that it was done by means of a clever but
comparatively simple matte technique. ...What makes the fairly rudimentary trick photography in *The Great Train Robbery* so noteworthy, then, is precisely the fact that it was not meant to be noticed at all. For the first time in the movies visual effects were used not as a form of spectacle, but as a way of making scenes in a film look natural and lifelike. (pp. 31-32)

Although Méliès may have been credited as being the first to use visual effects in the early days for more realistic and believable films, he was not alone. Norman O. Dawn, an American film pioneer, was also a great innovator of camera tricks used to fake reality. Dawn was not very popular, partly because of his unmemorable movies, which continued through the 1930s. "But in the paradoxical way of special effects work, his obscurity is also partly the result of his technical genius; the illusions he created for the screen were so skillful that audiences took them for the real thing" (Schechter and Everitt, 1980, p. 33). In actuality, Dawn was one of the first in a long line of anonymous effects experts; his talent guaranteed that his work did not go unseen. A photographer and painter, Dawn entered the field at the age of nineteen and worked for a Los Angeles engraving firm. In 1906, he traveled to Paris where he studied art. During this visit, he was introduced to Méliès and the Lumière brothers, at which time he experimented with the use of the motion picture camera. Upon returning to the United States, Dawn began production on a short film documentary titled *Mission of California* (1907). During the filming of this documentary Dawn, for the first time in his film career, adapted a still photographic technique known as glass shot. This technique was used as a result of a problem he encountered in the middle of production, when he was given the assignment of some architectural scenes around Los Angeles. Some of the buildings he was asked to shoot were in
poor locations and were surrounded by telephone poles and wires. This problem gave Dawn the opportunity to experiment with glass painting techniques and allowed him to combine his background in painting and photography. He painted trees onto clear glass and used the trees to hide the telephone poles, thus using visual effects techniques as a practical means of improving reality. Dawn was able to use the techniques applied in this assignment to other films to make life look better than it actually was. He is considered a prototype of the modern effects technician, the motion picture craftsman who brings artistry, engineering skill, and boundless ingenuity to the task of performing the possible. In 1911, Dawn devised a new and superior way of producing composite images called an in-the-camera matte shot and later worked with and developed many other effects techniques, including rear projection (Schechter and Everitt, 1980).

Frame by Frame: Stop-Motion Development

By the beginning of the 1920s, stop-motion animation was being integrated into film. The principles for stop-motion animation were already developed by the 1920s, but despite "some early pioneering efforts by the legendary George Méliès and a few others, model animation as a cinematic technique was virtually unknown in the early 1920s" (Hutchison, 1987, p. 23). According to Hutchison (1987) in June 1922, Harry Houdini invited Sir Arthur Conan Doyle to a meeting of the Society of American Magicians. Sir Arthur, who had dedicated his life to the writing of Sherlock Holmes mysteries and establishing the reality of the spiritual world, saw this invitation as an opportunity to pay back his adversaries at the meeting. The production work for creating a movie based on his novel The Lost World had
begun, and Sir Arthur took a test reel to show his colleagues, who had once ridiculed him for his belief in psychic phenomena. Sir Arthur was excited about the 3-D stop-motion animation that was done by a relatively unknown special effects artist named Willis O'Brien. The film showed several dinosaurs fighting in a prehistoric setting. Sir Arthur's showing of the reel caused the news of the film to make front page of the New York Times. The film made its debut in 1925 and is generally credited as the first full-length film to depend on model animation.

This film was the first of eight film projects that O'Brien would make with model maker Marcel Delgado. Delgado explained how he began to work for O'Brien, and the level of creative freedom he was given on these projects:

At first, O'Brien had an assistant named Cliff Markay. I don't know what he ever did for Obie [O'Brien]. ...I had a job at the grocery...and I wasn't about to give it up. Then Obie insisted that I should work for him. I must have turned him down fifteen or twenty times. When I saw the studio, I immediately changed my mind! Obie didn't know me from Adam. He was just taking a chance. I never did see that guy again....I was never taught how to make models. I did them on my own. There were no instructions; I had to rely on my own imagination. (Archer, 1993, p. 13)

O'Brien, who appeared to be comfortable with stop-motion animation may have gained this confidence through his earlier film production shorts. O'Brien began his animation career at the Edison company and in 1914 created his first stop-motion short called Dinosaur and The Missing Link. Ten more shorts followed, each costing $500, and by 1919 The Ghost of Slumber Mountain grossed $100,000. After completing The Lost World, O'Brien increased the challenge by creating King Kong in 1933. This film
used various techniques to blend stop-motion animation with live action footage. Two separate Kongs were created; one consisted of a make-up man in a monkey suit running around a scaled-down set, and the other of a full-scale mechanical giant ape. The make-up man, Rick Baker, had been fascinated by primates since childhood and had created five different masks, each mask expressive of Kong's basic mood in the shot. The mechanical giant ape, on the other hand, was designed by mechanical effects artists Glen Robinson and Italian designer Carlo Rambaldi. Rambaldi had worked on The Bible and War and Peace under Dino De Laurentiis, who had brought him to America to work on King Kong. Although De Laurentiis could communicate only through an English interpreter, the men worked in harmony. Before long, Robinson and Rambaldi were developing a hydraulic system that allowed the forty-foot, six-and-a-half-ton Kong "to wiggle" his arm, roll his neck, twitch his ears, roll his eyes, bend both legs, rotate on his hips, pull his mouth back to show his gums—and even smile. (Culhane 1981).

King Kong used every technological method of movie making known to visual effects artists at the time of its development. Beyond the meticulously precise stop-motion used by Willis O'Brien, large-scale mechanical modeling played an important role to persuade audiences to suspend their disbelief. To achieve the look of a 50-foot creature on the screen called for the contribution of a young Mexican sculpture student, Marcel Delgado. After the ball-and-socket jointed steel armatures were built, Delgado added the sponge, cotton, and the final latex skin to create the realism in the form. Delgado built up under the skin to give the creature the appearance of muscles. In addition, he used a bladder that could be inflated and deflated, thus swelling or retracting the chest to imitate breathing. In
addition, masking³ techniques derived from mattes⁴ were fundamental to the development of *King Kong*; therefore, more complex photographic masking means were used. The photographic techniques employed filter properties to exploit the phenomenon of shooting different scenes through different color filters in different color lights. Other techniques such as rear projection were additional technological methods used in the production of this film.

*Kong* turned out to be a remarkable success for O'Brien, the mechanical effects artist, and others who worked on the project. For O'Brien, in particular, the project marked the end of his second feature film. This film brought him the prestige of being the first animator to integrate such a large mechanical monster successfully into a story that focused not only on the animation, but also on the main actress, Fay Wray. Perhaps the most rewarding prize given to O'Brien was the enormous impact this movie had on viewers who, since that time, began demanding more mechanical monsters in feature movies.

One audience member who was astounded by the 50-foot mechanical ape was Ray Harryhausen. After viewing the film, the young Harryhausen sought out O'Brien and became his assistant. Harryhausen was only thirteen when he first saw *King Kong*, but this movie changed his life forever. He later made a name for himself through his work as an animator for Willis O'Brien "on *Mighty Joe Young*, which won O'Brien the Academy Award for special effects in 1949" (Culhane, 1981, p. 65). Harryhausen moved up from

³The basic principle is that if, for example, an orange object is viewed through an orange filter, it disappears but when viewed through a blue filter, it springs into well-defined visibility.
⁴An unsophisticated cinematic technique, matte has been traditionally used to mask off parts of the camera lens so that the portion of the film behind the mask is not exposed with the rest of the frame. The filmer is then free to add images in the unexposed area.
his apprenticeship position. "The first film on which Harryhausen had control of the special effects was The Beast from 20,000 Fathoms (1953), directed by Eugene Lourie from a 'Saturday Evening Post' story by Ray Bradbury" (Culhane, 1981, p. 65). Harryhausen had worked on 80% of the animation for O'Brien's Mighty Joe Young and felt confident about his work.

Plate I The Frost Giant mechanical operation

Most mechanical effects artist made attempts to patent their mechanical monsters or miniatures, but the devices were all built in basically the same way. Schechter and Everitt wrote, "Méliès could get away with a mechanically operated creature like the Frost Giant (from his film The Conquest of the Pole (1912)) because his movies were meant to look artificial, like filmed theatrical performances" (p. 153). The design of Méliès' mechanical monsters was primitive and manual because it employed the skills of strong men more than those of skilled engineers. Strong pulleys and ropes were used to lift the hand or to turn the head of the Frost Giant. Complex mechanics such as the hydraulics used by O'Brien's King Kong were not viewed as a necessity. The monster kept the same facial expression
throughout the entire short movie. However, close attention was paid to the overall motion of the miniatures, which employed the basic articulated armature similar to the one created by Jim Danforth for a *Friendly Monster*. O'Brien altered the creation of Danforth's armature to include ball-and-socket joints that allowed Kong to move more smoothly.

Most art historians agree that one of the best mechanical monsters made in the early days of visual effects for the movies was a representation of the dragon "Fafner" built for Fritz Lang's silent classic *Siegfried* (Schechter and Everitt, 1980). After witnessing the failure of Douglas Fairbanks' 1924 version of *The Thief of Bagdad*—a film that attempted to use a baby alligator in a dragon disguise for a part in the story that required a mechanical dragon—Lang had designed a 60 foot mechanical reptile. However, Lang's mechanical reptile was just a slightly different operational design from that of Méliès' *Frost Giant*. "Four men, standing inside the body of the sixty-foot reptile, operated its neck, head, and tail, while five more, hidden in a trench underneath the dragon's body, moved it along a track built into the fake forest floor" (Schechter and Everitt, 1980, p. 153). Lang had altered the mechanical effects used by Méliès when building his dragon, but future artists were able to improve on what he and Méliès started. As an effects artist, O'Brien sought a formal education in the arts that made it possible for him to design advanced models for his films. O'Brien attended evening classes at the Otis Art Institute in order to prepare himself for making his dinosaur film the *Lost World* (1923). After successfully designing the miniature dinosaur, O'Brien presented it to producer Herbert Dawley, who later patented the design of the dinosaur in 1920. His move to patent the dinosaur structure made it difficult for others who wanted to create dinosaurs. In 1933,
Willis O'Brien patented his design of a miniature rear-projection system (Hutchison, 1987).

Puppet animation, as in *King Kong*, was creating an effects category of its own. Different from that of O'Brien's miniature dinosaurs, the category of puppet animation excludes the use of real-time figures such as hand puppets. Like most techniques in visual effects, its exact point of origin is uncertain, but it began outside the United States. Canley and Korkis wrote, "though not common in the United States, puppet animation is recognized and encouraged in Europe and the East. In puppet animation, most puppets have an armature of wood, metal, or wire. This armature is a skeleton that allows the puppet to move slightly at body joints like elbows and knees and maintain that position while it is being photographed. To achieve different expressions, the animators often change the head on the puppets" (p. 101). George Pat was one of the puppet animators who migrated to the United States. He created acclaimed puppet animation in the 1930s and 1940s and later won several Academy Awards in 1943 for "the development of novel methods and techniques" of puppet animation. In later years he attracted apprentices like Jim Danforth, who was nominated for an Oscar for the visual effects in George Pat's 1964 MGM production of *Seven Faces of Dr. Lao* (Culhane, 1981; Cawley and Korkis, 1990).

Walt Disney's production of *Snow White and the Seven Dwarfs* (1938) marked the end of major innovations in traditional special effects feature films. Before Disney's production of *Snow White and the Seven Dwarfs*, most major innovations in traditional special effects such as glass shots, matte shots, background painting, mechanical effects, puppets and miniatures, rear-screen and front-screen projection, and optical printer and
traveling mattes were explored by various artists on a large scale. Even a great amount of minor visual effects were explored in feature films before Walt Disney's production of *Snow White*. Such effects include slow motion, time lapse, distortion, the spin, the freeze-frame, reverse movement, and multiple image effects. Although animation had been explored to a large degree through the stop-motion films of O'Brien, Méliès, and others, these artists explored the techniques of 3-D visual animation effects. Disney was experimenting with the techniques of 2-D visual animation effects, and, because there were others experimenting with this technique, it is difficult to tell with any degree of certainty who was the first to develop a film by using only 2-D animation effects.
The field of 3-D animation and cartoon drawings has its own rich history that can be considered separately from that of the other visual effects techniques. Before the 1900s, comic strips and cartoons illustrated the concepts of an object and its stages of motion in time. Like the contemporary storyboard artist, the comic strip artist used several panels to show the succession of the movement and the stages of a story. However, Thomas (1991) wrote that the forerunner of the early comic strip can be found in the cave arts and crafts of various ethnic cultures; such illustrations "can be found in an Egyptian wall decoration circa 2000 B.C." (p. 23). In successive panels, the wall decorations depict two Egyptian wrestlers struggling in a variety of holds. Another example can be cited from the cave art of northern Spain 30,000 years ago. The cave artist was presumably dissatisfied with his
drawing of a four-legged boar and added an extra four legs to trick the eye into believing that the animal is in motion (Thomas, 1991).

Plate III Cave art of northern Spain

Most pioneers of 2-D animation were also pioneers of the principles that were used to create visual effects in film. Like the lantern shows, shadow plays were presented in a similar form in the late 1830s. Shadow plays, which were common in Europe, especially England, were presented at night. For home entertainment, children created these plays through the use of sheets with human and animal silhouettes, which they pasted onto cardboard and cut out. These shadow plays were packaged toys that usually included silhouettes, instructions for constructing a shadow theater, and, often, scripts for simple plays. These shadow plays provided children with toys that encouraged them to create and appreciate 2-D animation. Shadow plays were only the beginning of animation toys and developed to the level at which they incorporated basic visual effects such as moving clouds, water, and atmospheric effects in the backgrounds of the silhouettes (Solomon, 1989).
Apart from the shadow play toy, other animation toys were also developed in the nineteenth century as a result of extensive research and inquiry to explain and, in some cases, replicate basic motion. According to Solomon (1989), this century was the great era of "philosophical" animation toys that began with the invention of the thaumatrope ("wheel of magic" in Greek) in 1826. This device was probably invented by John Ayrton of Paris or Paul Roget, a Frenchman who, according to Thomas (1991), invented and demonstrated its use in 1828. Its basic design consisted of a half-dollar coin size disc with an image painted on both side, threaded with string on either sides of its diameter. When the device was spun, the images on either sides were combined. Therefore, if a bird is painted on one side of the disc and an empty cage on the other, the result of the spin gave an illusion of a bird in a cage. The device was extremely popular, but the inquiry into motion continued. About that same time, Peter Mark Roget, the author of Persistence of Vision with Regard to Moving Object, began to investigate the "wheel phenomenon." Roget inquired as to "why the spokes of a rapidly spinning wheel seem to turn backward or forward or seem to stand still at different times" (Solomon, 1989, p. 7). In his conclusion, Roget reportedly "described
the important fact that the human eye will blend a series of sequential images into a single motion if the images are presented rapidly, with sufficient illumination, and interrupted regularly" (Solomon, 1989, p. 7). Roget's research into the question of the wheel led to the invention of the phenakistoscope ("an optical deceiver" in Greek) or fantoscope by scientist Joseph Plateau in 1826 or 1828. A more complex device than the thaumatrope, the phenakistoscope was made up of two discs. One disc contained a series of sequential images, the other disc, which was placed in front and closer to the viewer's eyes, contained number of slits equal to the number of frames in the sequence. The viewer held the cord up to a mirror and peered through the slits as the card whirled. The slits acted like shutters, allowing the viewer to see only short glimpses of the image frames. When the disks spun at the correct rates, the viewer saw a moving image. A similar device called the stroboscope was designed by an anonymous Austrian geologist around the same time. Nevertheless, the phenakistoscope remained popular through the century. Another animated device using similar techniques was the Daedalum or Wheel of the Devil, created by William Horner in 1834. In 1860, it was renamed the zoetrope or Wheel of Life. The design consisted of a drum that was customized with slits and strips of sequential images placed inside so that, when the drum was spun, the images seen through the slits appeared to move. The subject matter contained in these short-cycled sequential animation was usually taken from everyday life. These animation toys were popular forms of amusement for people in the nineteenth century (Solomon, 1989; Thomas 1991).
The kineography, invented in 1868, proved to be the least expensive, most durable, and most practical animation toy of its time. The kineography, or flip book as it is called today, consisted of a few dozen sequential drawings of photography bound in order, like the pages of a book. When the book is flipped through rapidly, the images blend and create the illusion of motion. The flip book was redesigned by Thomas Edison in 1895 and was renamed the mutoscope, a sort of mechanical flip book. The mutoscope was designed so that viewers could crank a ring of sequential photographs at greater speeds. Similar inventions followed in 1877 with the advent of the praxinoscope by Emile Reynaud. Reynaud's device was a great improvement to those of his predecessors. He combined his invention with a projector and began drawing animated stories, first on long strips of paper, then on celluloid. This technique of drawing directly onto the film stock was revolutionary and was later repeated by the 1930s by animators such as Len Lye and Norman McLaren. Although the praxinoscope used similar principles of the kineograph, there was one distinct difference between them: "the praxinoscope was not an animated toy but film" (Solomon, 1989).
Muybridge and Marey

James Muybridge, as he was originally named, was an English-born photographer who made frequent trips between England and the United States. As an artist, he contributed to the areas of photography animation and film. He was perhaps most popular for his research on a galloping horse, an assignment given to him by the governor of California, in 1872. Governor Leland Stanford of California made a $25,000 bet in connection with a dispute as to whether or not all the legs of a horse running at full gallop are off the ground simultaneously. Human eyes were not quick enough to register the exact movements and position of a galloping horse. Other artists were hired before Muybridge but the results were not satisfactory. Muybridge also failed in his first set of attempts to view the horse's exact movement over time. After taking a break from the research, Muybridge returned with an improved apparatus and succeeded in taking some initial pictures in 1877. The photographs were arranged in a zoetrope-like apparatus and were projected via a disc which was rotated by means of a handle. This device created by Muybridge was named the zoopraxiscope and combined various techniques such a lantern projection, as created earlier by Kircher, with the principles of the fantoscope (Neale, 1985; Quigley, 1969).

According to Neale (1985), Muybridge later demonstrated his equipment and his work in Paris, and it was there that he met E.J. Marey, a physiologist who had been working on the study and analysis of animation and human movement (p. 34). In the winter of 1881, Marey had produced a photographic gun that was an adaptation of the photographic revolver invented by Janssen in 1873. The gun enabled pictures to be taken at a very rapid rate. The mechanism within the gun allowed each photographic plate
to move in position once a shot had been taken. The development of Marey's instrument proceeded another step, a system known as chronophotography. This system allowed successive stages of movement to be recorded on a single photographic plate.

Scharf (1974) wrote,

> with the appearance of more or less instantaneous photographs from about 1860, artists were faced with yet another and very fundamental problem. For many of these images defied the customary ways of depicting objects in motion and, though they were factually true, they were false as far as the human optical system was concerned. Was the artist then to confine his representations only to observable things, or was he justified in showing those which, as the instantaneous camera demonstrated, existed in reality yet could not be seen? Convention notwithstanding, it was now possible to learn to see many of the new and startling forms or perceive them on a threshold, but the subjects of high speed photographs taken from the 1870's, some with exposures as fast as 1/1000th and then, in the 1880's 1/6000th of a second and less, could never be comprehended by the human eye alone. Though previously the photograph had been criticized for certain deficiencies of information, now the camera was accused of telling too much. (Scharf, 1974, pp. 14-15)

Both Muybridge and Marey were working precisely to cross this threshold in the interests of science and scientific truth (Neale 1985, p. 36).

**Two-Dimensional Animated Film Effects**

Various experiments of visual perception were conducted long before the 1900s, "but true animation could not be achieved until people understood a fundamental principle of the human eye: the persistence of vision" (Thomas, 1991, p. 23). Muybridge's efforts later culminated in the two volumes *Animation in Motion* (1899) and *The Human Figure in Motion*
(1901). He moved to the University of Pennsylvania in Philadelphia where he continued his photographic analyses of the movements of humans and animals. Although Muybridge and other animation research developers may have developed the tools that are used for animation, it was Emile Cohl who began to develop the art of 2-D animation. As described by Heraldson (1975), Cohl, an apprentice jeweler, in his teens found his interests divided between his cartooning hobby and setting diamonds in his father's Paris jewelry shop. Cohl put his hobby on hold until movie cameras became more accessible in France. In 1905 he experimented with single-frame exposures of cartoons, and later he set out to make a film in which each frame was a separate photograph of individual drawings. He altered the drawing slightly from one frame to the other to imitate live-action film. His first cartoon animation, titled Mr. Stop, was the first known to use the technique of frame-to-frame drawings. The basic story depicted a crudely drawn stick figure scientist who had the ability to freeze everything he sees to a complete standstill. The crude drawings moved: as a result, Cohl's work was hailed as a supreme achievement in 1907. Even Méliès came to see Cohl's animation and was impressed. After making another short film in 1908, Phantasmagoria, Cohl began working as a cartoonist for the Paris Weekly newspaper. According to Thomas (1991), Cohl was a political cartoonist who protested to the Gaumont Film Company that it had stolen one of his cartoons for an advertisement. Ironically, his overall impressive work earned him a job at the Gaumont Film Company where he worked as a gag man. Phantasmagoria was a work of rare imagination that required two thousand drawings and amazed movie audiences, who were astounded to see Cohl's crude drawings come to life. America began to show interest in Cohl's work, and, as a result, he moved to
New York in 1912. During his time in America, Cohl explained his limited knowledge to anyone who was interested in film making. After his first two films, Cohl developed nothing new. Later he found less time to devote to animation, and, although he had made the innovation of this art form, other artists worked on perfecting the craftsmanship of the art.

Cohl was not by any means the first to attempt this art of hand-drawn animation. In the United States a handful had tried, prompted by European attempts. James Stuart Blackton was an early animation pioneer whose first project was completed in 1906. According to Solomon (1989), Blackton was born in England and immigrated to the United States as an infant. In 1894 he was introduced to Albert Smith and Ronald Reader. The three young men were all British immigrants, and together they founded The International Novelty Company. The three were show-business men. Reader performed sleight-of-hand magic; Smith was an illusionist whose tricks involved technical devices; Blackton did quick sketching and chalk talk routines. The act was not a great success, and Blackton tried to use different devices such as the lantern to improve the act. The three men went on to found the Vitagraph Company, which would become one of the most important film studios of the silent era.

In 1906, Blackton became interested in the possibilities of frame-by-frame film making. He filmed an amusing project called *Humorous Phase of Funny Faces*. The faces were drawn with chalk on a chalk board and they were animated by simply erasing parts of the face and re-drawing it between camera exposures. The film was composed of several unrelated vignettes. The film was widely shown, and about the only drawback it had was the buildup of chalk smudges left on the board after each line was erased.
Nevertheless, Blackton was a much better craftsman than Cohl. Later, Blackton worked for the New York World newspaper while he continued to experiment with frame-by-frame animation. Apart from working at the newspaper, Blackton also lectured at art universities. Often viewed as America's first animator, he continued to experiment with the medium of film, but his next film *The Haunted Hotel* (1907) contained only 3-D stop-motion techniques and was viewed as a success in America and Europe.

James Blackton later approached Edison's company for an interview for the newspapers. At that time that Blackton convinced Edison to make a film on him that could be used for publicity. Edison made the film and provided Blackton with a projector for less than a thousand dollars. Blackton toured with the film and showed it to crowds of people who came to see it. But the crowd wanted more. After paying audiences requested an encore, Blackton had nothing more to show. There was no way for him to make a film. Edison did not sell cameras, and there was no way for Blackton to get one. The audience's call for an encore prompted Blackton to create a camera company of his own. The company was called the Vitagraph Corporation, which was the second motion picture enterprise in the United States. It made Blackton and his associates millionaires (Heraldson, 1975; Solomon, 1989; Thomas, 1991).

Blackton was a known inventor and innovator but lost interest in animation by the year 1910. He may have become busy with his job as supervisor of all the company production at Vitagraph or tired of the medium itself. He sold the company to Warner Brothers in 1926. But like Méliès' case, his bad investments in later years made him bankrupt. The bankrupt Blackton may have pioneered the craft of animated film making,
but his craftsmanship was never really developed, and it was Winsor McCay who demonstrated the artistic potential of the new medium and inspired generations of animators (Solomon, 1989; Heraldson, 1975).

New York became the melting pot for poor European immigrants between 1900 and 1910. Europeans were always linked in some way or another to the film-making process and, once in New York, most continued the trade and influenced others. George McManus was a cartoonist famous for the Maggie and Jiggs comic strip and had developed a short cartoon using his characters. He showed his film at the New York Herald after working hours. The movements of the characters impressed all the workers, with the exception of his life-long friend and cartoonist Winsor McCay. McCay believed that he could draw the frames faster and better than his friend George. The men agreed to a bet on the spot. After the bet was made by George, who challenged McCay to do twice the amount of work in the same amount of time, McCay increased the challenge by agreeing to draw in a background as well. Later, McCay developed his first animation “Little Nemo,” based on his famous newspaper comic. He drew close to 4,000 separate drawings for a film that lasted about three minutes and was considered the longest animation to date. As promised, McCay even included background, which he reused from one drawing to the other. He won the bet and collected on it that evening (Heraldson, 1975).

McCay, Heraldson (1975) wrote, became interested in film animation even before George McManus showed his animation at the New York Herald. In fact, his son Winsor McCay, Jr. first led him in that direction. While he and his father waited to cross a busy street in New York city, McCay Jr. picked up a flip book and excitedly showed it to his father, but instead of giving the
toy to his son, McCay pocketed it for himself. He later studied the sequences photographed in the flip book. He later used India ink on translucent rice paper and timed movement to a split second with a stopwatch. He not only refined the movements but also hand tinted each frame to match the colors of the comic strip. His first film premiered in April 1911 and was the precursor for his other animated films (Solomon, 1989). His second film was more technical and was entitled *How a Mosquito Operates*, but this film in no way improved on his first attempt.

His third film, *Gertie the Dinosaur*, was his most famous animation. Gertie was done with excellent draftsmanship, which caused most to believe that he might have traced it from a photograph. This animation formed the foundation of character animation, "the art of delineating a character's personality through a unique style of movement" (Solomon, 1989, p. 17). McCay communicated Gertie's endearing and somewhat childish personality by paying close attention, for example, to the angles at which she tilted her head to listen to other characters or flicked her tail to disobey. By this time, audiences were beginning to realize that they were seeing a new art form develop—one that used drawings to communicate a story on film. Solomon wrote, "within McCay's audiences were a number of young men who were so impressed by what they saw that they decided to become animators, including Walter Lantz, Dave Fleischer, and Dick Huemer" (Solomon, 1989, p. 17).
The animation business was on its way to becoming an industry. The animation industry, like the film industry, was centered in New York. The first studio to be opened in New York was the Raoul Barre Studio in 1913. Like most other animators, Raoul Barre began by drawing comics. His professional studio later joined with Charles Bowers Studio to form the Barre-Bowers Studio, and later they became the Bud Fisher Studio. Other studios were also established by independent animators. But it was John Randolph, a Michigan-born artist and businessman, who truly industrialized the medium to that of an assembly line production. Bray employed six animators to work out of his New York apartment. He wanted it all and realized early that any innovations he devised could be patented. His first patent in 1914 was for a system of printing backgrounds on sheets of paper. Bray was attempting to devise a system of patents that would give him control over the animation process. Although Bray was the first 2-D animator to patent an animation system or device, Earl Hurd's patent of celluloid in animation is most likely the most important patent of early animation history. Hurd's patent immediately followed Bray's patent in 1914. The celluloid or cels made Bray's printed background unnecessary;
instead, the animation characters were laid over a single background. Bray was eager to control the process of animation and became partners with Hurd. Together, they formed the Bray and Hurd Processing Company in 1914 (Solomon, 1989). Bray traveled to animation studios to enforce licensing laws for anyone found using cels.

Bray eventually sold out the business, and Earl Hurd found employment at Disney in the early 1930s as a story editor and worked on the production of *Snow White and the Seven Dwarfs*. Bray's interest had shifted to training films by the end of World War I. In the 1920s, Earl pioneered a combination of live action with animation. This method was not new to the screen, but Hurd was able to innovate its use in a unique method used in his film, *Johnnie Out of the Inkwell* in 1921 (Heraldson, 1975). Although still in black and white during the time of the Inkwell, "later some cartoons and nearly all live action films were colored, ... but color films were unstable and the colors had a habit of vanishing overnight but a workable color was developed in 1929..." (Heraldson, 1975, p. 42). With the advent of color, several musicals used early Technicolor and its precursor, line color.

By the 1930s, most corporations such as Warner Brothers, Fox, and RCA made contributions in the area of sound. Most animators were experimenting with sound and color in their animation during the late 1920s. As a result of these developments, live-action pictures developed into small stories and so did the animated shorts. But these developments also symbolized the growth from what was once a hobby into an industry. Independent animators now needed to have new, highly complex machinery to compete with the new companies. Although many before had tried, the one company best known for industrializing the art of animation is Walt
Disney. "Disney is credited with introducing the concept of story-board, which allowed for more attention to story structure" (Cawley and Korkis, 1990, p. 22). Disney's abundant inventiveness put him ahead of the 2-D and animation fields for decades after his first feature film release in 1937.

The studios were beginning to develop their own characters, which were in most ways improvements on the comic strip characters of the newspapers. The most famous--indeed, internationally famous--character of the 1920s was Felix the Cat. This character was created by Otto Messmer, who discovered the idea for the character after his wife brought a stray alley cat home on a rainy night. After studying the motions and attitudes of the cat, Messmer replicated it and added a human quality to the character. Both Otto Messmer and Pat Sullivan are credited with the development of the cat caricature (Heraldson 1975, Bailey 1982). According to Bailey (1982), "Felix followed the successful strip cartoon Krazy Kat and Ignatz Mouse, a wild, intellectual fantasy cartoon created by George Herriman. Krazy Kat and Felix set the trend for an anthropomorphism in cartoon that reached its peak with Mickey Mouse in the 1930s.... His influence on Disney's earlier cartoons appears as Julius the Cat in the Alice series" (pp. 34-35).

Walt Disney began his animation career as an apprentice at the Pesman Rubin Advertising Company in Kansas, where he worked with, amongst others, Ub Iwerk. Iwerk was a man of natural talent, and at the age of eighteen the two men decided to form their own studio in 1919. The studio named Disney Iwerk Studios, was the first business venture, which ended months later. The two began work for United Film Company in the same city, where they did lettering for advertisers to be shown in the theaters. By 1922, Ub Iwerks and Walt Disney made a second attempt at starting an
independent studio in Kansas City, by the name of Laugh-o-grams, but just a year later Laugh-o-grams was bankrupt (Azarmi 1973). The films were successful, but the company's finances were shaky. Animated cartoons, however simple, were costly to make. They cost between $1,000 and $2,000 for a seven-minute short. Disney insisted on giving the customer the best product possible and began cutting back the slender profits in order to perfect the product. Depressed by his second bankrupt company and disenchanted with Kansas City as a place for business fulfillment, Walt Disney caught a train to California's Orange Grove and the hills of Hollywood in 1923. With his brother, Roy Disney, as his new partner, Disney later encouraged Iwerks to work at the studio and promised to pay him $160.00 per month. Iwerks took the offer to come to Hollywood to assist on the Alice series (a series of films that integrated live action with cel animation to tell the stories of live actress Alice in a cartoon wonderland) (Solomon, 1982). At this time, still considered a beginner in the field of animation, Walt Disney produced work that was comparable to that of the New York animation studios. Other animators began to follow his style of character design, and by the 1930s Warners and MGM were unable to rival Disney (Culhane 1988).

The success of Disney's Studio can be attributed to his staff of creative character developers, who, although inexperienced, had a natural ability to invent animation principles that were used to train student animators in the art of motion. Today, Disney's principles of animation are well established and practiced by many animators in the industry. But the contributions of Ub Iwerks were crucial to the development and establishment of these principles. Undoubtedly one of Disney's most creative and valuable animators, Ub Iwerk designed the physical characteristics of Mickey Mouse. He later redesigned
the mouse to ease animating. It had been discovered that circular forms were simpler to animate effectively; therefore, Ub's original set of mouse designs took advantage of circles—two large circles represented the trunk and the head. Other smaller circles were added to represent ears, rubber-hose arms, and large circular feet. The gift of personality was, according to Finch (1988), probably Disney's own contribution to Mickey. Walt controlled the situations in which the mouse found himself, while allowing the animators freedom to develop and work collaboratively to create his personality (Finch, 1988).

After the creation of Mickey Mouse and such shorts as Steamboat Willie (1928) and the fifty-seven Alice comedies (1923-1927), Disney had acquired the confidence and capital required to produce a full-length feature animation film. The result was the color feature Snow White and the Seven Dwarfs. Heraldson (1975) wrote, "the most honored animated film of all times, Snow White and the Seven Dwarfs, was released to the Christmas time trade in 1937" (p. 46). Snow White brought a full feature animation to the movies and combined a great number of techniques that had been used in special effects. The film marks the end of technological invention for traditional animation, although many innovators have been introduced since that time. Through the film, Disney was able to mark the passing of time in the animation effects industry, and through their contributions and inventions over the years, many others contributed directly and indirectly to Disney's success.

Beyond creating the traditional effects of the early to mid-1900s, artists and scientists began to work on different techniques for visual effects that incorporated the use of computer technology. Computer technology had been used in the production of traditional effects before this time. Such devices as
the programmed mechanical arm, used to gain precise camera moves, are evidence of the integration of computer technology in the field of traditional special effects before the mid-1900. Beyond its use in traditional special effects, the computer was being developed by computer scientists who were determined to show other uses for the computer. Later, these scientists were joined by artists who were determined to create art out of the computer's graphics application. These artists, interested in computer technology, came from three primary traditional arts backgrounds—traditional fine art, film, and video. Because of the complexity of this emerging technology, artists often collaborated with computer scientists to learn about the technology that enabled them to create their art. In chapter three, I will focus on three pioneers, one from each of the disciplines.
Computers in Visual Effects

The mid-1950's was marked by a flood of small rectangular cards, punched full of holes and imprinted with the warning: 'Do not fold, spindle, or mutilate.' These IBM cards introduced the average person to the computer and data processing. At this time a computer hardware that filled a good-size room, and contained tens of thousands of electron tubes requiring enough electricity to power a high-rise office building was the prized possession of government and research organizations (Hutchison, 1987, p. 78).

Although computer drawings appeared in 1950, it was only in the mid-1960s that the first computer animation was created, followed by the introduction of color and 3-D modeling in the 1970s (Briggs, October 1988). Halas (1990) wrote, "computer films were first made in 1951, at the Massachusetts Institute of Technology, on a computer called Whirlwind" (p. 27). During these early stages of the computer's development as an art medium, its graphics designs and programming were primarily done by computer scientists. Halas added, "such early attempts had little impact beyond scientific and technical interest, and were confined to universities. The first major step towards wider usage was made by scientists at Bell Telephone Laboratories in the U.S. in the mid-1960s" (p. 27). Several experimental artists and animators were also becoming interested in the use of these early computer graphics. Their primary goal was to develop the aesthetic and perceptual dimensions of their work. These
artists applied their prior art knowledge to the evolution of the new technology; therefore, the artists who worked with technology during this early stage did not abandon their traditional art skills; instead, they viewed computers as tools that allowed them to extented the bounds of their creativity.

The pioneers of this new art medium came from various traditional disciplines in the arts and sciences. Working independently, John Whitney began using war surplus analog computing devices for his film experiments in 1957-58. These efforts were summarized in the film *Catalogue* (1961) (Solomon, 1989, p. 292). John Whitney and his brother James were two of the pioneers who, through their prolific imagination, creative insight, and sensitivity toward relevant aesthetic issues, contributed greatly to the field of computer graphics. Other pioneers were Ken Knowlton, an explorer in the art technology interface; Stan VanDerBeek, a contemporary filmmaker interested in modern technology; and Ed Emshwiller, a video artist and filmmaker (Russett and Starr 1988). Also creating films at that time were computer artists Lillian Schwartz, Peter Foldes, and Charles Csuri.

According to Solomon (1989), John Whitney and Charles Csuri are responsible for two landmark computer films that were computed in 1967. Abstract patterns of dots that performed complicated motions were the theme of John Whitney's *Permutations*, made under a research grant from IBM. This three-year research grant was awarded to Whitney in 1966 and enabled him to embark on an extensive study of motion design using the IBM System 360, a digital computer (Russett and Starr, 1988, p. 180). At The Ohio State University, Charles Csuri made *Hummingbird*, which showed a 2-D drawing of a hummingbird breaking into linear fragments. Another computer artist
creating films at that time was Peter Foldes. Foldes was best known for his Oscar-nominated short, *Hunger* (Canada, 1974) (Solomon, 1989).

"Whitney remains one of the acknowledged leaders of the independent computer-artist animators" (Solomon, 1989, p. 293). In 1952, he wrote, produced, and directed engineering films on guided missile projects for Douglas Aircraft. Whitney, best known as an experimenter and technical innovator in the field of computer-generated films, photographed the evolution of programmed abstract patterns with the aid of either a digital or analog computer. He also designs and builds his own specialized equipment that he uses to produce his animated films. Whitney had a keen interest in animating typography and various forms of abstract designs and invented a mechanical analog computer to aid in this venture. In 1960, Whitney founded Motion Graphics Inc., a company whose primary goal was to produce graphics for motion picture and television commercial titles (Russet and Starr, 1988). In an interview, Whitney explained his methodology for advancing from music and film to the incorporation of computer graphics medium.

**John Whitney: Early Digital Films**

The three practitioners all received a formal education in the area of traditional art at a college or university. In each case, they became interested in computers as a result of their involvement outside and beyond their schools. Throughout his early years, Whitney studied both music and film informally in the United States and Paris. In fact, between his childhood experiments with the camera and his close association with Arnold Schönberg's apprentice, René Liebowitz, Whitney gathered a wealth of
knowledge on aspects of these arts. According to Russett (1988) in an interview conducted in 1970, Whitney described the formal education he received:

I had a couple of years at Pomona College, and at that time was interested in music and thought that I would possibly become a composer. Simultaneously, I was also intrigued in a technical way with film and with cameras. I had played with cameras when I was very young. After two years at Pomona, I went to Europe and spent a year in Paris. And at that time, two things happened. I was a neighbor of René Liebowitz, who's a conductor, known for his position with the French National Symphony Orchestra. But at that time he was best known as one of the outstanding pupils of Arnold Schönberg; so he was writing and teaching Schönberg's music composition techniques. It was a very new thing, he was really of the radical avant-garde in Paris at that time, 1939, before the war. (pp. 180-181)

In Paris Whitney began to rely on Liebowitz for his training in music. He recalls,

I had a very close association with him. I saw him two or three times a week over a period of several months. And so, though I had no formal training, I gained quite an extensive background in serial music composition that long ago. (p. 181)

In Paris, Whitney was introduced to 8-mm film and began experimenting with the abstract film making. His experiments in abstract film making continued beyond his time in Paris.

I was there with an 8-mm camera and intrigued with the idea of using it creatively. I had never heard of this kind of a film. I thought I had invented the concept of an abstract film. I began playing around with making abstract films. I thought of them as a kind of visual musical experience. It was only when I returned to California in the following years that I learned about Oskar
Fischinger and the avant-garde filmmakers of the early twenties in Paris. (p. 181)

By the time Whitney returned to California, he was excited by the idea of making films that used traditional art tools such as the airbrush and techniques such as masking and stenciling for the basis of the film's abstraction. With his brother's assistance, Whitney began the process of using geometric shapes and meticulous layout designs for creating his art.

I met Man Ray in Pasadena after I came back, though he was there in Paris when I was there. So really, when I came back, then I began seriously to experiment with little abstract designs with an 8-mm camera, and by about 1940, my brother and I were working together. Those are still, to my way of thinking, very interesting little films. They're hard to show, they're silent. I was working on file cards and animating with an air brush, cutouts, stencils. The first film consisted of a simple circle and a rectangle. The two were juxtaposed over each other in a certain way. I cut a stencil that represented the circle, and another stencil that represented the rectangle, overlapping. And then I made a stencil of that clean circle, and a stencil of the rectangle. And then I made a stencil of the negative shape created by the circle and the rectangle and so on. (p. 181)

Like most artists who are trained to achieve a particular art or master a particular tool—whether it is a traditional tool or contemporary computer software—Whitney took great pride in the process used to achieve the final results. He understood the steps necessary to achieve a desired outcome. Whitney explained that the art of creating his abstractions comprised ten steps:

I fill out the shape. Then there was a possibility of using the negative, so I would put down the negative stencil of that shape and I would blow just a little bit around one corner and then air brush after around, until it completely enveloped that shape. So I had the shape in a positive form and a negative form, and the
motion generated by these cards was quite a lively motion with a front edge that would fade out characteristic of air brush. So, just from that simple technique, I had a whole library of all these different air brush sequences. They added up to about one hundred fifty to two hundred cards. (p. 181)

Soon, Whitney began building his own equipment for the purpose of creating his films. He was able to expand on the optical printing techniques that were being used by film makers for the creation of special-effects films. But throughout his artwork, he paid close attention to details and documentation of the process.

And at that point then, I conceived of the idea of using the optical printer and having made these cards, I photographed the cards onto Dram black and white film. I built an 8-mm optical printer, so that I could re-photograph those sequences according to a carefully worked out script, introducing color filters into the light source and photographing the sequences onto color film. (p. 183)

Very early in Whitney's career in the arts, he developed and redesigned the visual effects tools. As Whitney advanced from abstract air brush film to computer graphics abstract films, he continued to alter his tools. "I developed the technique that I am still using here with the optical printer now, with the computer-graphic material" (p. 183).

Whitney explained the various components of the optical printing device that allowed him the expressive capabilities to create his films.

Here's a light source, then a mirror goes here, and the filters rest on top of this condenser lens. Up above I have a lens tube extension and bellows arrangement, and the lens is normally at one-to-one; the field travels east and west and it rotates on its own dead center and another rotational point. It rotates down
here, as well as at this level, so I can locate a rotational center that's off the center of the field. (p. 183)

Whitney continued to develop and improve on the optical printer to allow himself the freedom to create his art with fewer limitations from the tool. And in his explanation of an improved version of the optical printer, Whitney concluded,

the first 8-mm optical printer had none of these complications. It was straight one-to-one, and I had no power to re-frame the image. But completion of the 8-mm films was one of the peculiarly rewarding experiences in making film, because despite the limitations, I had control of all the possible permutations of that original material. (p. 183)

Whitney successfully created various effects through the use of the 8-mm optical printer and later made a 16-mm optical printer. He experimented with superimposing images within the camera. He explained, "I'd back the film up in the camera and then run through a second time with a second color, some other element, working in a different way." The results of his work were that "the film strips could be threaded into the projector in such a way that you could mirror them, turn them over, or you could invert them. So, you had four different positions for each of the ten shapes." Satisfied by the results of the superimposition as a means of creating visual effects, Whitney created a 16-mm optical printer.

John Whitney often worked with his brother James. Together, they began working on films. The two also had a keen interest in sound.

My brother and I felt very strongly that we wanted to be able to compose music as well as the picture. I invented a pendulum machine for making a variable-area sound track; and with that
my brother and I together made the five abstract film exercises, through about 1944. (p. 183)

Funded by the Guggenheim Fellowship over a two-year period, Whitney continued to develop more creative and different ways to create with the new technology. He worked on a project called *The Five Abstraction Film Exercise* up until the late 1940s. During this time, Whitney became increasingly interested in real-time animation techniques as opposed to cel animation. He used the superimposing techniques and shot the project on film. His paper-cuts' real-time motion was spontaneous because he animated them to the classic jazz at the same speed at which they were replayed to the viewer. Often he completed a three-minute film in an afternoon. Whitney explained his reasons for changing media:

I could manipulate paper cutouts to music. I was working with jazz--music that had no pretensions or none of the complexity and subtlety of structure of traditional western music. I was finding ways of generating a visual motion by ways that avoided the tedium and the restrictions that you get by any cel animation or any conventional techniques. (p. 183)

Whitney continued to describe the details of the innovative film techniques he used at that time to create his art. The real-time performances allowed him to work interactively with the film and to choose the colors, as he explained:

I was manipulating cutouts and working with fluids, very much as they are used in the light shows. I had an oil bath on a level tray with the light below. I put dye into the oil until it was deep red, and then used red-blind film in the camera. With my finger or with a stylus, I could draw on this thin bath of oil; and that would push the oil away and the light would shine through so I could draw linear sequences very freely. (p. 183)
Generating these experimental films through the sole use of the camera and without the help of the optical printer, Whitney came up with prolific ways of creating his art. "I was experimenting a lot with contact printing ideas; I would combine positives and negatives. I would do one sequence and then print it in one color and a different sequence with entirely different kinds of action and print it with a second color and possibly a third color" (p. 183). He had created such films as *Dizzy Gillespie Hothouse* through the use of this technique. Confident of his new art technique, Whitney wrote a proposal to the University of California, Los Angeles, to work with light shows:

I made a proposal in the early fifties at UCLA that we set up an arrangement with six or eight video cameras and six or eight performers using these various manipulation techniques, and the cameras were to be mixed electronically, then you'd perform a real-time graphic experience as an ensemble. (p. 184)

Although Whitney had proposed a unique idea to the university, the project was turned down. Whitney explained the reasons they denied his proposal, in this statement,

The communications part of UCLA, just as it is at any other university, is pretty much oriented toward either educational television or training for the television profession, training directors and so on, and they stay pretty close to the standards. They follow instead of lead. (p. 184)

By the late 9150s, after his proposal was denied, Whitney's concept of motion picture had changed. He began to believe that "what the motion
picture camera sees to record is the thing that's important," more than the whole medium of motion pictures. As a result, he began to focus his energy in a new direction and concentrated more on mechanical design machines. His willingness to pay attention to mechanical design machines, Whitney said, "coincided with a growing skill that I was developing with the technology of the surplus junk yard" (p. 184):

And so, by 1957 or 1958 I was on to these analog computing devices that were used as anti-aircraft gun directors, and aware of the fact that I was able, for pennies, to buy mechanical equipment that's unbelievably costly, and involved fantastic skill in engineering design and production. And I began to see these things as containing within them, somehow, the possibilities for a very flexible design tool, which should be the thing of my interest, instead of trying to improve cameras or develop other camera techniques. And that led me into developing my animation machine. (p. 184)

Whitney worked on the mechanical-optical machine between 1958 and 1966. He used the machine to generate funds, as the machine was in demand. Whitney said, "it became quite successful. I did a number of commercials and feature film titles and titles for television shows, using that equipment" (p.184). But in addition to being used in various commercial films, a similar machine, engineered with Whitney's aid, was used for his brother's film, *Lapis*. Whitney explained why this became James Whitney's final film.

Jim made that, my brother. He continued to make films, he was not so much hardware-minded as I was, and he worked patiently by himself. He was having such frustrations with his machine. It was getting at him so strongly that he finally decided that he was not going to go on and work with film at all. He became interested in ceramics. And so *Lapis* sat around in cans for two or three years. Jordan Belson persuaded him to put it together in its present form. He's not been making films since then. (p. 187)
John made the transition from the machine for practical reasons. He realized that what he "was doing mechanically could be done on the cathode ray tube computer terminal" (p. 184). In 1966, Whitney submitted a proposal to IBM. Russett wrote,

IBM awarded him a three-year research grant which enabled him to embark on an extensive study of motion design using the IBM System 3600, a digital computer. The first artistically cohesive film that he produced with this system was Permutations, a beautifully composed abstract animated work in which he employs complicated forms of visual counterpoint. (p. 180)
When Whitney became a consultant for IBM, his home device, called the cam-machine, was available for use by his wife, Jackie, and oldest son, John. As an apprentice to his father, Whitney's son continued to work on improving the machine. Whitney said,

John has been making very significant refinements of that machine this year, changing it over, adding another level that was beyond me, working with servo systems, the most sophisticated of electrical engineering technology... they are motors that run according to computerized information that you give them. They'll run fast or slow and under absolute control. (p. 187)

Whitney was intrigued by his son's contribution. His son's work on the cam-machine provided the possibility that the machine was "going to become a functioning optical system under computer control" (p. 187).

Throughout his development, Whitney concentrated on the hardware and allowed it to dominate his art. Whitney's contributions to film were a direct result of his ability to create his art from used machines. Before he became a consultant at IBM, he worked with various old equipment. But as he conducted his research at IBM, Whitney explained,
I haven't had to be innovating or messing around with inventing new technical problems. Nor have I with the program that I've had. The program that I've had has had a few refinements made during the time I've used it, but essentially it's the same one that I started out with. And so, I've really had three years of the most rewarding creative study. (p. 187)

Among the valuable knowledge Whitney gained at IBM were insights "into structural solutions to learn how to make a graphic experience with some impact and done with some feeling and not just as a mechanism" (p. 187). Whitney used this knowledge in developing the film *Permutations*. He worked to increase the quality of aesthetics in his work. In response to the content of the work in the area of digital effects during this time, Whitney said, "film is starving for want of much more creative imagination in the area of formal aesthetic creativity" (p. 187).

Charles Csuri: *An Artist's Approach to Early Computer Art*

Born on July 4, 1922, in the small coal-mining community of Grant Town, West Virginia, Csuri went to high school in Cleveland ("Chuck," n.d.). His family had moved to Cleveland after his father, a West Virginia coal miner, was injured in the mines. The idea of an artistic career never entered Csuri's mind during his high school days. He planned to become an industrial engineer and majored in mechanical drawing and machine shop work with this end in view (Jacobs and Roberts, March 1947). But young Csuri enjoyed drawing and took drawing lessons at the Cleveland Art Museum.

After he arrived at The Ohio State University in 1940, his original plans for industrial engineering were soon pushed into the background. One
day he idly made a sketch of a friend and was gratified to find the likeness very good. Following up this new-found talent, he enrolled in a drawing course, during which he received so much encouragement he soon decided to change his major (Jacobs and Roberts, March 1947). The artist, who in his earlier days copied Rembrandt as a form of practice, now found himself digging deeper and becoming aware of different mythologies.

After earning a master's degree in fine arts Csuri, who had taught sculpture as a graduate student, joined The Ohio State University faculty and settled into teaching drawing and painting. For about ten years, he worked in various modes--some expressionistic, others surrealistic, still others conceptual--and in different media, even combining painting and sculpture (Hall, April 1990). Although his work with palette and brush was readily accepted, so accepted that he held one-man shows in New York City, in 1964 Csuri decided to turn the computer into an artist's tool (Trachtman, February 1995). By the mid-1960s, Csuri became increasingly fascinated by the applications of the computer to art. Studying computer programming in his spare time, he began using mathematical concepts in his art ("Chuck," n.d.). The computer confronting him at the time was a huge mainframe that required data entry on punched cards. Csuri had to become a programmer in order to communicate with the computer and enrolled in a computer-programming course (Trachtman, February 1995).

As a professor in the School of Arts, Csuri pondered the results of a visual form if mathematical systems were used to examine the various aspects of his sketches. He teamed up with James Shaffer, an engineer and programmer at the University's Computer Center, to find the answer that lay in the heart of the giant computers. Both men were interested in a
mathematical approach to art—especially those mathematical variations that resulted in forms impossible to visualize ahead of time. The computer enabled them to exploit the unique capabilities of the computer to process the visual data and to approach problems of artistic content in a new way. Csuri admitted that many of the drawings the computer produced in the early days were not difficult to copy, but it was the concept more than the drawings that was important. For example, Csuri made a simple drawing of a man's face. A grid of X and Y lines was then set over the face, and the points of each line were numbered. Those numbers then went onto computer cards.

Csuri's willingness to embrace this new and uncertain art form angered members of his traditional Fine Arts Department. Csuri was in discord with the department, and the university moved him from the Department of Fine Arts to the more tolerant Department of Art Education, with a joint appointment as professor of computer science.

The two men worked on the process for about nine months and created more than 300 drawings ("Artists," April 1967). In 1967, the art and programming efforts resulted in the Sine Curve Man, a face drawn in line art and distorted with mathematical sine curve equation. In another piece, Csuri produced distortions of faces, bodies, and limbs, all capitalizing on the computer's knack for varying themes more rapidly and precisely than an artist. In another Csuri drawing, Hummingbird, the computer generated 14,000 variations of one form. The animated film picked apart the drawn bird, scattered it around the screen, and then put it back together. The Museum of Modern Art in New York City bought the film in 1968 for its permanent collection ("Chuck," n.d.). In that same year, Csuri changed his focus as a faculty member at the university. After seeing what the computer
could do and the great deal of potential it had in the area of visual arts, Csuri focused more on the area of computer graphics and animation.

The National Science Foundation has sponsored his work in the field for 25 years. During the years, Csuri obtained $7 million in federal research grants to his research group, and occasional small projects were sponsored by private industry. In project assignments sponsored by the U.S. Naval Equipment Training Center, Csuri's research group (Computer Graphics Research Group) (CGRG) developed realistic looking buildings and trees on the computer. The detailed scenes were used in flight simulators to help train pilots. The relatively simple graphics provided pilots with more visual cues than had been available to them before.

As the computer graphics industry developed, Csuri altered his approach. He always viewed the computer as the latest in the long series of technical breakthroughs and admitted that he exploited this new medium for its expressive potential. In the computer's 3-D environment, he used this tool to mimic painting— the look of heavy thick paint or impasto, in which the brush marks trail off. Csuri's traditional art education allowed him to emphasize the dichotomy between two and three dimensions in his work. His background as both a painter and sculptor gave him the practical knowledge of visualizing 2-D images in the round (Hall, April 1990). But his experimentalist side is dominant and his style constantly evolves. Throughout his development, computers have enabled Csuri to sculpt images in three dimensions, view them from any angle, set them in motion, and alter them in ways that often blur the distinctions between special effects and art.
The Computer Graphics Research Group brought together graduate students with interests in programming, film-making, and visual arts. The programmers and artists of the research group developed proprietary software and worked with systems such as the Anima II. This computer system was designed to produce 3-D, real-time, realistic key-frame animation. The group used this program for various purposes. The group used computer graphics in projects that ranged from helping deaf children understand language arts to showing college students the effects of a near collision of galaxies in space. The group also developed the computer program that was later used in the climax to the Star Wars movie--the trench scene on the Death Star. In July 1986, Csuri established the Advanced Computing Center for the Arts and Design (ACCAD) at The Ohio State University (OSU), an expansion of the earlier research group. Built on OSU's history of collaboration between artist and scientist, ACCAD is a nucleus for students with backgrounds in the arts, mathematics, computer information science, and industrial design.

In 1982, Csuri helped found Cranston-Csuri Productions, a private computer graphics and animation company that specialized in the field of visual effects for television commercials. His company produced animation for ABC and CBS, NBC Sports, CBS Superbowl XVIII, and commercials for TRW, Sony, and General Electric. Csuri also had a keen interest, very early, in the development of computer imagery that could be used for scientific visualization.
Gardner: How did you become interested in computers at The Ohio State University?

Csuri: In approximately 1955 I had a very good friend, an industrial engineer who introduced me to computers. At that time, I was painting and exhibiting in New York. And we were close personal friends. Over a period of ten years we had a dialog about computers. What is a computer? What is a program? Algorithm? All of those basic notions. At the time, neither one of us realized that it would be possible to have a graphics output device and attach it to a computer, and we began to speculate. This is before dinner, drinking martinis in those days. We thought of the computer as a philosophy...the computer as an intelligent machine, as an art critic. And then played all sorts of absurd games about what you could do with the computer intellectually. Then in 1964, this is a dialog we've had over a period of about nine years, in 1964 I saw in the OSU Lantern a picture made by a computer at OSU. And what it was is a very simple picture, it was a photograph of a woman's face, and I thought, "oh my God what does this mean?" So I immediately went to the department and discovered what they had done was digitized the photography into contour regions and then they had attached a device called a flex-o-writer. It is a typewriter that could print in nine grade levels, and wrote a program that would try to reproduce the scan lines that were made and had a picture. And when I saw that, I immediately saw the implications because I had this background, this, let's say, conceptual framework about computers, and I knew that I had to
get involved in this. I knew . . . almost immediately signed up for computer programming because I knew where this was going to go.

Gardner: How did this increase in computers lead to your interest in computer graphics?

Csuri: [When] I got involved, the only graphics output device they had was the drum plotter, which was a pen that would draw pictures. In those days I was making line drawings and doing transformations on line drawings, faces, birds, things of that nature. And as time went on, I became more aware of how technology was advancing and learned about what Ivan Sutherland was doing at Utah. I realized that it was just a matter of time before I would be dealing with grade levels with color and things of that nature.

In this new medium, Csuri had little in the way of others' examples to learn from in the area of computer art. Csuri became a pioneer whose main concern was to create art with the computer. At this time, the field comprised mainly computer scientists and very few computer artists. Many limitations faced Csuri as an artist in a science field. For example, his final output was limited to the primitive output devices that served the computer scientist projects but were merely sufficient for producing art. The Hummingbird was one of the projects that was produced through the use of these earlier output devices. This film and others that were created around that time were limited to a basic line drawing on paper. Leeman (1985) wrote, "animation was done by filming each plotted still frame in sequence, processing the film and projecting the film to determine if the motion was
what the artist desired" (pp. 4-5). Leeman added there were also few vector displays available that were capable of producing real time animation, and most of these displays were not accessible to artists.

Over the years, the systems were developed more with the artist in mind. This kind of development was timely, and only over the last ten years have the most rapid changes occurred; however, some methods used to develop early output devices still are of great use in creating output devices today. Halas (1990) wrote, "the first commonly used output device was a pen plotter using paper or film. This method is still essential where working drawings are required or where cels are to be colored in at a later date" (p. 29).

Gardner: I read that you collaborated with James Shaffer on the Hummingbird and that was a success. Tell me a little bit more about the Hummingbird.
Csuri: Well, the Hummingbird was an idea I had about making a film and I simply made a drawing—a line drawing of a hummingbird, digitized it and that became a database. And then I had a dialog with Jim Shaffer, I did some of the programming, he did some of the programming. Everything was extremely difficult, unbelievably difficult in those days. And... put together a film where we were able to apply transformation to the drawing where the hummingbird would move. It would be translated or move in space, change shape of the flight method, things of that nature, and they really... compared with today's standards are very simple things that we did. We made this film, ten minutes long, much too long, but we didn't know any better. And... the film was entered in a competition and won a major international prize. I'm sure in part
because of the novelty of what it represented. And then the Museum of Modern Art bought a copy of it.

Csuri's limited knowledge of computer programs meant that he collaborated with computer scientists on his early projects. Because of similar limitations, the medium remained, for a long time, uninviting to artists. They had to learn an entirely new language in order to create an image or to communicate with scientists on collaborations. In addition, the boundaries separating the science world meant that artists had to have access to the large costly machines that were available at only a few large universities and corporations. Luckily Csuri had both, access to computers at The Ohio State University, and, before long, he had taken programming courses and made contacts in the science community. Csuri's computer refresher courses enabled him to explain the complicated transformation that was ahead of him.

His refresher courses were additional to the math and science. As an undergraduate student at The Ohio State University Csuri majored in art but, for a great part of the program, he took classes in industrial design. His science background included courses in college algebra, trigonometry, analytic geometry, and calculus, in addition to physics, chemistry, and engineering drawing. His background preceding his interest in computer graphics was much deeper than the math and art classes he had received at the college level. In the early 1960s, Csuri began independent studies in the area of neuro-physiology with emphasis on the brain (DeMaria, 1991). To investigate computer graphics, he took six months off from his traditional art routine to take classes that enabled him to program computers. Csuri began
collaborating with the members of the computer science community, but it was Shaffer who developed programs to create computer functions in trigonometry, coordinate systems, conformal mapping, n-dimensional geometry, and randomness.

His collaboration with Shaffer was essential for visualizing his mathematical approach to art. The two discussed this approach and decided upon the types of transformations to be used in the drawing. According to an anonymous writer,

They might, for example, tell the computer to use 75 percent of X and/or Y lines on the grid; then try 50 percent and finally 25 percent of the original lines to recreate the drawing. Shaffer then writes a program for the computer. That program tells the computer what mathematical changes are necessary for the desired transformation of the original drawing. The numbers that the computer follows are the numbers that Shaffer has programmed into it. (Artists..., April, 1967 p. 4)

The use of the computer and mathematics as tools in art was one of the few ways of generating a transformation of an image on the computer at that time. The line drawing showed the animation Hummingbird as it transformed from a normal line drawing to an obscure form of the image.
Csuri recalled that he began to work in two dimensions because it was easier and the tools (hardware and software) that were available to him at that time seemed to work better in two dimensions. Csuri's development was limited as he realized that in order to do anything more complex he needed far greater computational power than he had access to at that time. However, starting in two dimensions enabled him to experiment at a more basic level. After Csuri did several projects in two dimensions, a head administrator at the university provided the artist with his own Digital Equipment Computer and a full-time staff person. Further experiments then led to 3-D graphics that used raster displays capable of supporting a CAD/CAM system and animation through the use of mathematics and logic to manipulate their imagery. This development was a direct result of a collaborative work between artists and scientists to develop a custom program capable of fulfilling the artist's needs. (personal communication, Csuri, 1995; Leeman 1985)

Gardner: You mentioned Ivan Sutherland, was he one of the pioneers working at this time?
Csuri: Oh yes, very much so. Yeah, he was part of a research group at the University of Utah that developed software and they also trained most of the graduates who are today principal people at Pixar, ILM, you know, places like that. Ed Catmull [and others] was very instrumental in developing the technology. He was sponsored by the government, by defense projects, in trying to put together the technology for a flight simulator, head mount display and do some things in 3-D, stuff like that.

Gardner: Sounds similar to some of John Whitney's projects. Are you familiar with him?
Csuri: Oh yeah, I know John.

In the early days of computer graphics, MIT led the way in the development of computer graphics. Csuri may have learned from the computer graphics pioneers at MIT who wrote and published their findings in various publications. One of the early contributors at MIT was Ivan Sutherland, a computer scientist.

The single event that did more to promote interactive computer graphics as an important new field was the publication of a 1962 thesis by Ivan E. Sutherland, who had just received his Ph.D. from MIT. This thesis, entitled Sketchpad: A Man-Machine Graphical Communication System, proved to many readers that interactive computer graphics was a viable, useful, and exciting field of research. (Leeman, 1985, p. 3)

According to Solomon, "this Ph.D thesis created the first truly interactive graphics, enabling an artist to draw simple geometric forms" (p. 292). Such research benefited the industry as a whole, and by 1970 artists were using these interactive paint systems.
Gardner: Did these people influence your work?

Csuri: No not really because I had a different orientation. I was...my background was art...was painting and John Whitney was a film maker, Ivan is a scientist. And...so my whole viewpoint was very different than these people because of my background.

As a computer scientist, Sutherland may have influenced Csuri's direction more than the content of Csuri's art work. The two men entered the field from different backgrounds but still learned from each other. Most of the work was done for the sole purpose of experimenting; in fact, it was only in 1965 that the first computer art exhibition was held. The computer artists, scientists, and film makers interested in this art now had an opportunity to view the experimental results of the pioneers. The pioneers had the opportunity to learn from each other's results. Other shows were held in New York museums, namely, Some More Beginnings at the Brooklyn Museum, 1968, and Software at the Jewish Museum, 1970 (Leeman, 1985). Shows were also held at universities; in fact, "one of the first computer graphics art shows to incorporate...interactive vector displays was organized by Professor Charles Csuri through the College of the Arts at The Ohio State University in 1970. This was the beginning of real involvement by artists" (Leeman, 1985, p. 5).

Gardner: What was the goal? You set up the computer graphics research with The Ohio State University. What was the initial goal of this research?
Csuri: Well, I think it was again, doing basic research I felt that it's important to have an identity. It was not enough to simply to... say well we've got computer science students and some art students working together. I observed there were groups that became well known and they took on a kind of identity which had a name and it became known for certain kinds of research, and so that was my motivation to do that and by getting recognition it gave us more credibility and made it easier for us to get grants.

Gardner: Who were some of the people working at that time? Were they scientists mainly, or artists, or Art Educators?

Csuri: No they weren't Art Educators. It was mainly students in Computer Science, doctoral students in Computer Science. There were very few art students involved. The Arts Department simply was not interested. In fact, if I had not been a full professor with tenure I would have been in real trouble. They simply saw no use to it and felt it had nothing to do with art. And most of the people were from Computer Science. There were a few people that were in some of the other Engineering Sciences that I interacted with, and gradually over time a few graduate students in Art got interested and then when I moved from the Art Department, I transferred to Art Education, then we started attracting graduate students who became interested in degrees in computer graphics in Art and they began doing computer animation.

The establishment of CGRG meant that Csuri worked mainly with computer science students who were interested in the arts or computer
simulation. Later, more students from the Art Education Department joined the research group. The fact that the Department of Art created an area of emphasis for students interested in computer graphics was a sure sign that the research group was gaining more attention on the university campus. The CGRG consisted of graduate students at the master's and doctoral level; there was no mention of undergraduate students being involved in any way. The difficulty of the software at that time may have been the reason they were not invited to join the CGRG in the early days.

Beyond the reasons mentioned by Csuri, an additional goal of CGRG may have been to create a group of students who were supportive of each other. The newness of this technology meant that a supportive environment was essential for the success of the group. Scientists and artists were encouraged to work together and were given few incentives to compete against each other. For the research group to continue to succeed, they had to develop software and programs and work together to create computer simulations. This environment encouraged them to share their ideas and work together to improve the quality of work as the CGRG. The focus became a group effort rather than an individual's effort.

Gardner: You started Cranston-Csuri productions as well. How did that relate to the educational setting?
Csuri: It had nothing to do with it. It was a separate entity outside of the university. What I did was I found an entrepreneur, a guy who had lots of money who was very interested in what I was doing, and we decided to put together a company to do commercial production. And then I was able to attract former graduate students as employees, and ... so that
built up the staff, and then we had some graduate students who worked part time—but it was separate. The university was interested and supportive. They gave us space in one of the off-campus buildings, which we paid rent, okay. But . . . that was it, I mean it was just a separate entity.

Gardner: I read that you worked on Star Wars in 1972. With a location in Columbus, Ohio, how was Cranston-Csuri Productions able to attract such a contract?

Csuri: No, no, I didn't attract such a contract. The sort of thing that happened is that a person like Tom DeFonta, who graduated, was able to do things for different film companies. This has been the case all along when we say okay we have a connection to Lawnmower Man it is because one of our graduate students worked on it. So we did not attract those contracts personally. I think Cranston-Csuri...I'd have to go back and look at it. They may have done something for that film. I don't remember. But they certainly did a great deal of commercial production.

Gardner: In keeping with the Star Wars question, you said you didn't really work on it personally, but what do you believe caused computer artists to begin to create computer effects for feature films during this time period?

Csuri: Well, that's hard to answer. I think it has to be some combination of people in the film industry who gradually became aware of the technology and its potential and began to see its application for TV commercials. And I think once they began to see that, it became more a
matter of really persuading the filmmakers to commit resources and to hire artists to do it. Artists, let's say, who had experience in commercial production where actually we are talking about computer animators, we're not just talking about the average artist. I think that is sort of the connection. That's the way I see it.

One of the leading production houses in the area of digital effects during the 1980s was Cranston-Csuri Productions. The company that carried Csuri's name operated from a building at the OSU's west campus. Co-founded by Csuri, the company may have had one goal, to create computer-generated images for television commercials and feature films, a goal that ultimately helped to promote computer graphics as a medium for communication. During those early days, and even today, most of the highly successful companies operated from the east and west coasts of the nation. Other digital effects companies such as Robert Abel Associates and Industrial Light and Magic competed for a small market. At the company Csuri continued what he had started at the university.

In 1984, Csuri reported that the company's goal was to reduce television commercials from 75 percent of the business to 25 percent. The company had plans to move more toward the areas of medical, education, and simulation training. The firm had created 3-D images of major body organs that were showcased in *The Living Body*, a 24-part educational television series produced by Goldcrest Films in England. Csuri explained that one of the company's future plans was to "put together a videodisk for teaching medical students about anatomy. Then, with our data base, you'd
have new teaching aids to teach high schools and elementary children about anatomy..." (Lore, November 1984, p. X).

In reality, the effects artists at Cranston-Csuri were extensions of the CGRG. CGRG involvement in the production of television effects, 3-D games, and medical simulations began long before Cranston-Csuri was founded. Circa 1980, an anonymous reporter from the Columbus Dispatch magazine reported that "Csuri's research group also developed the computer animation for WBNS-TV (Channel 10) promotional logos and the technology for computer-animated sequences in the movie Star Wars. The efforts of the CGRG to research and develop new computational models of motion in the early 1970s helped produce the software needed to animate the battle scenes in Star Wars (Lore, January 1987). Even as early as 1977, Csuri's research group was involved in the production of 3-D video games for the Warner (two-way) cable television experiment and educational materials for severely handicapped children. After graduating, the effects artists at the CGRG continued to create animation at CCP and used the tools they had mastered at OSU.

Cranston-Csuri gained a reputation for high-quality graphics, making OSU a prestigious national center for graduate study in the field of computer graphics. Although Csuri operated the firm as an entity separate from the university, he hired a large number of students from the CGRG to work at the firm. And as his reputation grew, so did the number of applicants to the CGRG. In 1980, the CGRG consisted of six professors and 18 graduate students. In the mid-1980s the CGRG received more than 500 applications each year from individuals who learned of CGRG through television productions or through the various publications of Art Forum, Studio
International, Art in America, Newsweek, Time, and numerous books and magazines that carried articles on Csuri and computers in the arts.

Gardner: You mentioned microcomputers, the accessibility of computers during the time when you started. How do you think the advent of microcomputers will affect the advancement of computer graphics? What has accessibility done to computer graphics?

Csuri: Well, I think what is happening is that computer graphics is gradually being integrated into the culture at every level where, because of the combination of microcomputer technology and its power, and because of commercial software, more and more people have access to being able to create visual techniques and to use the technology in such a wide variety of ways for page layout, for newspaper, for magazine layout, or simple graphics, let's say, for a newsletter. Because the software and technology are becoming easier to use, more people are simply using them. It is almost going to become like the telephone in terms of communication.

Gardner: What are we seeing in the way of education and training for cultural sensitivity?

Csuri: I think that . . . I think it's good that people have access to technology. On the other hand, without speaking primarily to the relationship with the Fine Arts, without some sort of education and training that helps one acquire cultural sensibility, we're going to see some very very bad art. That is what we are seeing now. It is just that people who can't make many distinctions between art and technology
and special effects mistake these special effects for Fine Arts. This is where we need the education, and that is very difficult. At the same time, technology itself becomes so seductive that it is very easy even for people who are experienced in art to be seduced by it, to be misled and mistake the special effects for the art. Do you understand what I'm saying? The students around here get so excited, "Wow, I can do this and I can do that. Look at this, I can do this sort of complicated picture"...yeah...and that's nice. All right, big deal, where is the art?

In the early 1980s, computers were expensive, but they were soon replaced by microcomputers in the mid-1980s. Although microcomputers existed at least a decade ago, it was in the mid-1980s that they were widely marketed as a graphic tool, accessible to artists. In an article in the January 1991 issue of the IEEE Computer Graphics & Applications, Csuri wrote, "the early 1980s still found high-end computer graphics exceedingly expensive for artists, with multiple refrigerator-size cabinets for computers costing more than $100,000 and film recorders at $100,000-$250,000" (p. 30). This situation meant that the technology was affordable only to computer effects companies "charging $3,000 per second for commercials and advanced university computer graphics centers" (p. 3).

Technology became more accessible to artists and animators through microcomputers. In the early days of microcomputers not many universities had educational programs in computer graphics. However, the technology was being used by animators and artists who could afford to purchase the available, but expensive, graphic software and computer hardware and had
learned the jargon through the various computer conferences and publications. Csuri (January 1991) wrote that conferences such as SIGGRAPH and NCGA played a very important role, providing opportunities for the art community to learn about computer graphics with panels and courses. The film and video shows as well as the art exhibitions demonstrated the potential for the fine arts. Various publications, such as IEEE Computer Graphics and Applications, Computer Pictures, Computer Graphics World, and Leonardo, continue to provide a forum illustrating advanced methods and concepts applicable to the arts. (p. 3)

Gardner: At one time you were quoted as saying, "One of my short-term goals is to make pictures that when you look at them you won't think of the computer." What motivated you to set this goal for yourself?
Csuri: Well, I think in the final analysis I guess it has to do with my view that I want people to respond to the content, to be able to communicate feelings that I may have about something. The primary thing is to really communicate to people something that has to do with humanity and incidentally is done by the computer. I think that I still believe that we've got to find a way to transcend the technology to the point where we don't think about the computer when we look at something. So big deal everybody is working with computers, where's the art? Where's the passion? Where's the humanity? Where is the complexity of one level or another.

When exhibiting their computer art, artists often find that viewers attend to the artists' challenge with the medium more than the messages that they may have attempted to convey. Attention is paid to the efforts by the
artists to challenge the medium to produce artworks that are aesthetically pleasing to look at. They often approach works of computer art with great ignorance about the process or the medium. As a former painter, Csuri knows that in order for this new art form to be respected, it, first must be rich in content. The artists must convey messages through the pieces. The medium should not dominate; rather, it should serve as a medium through which ideas can be communicated. Csuri's statement does not suggest that computer art should be more realistic; rather, he hopes that people will look at the images and beyond into the ideas. As an artist, Csuri is interested in going beyond the normal mechanical and sterile look associated with computer art. He tries to add a human element to his work, a recognition of the relationship that exists between the artist and the technique. At times, he may even use textures and colors to give the deliberate feeling that the work is incomplete. Presently he works with 3-D computer art to explore the materialistic quality of the art. Csuri explained,

where it looks like it could...a part of a rock that has been pounded on that's deliberate, I want that...like it's some artifact from another culture...from another time. And I deliberately poke holes in things. I have a technique for making things look like they are fragmented... (personal communication, Csuri, 1995)

Gardner: So you just wanted to use the computer basically as a tool?
Csuri: Yes, it is a means to an end. I think that a couple of observations that I've made is that the computer medium is very different in many respects than traditional media, in that when I was a painter working in oil paint, I went through a stage where I developed the capability to control
the pigments. I understood what it meant to do underpainting, overpainting, and...whatever, and gained enough confidence that I only focused on the idea whatever it is I wanted to stress. With the computer...there is no final solution. The technology keeps changing, the software keeps changing so that you are put into positions where you need to learn something new all the time and there is this constant conflict psychologically between the technology and that dimension that you think of as art. Most of the time I am fighting the technology and I don't see myself reaching the point where, okay, I've learned it, I know it well enough and I just concentrate on the art. It's not that easy because there are always new programs that have new capabilities. There is a new technique that introduces a new way to communicate your idea and so you've got to learn something new. So there is constant learning that needs to go on. That's hard to accept and it is hard to become acclimated to that kind of thing.

This statement by Csuri suggests the absolute importance and need for constant learning by independent computer artists. The ability to be self-motivated and self-taught allows artists to keep abreast of the cutting-edge technology. The struggle Csuri has with the technology is also one that is faced by computer effects companies. Both independent computer artists and the companies must make conscious efforts to learn new trends in the technology to remain competitive, as they are constantly in search of a better, more expressive method for communicating their ideas—one that takes advantage of the qualities and maximizes the capabilities of a particular software or program.
The other thing is that computer art will tend to be an elitist activity mainly because of the resources required. It's not enough to have a PC. You've got to have a film recorder, you've got to have access to software. You've got to go to workshops to learn something new and it costs a lot of money to reproduce cebacromes or let's say light boxes or whatever, and so it is not going to be an ordinary kind of situation where okay I'll spend $50 for paint and canvas and I'm in business. So I think that the combination of the requirements of resources and the expense of it will make it a smaller community, so to speak. I'm not saying that people on PCs will not do art but I think the more serious art is likely to be done by people who have this combination of environment and resources working together, maybe collaborations, technical support persons working with the artist and the way you have projects that involve a team of people, that kind of thing. It is a very complicated thing.

Even today the cost of creating computer art carries an exorbitant cost to artists. Although there are many inexpensive microcomputers on which independent artists can create art, the artists may need to seek the help of other specialists to produce the final art output. The process often requires collaboration of specialists. To have access to a group of specialists, the independent artists may form their own small communities of specialists with access to the necessary equipment or become insiders at companies or universities that have the resources, both physical and human, for creating the art. Csuri continued:
I mean, the problem is, we don't have many role models. There aren't many people out there who have really done it in a significant way. Yes, you have a lot of people dabbling in it and doing things, but it's unfortunately going to take time before these significant artists are identified and . . . it is going to be very hard to really come up with criteria to determine what is good art because most people are going to mistake the gimmick or the special effects in and of itself for the art. How do we look at this? There are all sorts of issues with this from the point of view of aesthetics. Does it have a connection to the history of art? I think it does. In what way? I don't know. There are things that I have thought a lot about, some really interesting issues in terms of the process. How do you function at an operational level with the computer and what can you do to set up a kind of gestalt, let's say, that allows you to be more creative in the context of the computer when you are working with software and the programs? I think there are certain ideas that could be reinforced, that could be brought out, that are not at all understood by many people.

Gardner: So what is your advice to students today who are studying all these software?
Csuri: Well, see the problem is, I probably shouldn't say this, but it is the way I feel. I seldom see anything interesting on the students' monitors today. It is either boring or...students are very excited about what they're doing, but learn a technique. There are not enough people around to hit them over the head and say "hey folks, this isn't art." What can we do that might make it art? What position can we take? What can an attitude be?
How can we approach the way we use the software to make something that is more alive, reflects humanity or passion or a kind of eccentric view of the world? We don't have enough high-powered creative people around to really drive the students. We really don't, the faculty is so frustrated with trying to teach basic techniques. It takes so much time and energy. One hopes that over time as young people . . . let's say elementary school children become acclimated working with personal computers and software that they will have enough confidence and experience in working that ...that becomes less of an issue and you can focus more on the aesthetic issues. I could scream. I know it sounds very harsh but that is the way I feel.

Well I sometimes think that somebody should teach a one-hour or two-hour seminar on how to survive as a computer artist in the university, that is recognizing that you are going to run up against all sorts of biases and prejudices. Let's talk about social skills, let's talk about how you present your ideas. Let's have some situations where we have a scenario where somebody who is really very violent intellectually about what you are doing, how do you deal with that? I mean . . . I think a little bit of discussion about that can be extremely useful so that in the final analysis you become effective, you achieve what you want to achieve.

Gardner: Do you think people need to be more critical of their work?
Csuri: No, I'm just saying how do you deal with hostility? How do you deal with dumb statements people make about... artists make about computers. What sorts of examples can you come up with that will show them that they are being ignorant about what they are doing? People
say, "I don't want to deal with technology." Now wait a minute, during the Renaissance we had all sorts of technology. People were learning how to do underpainting, overpainting. There were methodologies and procedures. Making a sculpture you had to follow certain procedures for printmaking and so forth, and while it is not the same thing, it is nothing new. Artists have done this. This is what I mean. You have to begin to look at it in ways that you can counteract what is going to happen. You just don't simply say, "Well, you're an idiot. The hell with you." You can't afford to do that. Otherwise, you won't get tenure, you won't get... you won't survive, you know what I mean? It's hard, it really is hard. And... that's... I think some people learn that and some don't.

Csuri believes that, beyond the students' ability to create the art, they must be prepared to defend this new medium. Technology is not a new term created for computer art; rather it has been a part of the traditional art forms and continues to reshape these art disciplines in general. The process through which computer technology is affecting the techniques used by artists is nothing new to the evolution of any traditional art medium.

Csuri sees training and education as being as significant in artistic development. Through the examination of Csuri's work, one can discern a general clue as to the orientation and development of this art medium and the training of artists. The paradigm shift of this medium from a scientific origin to the arts was imminent due to its then new-found capabilities for producing line drawings. Csuri devoted the energy and acquired the resources necessary to motivate others to follow, while he tried vigorously to meet the challenge of exploiting the new medium for an artistic statement.
Before he started his experiments in the mid-1960s, the computer's early "visual interactive accomplishments of 1963 were limited to line drawing forms with a light pen. Color, so essential to the artist, was nonexistent, therefore, allowing only white lines to appear on a black field" (DeMaria, 1991, p. 3). In fact, Nadin explained, some of the earliest attempts at using the computer as an art tool imitated the line art of artists such as Paul Klee and others who have played with horizontal and vertical lines to create perspective in an image (Slattery, February, 1988).

The development of the computer medium enabled Csuri to refine his art. In the early days of the medium, Csuri trusted in its potential; therefore, every notch in the medium's refinement was reflected in his art. By 1969 when halftones emerged, Csuri's art reflected defined planes of solid geometric images, a strong quality of halftone computer art that reflected the time and definite development from his earlier line art. In the 1970s, when 3-D geometry became available, Csuri began creating 3-D art. He built on his prior knowledge and by the 1980s was fully aware of the tool's potential to mimic successfully the techniques of traditional 3-D sculptural art. Works such as The Mask of Fear illustrated concrete evidence of his progress. Csuri constructed this piece through the use of 2-D and 3-D graphics techniques. Csuri exploited the medium's colors, lights, shades, objects, and its ability to map a 2-D picture onto a 3-D object, a technique called brush mapping.
Over the years, Csuri and his CGRG have developed some of the pioneering computer animation programs. It was not long after its establishment that the students at the CGRG moved from 2-D to 3-D animation. The CGRG produced a small number of 2-D programs before the introduction of Anima II. Csuri and his research group developed such a system to provide an efficient environment for the creation of 3-D wire frame animation and real-time playback display of color-shaded polyhedron. The system allowed the group to achieve video output from the computer directly to the video-recording equipment and a standard color television set. Such collaborative efforts allowed Csuri and his CGRG to advance in the field.

Everyone at the CGRG was a beta tester and helped to refine the quality of the software; therefore, little focus was placed on training the students in the research group to use a particular software. According to Csuri, emphasis was not placed on the documentation of the computer software. The training at the CGRG was one-on-one, and it relied heavily on the prior knowledge of the trainee, who was familiar with the general kinds of software at the
university. There were no formal classes in this small environment; instead, students took independent studies and learned from each other.

The [art] students would learn Anima II and out of that would come an art-related project. Then somebody would develop a tool to make data, the consequence of that was that students would make more interesting objects that could be used in Anima II... we had other animation programs that we could work on. (personal communication, Csuri, 1995)

The students were already highly motivated and interested in working with the program. The uniqueness of the computer medium, Csuri explained, was the motivation that drove the CGRG to the point to which it was easy for them to understanding how the programs worked. Csuri added, "they wanted to learn; it was so exciting, the dynamics of it coupled with the fact that...nobody had done that before," fueled their motivation to learn. The abundance of commercial applications has caused this novelty to fade away. And today at the Advanced Computing Center for the Arts and Design (ACCAD, formerly CGRG), more emphasis is placed on the documentation of the applications and educating the new students to develop their ideas in a classroom environment. The concept of computer as an art tool is no longer novel; everyone does it. This was not the case in 1971, when only few people had access to the computer and felt fortunate to be a part of the pioneering development in this art. According to PDI president, Carl Rosendahl, "it used to be that it was a big feat if you could just render an image--now, that's assumed. Just the fact that you can make pictures with the computer isn't enough anymore: Design has become crucial to capturing the viewer's attention" (Solomon, 1989 p. 294).
The students who worked with Csuri in the elementary stages of CGRG were also pioneers in the area. They worked with Csuri to find solutions through research and development.

Today, these former students of the former CGRG and the present ACCAD are some of the founders and leading effects practitioners who help to link Csuri's training methods and computer art principles to production companies throughout the nation. As a San Francisco production company, Xaos may well have the highest concentration of Csuri's former students including some of the principal animators and designers. The result of more than eleven former students from OSU was no coincidence; rather, it was the deliberate efforts of the company's founders, Arthur Swartzberg and Michael Polson, to recruit students from OSU to tap into the apparently growing need for digital effects in television and film. Csuri's alumni have also founded effects companies, for example Unreal Pictures in Palo Alto, California, founded by Michael Girard and Susan Amkraut. In Ossining, New York, another alumnus, Chris Wedge, is employed as creative director and executive producer at Blue Sky Productions. Other alumni are employed at major west-coast companies such as Industrial Light and Magic, Pacific Data Image, Rhythm and Hues, and many more.

**Ed Emshwiller: A Video Artist Approach**

Born in Lansing, Michigan, in 1925, Emshwiller began his art career as an abstract expressionist painter in the 1950s and early 1960s. After graduating in 1949 from the University of Michigan, where he was an art major, he studied painting at the Ecole des Beaux Arts in Paris before working as an illustrator in the United States. During his early career in art, Emshwiller
earned his living by designing cover art for science fiction under the name "Emsh." Concurrently, he began experiments in film and video, producing several award-winning avant-garde films and videos.

Emshwiller began to combine his traditional knowledge with film technology. His first film, *Dance Chromatic* (1959), which combined live action with animated abstract painting, was completed in 1959 and received an Award of Exceptional Merit from the Creative Film Foundation. Shortly after, Emshwiller made two other films using animation techniques, *Transformations* (1959) and *Life Lines* (1960) and other films that allowed him to collaborate with dancers and choreographers. Following these early experimental works, he concentrated on cinematography and, in addition to creating a dozen or so of his own films, served as cameraman on numerous television documentaries and independent film projects. In 1964, he received a grant from the Ford Foundation that allowed him to complete one of his best-known films, *Relativity* (1966), an experimental feature which he described as a "film poem."

Emshwiller continued to experiment with the film medium until the early 1970s, when he began working in the video medium at the TV Lab at WNET-Channel 13. He continued to collaborate with the dancers and choreographers while experimenting with video as a medium of artistic expression (Boyle, *Afterimage*, October 1990). Since the early 1970s, he completed several works employing a new form of video animation, including a major production of his called *Scape-mates*, which was funded by the National Endowment For the Arts. The video demonstrated a classic combination of computer animation and video synthesis. He remained at the TV lab as artist in residence through 1979 (Russett and Starr 1988).
Now combining video and computer technology exclusively, Emshwiller continued along the path of his new-found art in the 1980s. At this time, he began painting with a digital video palette, producing some of his favorable video art, which includes *Sunstone* (1980), *Passes* (1981), *Skin Matrix* (1984), and *Vertigo* (1986). His last completed work, *Hunger* (1987), was made with Morton Subotnik and was presented in October 1990 at the Ars Electronica Festival in Linz, Austria. Of these works, *Sunstone* became a landmark tape. Produced with the assistance of computer programmers Alvy Ray Smith, Lance Williams, and Garland Stern at the Computer Graphics Laboratory, New York Institute of Technology, the piece is both symbolic and poetic.

It is a pivotal work in the development of an electronic language to articulate 3-D space. The opening image is an iconic face, which appears to be electronically "carved" from stone. A mystical third eye, brilliantly crafted from a digital palette,
radiates with vibrant transformations of color and texture. Sculpting electronically, Emshwiller then transforms perspective representation: the archetypal Sunstone is revealed to be one facet of an open, revolving cube, each side of which holds a simultaneously visible moving video image. (Zippay, 1991, p. 78)

Emshwiller was an art educator and advocate who taught at various universities. He taught film and video at the University of California at Berkeley, Yale University, Cornell University, State University of New York at Buffalo, and Hampshire College before he became the dean of film and video at California Institute of the Arts in 1979 and was appointed provost in 1981. In addition to being interested in education, Emshwiller was an advocate for independent media and worked as a board member of Film-Makers Cooperative and the Association of Independent Video and Filmmakers and as a trustee of the American Film Institute (Boyle, Afterimage October 1990).

Emshwiller discussed the process behind one of his earlier video projects, Scape-mates (1972), in an interview with Robert Russett in August 1974. Quotations from this interview explained how the scanimate\(^5\) process was used in the production of Scape-mates. The scanimate process uses a real-time video animation technique. Through the use of this scanimate synthesizer, Emshwiller was able to

explore the emotional effects of simultaneous imagery, the interplay of abstract animated environments and dancing figures, and the dramatization of surrealistic events. In

\(^5\) The scanimate animation system is a video synthesizer capable of producing real-time animation. Unlike stop-motion film animation, real-time video animation uses computers to completely calculate, update, and electronically manipulate the artwork during the actual taping process.
Emshwiller's real-time animation, the use of light itself and the technique of photography is being re-defined by advanced electronic forms of imagemaking. He is helping to merge the technique of animation with computerized video technology to create yet another kind of kinetic art. (Russett and Starr 1988, p. 206)

*Scape-mates* was Emshwiller's third video project. Before this project, he had done *Images Of Ed Emshwiller* at Brooklyn College where he collaborated with Charles Levine and Dave Davies. *Images Of Ed Emshwiller* combined live studio taping with films and tape delay. Later through the television lab, Emshwiller produced *Computer Graphics #1* at Dolphin Computer Image Corporation. At the time he also produced a short version called *Thermogenesis*. In these computer graphic projects, he animated a half dozen drawings using the scanimate system. Based on the experience he received on these projects, Emshwiller decided to increase the complexity of his work. The result was *Scapemates* (Russett and Starr 1988). The project turned out to be his most widely recognized experiment in video, as it cleverly blended the "'real' and the 'unreal' in an electronically rendered videospace, and the skillful manipulation and articulation of a sculptural illusion of 3-Dity, [it] ...introduced a new vocabulary to video image-making" (Zippay 1991, p. 76). The piece showed that Emshwiller had fulfilled his personal goals for creating video art. He explained, "my reason for going to video basically was to explore the possibilities of keying, mixing, and transforming images" (Russett and Starr 1988, p. 207). In the production of *Scape-mates*, Emshwiller used multiple video and computer techniques such as video composition and chroma-keyed effects. Emshwiller explained the process:
Scape-mates was made by first designing two dozen black-and-white cels, each having five different gray levels. The cels were standard size acme animation cels and the five gray levels in the art work were made with different shades of zip-a-tone material. These animation cels were then placed before the scanimate computer cameras. There were two computers, each having two black-and-white cameras. The computers animated the static art work and colorized it. One computer provided background and the other, foreground. By using a special color encoder, the computers could render each of the gray levels in any hue. The art work was animated in real-time while watching monitors which showed what was happening. Selected tapes of the animated art work were then played back in the studio where the dancers were chroma-keyed into the graphic effects. Other tapes of the dancers were processed through the scanronic computers before being chroma-keyed into the final image. Additional texture and transformations were obtained by using the Paik-Abe video synthesizer. (p. 207)

Plate XII Scape-mates (1972) stills by Ed Emshwiller

The scanimate used in Scape-mates enhanced the images of the dancing figures moving through an abstract and complicated environment of videographic effects. According to Emshwiller, almost all of the environments were created by using computers to manipulate the two dozen animation cels that were made at the start. A few of the background patterns
consisted of feedback that was made with the Paik-Abe or scanimate systems. All of the animation was real time as opposed to film animation.

This method of real-time computer animation allowed him to move quickly, because it was not as time consuming as traditional film animation. Emshwiller "spent two to three days making the cels, two or three days on the computers, two to three days in the studio with the dancers, and two to three days editing. I also spent a week doing the sound score" (Russett and Starr 1988, p. 207). *Scape-mates* was completed within two weeks beyond the pre-production of the basic image cels. When an artist works within those time constraints, the ability to animate in real time is advantageous.

Emshwiller did not use any film for this project; instead, based on his willingness to explore the possibilities of the video medium, he used this new medium in conjunction with static artwork and live dancers. His experiments on the production of *Scape-mates* led to a new problem with the medium. Emshwiller was new to the medium of video and had done few experiments with real-time computer animation. The problems he encountered were results of his inexperience with the process. This made his efforts to make a wide range of spontaneous decisions during the actual taping process even more challenging. And although the computer made his work seemingly less difficult, "these decisions involved movements and transformations which were not part of the computer program" (p. 209).

Emshwiller experimented with various forms of technology, but he did not allow the technology to change the theme of his work. In his film, video, and computer mixed-medium projects Emshwiller made dance a central element. The dance theme, he explained stems from his strong desire to
work with people rather than narrative. Dance visually enriched his work. He explained,

"Dancers reach us. They express qualities we respond to—kinetic, sensual, abstract—without the need of a plot or story line. I was a painter, not a writer, before entering film and video, and so I am basically concerned with visual rather than verbal concepts. By working with dancers I can deal with aesthetic and evocative visual forms that involve people, without using a verbal structure or narrative approach." (p. 208)

Others
Besides the three artists detailed in this chapter, several others have also contributed tremendously to the development of the computer as an art medium. In this section, I will look at these artists and scientists who have contributed to the development.

Kenneth Knowlton, an explorer in the arts-technology interface, received a degree in engineering physics from Cornell and a Ph.D. in communication science from MIT. Apart from his interest in the technical performance of his machines, Knowlton also had a keen interest in the human and aesthetic aspects of computer graphics. Knowlton worked on a number of his own computer graphics projects as an experimental animator, but between 1964 and 1970, he assisted Stan VanDerBeek in producing nine computer-generated films, and, more recently, he has collaborated on numerous projects with artist Lillian Schwartz (Russett and Starr, 1988). In a lecture given at Experiments in Arts and Technology, Kenneth Knowlton (1968) expressed his concerns and interest. He felt people should be obliged to use at least a part of the new machinery deliberately to make the environment more beautiful and inspiring through new forms of computer
design. He credits the computer for its role in blending the details, symmetries, regularities, randomness, textures, and richness that were otherwise impossible to achieve. The computer, he explained, helps us to appreciate, understand, and enhance our humanity. He believes that our success in this arena will be aided psychologically by our ability to perceive the computer as a friend—"as an instrument not necessarily of regimentation but one which can help us significantly to experience and assert our humanity" (Russett and Starr, 1988 p.193).

One of the most prominent independent artist-technicians during this time period was Lillian Schwartz, a landmark experimental animator who produced some of the first artistically conceived computer-animated films in the early 1970s. She worked for many years as a consultant to Bell Laboratories and IBM, applying aesthetic background and ability to scientific and technological projects. The work at Bell Laboratories and IBM gave her access to some of the world's most powerful computer equipment as well as to the staff of computer scientists and other kinds of support personnel (Russett and Starr, 1988). Describing her relationship with computers, Schwartz said, "with both research giants, I have joined a niche that artists would envy, and I enjoy the advantages of experimenting with technologies that will not be available in the commercial worlds for years" (Russett and Starr, 1988, p. 25).

This new computer art field attracted two primary proponents of education--artists, predominantly film makers, and computer scientists. Most often, as in the case of John Whitney, computer artists were involved with both film and computer science. Although John Whitney may have gained most of his science training from his days at Douglas Aircraft, where he
worked as a writer, producer, and director of engineering films in 1952, other artists such as Stan VanDerBeek were mainly interested in computers. Ken Knowlton, an acclaimed computer scientist, worked with several artists on computer art projects. Lillian Schwartz, a formally trained artist and filmmaker, became interested in computer art and became a self-trained programmer. Most artists who were interested in the field of computer art during the 1970s and the years preceding knew that an understanding of computer programming was important. Artists who had little computer knowledge sought out scientists to work with them on computer art projects or had affiliations with university research groups such as the Center for Advanced Visual Research at MIT. Others used these universities and other organizations to gain access to the computer equipment for producing computer art.

Knowlton (1968) described very broadly his opinions about the artists and scientists and classified them. The artists are creative, imaginative, intelligent, energetic, industrial, competitive, and driven. But scientists, or programmers, he said are "constricted, painstaking, logical, precise, inhibited, cautious, restrained, defensive, methodical, ritualistic, cold, and inscrutable in human terms" (Russett and Starr, 1988, p. 194). He said that programmers' exterior actions are separated from their emotions by several layers of logical defenses. They are less concerned with the motives of the art. Artists, he claimed, are "free, alogical, intuitive, impulsive, implicit, confused, bewildered, bewildering, experimentative, perceptive, honest, frustrated, sensitive, and vulnerable" (Russett and Starr, 1988, p. 194). He contended that artists do things without being able to say why they do them nor what they were trying to accomplish: he interpreted that the rule of the game is that one
does not ask. Knowlton concluded that he expected art to come from the artist or artists working with programmers, not from programmers alone. If artists can achieve this art solely through gimmicks, then, Knowlton believed it to be essential that artists and programmers collaborate in order to develop meaningful, understandable, and useful sets of tools and ways of using them.

Drawing on historical studies, Solomon (1989) saw the distinction between artists and programmers differently from Knowlton. But Solomon's approach was not to look at idiosyncrasies between artists and scientists; instead, he believed they faced the same problems during the evolution of this new art, distribution and money. Although artists such as Emshwiller experimented with a $50 Bally computer, computer animation was generally extremely expensive.

The Impact of Computers on the Traditional Art of Visual Special Effects

Within the field of visual special effects are many categories. Animation is one of the first areas within the field of special effects to be impacted by computer technology. Computers were used as a more practical means of producing animation. These new techniques allowed traditional animators and artists to draw and reproduce images digitally and store the digitized frames for later playback. Contemporary animators can use the computer to generate in-between frames without having to redraw the various frames of an object in motion. In addition, various transitions can be performed to 2-D data that will be too time consuming to achieve through traditional means.

This section will focus on the ways in which computers were used by conventional special effects artists in the early days of its development. The
section looks specifically at Ron Saks' transition from traditional visual effects to the use of computer effects.

After receiving a scholarship for the San Francisco Academy of Art, Saks, a former high school science major, decided to try to combine arts and science in college. At the Academy he majored in medical illustration, but his one session at the Academy expired. He transferred to the University of California at Los Angeles and was accepted by the school's medical illustration program. At that time, the university was in the process of changing from the semester to the quarter system, causing the medical illustration program to close down. The program's director and main professor retired. Saks joined the College of Letters and Sciences as an undeclared major and later petitioned to join the College of Arts, in a process that eventually took a couple years.

Once in the department, Saks took courses in drawing, painting, and photography, but it was in a fundamental sculpture course that he began experimenting in visual effects. Saks was fortunate to study under well known photographers and painters in the department such as Robert Heiniken and Jan Stucci. He considered himself a "2-D artist" and resisted a required sculpture course but eventually enrolled. One assignment was given for the quarter. This assignment required the students to produce a sculptural piece that showed a process and exploited the qualities of the cardboard material with which they were working. After thinking about the assignment for weeks, Saks eventually wound up building a large cardboard sculpture that had some match heads and a lens built into it with a specific focal length and had assembled it at the right angle and took it outside on a bright, sunny day. The light of the sun was focused onto the match heads
which lit them, and the cardboard caught on fire—the sculpture set itself on fire. Pleased with the concept, Saks used slide photographs and 8-mm movie film to document the process of its deconstruction.

Saks presented the results as a documentation of the process. He knew that if the sculptural concept worked, he would not have any assignment to show to the professor; therefore, he wrote a paper and turned in the charred lens. For the presentation he projected the motion picture film on one side of the screen, and right next to it, the slide images that were static, being one-after-another sequential fixed images. The 35-mm slides finished up much faster than the film, so he decided to run them in reverse while the rest of the film was continuing. One side had the sculpture burning itself out and turning to ashes, and the other side had it coming from the ashes and forming back together, until it was the fixed object.

The sculpture project got him interested in experiments that explored time and motion. After completing this project, Saks made follow-up inquiries into elements of time and motion. He became excited in particular about art that changed over time and the way to record and display and control those changes. His curiosity led him to enroll in animation courses at the university's Theatre Arts Department as an undergraduate student. In graduate school, Saks continued to focus on animation as a medium for dealing with art that changes over time.

As a graduate student in the Theatre Arts Department in the 1970s, Sacks had little exposure to computers for experiments in computer animation. At the time of graduation as an undergraduate student in 1971, Saks did not have any experience in using computers. He recalls that "unless you were a computer science major, there really weren't any kind of general
computer literacy classes, and even in '71, '72, there weren't any microcomputers out there, and you really didn't see micros until about '75." Saks was introduced to computers by John Whitney Sr. in 1974. Whitney taught a course at UCLA. He was a guest lecturer for one year and taught a course in the theories and concept of computer graphics. According to Saks, Larry Cuba assisted Whitney and wrote a few algorithms specifically for the course. "We'd go down to the biomedical lab where he had a computer that he could access. Larry would boot up the computer, and he'd show us the routines and some of the displays that we were getting." The course exposed Saks to different types of computer displays. "I was aware, at that point, of some of the different kinds of graphic applications, both in terms of motion control and computer-generated dot patterns--vector images that weren't displayed as lines but rather as points."

Having had a science background in high school and continuing to take calculus and physics in college, Saks was very interested in applied mathematics and, as a graduate student, found employment in the traditional special-effects field, where he combined his knowledge of mathematics, animation, and computers. During the early 1970s, Saks began working as a cameraman at an educational animation company called Stephen Bosustow Productions. He learned how to use the camera. Because the animation staff shot on a frame-by-frame basis, the cameraman was required to calculate the camera moves. At times, these calculations were as simple as marking the camera moves with tick marks on masking tape before moving the cameras to the next position. Other cameras had counters. As a counter wheel turned around, the camera went up and down a column, or the cable moved east-west to north-south. On the counter-aided cameras, Saks had to figure out a
formula for a particular move. There were various combinations of camera moves: "If you wanted to do a linear move or a slow-in or slow-out or a curved move, you'd have to figure out some kind of formula...." Saks later got the opportunity to apply his computer knowledge when he began to plot the camera motion on a computer at his friend's place of work. Therefore, while working at Stephen Bosustow Productions, he also worked on independent experimental films.

Saks became interested in the early computer graphic arts and artists in Los Angeles. He began attending screenings at which he viewed the works of computer graphics pioneers. He recalled,

in Los Angeles there was a little art film house called The Cinema Tech 16 and another one was on Sunset [Boulevard] and another one on Melrose called the Vanguard Theatre that Bill Morris, who ran the Tuesday evening screenings at the Vanguard and I can recall seeing some of James and John Whitney's films in the early 70s. There were James Whitney films done with punching holes in cards and re-photographing those things, and some of John Whitney's early work Permutations—got me interested.

Saks also had seen 2001 and was amazed by the motion control sequences of the stargate corridors sequence. These professional and private films intrigued him and inspired him to continue along the path of computer graphics.

While in the course taught by Whitney, Saks met Robert Abel and saw some of the work that he was doing for ABC Movie of the Week and was impressed by the television commercial he had produced for Television Francais Une. These works were all different from the normal animation at that time.
It was TF1, and their logo was a system of interlocking—the T, the F and the 1 all interlocked together to form this puzzle of the three letters, and then you could take one whole grouping of those and lock it together with another one, and I can remember seeing a flotilla, of all of these TF1s floating in space in various different colors flying through the sky and locking together with one another.

Saks found this commercial impressive. "It wasn't computer-generated—it was motion-control imagery where art had been set up so they were doing these short strokes and flying them around in space and controlling shutter positions and color filters ...." When he saw this work through John Sr., he was very much impressed with it because "it added the dimension of space to animation, which you didn't see very often at that point." According to Saks, most animation tended to be on the surface, moving a story idea along. Most motions tended to be lateral, either X axis or Y axis—there was very little Z axis. The graphics were extremely two dimensional; it was impossible for the viewer to experience a 3-D space.

According to Saks, Abel was engaged in a very different technology—using this motion control technology to build some credible 3-D space. This technique was not common in conventional animation.

I was interested—mostly because my interest was not so much in product or cartoons or story, it was in the process, and this was a new way of dealing with the process. It dealt very much with change over time, with motion controls. Incremental position changes that took place over some time and the ways to control and edit those kinds of changes.

The company used traditional tools controlled by a computer. The 35-mm motion picture cameras and (Stepper or Sero) motors were connected to
proprietary computer hardware and software that controlled the movements of the motors that moved the cameras. The computer, purchased from Evens and Sutherland in Utah, was capable of operating several different cameras, but only one camera was operated on a given project. The computer made it possible to control the camera rotation precisely in X, Y, and Z and translated in X and Y. The cameras were focused on a vertical plane unit called the Gimbal unit that contained the art information that was held in place through the use a peg-bar. The unit could be back lit for additional effects. Animation created on this system was sometimes combined with live-action film or traditional animation.

Robert Abel and Associates later began to recruit artists for their production environment, and, based on several recommendations, Saks was intrigued by the cutting-edge technology. Based on the success of commercial productions, Robert Abel began looking for practitioners to work at the company. Abel contacted Whitney and two others who had known Saks. Saks then contacted Abel concerning the available position and was hired in 1976.
He hired me as part of that growing group and I was very lucky in that I could recognize that what Abel was doing was very interesting, was kind of cutting edge, and was beginning to push things forward, that I was willing to go ahead and go to work for him for a lot less money than I had been making several years earlier doing conventional animation.

Saks had worked with Abel at Ralph Bakshi-Warner Bros. Productions in 1973, where they used custom-built systems to plot camera moves. At this production company they did not use computers. Instead, according to Saks, they took a lot of old telephone sequencer switchers and hooked them up to motors so that they sent pulse signals to the motors and were controlled with little thumb wheels as to how many pulses the motors were going to be
getting. They duplicated camera moves that way. This arrangement allowed them to combine one pass of rear projection with the map and the second pass of top-lit animation over black. They combined in-camera the animation and the live action by being able to duplicate the moves. "That wasn't a true computer, but this was like in '73, so we were starting to get into electronic control."

The seasonal production industry allowed Saks the liberty to alternate between school and work. According to Saks, in the 1970s, the animation industry was very much a seasonal one. The practitioner was often guaranteed employment in the field starting in June, July, or August at the latest, and would normally work right through Christmas, depending on what the product was and what the schedule was. It was often that way until the end of January, if the practitioner was involved in a Super Bowl or the Academy Awards project. Saks was able to get six months of work that complemented the quarter school system. "If I got laid off right at Christmas, right after the first of the year, I'd start the winter quarter at UCLA and go the spring quarter, and right after the spring quarter I'd go back to work again."

Not having to work while taking classes, Saks had the time to conduct further experiments at the university; these experiments allowed him to venture beyond his assignments as a student.

Saks had the opportunity to interplay the education he was receiving at UCLA with the corporate-training model. By early 1976, Abel and Associates had been reduced to 15 practitioners, of whom there were four key designers who worked closely with the technical directors. Because of his background, Saks was hired as a technical director trainee. "I wasn't a programmer—there were some technical directors—I was a technical director more in art and
background. There were some technical directors with more math and computer background." His duties on the job included camera work, designing the motions that were to be done and devising strategies to execute those camera motions given the computer programs that were available at Abel.

The small company gave him the opportunity to experiment and learn different areas of the business and learn from other practitioners at the company. "It wasn't real, real tight pigeonholing with 15, 16, 17 people— you sort of wore more than just one hat. But I had to learn how to use the motion-control system. I worked with some other existing camera technical director people, maybe a week." In that time he learned about the different mechanical devices, enabling him to become adjusted to the company's tools. He was trained by various practitioners at the company. Saks worked mainly with a practitioner who had been hired six months before him. In addition he worked and shared learning experiences with co-worker John Hughes, who had been hired in the same week with Saks but dealt more with science and with the motors and soldering boards. Another practitioner aided his training process with "things that dealt with lining up images and how the images fit together and creating mattes, matte strategies, and technologies."

Saks was eventually given the freedom to work on a specialized area at the company. He specialized in the camera aspects of the production and was given folders with art work and exposure sheets in addition to punch cards. As his skills developed, Saks began working more with the computers at the company to plot camera moves.
They started handing me just the name of the punch tape and what the name of the file was, and then I'd go up to the computer and I'd have to output those files and then started creating the camera moves myself where I would get key positions, either through the lens or by projecting clips through the camera, and take those key positions, feed them into some of these simple programs--we were using a program. It was our little editor program, and then I would output my own paper tape programs.

He was later given projects to direct and co-direct. The technology kept changing, and, as a result, the practitioners at the company began writing proprietary programs that allowed Saks to create more accurate camera control motions through the use of the computer.

By late 1977, the company acquired a commercial computer system that allowed Saks to view the camera motion on a graphic-specific box that had a vector display. He used this machine to help program camera moves for motion control. With the vector display, the practitioners at Abel realized that if they started making the displayed images a little more sophisticated, and figured out a way to control them very tightly, they could start to combine these computer-generated images with the motion-control images. Excited by the concept, in 1978, the company was deeply involved in the production of computer-generated images. Before 1978, when the first actual computer programmer was hired, the company's programs were developed by various practitioners who specialized in other areas. The programs were written by artists and some technical people who had backgrounds in computer science. However, the hiring of an actual computer programmer in 1978 meant that the company was developing in a new direction. Several computer animation languages and software were later developed at Abel and Associates by the company's co-founder, Con Pederson, who, for a long
time, had been intrigued by the idea of incorporating computers into the production process. Having worked as an effects supervisor on the film *2001*, Pederson knew of the computer's potential as an effects tool.

In 1979, Saks moved on and worked at various other companies, but by this time, he had already worked with some of the principal effects practitioners and computer programmers in the Los Angeles area. A number of the practitioners from Abel and Associates went on to form companies of their own, while others became principal effects practitioners at major national companies. Saks worked at such companies as Astra Image Corporation-Paramount Studios, Pacific Title and Art Studios, Clara Vista Images, and Abel-Graphix before working as an animation instructor at UCLA in 1985. He later worked for Cranston-Csuri Productions before working as an animation instructor at The Ohio State University. Saks is currently an art educator at Columbus College of Art and Design, where he has worked as an associate professor since 1988 and teaches film and animation.

**A Province of a Special and Different Category of Worker**

Special-effects techniques used by conventional effects practitioners have developed over a number of years along with the film industry. New effects were created to solve problems within the industry or to simply improve on a process, thus making the effects easier to create. As in the case of the "1950s invention of the blue screen effect, this process used a kind of colored background that made it possible to use more effective composite shots (for example, combining live action, miniatures, and matte background in the same shot) in the color films that were beginning to be made with
more frequency" (Sklar, 1993, p. 360). To the practitioners working in the conventional effects industry, inventing and innovating such effects techniques helped to broaden the industry. The revival of the science-fiction genre in the 1950s gave plenty of opportunities to special effects cinematographers and their co-workers (Sklar, 1993).

The advent of science fiction film began dominating the Academy of Motion Picture Arts and Sciences Oscars for special effects, which previously had been awarded mainly to war films. In 1949, *Mighty Joe Young*, a giant gorilla film from Ernest B. Schoedsack and Merian C. Cooper, won an Academy Award. The focus of film effects has since evolved to include effects that are generated on high-end computer systems. Digital effects have continued the trend to help create believable fantasy films.

Accessibility to expensive computer equipment in the early days made computer skills a special and different category of works. In the early 1950s, when the first computer-generated image was produced, there were not many places where conventional effects workers who were interested in this field could go to be trained or educated in this form of effects. In fact, "when computers first began making pictures, most of the images were sprung from the imaginations of engineers, not artists" (Trachtman, 1995). The limited computer labs made the practice elite. Few companies could afford the expensive computer, and the art of computer-generated images was limited to large schools such as the Massachusetts Institute of Technology or large corporations such as Bell Laboratories. People doing research in the area of computer graphics needed to have a concrete knowledge of computer science. A skilled artist who worked on the computer spent days working with a scientist to create a single image.
Conventional special-effects workers did not acquire computer skills because it was difficult to attain the three major components to get started in the early years: accessibility, capital, and knowledge. Since their origin as art tools up until the innovation of microcomputers, computers were not accessible to everyone. "Until recently, computers powerful enough to make interesting images were usually located in huge government, academic or industrial enclaves, where artists feared to tread" (Trachtman, 1995, p. 56). No one knew for certain where the development was leading, and only a small group, made up primarily of computer scientists, was interested in its development. Conventional effects workers were more involved with perfecting the trade of building miniatures and mastering other conventional effects techniques. To learn to use the computer meant that they would need to have access to a computer that was not available at their place of work, even if the access was limited to late evenings, like "Tart Em, who in the 80s found shelter for his computer experiments in the Jet Propulsion Laboratory at night, after the scientists went home" (Trachtman 1995, p 56). Further, it was not cost effective for effects companies to employ such techniques in their films. They would have had to purchase computers, which at that time could have been as large as a small bedroom. After incurring the high costs, these small companies would then have to train and educate some of their workers to use the unfamiliar computers. It was much simpler for the effects companies to continue to perfect the art of conventional effects; there were fewer risks involved. It was not cost effective to implement computer departments of visual effects, because the rewards were too uncertain. It took too long to generate a single frame, and the overall quality was extremely low.
In 1967, *2001: A Space Odyssey* became the first feature film to use computer-generated effects along with conventional effects. Conventional effects workers have traditionally been trained according to the apprenticeship model and have had little exposure to the computer training traditionally taught at universities. All the more reason why *2001: A Space Odyssey* was such an important film in the history of visual effects. The film showed that the computer effects can be used as another effects technique for creating fantasy films. But, like areas of conventional effects that are too elaborate or too sophisticated to be done by untrained effects artists, the computer effects work was subcontracted by conventional special effects directors.

Subcontracting has always been a common strategy employed by the film industry. Traditionally, when films needed particular effects, such as stunt effects, the film makers subcontracted companies that specialized in them. These companies usually worked with the film directors who employed their services. The labor was divided and, as a result, produced various small companies specialized in doing particular effects. However, such companies as Colossal Pictures and Industrial Light and Magic (ILM) have capitalized on the effects market by establishing large corporations made up of several specialized departments of special effects. Founded in 1975 by film director George Lucas, ILM, with its group of 300 employees, is now known as the leading effects facility in the world. In 1976, Colossal Pictures' co-founders, Drew Takahashi and Gary Gutierrez, began by contracting special effects for television productions. In the early days of the company, the two former apprentice animators at Korty Films in Mill Valley directed a large number of animation for *Sesame Street* and *The Electric Company*. Colossal
began as an effort by two alumni of UCLA and San Francisco Institute of the Arts and has since grown to a size of 150 full-time employees. The company, like ILM, does both conventional special effects and digital effects at the same facility (Goldstein, 1993). Both facilities are made up of various experts in all areas of the film and special effects; however, these companies may subcontract their services to the motion picture industry, and many of the effects are employed by directors of feature films, commercial productions, and attraction industries. At times, large effects companies will subcontract to smaller effects companies. This may occur as a result of heavy work loads with short deadlines or simply because the subcontracting effects companies may acknowledge that other production facilities have mastered particular effects styles or techniques.

Most established Bay Area computer effects companies have particular styles and methods that are trademarks of their artwork. Like every other area of the arts—dance, music, and fine arts—artists usually become specialized in particular styles of the craft. Digital effects are no exception. The film industry usually contracts with particular effects companies because the industry members appreciate the style and quality of the companies' work. Xaos, for example, has a unique style to their art and is known for the application of 2-D image processing techniques to 3-D graphics and animation. Its painterly computer image processing is a strong mixture of elements of abstract art techniques and computer science application. It has been subcontracted by Industrial Light and Magic, which works closely with them to complete contracted jobs.

In the following chapter, I will look at the pedagogical methods that have traditionally been a part of the practical industries. To what extent are
these methods of training used in the conventional film effects or the digital effects industries? The chapter also examines the traditional methods used to recruit new employees in industries.
CHAPTER IV
PEDAGOGICAL ISSUES

Introduction

After viewing the history of special effects, we can conclude that the education and training received by "conventional" special effects workers in the American film industry follow a recruitment and apprenticeship model common in craft industries organized by labor unions. At the time conventional visual effects were introduced to artists in America in the late nineteenth century, they were a craft performed by individuals. Most of the conventional effects techniques began in Europe but were developed in America. In the early days of visual effects, artists who wanted to learn the art either learned from someone who knew the art, or they experimented on their own. In a number of cases, artists studied as apprentices under masters of the subjects, as was the case in the craft industries during the late 1800s. In a number of cases, the options of apprentice models and experimenting were not exclusive. This is to say, if artists studied under masters of the arts, that did not restrict them from experimenting in their spare time. There was not a special effects industry until the early 1900s, before which the field of art was dominated by independent experimental artists. The rapid development of the field between 1900 and 1920 meant that the masters of this art were constantly learning new techniques and methods for achieving improved effects. During this period, there was not much to learn about special effects.
Most effects artists who were fortunate to have gathered the knowledge on the subject, such as the trick photographers of the late 1800s, preferred to capitalize on it and kept it to themselves, as these Americans learned from their European counterparts. The schools taught only the traditional arts, and special effects was not a part of any school's curriculum.

Unlike 3-D effects, the origin of 2-D special effects can be traced back to one man, Emile Cohl, but it was at least a decade later before his experiment became an industry. A French jewelry apprentice, Cohl began exploring the potentials of the film camera as a hobby. After work, he experimented in the backyard of his store. He later began drawing frame sequences on paper and came to realize that 2-D stop-motion animation was possible (Heraldson, 1975). As a result of his experiments in 1905, Emile Cohl was credited as the father of 2-D animation. The Paris native came to America to share his findings. In an informal lecture in New York, Cohl explained what little he knew about the subject before returning to Paris (Henderson, 1975). His lecture was heard by film makers who were eager to apply the information he had imparted. Cohl, a wealthy jeweler, simply wanted to see the art, once his hobby, explored. Individual artists informed others of the new technique that they had discovered. There is little recorded evidence that any particular apprenticeship model existed in 2-D animation during the period of 1900 to 1920. Most reports indicate that the animators worked independently.

However, animators such as Barre made attempts to industrialize the field in the late 1910s, but Barre's attempts later failed around 1930. Later, Walt Disney and others headed the industrialization of this specialized area of special effects called "cel animation." But even in the early days of 2-D animation as an industry, there was little in the way of apprentice models. It
almost seemed that individuals who drew well or had already developed styles of their own were welcomed, and others who couldn't draw were denied the positions.

The way that training and education are passed on in the special effects area in American industries can best be explained by examining the relationship between O'Brien and Harryhausen. Although obviously countless practitioners are exemplars of the apprenticeship training and education model, the reasons for choosing this couple are two-fold. First of all, their relationship has been well documented over the years; and, second, both individuals have achieved independent success throughout their careers.

Willis O'Brien was born in Oakland, California, and began his art career as a cartoonist for the San Francisco Daily News. While at the San Francisco Daily, O'Brien also worked as a sculptor for the San Francisco World Fair of 1913. He began experimenting with special effects and short films in 1914 (Culhane, 1981) and has been credited as the father of 3-D animation effects. O'Brien was head of animation effects for The Lost World (1925) and King Kong, among other films that he created. O'Brien gathered his knowledge on animation and visual effects while working at the San Francisco Daily News and experimenting on his own to create short test films. These short films were based on the use of stop-motion animation. O'Brien carried out his experimentation on the roof of a San Francisco bank. His films progressed in the complexity of the visual effects. He experimented with stop-motion by modeling and animating such figures as cavemen and dinosaurs. These objects were constructed from modeling clay molded around articulated wooden frames (Barnes, 1980; Culhane, 1981).
O'Brien built a reputation that impressed a producer enough to provide him with $5,000 for a more sophisticated five-minute short film called *The Dinosaur and the Missing Link*, released by Edison Company of New York in 1917. After the release of *Missing Link*, he animated several more films for Edison at $500 each. By 1919, O'Brien spent $3,000 on *The Ghost of the Slumber Mountain*; his popularity helped this film to gross $100,000. *The Lost World* (1925) followed, and O'Brien took evening classes in sculpture at an art college to help him perfect the crafting of the animals. He was constantly improving on his craft, and this film gave him the opportunity to make the transition from clay to rubber models. After completing *The Lost World*, the progression continued; he advanced to *King Kong* (1933), on which he worked as the head animator. But at the completion of *King Kong*, O'Brien not only gained more popularity, he also gained an apprentice.

Culhane (1981) wrote, "the connections here reveal special effects as a craft--an art, at its best--that is passed on from teacher to apprentice" (p. 98). Ray Harryhausen was only thirteen years old when he saw *King Kong* at Grauman's Chinese Theater in Hollywood, but he was bewildered by the animation of the creature. From that day onward, he idolized O'Brien and had great respect for his work...so much that the young Harryhausen knew from that point on that he wanted to be involved in visual effects. Harryhausen was already used to creating models on his own that were finished with fur from his mom's fur coat. By the time Willis O'Brien made *Mighty Joe Young*, Ray Harryhausen was twenty-nine years old and working as an apprentice to O'Brien on that Academy Award winning film (Culhane 1981).
Apprenticeship Models--History and Definition

The New Encyclopedia Britannica 1987 described apprenticeship as "training in an art, trade, or craft, under a legal agreement defining the relationship between master and learner and the duration and conditions of their relationship" (p. 494). Apprenticeship models date back to the earliest times in Egypt and Babylon when training in craft skills was organized to maintain craftsmen in adequate numbers. Some of the earliest craftsmen in Europe were slaves who built the Roman Empire around the 18th century B.C. By the 13th century, a similar practice reappeared in Western Europe in the form of guilds. "The guilds were controlled by the master craftsmen, and the recruit entered after a period of training as an apprentice, commonly lasting seven years" (Britannica 1987, p. 494). These systems were usually suited for domestic industry. The master usually operated the industry on his premises, where the assistant worked and resided in an artificial family relationship.

In the Middle Ages, apprenticeship models were not limited to the craft industry but were present in all aspects of training and education. The New Encyclopedia Britannica 1987 states,

The university accepted the same principle with its master's degree, and the religious orders insisted on the newcomer's passing through a novitiate. In medicine, the guild system applied to the surgeon, who also performed the function of barber and was regarded as a craftsman, with less prestige than the physician. The lawyer served an apprenticeship by working in close association with a master of the profession. The development of large-scale machine production increased the demand for semi-skilled workers whose skills were confined to a particular specialty, created by an ever-increasing division of
labor. The more ambitious among them sought to increase their effectiveness and potential for advancement by voluntary study. To meet this need, mechanics' institutes were established, such as that founded in London in 1823 by George Birkbeck, which still exist in modernized form as Birkbeck College, and Cooper Union for the advancement of Science and Art in New York City, established in 1859. (pp. 494-495, vol. 1)

Modern America

According to Kursh (1965), in modern America the industry has found that one of the best possible ways to train young people to become proficient is through apprenticeship or on-the-job experience acquired under direct supervision of qualified craftsmen. But one important question had to be answered: What advantages are there for entering an apprenticeship program? The Bureau of Apprenticeship Training in the U.S. Department of Labor was established in 1937 and promoted schemes for individual industries. The New Encyclopedia Britannica 1987 explained:

Apprenticeship normally is phased in periods of 1,000 credit hours, equivalent to six months and including 144 hours as the minimum of related classroom instruction. The trainee advances from phase to phase after passing qualifying examinations. Pay, varying from 60-90 percent of the journeyman's rate, increases at each phase. Apprentices can be indentured to the local Apprenticeship Committee and the craft, and thus, in effect, to the industry not to an employer. This has been particularly successful in the building industry. (vol. 1, p. 495)

This modern American apprenticeship, on-the-job method was also adapted by the early film industry, as indicated in the earlier example of O'Brien and Harryhausen. The incorporation of advanced technology such as computer-
aided cameras meant that a greater emphasis was placed on the training of the effects practitioners in a more classroom-oriented environment on the job.

**Apprenticeship Today**

The master-apprentice relationship in the crafts industries in many ways has grown and is very unlike that of the highly structured craft guild of the pre-industrial 1800s. In fact, in order for apprenticeships to remain a viable educational method today, they must transcend the medieval concept to twentieth-century concepts, which take new technologies into consideration when planning future models. Artisan-type apprenticeship of the early twentieth century was characterized by small-scale production units in which the master still personally taught the apprentice. This quality gave the artisan-type arrangement, such as the effects industry, two main advantages over other categories: they were taught firsthand by the masters; and they had the opportunity to receive more overall and all-around training (Kinsley, 1983).

Apart from the artisan-type apprenticeship model, there were several others common in the twentieth century. Kinsley (1983) details three models. These are the Capitalist Organization, Exploitive, and Premium-type apprenticeship models. The Capitalist Organization-type of apprenticeship model was one in which the master had relieved himself of the workshop duties, leaving the workshop training duties to the journeyman. The master was more occupied with business transactions. This method was usually structured to limit the number of new apprentices accepted into the trade. This model was most common in large urban centers such as London. The existence of trade unions dating back to the eighteenth century predicate the
existence of this type of organization. Unlike the model that has been mentioned thus far, the Exploitive apprenticeship failed to teach a worthwhile skill to the labor market. This model is commonly used in textiles, pottery, and other large industries that thrive on paying low wages for high productivity. This form of exploitation was later reduced by changes in the laws that resulted in more money spent on education. By the end of the nineteenth century, Premium Apprenticeship required that a particular sum of money be paid to the master before the apprentice could begin training, thus the term "premium." The premium apprenticeship model trained the apprentice for a managerial role at the craft industry. The money was paid possibly to discourage large numbers of people from choosing this form of apprenticeship (Kinsley 1983).

Another apprenticeship model created in the 1980s was the school-to-work model. These school-to-work transition programs were oriented toward work and occupational education. Its misleading name evokes an image of a one-time shift from school to work or the notion of work and school being separate entities, but these are all false notions. In fact, the school-to-work program runs on the belief that most individuals combine schooling and work for long periods of time, or they shift back and forth between the two. Individuals may continue to receive both formal and informal instruction from their employers. The student's program can last for several years, thus minimizing the notion that an explicit transition takes place. The school-to-work model was designed to serve non-college-bound students (or corresponding institution as it is called in Europe, Japan, and some other Asian countries). Three types of programs that shared characteristics with the apprentice model are agricultural education, high
school career academics, and technical preparation programs (Bailey and Merritt 1993).

Although today's conventional effects companies' training programs are modeled more after the artisan apprenticeship model than any other single model discussed, they also contain elements of the other models examined. It is difficult to determine the exact combinations of these models that are incorporated in any one conventional effects training program; however, because these companies usually employ various employees at different levels of prior knowledge, it is possible that no one apprenticeship model is used by any of conventional effects companies. Rather, the model may be adjusted to meet the needs of the individual trainee, according to their prior experiences in the field.

Recruitment

In my view, the conventional effects industry resembles the recruitment patterns and models used by the apprenticeship model common in craft industries. In her book, Exploring Apprenticeship Careers, Charlotte Lobb (1982) outlines the common practices of apprenticeship in some common apprenticeship training programs in the United States. In her research she has found that there are five common routes people have successfully taken to becoming apprentices in most models used in the late twentieth century in America: connections, testing, school, tenacity, and starting at a lower job. These routes are similar to the ones taken by artists who try to gain jobs in the field of visual effects. Through an interview with David Tart, I gathered information on one method of recruitment used in the special-effects industry.
Having connections in the industry gave Tart the opportunity to start off as an apprentice in the area of conventional special effects. Tart studied at San Francisco State University in interdisciplinary arts. In this program he was able to gain experience in the use of computers in visual effects as he studied on the Macintosh computer and became a skilled user. He used his major to experiment in film animation and worked on short animation using stop-motion. At school, Tart took full advantage of the equipment and computers that were available to him. Toward the end of his degree program at the university, he enrolled in an advanced class for 3-D modeling and animation; he studied under Professor Jane Veeder. His experience in computer animation and film animation techniques, coupled with his basic knowledge of programming, almost guaranteed him a position. But Tart was on his way to Germany to continue his studies of visual effects when he was encouraged to show his work at a year-end screening. His connections to others in the field, in addition to his outstanding images, were the main reasons his art was addressed in a major newsletter. The newsletter was read by two producers at Danger Productions, a Bay Area conventional special effects company, and Tart was hired to do conventional special effects. "Their goal then and their goal now was to hire combinations of experienced animators and apprentice animators so they saw that as an opportunity" (Tart, personal communication, December 1994).

But, according to Lobb (1982), connections or a contact person in the trade, such as an uncle, has been one of the age-old ways of being recruited as an apprentice. In some trades, connection is the only way to gain recruitment into the trade. As a result of the time involved in training apprentices and the often limited positions at these small companies, "connections are still
important in trades that do not have a closed union shop or hiring hall arrangement, or where the industry is made up of many small, owner-operated shops" (p. 18).

Often, as reported by Lobb, testing may be used in the recruitment of apprentices. In the conventional special-effects industry, this testing may take the form of portfolio reviews of the persons' works. Tart's screening can be viewed as a test, as the film screen was also an opportunity for his portfolio to be reviewed. Although formalized testing of apprentice applicants is found most in the construction trades, it may be applied to special-effects apprentices in the form of drawing or on-the-spot tryouts at animating stop-motion characters. Apprenticeship program examinations may include mathematics, vocabulary, reading comprehension, and a possible spatial-relations section. The spatial-relations section may include exercises such as block counting, solid figure turning, touching cubes, and cube turning (Lobb 1982). In the case of both conventional effects and other apprenticeship models, an oral interview may be required for those applicants who pass the screening test.

School can allow apprentices to experience the best of both worlds and is often used as a means of gaining connections or the knowledge to begin in apprentice positions. As in the case of the school-to-work apprentice program, students at institutions can also work simultaneously as apprentices. These programs can not only increase the persons' chances of being recruited into permanent positions after finishing school, but they can also provide them with the supervision and professional advice they may need to make a smooth transition from school to work. Conventional visual effects students often work as interns during school terms or during vacations. The internship allows them to build on-the-job experience in the
field that they wish to pursue after graduation. Internships are common in the conventional-effects industry. Companies like Industrial Light and Magic have established internship programs for college students to gain experience in the field. These interns may receive a minimum wage salary if they are interning in the summer. Although other conventional effects companies have similar programs, Industrial Light and Magic is one of the largest and most popular programs in the San Francisco Bay Area. Interns who show comparable skills or fast progress may be encouraged to apply to the company for a permanent position. These interns usually require less training time because they may have interned at the production facility for several summers. These individuals are commonly hired to work at the same production company or a similar facility at a later date.

Although it helps to be tenacious, more often young people may be recruited based on their willingness to "start at a lower job." In the earlier years of conventional special effects, the days when there was not a formalized curriculum at any particular school that was geared towards producing special-effects artists, potential, eager, and enthusiastic artists applied for any possible openings at the Bay Area production companies. Most were fascinated by the trade and simply did not have portfolios of conventional effects material or samples, while others who had developed portfolios or demo reels were unable to find openings to match their qualifications. In either case, these people took jobs as helpers--errand runners, office assistants, and other positions that did not relate to their main pursuit. In return, they gained a better understanding of how the industry operates and, on their breaks, received an informal education and training in different applications and areas of the field. They progressed in this
environment, often making friends with the people they once emulated or were in positions to which they wanted to advance. Often, workers in this field work long hours and were often at work on a project after hours. Young eager helpers often seized this opportunity to look over their shoulders. According to Lobb (1982), this kind of informal apprentice training could continue until the company management were sure that the individuals were reliable and responsible, at which point training begun. "It takes an average apprentice about two years to land the job he wants" (p. 26). In general, apprentices in all fields of specialization were sometimes encouraged to take these lower positions with the hope of getting a start and a chance to prove themselves. In the case of Carlos, an art director at Pacific Data Image, for example, he began working as a computer-effects artist and graphic designer for several years before advancing to the level of an effects and art director.

Training

The model of training used to educate new San Francisco Bay Area conventional special-effects workers is similar to the apprenticeship model used to train workers in the Logan Elm Press and Papermill at The Ohio State University. In her master's thesis, Kinsley (1983) focused on an apprenticeship model that was used by Logan Elm Press and Papermill to train its new workers on the art of the book. Kinsley, who worked at the Logan Elm, observed a number of university-sponsored apprenticeships in the art of the book and wrote primarily about her experience as an apprentice at the university-sponsored press. University-sponsored apprenticeship programs are becoming increasingly common, and the involvement of art
educators in apprenticeships is becoming evident at the university level. The development of criteria for both professional and production-craft training within the department of art education is cited at various universities (1983, pp. 2-3).

As an apprentice, Kinsley learned the various aspects of 19th-century book production, book design and layout, paper making, hand typesetting, printing, and book binding. Established in 1959 as a place for the study and preservation of fine printing and bookmaking, the Press provides university staff and students a professional workshop. Much attention is given to aesthetic concerns of the object produced by the printers. This concern includes the selection of quality materials that are appropriate to the character of the book, as well as the value of the literary and/or visual images, and the achievement of harmony of visual and tactile experiences. The success of the work is determined by many decisions regarding design and the choice of typography, materials, and binding techniques" (1983, p. 107). Fine printing, as is done by the press, is a skill that utilizes traditional printing techniques, such as lithography from stone etching from a plate and letter-press printing from raised type. This craft takes advantage of the careful, direct work by the craftsman's own hand, as opposed to dependence upon a machine which fine printing entails. No offset or lithography is done at the Press (1983, p. 108).

Various types of apprentice programs are offered by the Press. The programs are arranged to accommodate Saturday classes in book art, which are designed for use by the general public and area school students. In addition to offering credit courses and non-credit independent study options in the study of bookmaking and aesthetics of the book, the Press provides work-study positions that allow students to incorporate school and work.
Apprentices are selected on the basis of proficiency in the area of fine printing. "Entry skill requirements include that the apprentice must have experience with hand typesetting, preferably having done independent work on the letter press. Tertiary experience is preferred which may include printmaking, bookbinding, calligraphy, marbling, papermaking, or a fine art degree in an area related to the book arts" (1983, p. 113). The apprentice is paid for a specific number of hours of work per week. Similar to the computer-effects production environment, "the Logan Elm Press is unusual in a pedagogical setting for the fluidity of roles it permits. A large measure of student excitement, it is speculated, comes from the collegiate self-directed dynamic environment while providing exposure to and expertise of a master craftsman...modeled after an artisan shop, permits" (Blandy, 1982, p. 3).

The training model used at Danger Production is similar to the apprenticeship model at the Logan Elm Press. David Tart, a former apprentice animator at Danger Productions, described the training and education he received. In an interview, Tart (personal communication, December 1994) briefly explained,

Danger Productions animation supervisor, an animator for Nightmare Before Christmas, has been doing stop-motion for over ten years. He basically gave me a puppet and sat me in front of a frame grabber and I had the opportunity to experiment with the puppet and animating for several weeks before I started in production. I guess the training that I received was really in the form of me having problems trying to solve animation problems like how to get a puppet into a very strong pose that would read as a certain emotion.

Similar to the Elm Press students, Tart was left with little supervision to experiment with the equipment at the production company. Through
several tries, Tart was able to identify the problem he was encountering and knew the problem areas he needed to concentrate on. "A lot of the problems I had initially were that the poses weren't strong enough. The movements were not extreme enough. My timings were off because I wasn't sure how to translate motion over time." Whenever he encountered a problem that he could not solve, he consulted the masters for assistance. This was the extent of his training. There were no structured classes or lessons. Tart recalled, "basically the training that I got was more in the form of asking either Owen Klatte or Steve Buckley, who is another animator there, Anthony Scott, these are master animators, how to do that, how to break through those problems."

Of greater value to Tart were the constant challenges and opportunities to experiment.

The benefits of working at Danger [were] that, because of the volume of animation we were required to do, we were able to experiment a lot and get away with a lot. The animation didn't have to be perfect. One of the earmarks of stop-motion animation is that because you shoot a scene straight ahead, if it is wrong it means that you have to shoot the scene...do the animation from start to finish again and that's very expensive. Unlike computer animation where you can animate a scene and then go back in time and maybe change the arch of an arm or the ways the eyes blink without redoing the whole animation, stop-motion is a matter of spending the day or days redoing the animation completely. So there was a lot of freedom there to sit down and learn how to animate and have problems, ask questions, and get solutions.

Historically, there have been various apprenticeship models in place; however, after reviewing the historical origins of these models of the nineteenth and twentieth centuries, I conclude that a combination of these models has been adapted by the conventional special effects industry's
training programs. The training of conventional special effects workers at Danger Productions is similar to the training environment at the Logan Elm Press. This environment allows apprentices to work directly with the masters of the trade. An investigation shows the recruitment methods used by the craft industry are also used in the hiring of special effects practitioners.

This master-apprentice model has been the most common method for training in the practical fields throughout history. The computer-effects industry has a similar method for training the new practitioners. In the following chapter I will examine and compare the training methods used by three Bay Area companies to train new practitioners, and I will investigate the role of the trainers and senior practitioners in the training of new practitioner.
CHAPTER V
TRAINERS, TRAINEES, AND PRACTITIONERS

Introduction

I have carefully selected the interviews of six effects practitioners that took place at three Bay Area companies: Xaos, Pacific Data Image, and Pixar. Different combinations of two effects practitioners were selected from each of the three companies. The categories are illustrated in the following diagram. These categories were derived from the individuals' titles at their companies. Two effects workers, with different titles, were selected from each of the three effects companies. These titles formed categories called Trainer, Trainee, and Practitioner. Different combinations of two effects workers within these categories were selected.

Table 1 Comparison table

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<thead>
<tr>
<th></th>
<th>XAOS</th>
<th>PDI</th>
<th>PIXAR</th>
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<tbody>
<tr>
<td>Trainer</td>
<td>Roberta</td>
<td>Michael</td>
<td>Sharon</td>
</tr>
<tr>
<td>Trainee</td>
<td>Alexei</td>
<td>David</td>
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</tr>
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<td></td>
<td>Jennifer</td>
<td></td>
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</tbody>
</table>
In this section, the term "practitioner" is used to describe a person who has already been trained and continues to work in his or her specialized area within the company. This person is not an official trainer and is not involved in the training programs. In addition to following the trainer and trainee's criteria as indicated in Chapter 1, the trainer is primarily concerned with the documentation of computer programs and conducting programs that help to familiarize the trainee with the company's proprietary software. "Trainee" describes an individual who is new to the company and is generally a novice in the area of using the company's proprietary software.

The philosophical concepts of goals, possibilities, limitations, functions, and value are derived from the data collected in the interviews. These philosophical concepts are recurring themes and represent commonalties and were grouped into logical categories. The concepts are used to compare and contrast the individual of one of the three categories to another individual in that category at another production company. This analytic framework illustrates the primary method of comparison for the analysis of the interview data.

Goals

In this category I group statements that suggest the goal of the training program, the person in the training program, or the overall goal of the company. It includes the objectives of the training program.
Possibilities

This category groups words that suggest future plans for using the computer effects tool; the impact on the training programs on the university's curriculum; or suggestions made by the effects workers for improving the relationship between the universities and effects corporations.

Limitations

Limitations are statements made by the effects worker that suggest that he or she may be restricted or limited in any possible way. They are statements that suggest restriction of the artist's creativity by a particular computer tool; or the limitations of the artist in the training program; or the effects worker's limitations beyond the training program.

Functions

Functions are statements that directly describe what the artist does at the company in the chain of production and the process by which the artist fulfills his or her objectives at the company. Statements that suggest the structure of the company are also included in this concept.

Values

What personal rewards are gained by the effects worker as a result of producing visual effects? What are the motivating forces that compel them to continue to produce visual effects within the production or to specialize in a particular area beyond the training they have received at the company?
Background of Three Companies

Xaos, Incorporated

Xaos is an animation facility that specializes in high-end computer-generated designs and production for broadcast, advertising, and film. The company views the computer as an evolutionary tool for the creation of artwork, thus another step in a partnership between science and art.

Founded in 1989 by Arthur Swartzberg and Michael Polson, Xaos was established with a commitment to providing excellence in the area of computer animation and design. Although still considered a small production company, Xaos has grown phenomenally since that time. The goal of the company, according to Xaos's president and creative director, Mark Malmberg, is "to grow a computer animation company, based on high artistic standards, which would become one of the top names in the computer-graphics industry."

A strong motivation behind the growth of Xaos has been the development of computer animation as an expressive medium. At the time the company was established, the medium was predominantly associated with shiny, flying logos and slick graphics. Xaos' efforts have allowed them to stretch beyond such limits. Rather than accept the limitations of "turnkey" animation systems, Xaos wrote and develops its own software that allows practitioners more control over the images they create. The result is more "organic" and textural imagery, which has complexity that is unattainable with the software that is on the market. "We were trying to do something which generally wasn't done at the time: Bring fine arts knowledge and experience to the computer graphics industry," recalled Malmberg. He added
"as artists, we needed the freedom and ability to express ourselves with the fewest constraints imposed by the system."

As with any tool, the end result will be only as good as the talent and dedication of the individual artists who are involved in the production process, from design to execution. The Xaos production team's artistic skills range from sculpture, graphic design, and painting. The company is composed of several of the Ohio State University (OSU) graduates and practitioners from culturally diverse origins such as Brazil, India, Poland, and Russia. More than twelve practitioners at Xaos are OSU graduates. These artists most often work in various areas of production and are less specialized than practitioners of larger companies.

Xaos has been honored with many international awards, ranging from an Emmy to awards from reputable organizations such as National Computer Graphics Association, Broadcast Designers Association, Prix Ars Electronica, Imagina, and SIGGRAPH. *Wet Science*, an experimental series of tests, has taken honors across the globe for its unorthodox fluid imagery; the honors include permanent placement in the prestigious museum Centre Georges Pompidou in France.

The unconventional, organic style for which Xaos has become known has contributed to the success of numerous distinguishable projects: *Liquid Television* (open, close, and bumpers) for MTV, the Sci-Fi Channel open I.D.s, the feature film *The Lawnmower Man*, an entirely computer-generated music video for the Grateful Dead, as well as several national spots, including Capri Sun, 3M, Michelin, and Nike. This diverse array of projects represents the versatility of Xaos software and the diverse backgrounds of the artists who use it.
Xaos is located in downtown San Francisco.

Pacific Data Image

Considering itself the oldest continuously operated computer graphics firm in existence, Pacific Data Image (PDI) of Sunnyvale, California, is known for its development of graphics, special effects, and computer animation. Founded by Carl Rosendahl with his two partners, Glenn Entis and Richard Chuang, the company now employs more than 45 in its Sunnyvale studios and another 20 in its branch office in Hollywood’s Raleigh Studios, a studio that was established a little more than four years ago.

The company started in 1980, a time when people doing computer graphics wrote their own software and most of the applications being developed involved CAD/CAM flight simulation for the government. In the early days, PDI competed with four other companies for the small market. PDI began to excel after Richard Chuang wrote a program for rendering a higher resolution picture faster than any of the other production companies. The rendering software eliminated the problems of "jaggies" and made the edges of the images smooth or anti-aliased. The company then began producing broadcast graphics for Globo Television in Brazil. These projects allowed PDI to build a demo reel. The company's big break came after Globo introduced them to Los Angeles-based Harry Marks, who was heavily involved in the on-air graphics promotion for ABC. He hired PDI to work on a new opening for Entertainment Tonight, and when the graphics premiered, PDI began to build a clientele that continued to grow. By the mid-1980s, PDI computer graphics had earned them a four-year relationship with Roger Goodman at ABC Sports and News. The relationship with Roger Goodman
allowed PDI to excel in the broadcast graphics world. Some of PDI's earlier clients include HBO, Cinemax, and TNT. During that time nearly 100 percent of PDI's business was in broadcast graphics, and, although PDI is still involved in the production of this volume of graphics, this represents only 15 percent of their business today.

PDI is president credits their 12-member research and development staff for contributions that allow the company to stay a good two years ahead of available commercial applications. The R&D staff wrote 99 percent of the computer programs that the company uses. Applications created by the staff of R&D such as the morph tool, which was developed by PDI before Terminator 2, can be used by the company for various reasons. From the most obvious use in David Byrne's She's Mad to less obvious use to make trees move a little or make clouds swirl in the background, PDI is constantly creating new ways to apply morph tools; therefore, the staff of R&D continues to build successful applications such as morph tools.

Currently 50 percent of PDI's business comprises commercials, and at one time, they considered moving more into the feature film market, PDI still tries to get involved in the long forms of films (anything longer than 30 seconds). In the past years, PDI has worked on such television specials as Hanna-Barbera's The Last Halloween and has developed the performance interactive character called Waldo C. Graphics for The Jim Henson Hour. The technology used for Waldo was also used for one of the Nightmare on Elm Street sequels and in Barry Levinson's film Toys. In 1990 at the Los Angeles branch, the company created the first film scanner in Los Angeles, which allowed them to attract dozens of jobs in the area of tape-to-film. Before any other company in Los Angeles could obtain a similar device, PDI
had already worked on feature films such as *Star Trek VI, Batman, Lethal Weapon 3, The Babe,* and *The Last Boy Scout.*

With a company guiding goal of and commitment to becoming an animation studio, PDI continues to hire traditional animators. Rosendahl commented, "we let [these animators] do their own thing when they are not working on a client project... [they] are constantly challenging us to pursue new ideas. They tell the R&D people what they need to achieve their vision" (Skalsky, October 1992, p. 60). In the work environment, the art directors and creative directors are free to ask R&D to develop whatever program they may need. The company is "aimed at developing the best tools for traditional animators to do what they do best—bring characters alive and tell stories" (Skalsky, October 1992, p. 60). Furthermore, he explained, there is a full-time person who takes care of the R&D needs of the animators and experiments with new tools they may use to achieve their animation in the future.

PDI also employs a full-time person for training practitioners and documenting proprietary programs. The trainer is therefore responsible for training the new practitioners to use the computer applications.

**Pixar**

Pixar was formed in 1979 as the Computer Graphics Division of Lucasfilm, Ltd. George Lucas recruited Dr. Ed Catmull, then director of the Computer Graphics Laboratory at the New York Institute of Technology (NYIT), to develop state-of-the-art computer technology for the film industry.

At Lucasfilm, the Computer Graphics Division applied its research to the practicalities of motion-picture production. Sequences of computer animation were produced for *Star Trek II: The Wrath of Khan, Return of the*
Jedi, and Young Sherlock Holmes. They successfully created realistic computer images that were seamlessly integrated with live-action photography. The technologies used to accomplish this work ultimately led to the Pixar Image Computer, Pixar's first commercial product.

Because of the potential applications for general-purpose image computing outside the film and entertainment industry, the Computer Graphics Division was spun off from Lucasfilm in February 1986 and incorporated as Pixar. The division was acquired by the employees of Pixar and Steven P. Jobs.

The company also created commercial software and introduced the RenderMan Interface Specification in 1988, its first RenderMan-based software product in 1989, and a series of related software products in 1990. The company sold its Image Computer business in April 1990 in order to concentrate on its animation services and software business. Pixar's research in computer animation inspires advances in rendering technology, and the company maintains an award-winning, in-house animation group. Pixar's animated film Luxo Jr. received an Academy Award nomination in 1986 and won major prizes in a number of international film festivals. Tin Toy, produced in 1988, won the Academy Award for Best Animated Short Film.

Two Trainers

In this section I will look at the backgrounds of two trainers from two Bay Area companies, Xaos and Pacific Data Image. This section will precede the comparison of the five principal concepts detailed in the previous section.
The data were collected through main interviews and series of follow ups with the trainers at their places of work.

Roberta Brandao, Trainer at Xaos

Born in 1966 in Brazil, Roberta Brandao studied at the Escola Superior de Desenho Industrial, where she pursued a bachelor's degree in graphic design and industrial design and graduated in 1988. While in Brazil, Brandao worked in the clothing industry, in which she freelanced as a graphic designer and developed clothing patterns. In America, Brandao attended The Ohio State University, where she focused on computer graphics and animation. She received a Master of Arts degree through the university's Advanced Computing Center for the Arts and Design. Brandao explained the formal education she received:

My previous training was in design, graphic and industrial design. I kind of got into computer graphics while I was doing design, but I didn't have any formal education then. I had a few courses like programming. Then I came to Ohio State University, and that's when I got some formal education in computer graphics. So I went through a Master's program that taught the basic principals of animation, but applied in computer graphics. I took lots of courses in the more technical departments at Ohio State like Computer Science and Math. I did not take courses in any of the visual arts-related programs when I was there to get my master's.

As a graduate of the Department of Industrial Design with an emphasis in the ACCAD, Roberta received training specifically in the area of computer animation. She recalled, "when we were at Ohio State we didn't really get any formal training in animation, per se. It was very much focused on how to use the computer." But at ACCAD, Brandao acquired the skill to learn and
adapt to the changes in the computer programs. While Brandao struggled to learn the intricacies of the computer programs, she experimented with computer animation. Brandao began working at Xaos in animation development and special effects for the film, video, advertising, and broadcast industry from 1991-93. In 1994 she worked as a line producer at the same company.

Brandao is currently in charge of the training and documentation in the production at Xaos. In December 1994 I interviewed Brandao at her place of work. Brandao works part time and conducts training sessions for approximately five hours daily. I met Brandao early that morning for the first time. Before this meeting I had communicated, via telephone and letters, with Linda Jones, the company's publicist. After seconds of waiting at the receptionist's desk, I met the young woman who appeared to be comfortable in the environment. After a brief introduction, we moved to the company's conference room at Roberta's request. In the conference room we reviewed the company's demonstration tape that showed examples of the company's style and productions over the five years they have been in business. While the video played, Brandao took the opportunity to explain the purpose and process of the various short segments. The video consisted of various examples of portions from television commercials and feature films that were done through the use of Xaos proprietary software, and by the end of the approximately ten-minute video, Brandao had confirmed the positive image I had of the company's projects.
Jennifer Yu, Trainer at Pacific Data Image

Born in New York in 1964, Jennifer Yu attended Stanford University and majored in biology. After her graduation in 1987, Jennifer took a year off to prepare for the National Olympics in fencing. Jennifer began working for NeXT Computers, Incorporated in 1990 as a localization project manager. In this position she translated software, documentation, and on-line help files; she worked with the technical directors to resolve user interface design and interpretation issues that are involved in translating a software package into six foreign languages. At that company Jennifer worked with static images, and although she was involved in the development of computer user interface, she was not involved in animating graphics.

While at NeXT, Yu gained an understanding of how to work with a product and a process. In August 1994, Yu began working as a trainer at Pacific Data Image, a new environment in which the employees were involved in creating pictures on a large scale. This new position intrigued Yu because it allowed her to enable creative practitioners to use the computer as a tool without its becoming an obstacle in the way of their creativity. After receiving encouragement from a producer whom she knew at PDI, Yu applied to fill an available position at the company. Yu recalled that “it was more of a personal connection than me actually going after the job.”

After several telephone calls to the company, on December 16, 1994, I met with Jennifer at PDI. It was my second visit to the company. On the first visit I had spoken with Michael Collerey, who suggested that I speak with the trainer. Jennifer met me at the lobby in the area of the receptionist's desk, and we began a meeting that led to the company's kitchen area, then to a conference room. We settled in the conference room and continued to
become acquainted. This was also an opportunity for me to inform Jennifer about the purpose and goal of the research.

After the main part of the interview was completed, we moved to another conference room to review the work of the trainees' mock projects. Throughout the training process, the students at PDI are required to create a short 3-D computer animation that act as the final projects of the animators in training. Although these mock projects are done using 3-D animation techniques, training practitioners are encouraged to view the projects as an opportunity to focus on a specialized area of digital effects, such as digital lighting, animation, or building complex 3-D models.

As the trainer, Jennifer is involved in guiding new practitioners to develop their desired specialized areas within the field of visual effects.

Goals

The goals of the trainer in the production environment of Xaos and PDI range from simplifying the program manuals and fostering an environment that will be conducive for trainees and practitioners to learning a new software or program. The group collaboration in these industries often yields to group training. Brandao explained, "in my view when you are working in production, and especially with a company like Xaos, as an animator, you pretty much need to work as a team player, and that's how I see training in this field right now." But Xaos goals did not always promote a team-learning environment. Brandao recalled, "recently I started to train new animators, which is something completely new in this company and I believe in a lot of companies." Like several others, the company once used instructional videos and technical directors as a primary method of training.
But now, as Brandao explained, the goal of training is carried out through a training program, and the emphasis is more hands on and pragmatic. "Mainly the way you get trained is by doing it and by talking to the people who work with you. That is the way I was trained when I started, and while I was still animating I was already training the new people. As you learn, you already start to teach." This goal of having practitioners train each other at Xaos is also a goal at PDI. Yu explained, "some of the people from prior training classes have taught classes themselves." Unlike the goal of Brandao, Yu's goal is to bring the areas of production together. She said, "I'm more of a supervisor and coordinator because you really want people with production experience to teach the classes." Yu's background is not in digital production, whereas Brandao had worked in production at her present company before she became a trainer; therefore, she is able to use her experiences as an animator in training. Yu is inexperienced and relies on experienced practitioners at PDI to assist in fulfilling the goals of the training program.

Unlike Xaos, PDI has been committed to having a full-time trainer since it started. The longest gap without a trainer was when the last person left and when Yu arrived about six months ago. Similar to Xaos, PDI is dedicated to training for one main reason; they have proprietary software, and it is therefore impossible for the new practitioner to gather experience and knowledge of the programs at a university. According to Brandao, the proprietary software requires that the trainee "pretty much have somebody who has used it extensively to be able to teach it because a lot of it is not documented." The training at PDI "is for new hires... and also there is ongoing training because we have internal R&D."
Another goal of the training program is to build on the prior computer knowledge the trainee may have attained from a formal education or that a practitioner may have from learning a computer program in the past. But the goal is not just to help those who are familiar with computers but also to help those trainees who have a more traditional film animation background to become acclimated to the computer and its purpose as a special-effects tool. Yu explained that the training program at PDI

...assumes that most people will have somewhat of a computer background and have the basics of computer graphics. So as soon as they come in the door we try to give them a really broad overview, not exactly them becoming expert on one tool because the class is only about one or two hours a day. But just give them an overview of what is possible and the way we do things at PDI and I can show you some of those diagrams later on. There are some people, though, who have never touched a computer before. So we had one person coming over who said he'd used a Mac before. I think he had worked with claymation so it was quite different. So there are people like that we need to give them a broader background on how to use a computer.

Both trainers seemed to suggest that the ultimate goal of the training program is to bridge the gap between a formal education and corporate production. As Brandao explained,

when you are in a company, there is a much more focused goal. You are producing, that's why it's called production. When you are in a program like Ohio State, the students have their own goals but you are not working in a group environment. There are demands from the teacher and everything, so you are producing but you are producing for yourself. Another thing that everybody notices is the amount of work that you are expected to produce: the deadlines and the fact that the pressure is tremendously higher when you come to a production company. When you are in a program it is a much more relaxed
environment and the focus is not so much to produce as much as to learn.

The trainer's responsibility is also to prepare the animators to fulfill the needs of the clients in the most cost-efficient way possible and to provide a general understanding of the company and its functions. This was evident in the dialogue with both Brandao and Yu. In response to a direct question about the goals of the training program at Xaos, Brandao said,

the goal is to give them a better start in production. To give them an overview of what's available so that they can make their own choices when they have to, and to train them in the software as much as possible without actually being in production. The training doesn't stop with me. The training I do is just a preparation. Like when you prepare a kid to go out to school and then the kid has to go to school and learn on his own. It's just a preparation on how they are going to deal with the software and environment. Its more like a theoretical foundation.

In addition to maintaining these goals outlined by Brandao, the goal of the training program at PDI has two additional functions. According to Yu, the primary goal is to get everybody up to speed with the process and the way things are done at PDI; another is to foster an environment that nurtures, supports, and familiarizes the trainees with the entire "production process, not just the tools...like they are part of the company."
Functions

Trainers in the Training Structure

To meet these goals, the trainers are asked to perform certain functions. Yu functions more as a coordinator and is responsible for collaborating the human resources at PDL. Yu explained,

My involvement is to work with the other animation managers and also projection ID people to figure out what everybody should know. What things do they agree should be the basis of all the training classes. So it is sort of my job to pick people's brains and figure out what the core of the course is. The teachers are all people who are animators or R&D people and I sort of oversee the program that way and track progress. Yes, and arrange a lot of the classes for the ongoing training as well. I do documentation and supervise our technical writer as well.

Yu's function as supervisor of the technical writers is to ensure that the manuals are written with consistency. She supervises the writing of the manuals and writes the outlines "so that when people teach (because everybody has a different way of doing things or a different approach) ...they all sort of go through the same training points for every class." This results in an outline for the class and a model for delivery of instruction.

As a former four-year practitioner in the area of animation, Brandao is more practically involved in the training process.

I am pretty much using my previous knowledge and years of experience in animation here at Xaos. I just started this training program so it is a lot of trial and error right now. I try to gather pieces and put it in a more understandable and easy to learn manner for the animators, instead of having them go through it on their own....I create handouts and supplements to the existing documentation. I also videotape demos other people might give on a software....We [Brandao and the trainee] will go over it [the training program] as long as it takes to click in.
Brandao provides the trainees with a model for problem-solving Xaos software. Her training focuses on a systematic method for assembling different functions of the program, rather than simply going into detail on any single software. This approach provides the trainees with a practical template for using Xaos tools.

It gives them conceptual understanding and foundation on how to put things together. Because of the software we have, it is a very problem-solving-oriented situation. It is not so much learning the software itself but learning how to solve problems that come up with the software when you're using it. So there are some things that are basic to any kind of software that you learn, how to go about it. There are other things that you have to learn that are specific to each software.

According to Brandao, training is a challenge because the software programs were created over a five-year period by different people; therefore, "it is a software collage," and it often requires a different approach for learning them.

Similar to Yu, Brandao also schedules time for other practitioners to aid in the training process. Brandao explained, "sometimes I bring in other people, other employees who then talk about some specific areas that are their expertise or that I might not know best." But it is evident that at Xaos these practitioners aid the instruction and are not the primary instructors. Unlike Yu, Brandao does the majority of the actual training and is constantly learning new tools. Brandao explained why she is currently learning new software. "We are developing new animation software right now and I'm testing it and using it so that I can pass the information on." However, at both companies, production takes precedence over training.
Perhaps the most crucial difference between the trainers of Xaos and PDI is that the two trainers have distinctively different schedules. Brandao has two different types of days. She explained, "the first type of day I have is when I spend time with the animators, showing them the software practicing and talking about the theory behind it. The other type of day is when I am either looking at new tools and or documenting them. I also help other animators." Brandao helps anyone with questions that pertain to problem solving or troubleshooting a software. She works with the trainees for about an average of about three hours in a session. Her part-time obligation with the company permits her to train the students in periods of three hours per session. "We're going over some concepts or doing exercises," said Brandao. "Then when I'm developing, I figure out what kind of new exercises I need to develop." In contrast, Yu coordinates the various human resources and is more involved in the scheduling of the teaching practitioners to meet with the trainees for the instruction sessions, devising teaching methodologies, and assisting with software documentation.

Training Program Structure

The goals that pertain to training are often met by the various functions that are performed by the trainers or the company as a whole. To fulfill the goals of the training program at PDI, the entire staff may contribute. Yu explained how these functions are combined towards the goal of training. "We have technical classes on how to use the tools, and we also have classes with producers talking about the pre-production process, where we talk about bidding about client relations, with R&D." The trainees are trained by others in the company. "They are meeting with new people everyday, and the new
people get to see them, too, not just on a production all of a sudden. You get to see these people and learn who is an expert at what and they can learn about you as well." Trainees are assigned to mentors.

The mentoring process...it is very difficult to just be thrown in the system [production environment] and the mentoring process is to give them some feedback to learn how to use a certain tool for example, so they know how to work something and they can go through it. So the mentor offers more production-related feedback as well as just general support, technical support.

At Xaos, there are no officially assigned mentors to aid the trainees beyond the training program. Instead, according to Brandao, a technical director aids the animators beyond the training. This particular technical director is not assigned to any specific job. Instead "he or she works on every job and helps set up things for the animator." This technical director may also assist the animators to develop problem-solving techniques for approaching the project efficiently. Brandao added, "on a daily basis this person is like a technical guidance person." Whether through a formal mentorship program or through informal mentoring, at both companies the trainees rely on senior animators and technical directors for additional training beyond the training program.

Before the trainees can take advantage of the use of this technical supporter at Xaos or the mentorship program at PDI, they must have received some training at the company. This training prepares the trainees through an initial overview session. This overview session provides more general information about the system and programs. The overview precedes specific training on a particular software. These sessions are held every day for the first two or three weeks of training. "There is no classroom. It's usually me
and one or two animators." Brandao explained how the structure works. The structure of the training program at Xaos allows them to explore beyond the basics that they are taught, and combine different aspects of the software on their own. The trainees are not given any specific assignment that may reinforce their skills; instead, they will receive support from the trainer if a difficulty arises while they are practicing. "We work on something, and then after we go over the basics so the person understands what's going on. If they want to go any further and enhance it or do anything extra, then they are encouraged to do that on their own time."

At PDI, completing the training program qualifies the trainees to be assigned mentors. The construction of the program requires that trainees complete four to six weeks of training from the day they were hired. But according to Yu, this is the most favorable time to have them start because "...it is very difficult to pull people [trainees] off of production once they have committed to work on projects." Within the training period, the trainees are given "...a complete cycle from 2-D all the way to 3-D and lighting." The fact that the classes are taught by various practitioners within the company means that the structure of the individual classes may vary from organized to semiformal, depending on the teaching practitioner. As Yu explained, the instruction may range in intensity from conceptual to practical.

Some people tend to be really well organized and have things prepared in advance, and others will sort of construct things on the fly like this is how I would set this up and they will make a little ball and they will make it bounce and things like that. Other people, which I think is more effective, will have prepared examples, one we used in the past, which is actually a job that was done in production a couple of years ago.
At PDI, the trainees are assigned projects outside the classroom during the training period. Their assignments are of two categories—two dimensions, and three dimensions. The assignments provide trainees with guides for measuring and practicing what they were taught in class. In addition, these assignments give the trainee the opportunity to work out the problems they may have with the system before they are assigned to production. But the trainees may get real experience in how to produce animation or create images on a computer when using the company's proprietary tools.

Plate XIV Singing Cow Project, PDI

According to Yu, on the 2-D practice jobs the trainees work on images that are in production already—a singing cow from a past television commercial or a box that morphs and jumps up. For the 3-D project, the "focus there is to have them do what is called a mock job where they come up with a small little piece themselves." The real production experience appears at the point when they "storyboard it out and have a producer tell them set schedules" when parts of the project should be completed. Perhaps the least obvious, but most important, practice received from these 2-D and 3-D assignments is the chance for the animators in training to work on first creative ideas using the available tools at the company. Yu explained that "some mock jobs actually
become personal projects at PDI. Like Gas Planet, I believe that one started as a mock job as well."

Beyond the mock project, further evaluations for mastery of the material may be conducted informally by the trainees' mentors and managers. Yu explained how the managers may become involved in the evaluation of the students' projects. "If we have done something like a practice job, the manager will stop by and see, and also the mock job, too, and nobody can really do a mock job in a vacuum because there is so much that they need to learn." Like the training program at Xaos, PDI classes have the primary function to provide an overview of various programs. However, the trainees at PDI may also be evaluated by other trainees in their class. This also
helps the trainer to track the trainees' progress after they receive the instructions.

If someone wanted to learn a specific technique for a mock job they can call on other people in the group, then those people will give feedback later on. They may say that I helped this person on their mock job therefore can vow that they really know it well, or they didn't understand this part of it, and if so their manager will stop by and see how they are doing. Plus we ask them a lot of questions. We usually find that a few people won't hit this point, but almost everybody hits that one panic point where it is a little overwhelming and then it kind of calms down.

The training program is mandatory for all new practitioners at PDI, including new practitioners in research and development (R&D); however, similar to Xaos, "if there is a production crunch some people might get pulled off earlier or be asked to work part-time while they are training." According to Yu, the training program is really geared toward animators; therefore, any animator is hired goes through the full process. Yu explained the reasons for training the new R&D. "We want them to understand the production and the use of the tools that they will be developing."

The trainees at Xaos are not tested for mastery of the program before they are placed on production jobs. Although Brandao provides trainees with general guidelines and ideas of what to explore and even asks that the trainees show her what they have done as they are practicing, the true test is on the job.

I don't test them. They are tested when they start working on a job. I teach them and it is up to them to tell me if they have understood it or not. Once they need to use that tool in production then I guess that's their test. And sometimes what
happens is they don't feel quite confident or they didn't quite understand something so we go over it again. There is no testing or grading or anything like that.

Few real incentives are provided to encourage the trainees at Xaos to learn the proprietary software while in training. The main incentive is that it may save them time—an important factor at a production company. The fact that the trainer goes through the basics of the computer programs means that the trainees receive a guided tour—a walk-through of a program and its basic functions. "Okay here is how to load it and what it does, and how you do this and that." This procedure saves them time, because the trainees no longer have to figure out the entire program on their own.

Being a beta tester is one of the incentives used at PDI and Xaos to ensure that the trainees keep current with the changes in the software beyond the training. New tools are constantly being developed at these companies. After the training program at PDI, new practitioners are encouraged to test the tools being developed by the R&D practitioners. "So from the very start their feedback is incorporated so they are sort of tied to this tool from the beginning." But the true reward for these testers is the feeling that they are not limited by the software that has already been developed.

After trainees at Xaos have acquired a certain degree of confidence on the programs, they, too, can become beta testers and may work with programmers to create new software or trouble shoot existing software. On the way to becoming animation practitioners at Xaos, trainees will sometimes come up with ideas that may be useful for improving an existing software or that may create a more comprehensive program. Trainees become part of the research and development at Xaos and may join in on critiquing a software.
"We also have a person who is a liaison between the two worlds. In addition, people interact and talk about bugs and problems when a new tool is released until the tool is fixed."

In PDI structure, Yu functions as a liaison between the animators and R&D. But similar to the situation at Xaos, the animators at PDI also work with R&D practitioners to create new programs or troubleshoot existing programs. According to Yu, R&D practitioners rotate between working on a production as technical support and being assigned to a job. For example, she explained, "they are assigned to support...they are trying to create a new water effect. An R&D person might be assigned to support that effort and come up with new tools for that project." Additionally, there is also ongoing tools development, "like the paint program which might be used for many productions." So animators work closely with R&D practitioners on a project, as production support, "and they also give a lot of feedback on long-term projects." This collaboration may be initiated by either the animator or R&D.

Some R&D people really know if I do this to this tool it really optimizes it and it would be great. Like I know this one technique that would make this tool fantastic, much faster and much more capable. So a lot of it comes from R&D people based on things they have learned from SIGGRAPH or from each other or from other animators in other companies that they want to implement, and a lot of it is the animator saying I want to be able to do this, so it comes from both places.

Limitations

At both companies, trainers are sometimes limited by the structures of the training programs. Often these limitations are brought upon the trainers because of their own personal limitations of skills or limits of their
responsibilities at the production house. These limitations often prohibit them from performing their jobs in the best ways or under the most favorable conditions. Limitations are specified by the trainers to the trainees, or the companies to the trainers.

At PDI, Yu is often limited by her confined knowledge of producing computer effects. She relies on the practitioners at the company to teach the trainees. She coordinates and documents but is not qualified to teach the various practical applications. As Yu explained, "I can say, oh, it looks good, but really someone with production experience could say this image needs to be tweaked a little bit this way, or you might try this approach." On the other hand, Brandao, once an animation practitioner, knows how to produce computer effects using the computer applications and is not limited by a lack of knowledge of the computer programs.

Undocumented software may limit the new practitioners' abilities to perform and continue to learn independently after the training program at PDI. At both companies, trainers have reported that it is impossible to investigate all the computers during the limited training period. But as the trainers attempt to organize a systematic method of instruction, they run into obstacles. One of the primary obstacles lies in the fact that most of the older programs have not been documented. Students must rely on consulting older practitioners for answers to problems on undocumented software. This practice limits them, but it is impossible to learn these software on their own.

A lot of it tends to be sort of folklore asking people...there is quite a bit of verbal history around here, so I think there we could do a little bit better in that area of formalizing that and spreading that knowledge. Right now if I had a question about some 2-D effect, I will go to Ray for example. The information is
all out there. It is all in people's head. So when somebody new comes in it is a little harder for that person to figure out which tool to use or how we use it.

In the past, trainees had limited user interface options. The only option was to work with the command line interface, and there were few interactive user interface designs. The command line interface limits the artists' creativity, because the interface is non-intuitive and does not allow the artists to view the work and interact with it simultaneously. Yu explained why PDI is working toward the development of more interactive user interface.

We had to get away from the command line interface because animators are very visual people. So we really try to make more of our tools interactive, especially for people coming from a background of third-party software; they are not going to pick up the command line very quickly. So we like to help those people along faster.

At present, the learning process for each tool is different and can be confusing. Yu added, "if you want a mass number very quickly, you have to have a consistent user interface so that part of the learning they don't have to worry about."

At Xaos, there is less limitation on the trainer-to-trainee relationship, but the structure at Xaos limits the trainer and may affect the way the classes are taught and the cumulative hours they meet. According to Brandao, it is difficult to have them in training anyway, since after the initial two or three weeks, they are already assigned to production, "so they can only go to some sessions once or twice a week. At the same time, they have these other responsibilities so after they are done with the training they usually go back to
work on their job." Yu has described a similar situation. However, Brandao has further limitations in this area. She does not have the liberty to schedule actual classes; instead, she works with the individuals in personalized sessions. Her training schedules with the individual trainees depend on the trainees' production schedules. "It really depends upon their availability. Because I don't make the decision on how much can I train them for how long. It's depending on how much time off they have from the job." This time constraint may be the main reason why trainees are not trained on the details of the various software.

Perhaps the core of all these limitations derives from the fact that the aim of the trainer is to train as opposed to educate. This factor implies the reasons why the trainees are given less of the whole picture and are limited in their focus. Brandao further explained the differences:

Academia in my view is really focused on theory more than practice, and we're really much more focused on practice than theory. It's like, two worlds completely apart. When I say I give them a theoretical foundation, I mean I give them a theoretical foundation on the practical applications that they're going to use. In a program like a Master's degree you really mainly learn theory, and only go into practical applications of what you've learned when you are out of the program.

Value

The values are the summary of the artists' statements that suggested some benefits or motivation for entering the training program. In addition, this section examines the value of the trainees to the trainers.

Once an animator, Brandao values the training program and knows the frustrations of new practitioners at a production company. Brandao is motivated by the fact that she is involved in a valuable and meaningful
program that utilizes her prior knowledge as an animator in assisting new animators to make the transition from a formal education to production.

Well, the reason why I wanted to start training was because I went through a lot of frustration and there is a really high level of burnout in computer animation and production because it's a stressful job and it demands a lot from you, and in most cases you don't have any training so you really have to learn on the spot. A training program benefits everybody, the company and the employees. So for me it was a way of contributing to both at the same time, so that is what motivated me.

Beyond this motivation to teach others comes the personal value that the trainers are often able to learn the programs along with the trainees. Brandao is able to learn both from the experienced animators and by working with the trainees. "The way I learn more is by talking to animators when they are working in production, since they might be using tools I am not completely familiar with or might be running into situations I haven't dealt with."

Possibilities

In this section I will examine the statements that suggest a need for improvement of the training program or the statements that suggest possibilities for further trends of the training program or the company as a whole. Additionally, this section looks at the advice given by trainers to suggest ways of revising the computer graphics curriculum at the university level to better prepare individuals for the field of special effects.

Both trainers seem to agree that flexibility is a key qualification for working in the production industry. Therefore, trainees need to develop good problem-solving and creative skills for approaching computer effects.
Granted that these individuals may not have access to proprietary programs, they may, as Yu advised, try to use whatever off-the-shelf software may be available to them to create a desired effect. According to Yu, these individuals should also concentrate on developing an understanding for the underlying principles as well. "We find that people without a computer background can be really successful here, too." But these individuals should develop the confidence to approach the computer. They should at least not be "scared of typing something for fear of blowing up the world." In addition, Brandao believes that individuals can also prepare themselves for the field by learning what the options are for employment in the field. They should also produce as much as possible. Both trainers agree that computer-generated special effects can be taught effectively at the university level to produce specialists in the field. Brandao described the criteria that will allow the schools to meet this objective.

I think most programs should change because you do need a solid theoretical foundation, like most universities provide. But you need the practical side, too, and most programs right now are very individual oriented, where students produce their own things. They have their own research but they don't work in groups and they don't learn how to communicate and the whole idea of interacting together in a group situation when you are producing a collaborated product. And that is mainly what you have to go learn when you come out. I also think that the university should encourage students and even require them to go out in the field and get some kind of practical training prior to finishing their degree. From the university's point of view, I would try to create some link with CG companies and bring professionals in the field to the university to talk to the students about what is out there.
By establishing a concrete relationship with effects companies, both the universities and the industry will benefit. The universities will have a first-hand knowledge of the current state of the industry. This knowledge will provide them with the information they need to steer a computer graphics program curriculum in the direction of production. It will also expose students to various possibilities of the interdisciplinary arts environment of the industry. In return, the companies can profit from being involved in the students' education from an early stage. This plan will provide companies with the opportunity to monitor the progress of the students and establish a concrete relationship with them before possibly hiring them. Consequently, less training may be mandatory at the time the students are hired because the companies will have helped to guide and direct the students at an earlier stage.

In the future, PDI hopes to develop consistency among their program interfaces. Yu explained that "right now some of our tools have a different user interface because they were developed at different times in different atmospheres...in one tool when I press on the mouse button it might zoom ...and in another program this command might do something else."

Brandao was optimistic about the future. She believes "the training will die eventually," but first the animators must understand the tools enough that they will have to rely only on the technical director for guidance. The termination of the training program is evident at Xaos, as the training program is not mandatory for all new hires at Xaos. "Maybe somebody who feels confident in just jumping in might not go through the entire training program."
Discussion

Training at these two companies follows the basic format of presentation, practice, and feedback. Trainees are presented with the new material during the class or session. At this time they may ask questions that will help them to clarify the material. They are then given time to practice what was presented to them by the trainers or practitioners. This practice time may range from a couple hours to several days, to several weeks for the overall mock project at PDI. After they have completed the practice lesson, they may be given feedback by the trainer on the work they have done. Often, these three categories are inseparable. The trainees may encounter a problem that may prohibit them from finishing the practice lesson, and they may have to consult the trainers for additional presentation and preliminary feedback because the practice is not completed.

The overall purpose of the training programs is to prepare new practitioners to produce computer-generated special effects through the use of proprietary software of the companies. However, time is an important factor; therefore, the trainers must come up with an efficient way to train the new practitioners in a limited time. When appropriate, the trainers may appoint specialists in particular areas of computer effects to instruct the course.

As a result of examining the statements of the two trainers, these differences were discovered:

The training program is not mandatory at both companies. At Xaos, the training program is not mandatory for all new practitioners in production, but at PDI all new practitioners must go through the training program.
At Xaos, the trainees are not tested before they are put on production, but at PDI the training program requires that the trainees complete a mock project before they have completed the training. The trainees at PDI are constantly being evaluated by other practitioners, including their peers. Other than the trainer, other practitioners may evaluate the progress of the trainees. They are assigned to mentors, who may evaluate them while helping them to become familiar with the production environment. In addition, they may be evaluated by their managers and technical directors. These evaluations are seldom formal, but they suggest that in an environment of more support for the trainees, there are likely to be more evaluators monitoring their progress.

At Xaos, the trainer takes an active part in instructing the new employees, whereas the trainer at PDI is primarily involved in coordination of schedules. Although Brandao may coordinate the schedules to work with the trainees, she is also responsible for documenting the manuals and instructing the trainee during her part-time commitment at Xaos. Yu, on the other hand, is responsible for assisting with documentation and coordinating class meetings with the practitioner. Yu acts as a liaison between the two worlds of the company's computer artists and programmers.

Two Trainees
In this section I will compare the backgrounds and the five philosophical categories, mentioned in the earlier section, of two trainees—Alexei Tylevich of Xaos and David Tart of Pixar.
Alexei Tylevich, of Xaos, Inc.

Born in Minsk (Belarus), Russia, in 1972, to two visual artists, Alexei Tylevich was exposed to art from a very early age. Continuing on his own predetermined path, Tylevich earned a bachelor's degree in painting at the Minsk School of Art, Russia. After this, he moved to the United States and continued to study art. He began at Minneapolis College of Art and Design in 1990 and majored in Visual Communication in his freshman and sophomore years. In his junior year, Tylevich was introduced to computer graphics and animation, which became the focus of his major at the college. At that time, Alexei said "they didn't have an extensive computer lab facility so I studied illustration and graphic design." He took graphic design courses, in which he received Macintosh experience. "From the Macintosh I got more into 3-D than computer animation. So I started with the Mac 3-D software and that was real limited so I decided to use the SGI. I took...one year of Wavefront classes..." Tylevich did not study 2-D computer graphics; instead, he went directly from graphic design to 3-D computer graphics. His main reason for shifting his focus to computer animation may have been the restriction he felt while in graphic design. "At some point print became too limited...I was interested in what was going on in the video industry. I got more interested in moving the images I create." Tylevich became interested in synthetic creation. He graduated in 1994 with a BFA degree in Visual Communication and Computer Graphics.

While pursuing an academic career at the college, Tylevich was also involved with the professional design world and worked extensively in that area. Between 1992-93, Tylevich worked as a graphic designer for P. Scott Makela Work and Pictures for Business and Culture, after which he found
employment at Walker Arts Center, where he worked for six months. From 1993-94 Tylevich worked for freelance art director Bill Thorbum. Tylevich began working at Xaos Incorporated in animation and special effects for the film, video, advertising, and broadcast industries in October 1994. Before going to Xaos, Tylevich freelanced and was involved in the art direction and, in some cases, did computer graphics for Sega, AirWalk, Microsoft, and Nike. But it is his three-minute animation that gave him the most attention, even by the recruiters at Xaos. After viewing the three-minute Wavefront animation that was shown at SIGGRAPH in 1993, Xaos hired Tylevich. His animation was shown at many other conferences in the following years.

Currently employed at Xaos, Tylevich is being trained to use the proprietary tools at Xaos. In December 1994, when I visited Xaos to speak with Roberta, she selected Tylevich as the trainee to be interviewed. After a 30-minute tour of the complex, I interviewed Tylevich. His small office was on the second floor and housed two practitioners. His work area consisted of the bare essentials for a computer animator—a large SGI monitor, a desk, chair, and electrical cords, naturally woven together, that linked his monitor to a CPU housed on another floor. There were no windows to allow the sun's rays to peep in; instead, fluorescent bulbs completed the look of a business office, even in the back room that Tylevich calls home for forty-to-sixty hours a week.

Tylevich agreed to meet me in the conference room where the interview was conducted.
David Tart, of Pixar

Born in North Carolina in 1963, David Tart began his arts education career at Odessy, an alternative middle school, where he studied music, photography, printmaking, and drawing. The staff at Odessy included photographer Bill Dane and printmaker Rupert Garcia. Tart continued to pursue an academic career in art and attended Carbrillo College, where he studied music and computer science. He eventually transferred to San Francisco State University, where he joined the Department of Interdisciplinary Arts, a department that allowed him to mix various disciplines.

In the department, Tart constructed a personalized course of studies that combined classes from the disciplines of computer science, computer animation, and film animation. Tart took time off from school in the late 1980s to freelance as a graphic artist. Using desktop publishing, he worked for various print shops and designers in the San Francisco Bay Area. In 1991, Tart returned to school at San Francisco State University. At the university, he majored in interdisciplinary arts. He entered that program with hopes of becoming involved in computer graphics and computer animation, but no program existed at that time at San Francisco State that was designed specifically for computer graphics and animation. Tart decided to enter into a more open-ended interdisciplinary arts focus, in which he could choose his art courses and core major. Tart took a combination of traditional animation courses and computer graphics courses. The computer graphics courses he enrolled in ranged from 2-D Macintosh paint applications to Macintosh 3-D animation programs and Silicon Graphic Iris, Wavefront.
His goal was to learn how to use programs to create 2-D art and 3-D art and then combine those into integrated programs like MacroMedia Director to create animation. Concurrently, he decided it would be in his best interest to take some computer science classes in the Department of Computer Science. He wanted to be more than just an end user, and by enrolling in the science courses, Tart tried to gain a more concrete knowledge of how the computer work and what it is doing to his images. "I wanted to have a little bit more knowledge and possibly a little bit more control over the computer." Tart took UNIX courses and some computer fundamentals courses in the sciences. He did programming and wrote a compiler. "The programming courses were fairly intense and I decided at that time that I didn't want to become a technical director." Tart recalled.

What I saw happening in the industry at that time was that there were really two positions opening up for computer animators. One position was the computer animator who was responsible for the character animation, movements, and otherwise whatever character or object was on the screen. Then there was the technical director who was responsible for maintaining the latest versions of software, working with the animator to make sure that the animator wasn't having any trouble with the software and basically being more of a technical backup for the creative person, in this case, the animator. So being involved with hard-core computer science students sort of pushed me to move towards the more creative side and that's when I decided to begin immersing myself in traditional animation.

At San Francisco State, he took classes in traditional animation through the Department of Cinema. He enrolled in a series of four courses taught by Pat Amblin in the Bay Area. "Pat Amblin emphasized learning the basics of animation and working in a lot of different mediums." In the first course, he
worked on five projects in four different media—paper manipulation, cel animation, claymation, and computer animation. Amblin's class allowed Tart to become immersed in the production and to experiment in a lot of different mediums. The education he received through the university's cinema department was geared toward preparing students to be creative directors of independent animation films. Tart attended two semesters of traditional animation classes, during which he engulfed himself in the medium. He enrolled in advanced computer graphics courses in which he studied under Jane Veeder, of the Interdisciplinary Arts Department. "She was very educated and very familiar with a wide range of computer graphics systems and platforms." Tart graduated from the San Francisco State University in 1993 with a Bachelor of Arts degree from the Interdisciplinary Arts Department.

After graduation, Tart had initial plans to continue his studies at a university in Germany. He had planned to focus on virtual-reality-based interactive art and continue to explore computer graphics applications through the use of high-end workstations. After receiving a job offer at Danger Productions, a traditional animation production company that had just landed a Saturday morning series with the ABC children's show Bump in the Night, he decided against continuing school. At Danger, Tart worked with a group of animators who had just finished working on The Nightmare Before Christmas, a high-end stop-motion feature film. "I was able to be thrown in with them and learn from them. Basically I asked a lot of questions. I needed to get a lot of information about how to animate properly. I continued at Danger until I sort of was saturated with information, and that was good."
At this company, Tart worked primarily as a conventional stop-motion animator but also did some 2-D image compositing for a period of a month and a half before going back to traditional stop-motion. Tart did a 2-D image composite for a three-minute segment at the end of *Bump in the Night*, called The Karaoke Cafe. Not happy with the amount of work that needed to be done, Tart opted to move to another project. He designed a couple of the 2-D computer background and animation foreground scenes in various current episodes. Overall, Tart enjoyed working on the project but felt that he was limited by the computers that were available. He became frustrated by the Macintosh Power PC, which was very slow for the amount of image processing that was required for the episode.

Today, Tart still ponders whether it was luck that landed him a job in the industry. He remembers when he was a student he would inquire about jobs. At that time it appeared it would be difficult to get into any aspect of the field, far less start working as an animator. Partially, he believes a lot of it had to do with networking. Tart got the job at Danger. The president at ASIFA had attended the students' year-end screening at San Francisco State. Tart had several animation shorts at the screening and later when all the animation were reviewed in the ASIFA newsletter, Tart received a good review. Danger Productions' goal, then, was to hire combinations of experienced animators and apprentice animators, and they saw the opportunity to hire Tart.

Tart had always admired the work of Pixar and knew very early he wanted to work at this production facility. The company's reputation for producing high quality computer animation and their efforts to apply traditional animation principles to computer animation are just some of the reasons Tart admired the company. When Pixar began hiring animators for a
feature film project, Tart immediately applied. Pixar found that stop-motion animators could make a transition to 3-D computer graphic animation fairly easily. This revelation happened when a practitioner who worked on *The Nightmare Before Christmas* went to Pixar directly after the project was completed. He worked on several commercials, and Pixar was impressed with his performance. He paved the road for stop-motion animators to transfer their skills in traditional animation to Pixar.

Encouraged by a few of his co-workers who were hired away from Danger, Tart sent a reel to Pixar. Through this networking, Pixar took a look at it. He believes the strongest element that allowed him to get to Pixar from Danger was his skill in character animation and acting, skills he acquired and has continued to study. He believes that these skills are crucial to his being a marketable animator. But Tart had begun preparing himself for the field long before the opportunity arose. While at Danger, he studied theater, movement, and dance. He took creative movement classes and classes in which "you go in and pick up a shoe and you act like it is a telephone or a banana, just stuff that makes you look real silly but increases your ability to animate." By utilizing the information from his theater studies, he put together a reel that showed a lot of character animation, because traditional animation skills were sought by many computer effects companies.

Tart worked at Danger Productions for a year and a half before moving to Pixar, where he currently works on the production of Disney's *Toy Story*, the first fully computer-animated feature film. On December 21, 1994, I met with Tart at his place of work. The interview was conducted over lunch at a nearby park. Due to the company's current confidential project I was prohibited from the areas that were used for production.
Goal
None recorded.

Function
Pixar is a highly departmentalized production company that hired Tart to specialize in a single facet of the visual effects process. Pixar is divided into different departments. There is a layout department, a modeling department, a lighting and shading department, and an animation department. Their animators are solely responsible for movement. They move the models and the characters and animate them, and they have technical people who are responsible for lighting and shading and creating new algorithms, maintaining software, and model builders who use a variety of modeling software. As an animator, Tart has one responsibility: to animate the computer models. The animation department interacts with a few other departments at the company. Tart explained, "we do interact with the laying department and the technical department. They support us if we have a problem. And if they have any problems with our animation they will get with us."

As a new animation practitioner, Tart went through a short informal training program at the company. According to Tart, the program was geared toward teaching student animators how to animate using the tools at Pixar. The animators started on the software with a very simple model of a ball, and that ball had a set of variables for animating, translate X, Y, and Z squash and stretch, so they could make a bouncing ball and become familiar with a model that was simple and easy to animate. They then moved to a more
complicated model of a lamp or Luxo–Luxo Jr. from Pixar's *Luxo* films. They were then told to animate the model and get creative with it and see what could be done with it. Each assignment brought the challenge of creating an increasingly complex 3-D model. "It had several more variables to work with, sketches and translates and squashes and so on," said Tart. From there they moved to a much more complex model of one of the characters in the movie that they are currently working on and that the animators would be expected to animate. "Those models have up to 400 variables for controlling hands, arms, body.... They are very intense. So the training consisted of starting with a simple primitive and working up to more complex models." The animators are taught by a senior animator at the company who is responsible for shepherding the trainees. The senior animator assigned to the group is both trainer and mentor at Pixar.

At Pixar, the training program has no specific length; instead it is assessed on an individual basis. Although Tart was hired concurrently with two other animators as a new batch, his training ended somewhat quickly. His familiarity with computer graphics and with workstation-type applications such as Wavefront, coupled with his UNIX and computer science experience, meant that Tart spent only two weeks in the training program. "That allowed me to excel. Generally it can take up to four or five weeks."

This model of training indicates the extent to which this company is departmentalized. Unlike Xaos and PDI, where the training program looks at all facets for the production of visual effects, Pixar trains its effects practitioners in one area. The animators are asked only to animate and are not trained in digital lighting or any other aspects of the field.
Although he was also hired as an animator, Tylevich, in contrast to Tart, is still in training and works at a production company that encourages him to explore a variety of areas within the field of visual effects. Like most other new practitioners, Tylevich has a background in using turnkey applications such as Wavefront and Macintosh applications. Now at Xaos, he is presently being trained in how to use the proprietary applications as a tool for creating visual effects (see Appendix F). While Tylevich is still in training, he is not given any projects that may exceed his capability and knowledge of the software. However, he is encouraged to use his background education as a graphic designer. He has produced storyboards and is often given small projects that he is capable of doing at this point with his background education. Tylevich uses the Macintosh to do small art project designs and is also involved in art directing. He explained,

as far as I'm concerned at this point there is no strict separation, people do different tasks. I've done some storyboards myself, so people are doing different tasks here and it is not that formal. I worked with the art director as well, because I have to show what I've been doing on the storyboard. I don't see a lot of hierarchy...it is not that narrow. And at other times the storyboard is drawn outside the company.

Similar to Tylevich, Tart is not given any work that exceeds his capabilities. "We work from storyboards. The production supervisor throws out the shots and those shots have the storyboard, dialog, and camera direction information on them." These shots are distributed according to the animators' familiarity with the program.

At both companies, the new practitioners may receive help from any of the senior practitioners other than the trainer or assigned animators during
and after the program, but at times they may learn on their own. According
to Tart at Pixar there is a supervising animator and an animation director
and, like all the other animators, the new animators can consult them when
they are having problems with animation or have any technical questions
concerning the subject. For the technical questions, the animators are
supported by the various members of the technical directing staff. New
animators will use electronic mail as a means for requesting help from the
technical directors (TD). This action usually results in an immediate response
from one of the TDs. At times when the new animators are working on
specific assignments, they may first draft out the action with the supervising
animators and the directors. Then as they refine the animation, it is
reviewed concurrently by both the supervising animators and the directors.
Although the training program is cumulative and there are various resources
for support in learning the animation program, the animators may still be left
on their own to learn the more intricate details of the subject. For example,
Tart said,

when you are assigned a difficult shot and that shot entails
animating in ways that you haven't animated before, using parts
of the program that you haven't used before, you have to just
learn it. ...You ask questions, you pick up the manual or you ask
one of the animators who has been there longer than you. So it
is really a group teaching process, we all learn from one another.

Tylevich often receives help from Brandao on the basic functions of the
proprietary software, but like Tart he, too, must investigate the details on his
own. The model for teaching is more practical than theoretical and resembles
the university model because the teacher is dedicated to training and is not
involved in production. Tylevich explained, "Roberta is helping and I study
some of the documentation on my own by referring to reference, and I am getting little projects so that I can learn more about the software as I go about the project I have to figure out a way of doing it." Brandao shows him the possibilities of the program. "We have set hours, generally two days, four hours a day that I have set for training where I spend time with Roberta." In addition, he uses instructional videotaped documentation to enhance his understanding of the software. These videos are produced by the programmer who has created the software.

The art of creating special effects at these companies is viewed as a collaborative process, and the new animators are usually not allowed to significantly alter a project without the approval of the group. At Pixar, suggestions to change a shot may come from the various practitioners after viewing the shots in the Animation Dailies. According to Tart, when assigned a shot, he is usually asked to come up with some good ideas with some funny actions. Before starting the time-consuming task of animating the shot, he first suggests the ideas for the actions. He will discuss those options with the supervising animator and the director. All the animators will suggest things. They will view the shots together two or three times a week in the Animation Daily, a general screening of all the animation in progress. At this time, the animators point out things to one another, and it is an open session for suggestions from the group, which consists of the director, supervisor, animators, and attending personnel.

The Animation Daily is crucial for determining when the animation has been completed. Tart is constantly perfecting the animation to the satisfaction of the practitioners attending the Animation Daily. Tart explained how he prepares himself for the dailies.
Let's say it is an average day where I am just about to get a shot finalized and take on a new shot. I come in in the morning and there may be animation dailies at 9:00. I'll have exported my work, the latest version of my animation, to the main computer where it can be accessed from the screening room. In the screening room it would be looped over and over and over again with the sound and it would be scrutinized and considered by the director and all the animators there. At that point, let's say everyone likes it and it is finalized. I then send that shot to be finaled to the layout and lighting and all the other departments who are going to take care of the final shading and rendering of the scene. At that point, I'll get a new shot and that shot may consist of one or more characters in a particular project that are interacting in some way. I'll discuss the action and screen direction with the director and the supervising director and I'll start what is called blocking. Blocking is a very rough animation. You move characters from point A to point B in Cartesian coordinate space. You do simple gestures indicating their motions in some rough way and that will consist of most of the day. Later on I'll be ready to discuss the blocking with the director and the supervising animator. They will come back and make some suggestions. I'll work on those suggestions and generally by that time it will be about 6:00 or 7:00 and it is time to go home. That process will continue the next day and the next day until we wind up back in dailies with it being finaled again.

As a practitioner in training, Tylevich's work days are perhaps less stressful than Tart's. Tylevich is not committed to any major project while he is in training. He described a day in training:

I train before lunch for about four hours...so it's basically 9-1. After lunch I do whatever I need...whatever I have to do at a certain point, like work on a small project or do some designing on a Macintosh, or if I have to do some small parts of a project that's going on. Its usually working on some big projects that are in progress and I am doing some parts of it that I can do at this point. So from lunch until six o'clock or whatever, it depends on how long it takes. I work on...coordinating with other people.
Limitation

Both new practitioners have a fair number of limitations that are the result of being new practitioners. The limitations range from creative, as a result of not knowing the software well enough (this is especially the case for Tylevich), to departmental restrictions that force the individuals to specialize in one area of visual effects and prohibit the individuals from gathering a broad base knowledge of the various areas in the field, which Tart has experienced.

Values

Knowing that training allows Tylevich to be more productive as a member of the company, he is allowed time off of production to work on improving his skills. Although it is not mandatory for Tylevich to be in the training program, he believes that the training is of great value.

The company lets me take time off from production, because it's working hours, and have time that is specifically set aside for training. Because, I know in the past people have been just thrown into production and they just have to learn on their own time or at night or whatever.

Perhaps another reason for his self motivation comes from his awareness of the company's alternative options for an unproductive employees. Tylevich said, "I have to know as much about the program as I can in order to be useful and productive. The more I know about it the better and the more efficient I can be."
Possibility

Tart believes that the training that he is receiving at Pixar is similar to the model for educating students in of visual effects at San Francisco State University. "At San Francisco State in the computer department certainly we start out with very simple and easy to perform tasks and work up to more complex tasks." This department also combines some of the processes of traditional animation "where there was a degree of experimentation and creativity, you know, running into problems and then asking to have the problem solved and asking for answers on how to solve those problems." These are some of his first-hand experiences with the university that lead him to believe that computer-generated special effects can be taught effectively at the university level to produce specialists in the field. However, he believes that universities need to adjust their curricula to accomplish this. He believes that they need to allow more professionals from the industry access to teach and give seminars at the universities in conjunction with theory.

Students who are interested in pursuing a career in visual effects should engulf themselves in the field by speaking to professionals and attending the conferences. According to Tart, they should survey the industry to find out what positions are available. They should attend interviews and begin early on to tailor their studies towards obtaining a goal. If individuals want to become TDs, they should take a lot of computer science classes in conjunction with graphic user interfaces. If they want to be animators, they should take various traditional animation courses and maybe skip computer graphics altogether. If they want to get into digital image processing, then perhaps they should study a lot of film, optical printing, traditional matte
painting. Tart believes that traditional art courses are also mandatory for everyone; such classes as traditional art history and painting help to provide a language with which to converse. Tart recalled,

when I was in school I attended SIGGRAPH conventions and I would ask people in the industry what is going on, where are you going, how did you get there? It is funny but one of the first panel discussions I attended at SIGGRAPH was hosted by John Lasiter and he really set forth a design for course studies that I followed specifically; and ironically enough, now I'm working for him.

As a result of working in a more mixed and diverse environment, Tylevich advises students to study various aspects of the field. This study includes taking courses for both technical directing and creative computer animation. He believes that they develop an understanding of the foundation of computer graphics, which will help them to understand any software. A concrete foundation, he believes, will allow the individual to be adaptable to the changes in software. In contrast to Tart, Tylevich believes that it is important for a computer animation student to study programming.

Discussion

The trainees at these two companies are faced with the task of learning the companies' proprietary programs. They are usually given a specific amount of time, but this time may vary depending on the prior knowledge of the individual. Ultimately, the companies' goal is to prepare the trainees for production in the least amount of time necessary that will enable them to perform efficiently in the production environment.
The trainees are usually taught by several practitioners other than the trainers, and the training of the trainees is usually done as a collaborative group effort by the various practitioners and the trainers at the companies. In the highly departmentalized company of Pixar, new animators may receive training from assigned animation practitioners and may receive additional help from other practitioners in other departments such as the research and development department. This group training is also true for Tylevich, who has received the majority of training aid from Brandao, but he also consulted other practitioners for additional help.

The main differences between these two production facilities is the way they organize their individual training programs; the overall structure of their environment; and the content of their current project. Pixar is a formally structured larger company that is presently involved in the production of a feature film, but Xaos' structure and establishment of the physical space allows practitioners of different backgrounds to work closely together to produce effects for television.

Two Practitioners

In this section I will compare two practitioners of different backgrounds, Michael Collerey and Sharon Calahan. Michael Collerey specializes in animation and works primarily on television commercials. Sharon Calahan focuses on digital lighting and is currently involved in the production of a feature animation film.
Michael Collerey of Pacific Data Image

Born in Long Island New York in 1954, Collerey became interested in art from an early age. Influenced by his sister, just four years older and an art student in high school and, later in college, Collerey did not begin an official academic career in art until he was in college. Collerey became interested in expanded arts at The Ohio State University's Department of Fine Arts where he explored the interplay of performance art and multimedia. He became increasingly interested in arts and technology and began to focus on multimedia as an artist. In his art work he incorporated aspects of film and video. Concurrently, Charles Csuri was doing leading-edge work in art and technology at The Ohio State University. Collerey became interested in what Csuri was doing and did everything he could to become one of his students.

With a focus in dance, Collerey later became a part of the Computer Graphics Research Group (CGRG), which he joined in 1979.

Collerey was one of the initial eight people chosen from CGRG to aid in the establishment of the Columbus-based computer effects company called Cranston-Csuri. Collerey worked at Cranston-Csuri as a director of animation from 1982-87. He recalled that "everyone was making themselves director of something or other so I decided to be director of animation." Although director of one of the nation's first digital effects company, he had little experience in producing commercial graphics, and there were few who knew enough to help him. Collerey learned as he produced. His only prior experience in producing computer effects was as a student in 1980. During this time he had an opportunity, for two years, to work on a creative project with Csuri to help get Cranston-Csuri off the ground. In addition, Collerey also did computer simulation for the Navy, which, in return, funded his
education as a graduate research associate. Collerey graduated in 1983 and continued to work at Cranston-Csuri until the company closed in 1987. During this time, Collerey was a part of the pioneering production efforts toward the development of broadcast graphics and special effects.

Collerey was influenced by several of the computer artists during the 1970s and 1980s. He remembered, from very early on, learning the history of the computer as an animation tool. Collerey was also impressed by the crude work of Peter Foldes's *Hunger* (1973), Lillian Schwartz, and the few others who were involved in this research during this time. He also studied mathematics, computer science, and computer-aided architectural design at the university. But in the early years he did a great deal of programming, because this was a skill that was necessary for creating software. There was a small amount of software available for doing computer graphics, so the artist had to create the tools. Collerey recalled "even something as simple as easing in or easing out a camera move; if I wanted to do that I had to write the routine to do that. Anything that we did, we had to write ourselves back in those days. I spent about half my time programming."

After Cranston-Csuri went out of business, Collerey was hired by Pacific Data Image, which had seen his work and offered him a position as an animator. Being competitors in the small industry, PDI knew of Collerey and had seen his work. Collerey currently works at PDI in character animation.

Sharon Calahan of Pixar

Born in Washington in 1958, Sharon Calahan became interested in art from a very early age and began to focus on an art career. She enrolled in a small community college, Spokane Falls Community College in Spokane,
Washington, where she majored in advertising art. After earning an Associate of Arts and Science degree from the community college, she continued to take classes in computer programming and mathematics. The small school did not offer any conventional lighting or film classes, so Calahan took classes in photography and learned aspects of lighting in real-life situations.

After graduating from the Community College in 1979, Calahan worked in broadcast television. She left the company in 1984 and worked as a designer at an advertising firm for a year. This move preceded her freelance work in the area of design and illustration. Her freelance clients included the Spokane Symphony, the Spokane Chamber of Commerce, and the advertising agency where she was employed. While freelancing, she worked with a number of professional photographers. But Calahan always paid close attention to aspects of conventional lighting and even studied cinematography and other lighting techniques in her spare time. Calahan also learned from studying the lighting of older films.

I love watching old films particularly, you know, a lot of the classics like Citizen Kane I love jogging through it on my laser disc and watching the lighting, the compositional lighting and the transitions between shots. It's just a very visually rich film. I like studying films like that and learning from them.

In 1986 she joined the staff of Pinnacle Productions and worked as an animator and designer. Through her exploration, Calahan learned the fundamentals of lighting and animation and developed techniques at this company that she still uses today. At this company, Calahan was introduced to computer animation and also worked with a turnkey package called
"Paint Box." In 1987, she worked at an animation company called Vertigo where her title was Engineering Animation Specialist. At this production company, her job was to help guide the development of a new software, specifying the features and changes that make it more user friendly and more applicable to the user's needs. This position allowed Calahan to be involved in all areas of software production, including software testing, advanced customer service, and advanced training for the staff. While at this company, Calahan produced an animation called Night Cafe, which was shown at SIGGRAPH in 1989. This was also the first personal lighting project. At the end of 1989, Calahan began working at Pacific Data Images, after submitting a demo reel to the company. At PDI, Calahan did her first commercial lighting project for a Robitussin commercial. She also was involved in training and documentation and found the time to work as an animation practitioner in the area of digital lighting and shaders for the company. She worked on projects as a lighting director for such productions as The Last Halloween, which won PDI an Emmy Award for visual effects.

Calahan credits a lot of her knowledge to the training that she received through the company's six-week training program, which was used even when she started in 1989. At the time she was hired at PDI, she was required to attend the same program before being placed on her first job. "I felt like I was pretty well equipped by the first time I got on to a job to be able to do whatever they put in front of me, within reason. I mean it takes a good year to really kind of feel like you have it...." Not long after her training, Calahan mastered the use of the company's computer programs and began to process the technical information into lateral thinking on what she could do with the tools.
Working in the commercial production environment as a lighting practitioner meant that Calahan was responsible for everything to do with the way the final image looked. This involved shaders, positioning lights, rendering parts of the images, and all the compositing effects.

At Pixar since 1994, Calahan is currently involved in the digital lighting and production of the first computer animation feature film, Disney's *Toy Story*. Calahan, a former trainer at PDI, left the position to work on the feature animation. On December 21, 1994, I interviewed Calahan at her place of work. Calahan was recommended to me by Jennifer and others at PDI. Before Calahan was offered a position at PIXAR, she had planned to work with Jennifer in training and documentation at PDI. I interviewed Calahan in the company's lobby, as I was prohibited from going beyond the general areas by the company's rules aimed at keeping the film concealed from the general public.

**Goal**

Beyond the ordinary goals of creating visual effects and working with the clients to ensure their satisfaction, the senior practitioners' goals also include training the new practitioners and, at times, shepherding assigned individuals through the learning process at the company. One of their goals may also be to unify and maintain communication between the old and new practitioners to ensure that they are able to utilize the strengths of all the individuals in the company. They try to instill the notions of teamwork and other company values to new practitioners and, as seniors, they help to set the tone for the company.
The goal enforced by these companies on practitioners is to keep abreast of the other companies' proprietary programs and commercial software. To survive in the industry means that each company must create proprietary software to produce competitive effects. Collerey explained the steps PDI takes to fulfill their goal of remaining abreast.

At PDI we are constantly evaluating outside software, so at least if we are not actually using it we're at least looking at it to figure out, oh if they can do that we'd better start to figure out how to do that. That's one way of keeping up with what is out there, how are people doing things and sort of adjust our stuff accordingly.

Competition is the main motivating factor for PDI's productions. They are motivated by the goal of being competitive. Collerey added,

we're driven kind of by our competition. Like if ILM is doing a dinosaur then we figure we'd better figure out how to do that. Also by our clients that say we need a rhinoceros for this TV commercial, we've got to figure out how to do that. We're driven by competitive software companies. If Alias has this really cool render, we'd better figure out how to make our render at least as good as that if not better, and we're also driven by our internal projects, like you know, somebody's got a neat idea that they want to do this animated piece so we just figure out how to make it happen for them.

On film projects, the goal of the practitioners is to work with the art directors to establish what the overall look is going to be. According to Calahan, ultimately the goal of the effects practitioners on films is to try to bring the directors' visions to life while adding a bit of personal creativity and style. She said, "I try really hard to plug my own vision of what it should look like into theirs so I can see what they are trying to see in their mind"
because that's the only way that I can really bring it to the screen the way they'd like to see it."

**Function**

Practitioners are usually focused in one area of visual effects at their companies, and they are usually viewed as one of the companies' experts in their particular areas of emphasis. Calahan specializes in digital lighting, which relates to everything about the way an image looks. While others specialize in the modeling, geometry of the scene, or character motion, Calahan is responsible for taking the object to its final stages and is not required to fulfill any duties in the other areas. After the animation has been finalized, Calahan makes the necessary transformations and monitors it from that point all the way through the final rendering. She decides what the final colors, textures, and the lighting are going to be, and whatever compositing effects needs to be produced to create a desired look. But while working on a feature film at Pixar, Calahan is not involved in all aspects of the lighting as she was in her former position at PDI. "Working on a feature there are more people and more specialization." At Pixar, Calahan focuses on the actual positioning of lights and rendering. The shaders are already done by another practitioner. "I'm mostly taking a scene and positioning the lights for mood and making the characters feel good and look good."

While she is working on the feature film, Calahan's days are scheduled and predictable. She said "I kind of have my little slice that I'm working on, everyday is pretty much like every other day." Her day at Pixar starts early in the morning. She begins her day by reviewing what was rendered the night
before and checks to make sure that the frames meet a desirable standard. She then tries to patch any frames that are bad and starts work on the day's shots.

I have usually a packet of shots sitting on my desk that need to be lit. My quota is to do about three shots a week. I try to do a little better than that if I can. I try to do four or five shots a week. I basically just sit all day, positioning lights, rendering frames, seeing how it looks until I get a shot that I think looks pretty good.

These shots are then shown to the art director for his approval. He'll sign off on them, and then she renders them overnight as a low-resolution test and presents them to the director in the next lighting review meeting. The director may or may not approve the shots, and she may have to make changes to them until they meet his standards. At this time, Calahan may go back and revise the shots or move them farther along in the pipeline and get them ready for film that is rendering. Calahan processes several shots simultaneously. She has total control over what she decides to process for review by the director.

Most of Calahan's training at Pixar has been from her experience on the job. As a senior practitioner who has made the transition from one production company to another, Calahan was given little formal training and was not required to go through the company's training program at Pixar. She explained, "here they gave me pretty much two days of training and then gave me a packet of shots to start lighting. So I pretty much hit the ground running." Within her two days of training, she met with an experienced practitioner for two to three hours at a time. She added "they would show me what I needed to know to do a particular thing... mostly it was just kind of playing with it until I was comfortable."
Calahan is a part of the TD group at Pixar. As an artist in the scientist group, she communicates her ideas to the scientists. She takes advantage of her position as a TD on the feature and keeps an open communication with them. She makes suggestions to them for the creation of programs that she envisions in the future or changes that may improve an existing program. A large percent of the technical practitioners are assigned to lighting; therefore, suggestions for improvement in lighting programs may be promptly considered. At other times she may work with the other practitioners in the TD group to work out more immediate problems. She explained, "I keep running across things that I can't figure out how to do or it is not efficient for me to figure out how to do it and I'll ask one of the technical guys to help me out and they are always very responsive."

Calahan may work closely with other specialized departments and individuals, but she admits that she is less likely to work interactively with the animators or the animation department. She explained the difficulties she anticipates if she works directly with the animation department on a film.

It's very difficult for us to light a scene that hasn't been animated yet and because things change so much. Like if you just have a scene that's kind of blocked out and you try to light it, by the time it's moving, you see problems or it doesn't look the way you expect or maybe it's been animated and you light it and then they go back and the next episode you have to completely re-light the scene because it doesn't work with the new motion. So it is usually best if lighting doesn't begin until the motion has ended.

Animation shots are passed on to her in the form of a pipeline on the film project; however, the one drawback of this method is the difficulty the practitioners may face in trying to keep track of the locations of the shots, and
monitor its progression. "It takes an enormous amount of tracking to figure out where 1,600 shots are in the pipeline at one time." On a feature with so many shots, it takes an enormous amount of time to track and account for all the shots and to figure out how much time is being spent on any given shot. To combat this difficulty, the company organizes the shots systematically, and Calahan may take several shots at a time that have similar lighting needs. After the animation process is complete, she may be given several packages of shots.

I get a packet of shots that have similar lighting in that packet. Sometimes there is only one shot in that packet. The packet I'm working on now has 50 shots in it that are all kind of in the same general area. They kind of get basically the same general lighting set up. Every one of them is fine tuned, but I kind of know that I'm working in that one general area. I get a packet and some of the shots may have been animated already, some of them may not have been. I try to work on the ones that I know have been animated. Occasionally shots end up being kicked back again for a layout change, a composition change, the framing of the shot, or some motion changes, but most of the time by the time I get it it's pretty much stable from then on. Then we kind of hand hold that shot the rest of the way through the pipeline until it gets onto film and it is signed off. So, you know, we do the lighting and we set it up for rendering with the help of the render wranglers [technical directors who monitor the rendering process] we make sure it gets the rest of the way through.

In contrast to the film production environment at Pixar with its use of the pipeline system, the commercial environment at PDI demands less hands-off from the lighting practitioner. In the commercial production, the lighting practitioner may be involved in the project from start to finish. This practitioner may work more interactively with other specialized practitioners. Calahan explained the differences with the commercial environment at PDI:
I was doing set up. At the same time that the TD was setting up the motion, I was setting up the lighting. Around the time the motion people would start working their way off a project, that's about the time I'd actually start lighting shots, and doing the textures.

However similar, in both worlds there is always a hand-off stage from motion to lighting.

When working on a commercial project at PDI, the animation department may have a workload that is divided amongst the animation practitioners, who select the available tools or independently learn new tools to achieve a desired motion. For the production of David Byrne's music video, the animators were selected to work on particular sections based on their personal styles. For Collerey, this project meant the opportunity to combine a great number of programs, putting various pieces of learned software together to create the desired effect. Collerey worked on two shots in the music video in which he used the tools to exaggerate the singer's facial expression. The shot called for Collerey to apply cumulative knowledge of the various tools to create an animation in which the entertainer's eyes popped out.
Almost all the animators and practitioners worked on this music video project, but the manner by which a project is passed on to the animators at PDI varies from project to project. Most often it is just a matter of scheduling the human resources based on when a job is finished and when another starts. According to Collerey, many times the animators may find out about projects while they are in pre-production. If the animators would like to work on the projects, they can ask the producers' permission to work on the assignments. With in-house pieces, the process is usually very informal. The animators may just be talking to other practitioners, and they will decide to work together on a project. "Often you are just assigned to a project based on your availability." The people who assign the task are familiar with the animators' capabilities.

The senior animators at PDI attend the informal training sessions to keep abreast of the changes in the software or program. The programmers at PDI have been making efforts to create more user-friendly interfaces for the new developments that are consistent with the tools in use but provide a more interactive intuitive interface for the artists. According to Collerey, approximately 50 percent of the proprietary software written consists of an interactive user interface, which is usually easier for the artists to learn.
Whenever new computer programs are written or existing programs are altered, manuals usually explain how to use the programs. For some complicated tools, these manuals are accompanied by procedural pages that provide the animators with the basic steps that should be taken when the tool involves more than one program. The programmers usually assemble a group of animators to illustrate the basics and purpose of the program. The programmers also continue to offer technical assistance to the animators while they are using the programs on actual assignments. The animators may also help each other to learn the new programs.

Although there is an assigned documentation person at PDI, the senior animators may create procedural pages for software. Animators who are between jobs may use that extra time to document the procedural steps to animate in particular programs. This action is often taken by animators who have mastered the programs or have become familiar with how they can be used to achieve certain techniques. They develop procedure pages to share their findings with other animators. By following the procedural pages, other animators will be able to achieve a desired result efficiently.

Some of the software used by PDI's animators are commercial and require a different method of training. According to Collerey, the company may purchase commercial software licenses for a new software on the market. In the past, the company has purchased commercial packages that were entirely interactive. For the purpose of teaching animators how to use the commercial software, the company hired outside trainers to give one-week training courses to the animators.

Both practitioners may aid in the training of new practitioners in their specialized areas or in the field in general, as mentors or as informal trainers.
for their specialized areas of emphasis. At PDI, Collerey may mentor new practitioners. According to Collerey, when new people begin work at the company, they are assigned mentors, "but then there's also a training person who coordinates their training and schedules classes for them with various experts within the company." His role as a mentor is to check in on the protégés after their classes and find out if they have any questions pertaining to the material they have covered in class. Collerey also helps the protégés to plan out the mock jobs so that they may use the techniques that they learned in the classes on this project. "As a mentor to somebody you sort of help them figure out what this project is going to be and you just give them support during that project." These projects come after their classes in such areas as Introduction to Lighting, Introduction to Compositing, Advanced Lighting, Advanced Modeling, and Character Motion. The classes are coordinated and scheduled like school, and specific small assignments are given to the individuals to prepare them for the final mock project. Similarly at Pixar, Calahan may help new practitioners in the area of lighting to become familiar with the company's lighting tools.

Limitation

Although they are generally more user friendly, these interactive programs, Collerey believes, can limit the animation practitioner's creativity at PDI. Collerey did not view this limitation as being totally negative. "They definitely limit you...." But according to Collerey, these limitations are not necessarily terrible because the animator gets to know the tool and accepts it for what it is able to do. He explained,
you know what your tool set is and you can go about making images with that tool set. I think when you run into trouble is when you are dealing with a client or somebody who wants something that the package just can't deliver you end up just banging your head trying to get something out of that package that it is really not designed to do. But I think if you know what your limitations are, then you start figuring out ways of dealing with the limitations.

While Collerey has mentored several practitioners over the years, he agreed that he did not always have the time to do his best as a mentor. As a mentor, Collerey was often involved in production concurrently. He admitted that this is often frustrating for him because it limits the time he is able to spend with the protégé. "You feel like you are not giving the guy or woman enough time, that kind of thing."

At Pixar, the company's entire structure for creating the feature film requires artists to specialize in small areas of the production of visual effects. As a senior practitioner in digital lighting, Calahan is used to looking at the entire scene to determine how she can best apply her knowledge of programming, shaders, and light intensity to create the desired mood for a project; however, when working on a film she is given a more specific task, and although she may have the knowledge and experience in another area of lighting, she must perform the same limited task until the film ends. The company may then have a limited training program that prepares all the new practitioners and restricts all the experienced practitioners to becoming efficient in performing a specific task.

Right now we're kind of in a single focus...you know, we have this single vision of getting this film done so basically when a new person is hired they are trained to do their specific job and
there isn't too much emphasis ...put on cross training or broader training.

But the company may allow practitioners to work in different areas after the film has been completed. This change may require a new course of training. For now, the present company structure is most efficient because it yields satisfying results in that environment, as in the other production-oriented industries that are similarly structured.

When the film is done we'll have the luxury of being able to do that, but right now we need to get people up to speed as quickly as possible doing a specific task. Later on in the film [the practitioners] may be transferred over to another area and do something new and you'll need to get some training in that area, but they don't typically get the broad training that they would ordinarily get.

The training is targeted to what the practitioners will be doing on the films. "That's unusual I think," said Calahan, "but necessary for the time being."

Calahan's basic technical knowledge limits her from experimenting with some of the other programs at Pixar that she was not trained to use. According to Calahan, the software at Pixar appears to be extremely technically oriented when compared to the programs she used at PDI. Using the programs at PDI, she was able to write programs, manipulate shaders, and write codes. But at Pixar, she said, "I don't have any exposure to that now because I am pretty much just kind of positioning lights and stuff." In particular, Calahan would like to learn Pixar's programming language used for scripting, but without training this endeavor is difficult. "It's harder, it's a harder one to try to kind of pick up on your own here.... It's like I need to have my hand held a little bit more."
Even more limiting for Calahan is the absence of program manuals at Pixar. There are no manuals or procedural pages, and as a result, Calahan often learns by trial and error. Learning Pixar tools without a manual can be frustrating.

It's mostly, you kind of stumble through it, you ask a lot questions and make a lot of mistakes and things seem really fuzzy for a while and you just only barely know what you are doing, and then as time goes by all of a sudden things just start clicking.... Eventually things start making sense.
The limits for practitioners in the commercial environment derive mainly from the fact that they have to please the clients; therefore, the practitioners' ideas may be placed on hold until suitable projects come along. David Byrne's music video was most intriguing for the animators in particular, because they were given the freedom to create and experiment, whereas the Coca-Cola Japan project was rewarding for the lighting practitioners. As a lighting practitioner, Calahan worked on the project. The ideas that she was able to implement for this project had been in the conceptual stages for years. However, Calahan had to wait for the right project and for the correct render to be written to transform her concepts into practice. "It was just really satisfying to have something actually kicking around in the back of your mind for awhile and be able to make it happen." But this is just one of the many lighting ideas that Calahan has in mind. She explained,

I still have probably 20 visual ideas in my head for the type of imagery that I'd like to see, but I either haven't had a software or I haven't had the right project to apply it to. It's not like we have the license to go out and make any kind of imagery that you want just because it looks cool. I would love to have the opportunity to do that someday, but that will not happen.

Value

The programs used by the animators are usually complicated and require that the animator read the manual. These complex programs allow the animator to achieve more intricate motions. Without the manual pages, it would be extremely difficult or impossible to animate a complicated object beyond the
basic training the animators usually receive on new programs. Collerey believes that the manuals are extremely valuable and their absence can limit the artist's creativity to animating simple images. He described its importance:

If there is a program you can kind of just try it out to see what it can do without a man [manual] page and sometimes you end up doing that but obviously it's got to be a pretty simple program for you to be able to master it. It's got to be on like a very specific thing that it does and you can just like try a bunch of numbers and then figure out what it does and then you can use it, but that's a pretty isolated case.

Collerey thinks that the limits created by interactive tools are in some ways an asset to the animators at PDI. Collerey explained,

in some ways it is kind of invigorating to know that here is my limit. What can I do within this set of limits? There are systems, I can do this, I can do this, I can do this. It is like a tangled web that you can possibly weave together with a contained system. Then it is kind of like you don't have to worry about what . . . well could I do this. You basically know what you've got to work with.

However, a much greater asset to him comes from the pleasure he receives from doing the actual animation and solving the problems along the way. A student in the early days of computer graphics, Collerey has acquired a high level of tolerance over the years for the tools of his trade. Today, he enjoys the challenge that is brought on by the animation process.

I've always enjoyed the process. . . . A lot of times it's kind of like solving a puzzle, or your mind is like very stimulated—it's like how do I solve this problem. Then every step of the way, you
know, is very rewarding. I tend to enjoy the process more than the product. I'll often take things like three quarters of the way and then maybe somebody else will have to pick up and actually finish the project because I just enjoy the process of creating the effects and figuring out problems. And obviously when you do finish the product then you get the reward of seeing the people and watch it and enjoy it. But it is very rewarding.

Collerey enjoyed working on *Gas Planet* for most of these reasons, in addition to the fact that the film was not a client's project and allowed him to push his creative limits. *Gas Planet* was produced through the collaborative efforts of Collerey and another practitioner at PDI. The animation was produced as a personal animation so, said Collerey, "we had a lot of artistic freedom." But according to Collerey, the main reason he appreciates this animation is the fact that people enjoy watching it.

Calahan is also intrigued by the constant challenge that she faces every day in production. When she worked on commercial projects, she always focused on a part of the project that motivated her. She recalled,

I've always been really good at finding something about the job that motivates me even if I have to create it in my own brain. There is a line that we used to use at PDI that you can't polish a turd but that was something that I always tried to do. I always tried to find one thing about the job that I could make it shine, I could make it better than had been done before. I just found ways to motivate myself. It was always pretty easy when a new job would come in that looked really interesting to find some angle on it that I could really get excited about.

In the film environment, Calahan enjoys the liberty she is allowed to select the shots she would like to process at a given time and the freedom to make them come alive through the lighting process. This allows her to be more efficient because she can process a group of shots that have similar
lighting needs. Calahan is also given creative freedom in terms of the lighting style.

We have kind of a general style we're going for, but within that there is quite a bit of range for little subtle nuances of light and how it falls on a surface that you can really make an image come alive. The director is really open about allowing comments and advice.

Possibility

Collerey agrees that there is a great number of opportunities for individuals who would like to pursue a career in the field presently; however, most often these positions require prior production experience. He believes that an individual can acquire the necessary production experience at a university or at a small production facility. However, he believes people can increase their chances and attain more by attending a university and studying as much science, art, physics, and programming as they can. The work doesn't have to be for a client, but people need to get some production experience, which Collerey think could be achieved at school. This project will help the individual to convince prospective employers that he or she can produce images.

Calahan believes that determining the best way for a university student to prepare for the field is difficult, but like Collerey, she suggested that the individual should have knowledge of both technical and art sides before focusing.

You can't underestimate the value of a really good arts education. I think the more color and design classes, illustration, photography, you name it, anything visual can
make a big difference. The technical side of things is also important but a lot of it depends on what you want to do. If you are definitely visually oriented I would focus on that, and if you are technically oriented, I would focus on that. I think it is hard to walk in the middle ground. Some people do it well but I think those people are more rare. For me, personally, I have taken advantage of my art background. I've been able to just get by technically. I learn what I need to learn to keep going to do what I can, but it's not like I'm any kind of rocket scientist or anything.

Students who are interested in gaining entry into the computer effects industry as artists or designers should choose a medium other than computers for expressing their creativity. According to Calahan, it is often difficult to be both an artist and a computer scientist; however, I believe people should have an understanding of both fields when working in this environment. They need not be masters of the both disciplines, but they should have sufficient knowledge of both to understand how the two work together as a whole. For example, students who are interested in the arts discipline of computer animation should not only have a background in traditional animation, but should also understand the basics of the computer programming. Furthermore, people need to gain a broad knowledge of the field, and they should not become tied to any specific applications; rather, they should gather the knowledge that will provide them with a template for combining various commercial and proprietary programs. This template can be achieved through a broad-base study of the field. Individuals who have achieved such an education will be prepared for the challenges of a company's proprietary software training program.
Discussion

These two practitioners represent two separate departments, and although they once worked together for the same company on the production of primarily television commercials and music videos, they now are involved in two completely different environments as experts in their departments. Both practitioners have gathered a significant amount of experience in the field of visual effects. Collerey has also gained a significant amount of experience in the area of computer animation.

At the two companies, both practitioners aid in the training process of new practitioners; however, their environments are structured differently. After examining the two practitioners and the structures of their work environments, I found the following differences.

At PDI, there are documentation manuals and procedural pages to aid the effects practitioners to learn the programs and proprietary software; however, manuals are not accessible to all the workers at Pixar. According to Collerey, manuals and procedural pages are important sources of learning for all practitioners at PDI. These are the main texts used by individuals who wish to further their knowledge of a program after the training has been completed, or for practitioners who would like to learn the specific procedures that will allow them to link two programs together for a desired effect. But Calahan said that these manuals were not accessible to her during or after her two-day program briefing at Pixar.

The training program at PDI is very general, and at Pixar it is very specific. Practitioners in the commercial production environment at PDI are given a more in-depth broad-based training on the various aspects of production. This type of training helps them to be more adaptable because
the various projects may range in complexity in achieving the goal satisfying the client. However, the training of the practitioners in the film production at Pixar is narrow and may center on preparing the practitioner to perform a particular task.

PDI requires all the new practitioners to attend a training program regardless of their prior knowledge. However, this training program may be less rigorous for practitioners with any prior knowledge of the field.

On the production of a feature film, various barriers prohibit artists of different departments from learning from each other; these barriers are not as strong in the commercial production environment. At Pixar, the artists are physically placed into different departments depending on their areas of specialization; therefore, it is not common for the practitioners of one department to collaborate and learn from the practitioners of another department. At PDI no strong departmental barriers that separate the practitioners into narrow specialized groups. The practitioners are free to learn from each other and in a more interactive environment.

The practitioners at PDI act as mentors and are assigned protégés, whereas at Pixar the practitioners are not mentors. When new practitioners enter the training programs at PDI, they are paired up with experienced practitioner's, who mentor them through the learning process. At Pixar, such a mentorship program does not exist.

On the production of a feature film at Pixar (a feature film production environment) the practitioners may be given the liberty to make changes easily, whereas at PDI (a commercial production environment) the practitioners may have to limit their creativity to meet the needs of the client. If the lighting practitioner comes up with a more creative and effective way to
light a shot, she needs only to ask for the approval of the art director or the film director before her idea is finalized and put into effect. However, at the commercial production environment, a change in a project may need the approval of the client and may most often require a formal meeting and possibly a new storyboard.

At PDI, the lighting practitioner is involved with a shot from the start to the end, whereas in the film environment at Pixar, this practitioner is focused only on lighting. At Pixar, the lighting begins after the motion has been finalized; the lighting practitioners may then process the shot and pass it on through the pipeline. They are not involved with the shot anytime before the animation has been completed. However, at PDI, there is very little hands-off time for the lighting practitioner between the stages of the shots development.

Conclusion

The investigation of these three companies' structure and their training programs forms the foundation for further discussion on the training practices of the special-effects workers at all levels of production. The investigation suggests the following:

Within these three companies the new-practitioner duration of training may vary, but the principal goals of the training programs are consistent amongst these companies. The principal goal of these companies' programs is to train new practitioners to perform specific tasks at the companies in a limited time. In the training program, the trainees gain an understanding of the terminology, general structure of the companies, and
the proprietary software. New practitioners may spend an average of four to six months in the training program.

The training prepares new practitioners to become apprentices. The training teaches the trainees the basics of the company and prepares them to work with experienced practitioners or under project directors. As informal apprentices, they are trained on the job, and they learn the in-depth functions of the programs used on a particular project. At this stage, learning is less conceptual and more practical.

Training is the duty of all the experienced practitioners at the company. At both Xaos and PDI, people are assigned the responsibilities of training the new practitioners. These corporate trainers are also responsible for coordinating the program and scheduling specialists at the company to teach the trainees the basic principles of a software. At PDI, the classes are often taught by various specialized practitioners, whereas at Xaos, the trainer is also a trained practitioner and may seldom need to schedule specialized practitioners. Apart from the practitioners involved in the training sessions and classes, other practitioners at the companies also contribute to the new practitioners' training outside the training programs. At PDI, trainees may receive additional assistance from assigned mentors, production managers, and other trainees in the program. This mentoring process is common in both companies. After the training programs, new practitioner may also learn from the manual or procedural pages written by other practitioners at the company.

The training model is similar to a university's program model for educating students in a practical course. Practical courses have traditionally been taught in three stages—presentation, practice, and feedback. This model
is also used to train new practitioners at the production companies. The companies may also test trainees for mastery of the information covered in the training programs. At PDI, the trainees are given a mock project to test for mastery of the material. Other companies, in an attempt to be more efficient, may test trainees on a specific client's project. These empirical tests are informal and simply help management to monitor individual needs.

Some universities have developed programs that are precursors to the training programs at the production companies and prepare students to examine the issues in the field of visual effects. In the following chapter, I will look at and summarize the various issues that are currently being addressed in the field of visual effects. In addition, I will discuss the role of the university in the development of digital-effects practitioners for the field. Second, the chapter will look at the impact of computers on other art-related areas at The Ohio State University.
CHAPTER VI
COMPUTER-ART ISSUES AND INFLUENCE ON ACADEMIC PROGRAMS

Contemporary Digital Effects

The use of computers in academic programs in the arts has opened a whole new dimension for the artist; thus, the curricula are changing in most universities. The influence of computers in the arts has driven most universities to adjust their conventional art programs. In most cases, this adjustment is not in the form of eliminating traditional art programs but merely adding new programs to the existing curricula. Most universities have realized that computer art programs or artists often need an interdisciplinary background. Developers of these curricula have realized that the computer, like oils, airbrush, or pastels, is just another tool for the artist. Carlos Arguello has been a computer effects practitioner at Pacific Data Images for the past eight years. As an art and effects director, Carlos credits his creative talents to his strong architectural and design background. In an interview, Arguello (1994) explained that digital medium is a medium like any other; it just happens to be the newest. There is a particular look about the medium that excites people and attracts them to it, he said, but added that knowing how to use water color or oils does not make one a great artist. The art and design elements have to come from elsewhere, not from the computer.
Currently, computer-generated effects have influenced many young animators who, in the past, might have devoted themselves to the production of traditional design or animation projects. They have focused their creative abilities on the production of high-powered television advertising, digital short entertainment, feature film computer effects, music video effects, and other computer-generated ventures. Their work utilizes the latest development in computers, video, and broadcast technology and makes a tremendous impact on a mass viewing audience numbering in the millions. The impact of computer effects on feature films is spectacular and is appreciated around the world.

Most computer generated-effects made on powerful high-end machines are executed by artists and computer experts whose primary concern is technical. In the past, the tendency has been to work with complex and mesmerizing surface effects without investigating the medium's possibilities as a sustained form of personal expression. It is no surprise, then, that the most significant artistic contributions being made today in the field of computer animation and generated effects are by individuals who have access to modern technology such as high-end Silicon Graphics machines (Russett and Starr, 1988). Like gods, they, too, have the power to recreate, create, and simulate. As the president and founder of one of the Bay Area's most exhilarating computer effects companies, Rosendahl sees himself as one of the computer animation industry's visionaries and defenders. He admits that the present public expectations of computer-generated effects is extremely high. He relishes his role, "except when he's viewed as some sort of god who can bring beloved actresses back from the dead, or a demon who can manipulate reality and play with a viewer's mind" ("Hollywood," 1993, p. 59).
Similarly, after viewing Michael Jackson’s music video "Black or White," a viewer impressed by the fifteen faces merging rapidly into each other gave PDI a job offer. A Midwestern woman asked for help solving one of her life’s greatest questions: "Was she Elvis’ love child?" ("Hollywood," 1993, p. 57).

The real impact of computer-generated special effects can be seen in the film industry. Films such as Terminator 2 and The Abyss have had a profound impact on the film industry. These films have used computer-generated effects as spring boards to tell stories. They have, through the use of computers, made it possible for the viewer to visualize fictitious stories in their entirety. These films showcase what computer-generated effects can do to alter the visual quality of stories. Such techniques as wire removal, morphing, and digital composition have made it safer and possible to achieve the creative effects in films. Changes in the technology of special effects can be seen by the influence of digital effects in film that range from simple moving graphics on a monitor inside a space station set to complex computer simulations of 3-D objects such as the spacecraft in The Last Starfighter. In Terminator 2: Judgment Day, use of the liquid metal exemplifies the elaborate manipulating and interweaving of photographed and computer-generated images. However, apart from its use in the film industry, computer-effects technology has made its way into all aspects of television advertising, from animated logos to fully computer-generated commercials, which gives the industry a financial base as well as an arena in which to develop and test new technologies (Baur, 1993).

Computer-generated virtual reality (VR) is just another medium through which computer effects are being explored. Virtual reality has made a great impact in the games industry, and because of its interactive
capabilities, it is bringing new dimensions to marketing medicine, training, and design. This medium of virtual reality, Delaney (1994) wrote, "is essentially an experience, not a technology, and may be created in many ways" (p. 40). In addition to its equipment, which comprises mainly a glass front-CRT, input glove, and 3-D glasses or helmet, the medium of VR allows the explorer to interact with, in most cases, a 3-D computer-generated world. By definition, VR must have 3-D-modeled objects and must be computer mediated, with provisions for random interactivity. Rapid improvements to VR components have ranged from monumental to astounding, as a result of the rapid changes in technology. Improvements in the raw computer power and graphics processing, use of the 3-D wrap-around version of high resolution, and high frame-rate multimedia experience are some of the headings used to gauge and measure VR's improvement. Today, configured Silicon Graphics Onyx Reality Engine workstations deliver a real-time interaction of thirty frames per second.

Considered to be the father of VR, Ivan Sutherland began experimenting with this medium on New Year's Day 1970. Some fifteen years later, engineers at NASA's Ames Research Center, led by Scott Fisher, put the VR workstation to use. This system was considered complex for its time. This technology was later used in the film industry to create the computer effects for The Lawnmower Man. This movie was followed by a wave of hype, and an industry was born. The industry has made its biggest impact on the games industry, while it makes a slow, steady inroad into business. The industry is not only limited to video games in the arcades, but has also expanded to rides at theme parks and other areas. At Disney World Pleasure Island, for example, one can ride VR games such as the Straylight’s
Cybertron. Other rides can be found across the United States; for example, at the Foxwoods Casino complex in Connecticut there is the Iwerk/Evans and Sutherland Cinetroplos collaboration called Virtual Adventure. In Las Vegas, the Luxor Hotel features VR-like attractions with an Egyptian theme. The Virtual World Entertainment's Virtual World Center offers excitement to its audiences even before they enter the main complex through such games as Virtual Geographic League Club and Red Planet, which involves a desperate race through the canals of Mars (Delaney, 1994). Similar to film effects techniques, VR has also demonstrated its ability to remove the viewer temporarily from the real world, thus suspending reality.

In the television commercial world, computer-generated effects have helped those companies that are limited to thirty seconds to sell their products, goods, or services. According to Rosendahl, Pacific Data Image and the digital effects industry has been able to "maximize an advertiser's bang for the buck," while at the same time conveying the advertised information to the viewer through the use of morphs. Rosendahl added, "when you have only thirty seconds to get your point across, people like to watch morphs" (Quinn, 1993). Today there are animation software packages to meet every need, and their availability is changing how and what agencies create, from potato "chipchopping" taste buds to bottles swinging on vines. Companies become known for particular styles and techniques. For example, Xaos is becoming known for its ingeniously realistic "liquid" or "particle system" animation. This tool is used extensively by the company as a way of animating a very large number of objects while giving very naturalistic attributes of mass and inertia. This technique is used by the company for making liquid and atmospheric effects. It allows practitioners such as Mark
Malmberg to generate abstract, flowing, colorful imagery and painterly effects. The system was used to create a fragmenting peacock for an NBC logo; a 30-second ID for the Sci-Fi channel; and the MTV "Top 20" video countdown logo, in which liquid appears to run down the screen (Soter, 1994). Computer-generated special effects add appeal and improve the quality of the message in the final production.

Plate XVIII Particle system used in The Lawnmower Man, Xaos

Plate XIX Pillsbury Doughboy, PDI

Over the 27 years the Pillsbury Doughboy has been in existence, it has adjusted to the changes of technology in the industry. The character has proven to be flexible both in its physical movements and in its assimilation to the changes in the industry. Now in a high-tech world, the Pillsbury Doughboy has not only taken on a new look that has required practitioners at PDI to take dance lessons to understand the body language they are trying to
replicate, but it has also bridged the gap between conventional and computer effects in television commercials. Today the use of computer animation represents a first for Pillsbury, which had previously created the Doughboy using stop-motion animation. PDI director Tim Johnson explained, "the goal of our Character Animation Group was to create the classic Doughboy and capture his combination of charm and shyness. We simply used the advantages of computer movements." Although the mambo lesson enlightened the animation team, their greatest advantage was within the medium of computer-generated effects. Unlike traditional stop-motion, the computer animation process affords the chance to fine tune an image frame by frame without redoing the entire scene. Based on his experience in the conventional effects industry, Tart explained that a mistake in a stop-motion scene means that the entire scene has to be redone. On the other hand, computer effects practitioners have at their command powerful computer tools and the freedom to explore a wide range of ideas and effects such as motion blur to make the character appear more natural. In the computer effects world, technology has allowed its users to achieve the best of both worlds; according to Johnson, "they have the 3-D look of stop-motion, plus the ability to do low resolution tests like hand-drawn animators..." ("PDI Takes," December, 1992; Tart, 1994).

Besides its ability to improve the quality and message in the film and commercial industries, computer-generated effects has also been a tool used to impact society's perception of history. Computer-generated effects has allowed historians and directors to tell the stories of history by creating simulations of artifacts and cities that are no longer exist. It has provided equal access to visualizing valid historical information. In the PBS series
Civil War, the use of computer-generated effects made it possible to recreate the historical events without the aid of a cast or crew. In a particular part of the series titled 500 Nations, the producers simulate the past with computer-generated graphics. The computer-assisted portion of the miniseries studies 50 native cultures that inhabited much of the North American continent, from Canada's Northwest Territories to Costa Rica. More than six minutes of pure computer-generated imagery was used along with sixteen minutes of digital cartography—maps treated with digital camera moves, morphing, and animated events. An additional eight minutes of sophisticated digital matte paintings were also employed. The combination of art directing by John M. D. Pohl and the creative effects of Santa Barbara Studios helped to make this project a successful television program. Pohl, a Ph.D. in archeology, was provided a theoretical basis for the creation of the landscape and artifacts to be used in the film. To ensure precision, the 3-D objects were first sculpted then scanned into the computer (Solman, 1993). The use of computer effects has allowed the viewer not only to visualize the realistic textures of the artifacts, but also to gain a bird's eye view of the environment of these past cultural lifestyles.

In addition to their use in the film, television, and games industry, computer-generated effects are developing in new directions for pre-visualization and synthetic actors. Pre-visualization in the film industry can range from digital storyboarding to programs that help directors see how effects will fit into scenes. Pre-visualization is often the most vital communication link in a film's production, because it allows the director to check scene continuity and effects gone awry. However, the director may not be the only person benefiting from pre-visualization. It is increasingly used
as a conceptualization and marketing tool to show key scenes to potential investors. Storyboards are also being moved to the digital medium, which allows for tight integration with the scripts, schedules, and databases of props, sequences, and effects. For example, when the *Addams Family Values* was being created, a digital storyboard was used to guide the action and cameras. Similarly, when Paramount executives wanted to sell *Star Trek: Voyager* as a first-run syndicated series, they, too, employed the technique of pre-visualization. This technique of digital effects is usually done by a branch of special effects known as Autographic. Autographers usually use low-end software such as Photoshop and Macromedia Director to convey the story of the film.
Another of the latest techniques employed by computer special effects artists is synthetic actors. Initiated by the New York Institute of Technology, synthetic motions are the latest challenge for effects artists in the industry. The process of synthetic motion uses an input device such as a laser device to create a computer model of the person. The information for the digital character can come from a live actor or from a scanned or digitized film or video. Synthetic actors are also created from scratch, but artists can save time and create more realistic simulations with motion-capture technology, in which the movements of human actors are recorded using sensors and then transferred to a computer model. The motion capture allows realistic motion to be captured quickly and accurately enough so that the movements match those of the live actors. There are two types of motion capture sensors: the optical motion capture, in which the performer wears reflective markers
taped to his joints; and the magnetic method, which uses similar techniques as the optical, but, because of the limited number of sensors, the information may be limited ("Hollywood," July 1994).

Plate XXI Moxy, Colossal Pictures

Motion capture dates back to 1989, when Pacific Data Images created a 3-D computer-generated character named Waldo C. Graphic for The Jim Henson Hour television show ("Hollywood," July 1994, p. 40). PDI used this technique to capture motion from an armature with a hand puppet interface at one end. The image of the character was composited on a line video monitor on the set. Composition allowed the muppeteers to see and interact with Waldo in real time. Today, motion capture is used in commercials and movies alike. This technique is sometimes combined with the talent of actors such as in the case of the Colossal Pictures creation called Moxy. After Waldo made his appearance on national television, Moxy was next to make regular appearances on the Cartoon Network. Born through a collaboration between the Cartoon Network and Colossal Pictures of San Francisco, the 5' 6" sheep needs 3 humans to bring it to life: a puppeteer outfitted with sensors, a computer operator to control the 3-D character's expression, and a voice person, comedian Bob Goldthwait. In a similar manner, Industrial Light and Magic has been integrating synthetic actors with live action since Terminator
2. The effects was used in this film to create scenic parts of a liquid chrome-like model. But this was only the beginning of a long list of synthetic actors used as the means for creating complex computer effects in the film and commercial industries (Goldstein, July, 1993; "Hollywood," July, 1994).

Judging from the current state of computer-generated special effects, one can conclude that their impact is not only felt by society but by the film, commercial, and games industries. Computer-generated effects have made it possible to interact in real time with a simulated environment or to view simulated prehistoric elements and creatures. Whatever the effects' use, they will not work if the audience does not believe in the fictitious images. The audience most often suspends reality long enough to believe in the effect, a belief that would most likely be questioned seconds or days later. In other cases, the artist creates a realistic computer simulation, and the audience accepts the effects, as in the computer-generated jeep scene in the motion picture Jurassic Park (1993). This representational object or effects may never be questioned until the tricks are revealed by the effects company. Today, computer-generated effects are becoming common in films and television commercials. However, there is still a need for better integration of these effects with the story of the film, because the effects are often misused or the story becomes an excuse to explore computer effects. Through the pre-visualization tools, the director and producers will have an opportunity to examine and scrutinize the stories along with the film effects.
Two Academic Programs

In this section I will compare two academic programs at two universities—the Advanced Computing Center for the Arts and Design (ACCAD) at The Ohio State University, and the Computers in Art and Design/Research and Education (CADRE Institute) at San Jose State University. The comparison will help to examine the extent to which ACCAD and the CADRE Institute academic program models—for preparing graduate students for the field of visual effects—are similar to the model used for the corporate training of new practitioners. In addition, the two universities are compared to show the extent to which ACCAD, as established by pioneer Charles Csuri, is similar to other academic programs such as the CADRE institute, established by former MIT faculty member, Joel Slayton. These similarities may lead to suggestions for the development of other programs at the university level.

ACCAD

Graduate students who are interested in pursuing graduate degrees in computer graphics or animation at The Ohio State University can register for these classes via various art-oriented programs—mainly Industrial Design, Art Education, or Art. Although the students may come from different departments and disciplines, the main course of computer training and education takes place at the Advanced Computing Center for Art and Design. At this facility, students take courses in image processing, computer animation, and programming for high-end computer systems. The main course taught to new graduate computer animation students is known as the 750 series, which requires a one-year (three-quarter) commitment and asks
that the group of students complete 15 credit hours over the time period. The
group of 10-12 students usually works together to learn the programs and
software at the west campus facilities. Although the professor teaches the
basics of the programs, the students are encouraged to explore the facilities
and programs to complete assignments.

Graduate students' education and training in the program at the
ACCAD are similar to the methods used to train and educate computer
special effects practitioners. Most students enter the university graduate
program with the goal of learning the tools necessary to create an animation
on the computer. Computer programmers write the proprietary programs at
the facility, and the programs are mainly used in conjunction with
commercial software. Although the 750 series are not required for students to
create animation at the university facility, classes are viewed as the
orientation course, and they are strongly suggested to all new graduate
students. Students meet twice a week for two-hour class lectures on
theoretical foundations and on the software or programs. Class assignments
are usually practical and require that students apply the information they
learned in class sessions. The assignments are done outside the class meeting
time and are usually given a deadline or date for completion. Teachers and
the students critique the student projects.

Industrial Light and Magic indicated that there are ten major steps in
producing computer graphics effects. Although these steps are not always
applicable to the university environment, they are mandatory in most
computer effects production houses. These steps are explained as follows:

**Storyboarding.** Special effects sequences are storyboarded to clarify the
client's vision and define the scope of the work, saving time and money and
ensuring better results. The boards can be furnished by the client or produced in collaboration with an art director and effects supervisor.

**Bidding.** This process breaks down the script or storyboard into a detailed "fx breakdown" and "fixed bid" of costs.

**Modeling (or digitizing).** In this step, numerical information is entered into the computer to create 3-D objects.

**Scanning.** Information from live action plates is scanned into the computer to provide backgrounds. Textures from other sources can be scanned and mapped onto modeled objects for realistic effects.

**Motion Test (or Animatics).** These are made to arrange and choreograph the object scene by scene and to check the placement and motion.

**Lighting and Look.** As with live-action cinematography, computer-generated objects are "lit," using shadows, highlights, reflections, and refractions.

**Low-resolution Rendering.** This test of a scene ensures that no technical errors exist in the work before devoting large amounts of computer resources to produce the project at high resolution.

**High-resolution Rendering.** Here the scene is computed at a deliverable resolution.

**Digital Compositing.** This step assembles all elements--modeled objects, backgrounds, mattes, etc.--to create the scene. Image-processing techniques, such as blurring, sharpening, and hand touchups can be used to enhance the final scene.

**Final Recording.** The last step is printing the scenes to film or transferring them to videotape for final delivery.
Most of these steps are taught to students in academic training programs; however, steps such as bidding are often left out of academic curricula as they are not important steps in the actual production process. Often the university equipment is outdated; however, it is important that these steps are covered in all academic training programs.

At the ACCAD, the academic program is structured in three parts over three quarters and is geared toward helping students learn the computer tools necessary for creating animatics. Similar to practitioners working at computer effects companies, students at ACCAD are taught the steps necessary for creating animation, using 3-D software. The first quarter may focus on learning to build 3-D objects using both proprietary and commercial software packages. This method involves the use of primitives and learning how to build objects by digitizing its 3-D form. In the following quarter, students learn how to stage objects and render attributes—textures, brush, and environmental maps. Lighting is also taught in the second quarter. By the third quarter, students learn how to animate the 3-D objects they built in the first quarter. In addition, they learn how to animate textures, lights, and the camera within the animation stage. After completing the three quarters, students may continue along the same path, as established by the class, to complete the animation that were started in the last quarter, or they may simply start on completely new projects.

The university facility at ACCAD, like the production house, consists of computer scientists and programmers who are considered the "team of researchers and developers" and, at times, may be essential in the education of new employees. ACCAD, like the production environment, is made up of computer scientists and artist/animators. When computer scientists develop
new proprietary software or programs in production or university environments, they are considered the experts on those programs. Often they may hold informal training meetings to share the pros and cons of the software with the entire staff of scientists and artist/animators. Usually the scientists give brief demonstrations of the software capabilities. These demonstrations give the scientists the opportunity to have their software or programs tested by various students or practitioners and, in the case of production houses, help them focus on the parts of the software that may require further development before they can be used on projects. At ACCAD, as in the production houses, the quality of training and education received by computer special effects artists relies heavily on their relationship with the scientists. The artists must be willing to refer their questions about the software directly to the scientists who created or developed them, and the scientists must understand the cognition of the artists when developing programs for animation.

Joel Slayton and the CADRE Institute

Joel Slayton is professor of Fine Art and director of the CADRE Institute (Computers in Art and Design/Research and Education) in the School of Art and Design of San Jose State University. Joel Slayton's artworks involving computers and media technology have been presented internationally. Slayton's most recent work involves directing and producing site-specific multimedia performance events. He is recognized for his innovative use of computers and media technology. His new performance work, commissioned for the Palo Alto Centennial Celebration, premiered in April 1994. Slayton is concurrently designing two new
interactive media installations for museum presentation. Joel Slayton received a 1991 National Endowment for the Arts Grant for a site-specific experimental media performance, *Do What Do*, commissioned by the San Jose Institute of Contemporary art and the City of San Jose. *Do What Do* is best described as a techno-urban drive-in movie experience exploring Silicon Valley's romance with multiculturalism. *Do What Do* premiered October 16 at the 1992 International Computer Music Conference. Slayton discussed the integration of *Do What Do* computing technology at the 1992 International CyberArts Conference. From 1989-91 he was Visual Coordinator for the George Coates Performance Works (GCPW) in San Francisco. The GCPW productions, *Invisible Site* and *The Architecture of Catastrophic Change* received rave critical reviews for their spectacular computer controlled multimedia effects. In 1990, Slayton collaborated with the internationally renown choreographer Tandy Heal to produce *98.6 FM*, an audience interactive performance work integrating computer media, video walls, image projections, microwave transmission, sculpture, and videodisk. The performance culminated with a deep space message transmission live from the theater (personal communication, Slayton, 1994).

Computer installations have been featured at the Muskengon Museum of Art, San Francisco State University, Allegheny College, and The Triton Museum of Art. Video screenings include: Tile Durban International Film Festival (South Africa), Tage fuer Nueue Musik (Germany), and the School of the Art Institute of Chicago. Joel Slayton's computer print works have been included in exhibitions at the Friends of Photography in San Francisco, New Mexico State University, The San Jose Institute of Contemporary Art, Smithsonian Institute, Brigham Museum of Art, Craft Alliance Gallery, and
Arnofillini Gallery in England. Slayton has developed projects in conjunction with the NASA Ames Research Center, Polaroid Corporation, Sun Microsystems, Silicon Graphics Inc., Stellar Computer, Intel, IBM and Pacific Bell. He was a recent visiting artist at the School of the Art Institute of Chicago, Art and Technology Program (personal communication, Slayton, 1994).

From 1978-82, Joel Slayton taught at the Massachusetts Institute of Technology, where he specialized in experimental imaging systems and computer graphics. In 1983, he was visiting professor at the Center for Information and Communication Studies at California State University Chico. In 1984, he became director of the CADRE Institute (Computers in Art and Design/Research and Education, an interdisciplinary academic program dedicated to experimental applications of computers in the fine arts and design. As director of the Institute, Slayton coordinates MA and MFA programs. Current Institute research activities include digital imaging, computer animation, interactive multimedia, interactive environments, interface design, networking and distributed learning environments. Slayton has organized two national symposiums on art and technology, "1989 The Dimensions of Interactivity and The 1986 Silicon Valley Festival of Electronic Art." Slayton is currently coordinating CADRE's 10th Anniversary Exhibitions Program and Workshops on Virtual Reality and Distributed Learning Systems (personal communication, Slayton, 1994).

Joel Slayton began his advanced degree at The Ohio State University's Department of Photography and Cinema. At OSU, he began conducting experiments through the use of photographic processes that would eventually incorporate computers. The department did not support his interest, and in the last year of his graduate program, Slayton transferred to
MIT and did his thesis project there. After graduation, he joined the faculty at MIT, where he taught in an area called the Devisable Language Workshops, one of five semi-autonomous art groups at MIT, premedia laboratory. He later met Ron McNeal and Nicholas Negroponte, who introduced him to computers. He helped them, specifically Ron, to build and design a computer airbrush painting machine. As a junior faculty member, Slayton merely tagged along and mainly observed as McNeal did most of the work. He later became interested in 2-D image processing and began to digitize images and manipulate them.

Gardner: How did you advance technically from that time to your present position?

Slayton: Self taught. Well, like present; well it's been, what?, 15 or 20 years almost. I started by teaching myself programming and working on hardware and building the system and devices that I needed to have in order to do my work. From that I started to study areas of technology that I was interested in, both practically and theoretically, and then that gave rise to positions in the field that I was qualified for. I just kind of learned it as I went. There wasn't much you could study anywhere.

Slayton had gathered enough knowledge of the computer and technology from his experiments at MIT. As a student and faculty member he researched and developed a broad-base understanding of the field on an independent basis. In this way, he continued to study both the technical and artistic sides of the field. This research enabled him to prepare himself for his present position at the CADRE Institute.
Gardner: What motivated you to go into teaching computer graphics?
Slayton: Ah, well, it wasn't specifically computer graphics that I was interested in teaching. It was a broader area of art and technology that I was interested in teaching, and I was very motivated because there was this new emerging need, and I wanted to be part of defining that media and how people would think about it, and so that was the real motivation in college teaching.

Gardner: So you were connected more to the art side than the computer graphics side?
Slayton: Much more so. My concern was principally in the Fine Arts end of things and I saw technology in general and computers specifically as a way of realizing my work and, in fact, the only way of realizing the ideas that I had so I...out of necessity I learned how to do it.

Gardner: So it was just a means to the end?
Slayton: Absolutely.

Slayton, like most other artists in the early days of the computer, was interested in incorporating computer technology into his traditional field of emphasis. He was more interested in using the computer as a tool to alter his photographs and continued to look for ways to use it in the area of fine arts. The establishment of the CADRE Institute gave him the opportunity to teach classes that specifically focus on the use of the computer as an art tool.
Gardner: Do you believe that academic programs in art have been influenced by the use of computer art?

Slayton: Oh yes, dramatically so.

Technology has traditionally had an impact on the arts. According to Slayton, computers are having the same impact on the arts that photography did in the mid part of this century, when they were incorporated into academic institutions. There wasn't a painter or a sculptor or a performance artist or an installation artist who did not somehow realize the potentials of those new tools. But, also, technology changed the way they thought about reality, and so it definitely influenced the theoretical, the aesthetic choices they made in their work. Slayton believes that today we are seeing that cycle repeated, maybe even more dramatically now than in photography. This is evident in the paradigms of the graduate art programs at the Institute. The graduate program in computer art at the institute, outside of painting, is the second largest group of graduate students within the art department. "There are more computer artists than...maybe this is not fair to say, but more computer artists than sculptors, but a lot of the sculptors are working with computers." Although uncertain of the exact number, he believes that a lot of the painters are working with computers. "I think that is great. It is integrating itself thoroughly to Art Departments." Since the time of CGRG, more students of traditional fine arts background are beginning to integrate facets of computer technology into their art work. The Department of Art that once denied Csuri the freedom to experiment with technology in his art work has begun a special emphasis to accommodate graduate students with this unconventional art interest.
Gardner: Do you think that academic programs in art have been influenced by computer-generated special effects?  
Slayton: Ah . . . they have been influenced by computer-generated special effects in the sense that artists are aware of how media represent ideas in society period. And so artists respond to that concept; they continually reevaluate how media represent ideas in communications, and since special effects are part of that bigger picture. And so you might see artists incorporating aspects of that in their work. But I wouldn't say it's affected the art in the sense that they too are just doing special effects. It is one aspect of their response to how media represents politics and economics and cultural issues and so on.

Similar to ACCAD with its goal of providing an interdisciplinary computer environment where artists and scientists collaborate, the CADRE Institute designed its program with two goals in mind. The first is to create a highly interdisciplinary environment for the exchange of creative ideas. To achieve this goal, the CADRE enrolls students in the graduate program and undergraduate program from all walks of creative life. Presently, the program consists of several creative fields, which include film making, photography, sculptures, performance art, painting, print making. They all come to the program with different ideas and different ways of working. The second is that it is focused exclusively on experimental applications. The Institute, according to Slayton, is less concerned with or interested in, teaching the techniques of interactive multimedia or just computer animation techniques so that students can just obtain jobs in those fields or
industries. Instead, the CADRE Institute aims to help students to "define the technology as it emerges by what they do." Like the CADRE institute, ACCAD is more interested in constructing an environment in which student can receive an education in the various disciplines of the field, in contrast to a program that trains individuals simply to be end users of off-the-shelf applications. However, the goals in both programs may not match the goals of the students, who may view the programs as opportunities to tailor programs, in an education setting, that will train and prepare them for jobs in the effects industry. The question, then, is: Are the universities capable of preparing the student for the contemporary effects industry?

Gardner: Do you think that computer-generated special effects can be taught effectively at a university to produce specialists in this field?  
Slayton: Oh yes. Certainly. You simply have to have a good faculty person who has practical experience in that area and is able communicate it to the students and have the resources to teach it with and that's probably the biggest thing. Most schools want to be able to do the special effects and animation for example and they just don't have the resources to do it professionally [at a professional level] and so...

Although schools may not be in a position to update their equipment regularly, they can still teach the principles of visual effects. In addition, the constantly changing resources and changes in the technology make it difficult for schools to keep pace with developments. According to Slayton, in spite of the expense, making many art department financially ill equipped to meet a high-end computer approach, the fundamentals can still be taught on lower-
end technology. The students, then, simply have to adapt them to the environments in which they are going to work. But even the fundamentals are constantly changing. Slayton said,

We are constantly redefining the program—not that we've really done it—based on what new technologies are emerging. And so, where multimedia was the craze five years ago or three years ago, then teleconferencing and the worldwide web are the craze today. What is the craze for tomorrow? I don't know. Whatever it is, you want to be one step ahead of it, and that's what we try to do.

Although I agree that universities must try to remain abreast of the industry if they wish to prepare artists for the field, the programs are changing faster than university curricula. Diminishing financial resources have made it difficult for the universities to lead the research in this field.

Schools like the CADRE and ACCAD rely on current trends in the corporate industry to design curricula for teaching this newer medium. The schools must continue to remain on the cutting edge of the technology, by adjusting the curricula to match the changes in the field. In the early days, centers such as OSU's CGRG and MIT led the way in the research and development of the field. They mandated their own destiny as a group of universities learning from each other. Today, an established field is led by the effects companies in competition with each other.

It appears that both CADRE and ACCAD graduates who are interested in working as practitioners may most likely have to go through training programs at effects companies. As we learnt at any of the three companies detailed in this document, the training programs are mandatory for all new practitioners without prior production backgrounds. New practitioners train
for four to six weeks, regardless of the training they may have received at universities. Companies often create proprietary software and may rely on these software for the majority of their creative effects. Traditional film animators (with no prior computer knowledge), and computer animators (trained in digital effects at universities) are trained in the same programs for the same duration. With the constant changes in software and the fact that the companies' proprietary software are not available to universities, it is difficult to train individuals at universities, but universities can educate individuals about the theoretical principles and issues of the field. These universities can guide the students' projects so that the students have a working knowledge of using the computer in accordance with the ten steps mentioned earlier and are capable of demonstrating the principles through the use of these software.

Gardner: How do you keep ahead as a teacher, learning all these new software and all these new programs?

Slayton: There is a balance between doing research and doing ... by research I mean real research where you are basically inventing and engineering new technologies, so you have to be abreast of what is happening in the field. Artists have always invented their tools so it is a natural kind of a process to become, if you will, a pseudo-scientist about your work; therefore, like any other scientists if you are going to be current, you read the literature, go to your conferences and you do this and you do that. Basically, you experiment.
Although Slayton, like ACCAD staff, does research in the area of creating his own tools, commercial tools are being created so quickly that most artists and pseudo-scientists are finding that it is most efficient to purchase their tools as opposed to creating them. In the commercial environment, where most large effects companies create their own proprietary software, some production companies such as PDI may purchase commercial software to keep abreast of their competitors while remaining efficient as a company. Both production companies and universities may purchase software to aid their proprietary programs.

When companies begin to utilize more off-the-shelf or turnkey commercial software, the education programs at the universities will become a more effective means of preparing students for the industry. Unlike the companies' proprietary software, commercial applications can be made available to the universities. The use of commercial software by companies will provide equipped universities with the option to train students directly for the production environment. This is fast becoming a reality, because some companies are finding that it is more cost efficient to purchase commercial applications as opposed to hiring specialists to create unique and specialized programs. Consequently, the duties of training for companies will become the responsibility of the universities, because students will then demand more direct training from university curricula.

Gardner: Is there any periodical or book that you recommend to students who come to your program that probably would give them a holistic look or view of the field of computer graphics or that reviews the CADRE program?
Slayton: There is no single text that summarizes enough material to do that. There are different kinds of books that we use. Michael Benedict's book on Cyberspace. Brenda Laurel's book on human computer interface for multimedia [The Art of Human-Computer Interface Design (1990)] and Howard Rheingold's book on virtual reality [Virtual Reality (1991)]. We try to get the students a real big picture by giving them reading that is going to present them with pros and cons of the technology, and what things cannot be done with it, a good theoretical base, but there's no single text—I don't think. It would be great if there were.

Gardner: Do you have any closing thoughts on the subject?
Slayton: Well then, my closing thought is that this whole field, if you can call it a field--computer arts--the art technology field is really . . . the kinds of students and the things that they need to know to go out there and be successful are that they need to know how to learn to learn, and you can teach them anything specific, and whatever that is will be obsolete by the time they leave your class. There is something much more important than teaching how to use the technology that I think universities have to really look at very closely, and learning how to learn about technology is not an easy thing. I'd like to think that students that leave here could sit down at any computer workstation of any nature, of any type, dedicated to any purpose and within a reasonable amount of time figure out what they could and couldn't do with it and then put it to some useful purpose--to me, that is the goal in education. In other words, if you are an artist, you ought to be able to make art out of a Timex watch or out of a CRAY
Supercomputer, either one. You ought to be able to do both. The thinking would be applicable to both technologies. You have to think bigger than the machine. In terms of special effects, I see it as just one aspect of what people need to be aware of and be able to do. The broader we can be the better.

The training and education model used by trained practitioners in the field of computer special effects is similar to the model used to train and educate new graduate students at The Ohio State University's ACCAD. However, the university has focused more on the colossal picture of art education. The alternate goal in both the academic and the production environments is to create art using computer systems; however, the CADRE Institute and ACCAD have focused on the creative art process rather than the specifics of any computer application or technological device. By collaboration with computer scientists, computer art students are able to get first-hand experience and knowledge of how to transcend smoothly from one program to another.

The large influx of the Ohio State University- and CADRE-educated animators who work in these Bay Area computer effects companies may be one of the main reasons for the similarities among the training programs and the academic programs. The Advanced Computing Center for the Arts and Design, formerly called the Computer Graphics Research Group (CGRG), was established by Charles Csuri in 1979. Established with the goal of training and educating artists and scientists to research the area of computer graphics, the facility has since trained and educated many artists and scientists. For
example, a former student of ACCAD, Brandao uses a congruent model to train the new practitioners at Xaos.

As a pioneer and former director of ACCAD, Csuri has had appointments in both the art education and the information science departments. These appointments have led him to develop training models that are used by the alumni, who may now be trainers. Apart from his establishment of a graduate program for artists and programmers, Csuri also founded Cranston-Csuri Production, a Columbus, Ohio-based, special effects company. He trained and educated students at school and on production. Csuri is both an artist and scientist who understands the importance of a relationship between artists and scientists. At Cranston-Csuri Production and at ACCAD, he established a study model that encouraged them to work together as a team of researchers in the field of computer graphics.

Now an emeritus faculty member at The Ohio State University, Csuri has already set the path for education, training, and research, which others in the field will follow. Other universities use, or aspire to use, similar models for training graduate students in computer graphics, and their graduates employ this method for training new practitioners in the production effects environment. Apart from The Ohio State University, Massachusetts Institute of Technology has used a similar study model for training and educating researchers in the area of computer graphics since the 1950s. The similarities stem from the model of the academic computer environment that promotes the collaborative efforts of artists and scientists. Both universities have been dominant forces in the pioneering and establishing of an effective method for using computers as a special effects tool.
As a student and faculty member at MIT and a graduate student at OSU's Department of Photography and Cinema in the mid 1970s, Slayton may have been in tune with the work that Csuri was doing at the OSU during this time. Ironically, both men received little support from their departments, both as teachers and students at OSU in the early days; in fact, for Csuri to progress and continue research in this field, he had to join another department at OSU. Similarly for Slayton. To continue his experimental photography, he transferred to MIT, where he began incorporating computers into his photographs. Both men established programs that were geared toward familiarizing students with the various aspects of digital technology.

Influence on Art and Art Education Academic Programs at The Ohio State University

Computers, more than computer-generated effects, are changing the academic programs of both art and art education departments at the university level. In 1968, Charles Csuri, professor in the art department at The Ohio State University, was awarded $100,000 from the National Science Foundation to investigate the potential of computer graphics for the visual arts. Csuri, a traditional oil painter, at that time had begun exploring his interest in computer graphics before receiving this award. His exploration of computer science, coupled with his traditional fine arts background, resulted in a piece of art he called *Flypaper*. In the next 25 years, Csuri receives 25 NSF and other grants totaling seven million dollars. The Art department grew weary of Csuri's involvement in this new medium, and the University moved the tenured professor to the more tolerant department of Art
Education, where he held an joint appointment with the department of Computer Science (Trachtman, 1995).

As early as 1967, Csuri experimented in computer graphics with the belief that someday the artist would have conversations with the computer and the two would decide how to make the art. He explored his primary assigned goal of computer graphics as an educational training tool for Army tanks or helicopter crews, among other projects. The funding for these projects also provided him with the opportunity to train graduate students in computer graphics and animation techniques and to advance the computer as a medium for artists. Csuri felt it was important for computer scientists and artists to have an identity as a group at The Ohio State University to give the computer science group more credibility and recognition and to make it easier for the center to get grants. In 1984, Csuri established the Advanced Computing Center for the Arts and Design (ACCAD), an expansion of the earlier Research Group, which included more artists and art educators and scientists (Holland, July, 1986; Trachtman 1995; Csuri, 1994).

Art Professor Susan Dallas Swan agrees that the influence of computers on academic art programs at The Ohio State University is imminent. In an interview, Swan (1995) explained,

At OSU the art department has resisted the influence of computer art, but in other locations throughout the university and throughout the United States and Europe, computers have had a strong impact on the art world and the art of academia. The use of computer-generated holography has allowed us to use space in a new way, and we are seeing images that we have never seen before. The students are able to create art that projects the human presence into new ways and new approaches. Technology will not stop at any level so the third world will be technologicalized as well as academia. We are
going to see a change, and we cannot stop it from occurring. The main thing we can do is try and humanize it, and we are seeing some academic programs take that approach. Others are taking the approach of completely using computers and using them as a commercial base so that people are trained to interface with them in a much more technical way than most academic programs allow.

Professor Jim Kaufman, chair of the Industrial Design Department, agreed that, even in the design arts, the computer has taken precedence over traditional tools. Computers in many ways have changed the design of academic programs in industrial design. Kaufman (1995) explained the changes he has observed as a professor and chair:

The bulk of the design community is that we have replaced the traditional methods and some of the hand-skilled methods, with the computer. For instance, in graphic design they used to sketch typography or use rub-down materials that are now replaced by computer technology. In product design, most of the drafting is now being replaced by computer-design systems. And it has actually given designers in academics opportunities to expand on themes we could not do before. In other words, you can take things to a further degree because you have this tool now that will do everything so accurately...so cleanly. This was not the case in the past, but there are many other examples...so it has totally changed the whole design profession.

The influence of computers in the arts is an issue that has impact on both academic art programs and the art world; but according to some, digital technology is eroding the foundation of the elite contemporary art world. Laura Trippi (Pinchbeck, December 1994), a curator at the New Museum of Contemporary Art, vowed that "the art world is scared of this stuff [digital revolution]." Furthermore, she added, "we are seeing a breakdown of the art object which reflects the fact that the field of fine arts itself is breaking down"
(p. 158). Digital technology is blamed for this breakdown. Some artists who were once creating originals on hard copies are making the transition to the creating their art through the use of digital technology. The debate is caused primarily by the distinction between original and copy. Thus, the computer artist creation exists only as a copy.

Although some artists have embraced the computer and have accepted it as an art tool, the gap between radical artist and digital artist continues to grow. According to artist Ronald Jones, this separation "is like the separation between the First and the Third Worlds" (Pinchbeck, December 1994, p. 158). Jones used this analogy to describe the widening gap between those disciplines comfortable with advanced computational tools and those that are not. The dilemma of the art world toward computers is exacerbated by the fact that digital art work has no intrinsic value as an art object. This art form consists of pure information that can be molded into a picture, a sculpture, an animation, or any imaginable form. This art created by computer artists confounds art dealers and the economic system of the art market. Artists such as Ronald Jones are transforming the new medium back into a traditional form to make it more viable for art world. To combat commercial failure, Jones, an artist involved in the reality sets, takes objects out of his virtual reality sets and has them made into sculptures to sell as traditional art works. In addition, Pinchbeck (1994) wrote:

Today's radical artist is stuck smack in the middle of a classic 20th century dilemma: how to remain disassociated from corporate pressures while at the same time succeeding within an art establishment that is dependent on corporate and institutional largesse. The digital revolution has sharpened the point of this problem, since the tools of digital culture--rendering programs, photo and video applications--are
developed in the context of commercial art (December, 1994, p. 158).

The Impact of Computers in Art Education

As is the case in other arts-related fields, computers have also changed the discipline of art education. According to art education professor Carol Gigliotti (1995), computers have not changed the details of Art Education but the overall relationship they have provided to art and education. That relationship has encouraged art and the world to really look outside themselves. The use of the computer is so provocative in our culture at this time that its use has provided an interdisciplinary context in art and art education and other disciplines.

Through their efforts, Csuri and others have demonstrated that computers can be integrated in art and art education academic programs. However, the influence of computer-generated special effects on academic art programs has ranged from minimal to highly influential, depending on the professor. As art professor, Susan Dallas Swan (1995) explained, "I don't see any relation between academic programs and computer-generated special effects other than the popular culture and how it influences people every day. I think academia, for a large part, uses special effects for their advertising and for their videos, but as far as influencing how academic art programs are structured, I don't see any relation."

Charles Csuri was not only involved in the academic and research applications of computer graphics, he was also interested in commercial and technical applications. His efforts have proven that computer-generated special effects can be taught effectively in an academic environment to
produce specialists in the computer production. When Csuri established the
Computer Graphic Research Group in 1971 as a cooperative effort of the
departments of Art Education, Computer and Information Sciences, and
Electrical Engineering, he had already achieved the facilities for training
visual effects practitioners through the use of an academic environment. The
facility at The Ohio State University received projects that were sponsored by
the U. S. Naval Equipment Training Center. Csuri's computer graphics team
developed realistic-looking buildings and trees on the computers and flight
simulators to help train pilots. The special effects were aimed toward
providing more realistic visual cues for untrained pilots (Columbus Dispatch
undated). Csuri went beyond the confines of the university and helped to
found Cranston-Csuri Production, a computer-effects company. With lease of
university property, he proved that the company, made up of primarily Ohio
State University graduates, could compete with effects companies in New
York and California, based on the education and training the staff had
received in the academic environment. I am not suggesting that the primary
goal of academic programs should be to compete against professionals; rather,
I am merely making the point that this was at one time possible.

From the interview, Slayton (1994), when asked whether or not
computer-generated special effects can be taught effectively in the academic
environment to produce specialists in the field, replied immediately, "Oh yes,
certainly...You simply have to have a good faculty person who has practical
experience in that area and is able communicate it to the students, and has the
resources to teach it with. That is probably the biggest thing, most schools
want to be able to do, the special effects and animation, for example, and they
just don't have the resources to do it professionally."
Charles Csuri and The Ohio State University's Advanced Computing Center for the Arts and Design is a prime exemplar of how academic programs can train and prepare students for the field of computer-generated special effects. The NSF, through its grants effort, made it possible for Csuri to outfit the university with the state-of-the-art computers, and his experience in the production environment of Cranston-Csuri provided him with the practical experience. Even today, Csuri alumni have moved on to create companies of their own or to become the primary practitioners at major effects companies in New York and California. A protégé of Csuri, Jeff Light, who now works at Industrial Light and Magic and who helped to create the dinosaurs in the film *Jurassic Park*, explained that "Csuri taught me the importance of art history, of keeping the issues of art in focus [because] you can get so caught up in the technology that you forget about the image sometimes" (Trachtman, 1995).

Conclusion

The historical background has shown that visual effects have predated film. With the advent of film effects, artists began to find ways to incorporate their traditional skills with the new technology. In fact, the trend of artists incorporating new technology into their traditional art dates back to cave of art itself. Throughout the history of art and technological development, as examined in this study, artists have often worked closely with scientists, engineers, and the creators of the technologies to devise methods for using the new tools in their art. This trend has continued on in the film and computer effects industries.
Conventional visual effects companies were once the only outlet for generating special effects for the film industry. As a province of the effects industry, computer effects companies have introduced a whole new level of sophistication; however, their structures, principles, and business protocols are comparable to those of conventional effects companies. In the early days of O'Brien, there had already been concrete evidence of the contracts, subcontracts, and other ways of exchanging specialized services within the film industry. Thus, the film makers, when contracted to create films that called for optical effects, subcontracted to companies or practitioners who specialized in this art form. The advent of computer effects not only introduced a new exemplar of film effects but also illustrated a shift in the paradigm of film. Thus, the film industry now can contract both computer effects companies and/or conventional effects companies to produce the film effects. In addition, many different combinations and models of contracting and subcontracting exist in the film industry among these categories of workers.

The model used to educate and train conventional special effects workers in the American film industries has traditionally followed the recruitment and apprenticeship model, similar to that of the craft industries. This model of training and education was also adapted by early computer effects companies, and even today it is still used in conjunction with the study model derived from university graduate study. The training of digital effects workers is different from the training of traditional visual effects workers. The training of conventional effects workers means that an group of experienced effects workers may hire individuals to work as apprentices. These individuals start working on actual productions the following day,
under the guidance of the masters. They are strictly trained on the job. In the contemporary digital effects industry, the individuals are first trained to use the sophisticated computer tools in classes or in group sessions at the companies. This model of training is similar to the university education model used to teach effects to students. In addition to adopting this training program, the digital effects company also uses the master-apprentice model. After trainees have advanced from the company's training programs, they are then qualified to become apprentices and are often assigned to mentors, as is the case at PDI. The study's specific examination of the pedagogy of special computer effects practitioners in Bay Area companies, namely PDI, Xaos and Pixar, also concludes that the training is geared toward preparing individuals to perform specific tasks in specific areas of production; training is the responsibility of the entire staff of experienced effects practitioners.

Universities can provide students with the theoretical background, as the practical training received at a university may be of little use to students who want to work at effects companies. Today, more universities are acquiring the resources and skills to teach the techniques and principles of computer graphics. Although the educational model for teaching visual effects at OSU and the CADRE Institute is similar to the model used for training digital effects workers, universities often lack the funds to keep abreast with the constant changes in the software and hardware. In addition, the education cannot prepare the students to use the proprietary software at these companies. Therefore the universities must encourage a relationship with the companies to gain an concrete understanding of the human resource needs of the companies. In addition, the companies need to take an active
part in educating of effects students at the university level through guest lectures or more in-depth internship programs.

The computer's major impact on the field of visual effects and art education today is the direct result of the contributions of the computer graphics pioneers. The three pioneers detailed in the study have contributed significantly to the field of computer graphics and art education. The three pioneers have all been affiliated with major universities, where most of their earlier research was conducted. They found ways to incorporate computer graphics and technology into their traditional fields of painting, film, and video. Through their affiliations with major universities as art educators, they have organized the models for the transfer of knowledge in this area and developed curricula that are used today in computer art education. Their early work has proven to be significantly beneficial to the corporate informal computer art education environments, which still benefit today from the students of these pioneers.

Further Research

There needs to be a more in-depth study of the individual companies and the roles of the practitioners in the training programs. It is difficult to get on the inside to conduct interviews with the practitioners. There is so much private information about the proprietary software and business procedures. Researchers may need to become employed at the production companies to get close to such privileged information on the methods of training for particular computer programs. More observational and empirical research is needed to gain a more in-depth knowledge about the training environment. Researchers may find it useful to conduct action research by sitting in the
classes during training and following up on several practitioners after they have gone through the training. How long does it take practitioners to complete the training and feel confident to the point where they begin to train others? How much additional training is needed after the companies' training, and how much of the additional knowledge is gathered by the artists independently?

The mentorship program at PDI has an important role in that company's training process. There needs to be a more detailed study into the duties of the mentors and their protégés. What are the advantages of such a program in a production environment?

Further, more detailed research also needs to be done on ACCAD's and the CADRE Institute's curricula for teaching computer art. As Slayton (1994) mentioned, schools need to focus less on the specifics of any one application or computer software and more on the larger picture of the computer art industry as a whole. The question for further research then becomes: How can the industry assist universities to achieve this goal while ensuring that students are given enough practical knowledge to prepare them for the proprietary software at the production environment?
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Charles Csuri to present commencement address. (1985, December 5). *onCampus*, p. 4.

Chuck Csuri computer world. (date unknown). *Columbus Dispatch magazine*.


PDI takes the Pillsbury Doughboy into 3-D animation. (1992, December 18). Back Stage *Shoot*.


APPENDIX A

Preparation for Interviews in the Bay Area
APPENDIX A
Plate XXII Map of San Francisco Bay Area Companies
APPENDIX A

Preparation for Interviews in the Bay Area

Contact Person and Address of the Companies.

Linda Jones
Xaos, Inc.
1600 Townsend Street,
Suite 271 E
San Francisco, CA 94103
Phone: 415-558 XAOS

Monicia Corbin
Pacific Data Image
1111 Karlstad Drive,
Sunnyvale, CA 94089
408-745 6755

Nagisa Yamamoto
Industrial Light and Magic
P.O. Box 2459
San Rafael, CA 94912
415-258 2000

Marie Shell
Colossal Pictures
2800 3rd Street
San Francisco, CA 94107
415-550 8772

Raugh Guggenheim
Pixar
1001 West Cutting
Richmond, CA 94804
Fax: 510-236 0388
Phone: 510-236 4000
APPENDIX A

Preparation for Interviews in the Bay Area.

Contact Sheet.

<table>
<thead>
<tr>
<th>Practitioner</th>
<th>Company</th>
<th>Title</th>
<th>Dates</th>
<th>Comments</th>
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</thead>
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<tr>
<td>Doug Smythe</td>
<td>ILM</td>
<td>Sup/FX</td>
<td>12-12-94</td>
<td>lm/ph./con.</td>
</tr>
<tr>
<td>Marke Dippe</td>
<td>ILM</td>
<td>Sup/FX</td>
<td>12-12-94</td>
<td>lm/ph./con.</td>
</tr>
<tr>
<td>Mark Chew</td>
<td>ILM</td>
<td>COMP</td>
<td>12-13-94</td>
<td>con.</td>
</tr>
<tr>
<td>Chad Taylor</td>
<td>ILM</td>
<td>COMP</td>
<td>06-94 to 08</td>
<td>con.</td>
</tr>
<tr>
<td>Ken Warlson</td>
<td>ILM</td>
<td>FX</td>
<td></td>
<td>lm/ph.</td>
</tr>
<tr>
<td>George Lucas</td>
<td>LEF</td>
<td>FX/pion</td>
<td>10-10-94</td>
<td>nointerst</td>
</tr>
<tr>
<td>Micheal Collerey</td>
<td>PDI</td>
<td>ANIM</td>
<td>12-13-94</td>
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<tr>
<td>Jennifer Yu</td>
<td>PDI</td>
<td>TRAIN</td>
<td>12-16-94</td>
<td>1st interv.</td>
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<tr>
<td>Carlos Arguello</td>
<td>PDI</td>
<td>Art DIR</td>
<td>12-13-94</td>
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<tr>
<td>Andrew Adisson</td>
<td>PDI</td>
<td>FX</td>
<td>12-13-94</td>
<td>nointerv.</td>
</tr>
<tr>
<td>Raugh Guggenheim</td>
<td>Pixar</td>
<td>President</td>
<td></td>
<td>letter</td>
</tr>
<tr>
<td>David Tart</td>
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<td>Pixar</td>
<td>DIG/LT</td>
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<tr>
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<td>Xaos</td>
<td>TRAIN</td>
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<tr>
<td>Alexei Tylevich</td>
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<tr>
<td>Agata Bloska</td>
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<tr>
<td>Stuart Cudlitz</td>
<td>Colossal</td>
<td>DIR./MED</td>
<td>12-12-94</td>
<td>nocon./lm</td>
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<tr>
<td>Robert Lurye</td>
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APPENDIX A

Preparation for Interviews in the Bay Area.

Contact Sheet.

<table>
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<tr>
<th>Pioneers &amp; Prof.</th>
<th>University</th>
<th>Title</th>
<th>Dates</th>
<th>Comments</th>
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<tr>
<td>Charles Csuri</td>
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<td>Prof./Pion.</td>
<td></td>
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<tr>
<td>Joel Slayton</td>
<td>SJSU</td>
<td>Prof.</td>
<td>12-16-94</td>
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<td>Susan Dallas Swan</td>
<td>Ohio State</td>
<td>Prof.</td>
<td></td>
<td></td>
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<tr>
<td>James Kaufman</td>
<td>Ohio State</td>
<td>Prof./Chair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carol Gigliotti</td>
<td>Ohio State</td>
<td>Prof.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ron Sacks</td>
<td>CCAD</td>
<td>Instructor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key Code Directory
- ANIM: Animators
- con: Contacted the individual
- COMP: Digital Compositor
- CCAD: Columbus College of Arts and Design
- DIR: Director
- DIG: Digital
- FX: Visual effects both traditional and computer
- ILM: Industrial Light and Magic
- lm: Left message
- LEF: George Lucas Education Foundation
- MED: Media
- nocon: Was unable to contact the individual
- nointerest: Was not interested in the research at the time
- PDI: Pacific Data Image
- Pion: Pioneers
- Prof.: Professor
- Sup: Supervisor
- SJSU: San Jose State University
- ph: Telephoned
- 1st interv: First interview of many others
APPENDIX B

Letter to the Companies
APPENDIX B

Letter to the Companies

November 29 1994

Ms. Yamamoto
Industrial Light and Magic.
P. O. Box 2459
San Rafael, CA. 94040

Dear Ms. Yamamoto

I am currently a doctoral student at The Ohio State University's Department of Art Education and the Advanced Computing Center for the Arts and Design (ACCAD). I will investigate in my doctoral dissertation the impact of computer graphics on the area of visual effects. In partial fulfillment of this degree, I have proposed to carry out a case study of those involved in the production of computer visual effects (i.e., computer graphics animation, computer effects director, software developers and other end users of proprietary, commercial animation, or computer effects software) in the San Francisco Bay area and New York. My research is designed to gather information on the ways people learn to use computers to generate visual special effects. The data collected will provide information that will significantly add to the development of my research project.

Enclosed, you will find a copy of my proposal, and a list of criteria for both the teachers and the students I am aiming to interview for my dissertation. I would be grateful if, while reviewing the list of criteria, you could suggest some names of practitioners at your company who may be best suited for these interviews (at least two teachers and two students). These interviewees will serve as the informants for my research. I have also included criteria for locating a pioneer in your company. I hope that this pioneer will help me (through an interview) to gather information on, and documentation of their personal experiences in the field of visual effects. The information received from the pioneers, teachers, and students at your company will be audio taped and transcribed. In any event, the informant can, at his or her request, choose to remain anonymous. These primary sources of information will serve as raw data for the case study and historical section of my dissertation.

I will be conducting this field research in the San Francisco Bay area from December 9, 1994 to January 2, 1995 and would like to know if your company would like to be involved in this research. To respond, please call or write to the above address.

Thank you for your continued cooperation and support.

Sincerely,

Garth Gardner
APPENDIX C

Pool of Core Questions
APPENDIX C

Pool of Core Questions

Structured questions pool

Demographics

1) What was the last school you attended?
   Did you study visual effects, conventional or digital, at this school?
   Did you take any classes in traditional art?

2) How did you become interested in digital effects?
   What motivated you?

3) What was first position you held at a production house?
   What were your experiences at this position?
   How did you advance technically from this position?
   Did you do computer effects at that company?
   What was your first computer effects position?

Influences, education, and training

4) Were there any particular computer artists who has influenced the process by which you create effects?
   Who are they, and where are they?

5) Whom or what would you credit for your technical ability today?

6) Did you learn any new programs or processes for the last project you worked on?
   Who taught them to you?
   Is this person your mentor?
APPENDIX C

Pool of Core Questions

Structured questions pool (continues)

7) How were you educated and trained to use the technical programs?
   Do you attend classes?
   When are the classes held and how long do they last?
   How many practitioners are in the class?
   Is the training more like a teacher-student, or master-apprentice model?
   Do you ever train other practitioners?
   Do you collaborate with other practitioners during the training period?

8) Do you design your animation with a particular audience in mind?
   Who specifies the target audience for the computer effects?

Philosophical and others

9) What pleasures do you get from creating digital effects?
10) How does a project get passed on to you at this company?
11) What project that you have worked on gave you the most enjoyment or satisfaction, and why?
12) Technically, what causes a project to fail?
    What didn't you like about the project?
13) Describe the impact which you believe computer-generated effects has made on society?
    Do you believe these impacts are negative or positive?
14) What advice would you give to someone who wants to get involved in this field today?

15) What are your future plans in the area of digital effects?

16) What do you enjoy best about working in this field?
APPENDIX C
Pool of Core Questions
Structured Questions Pool

In addition to the general pool of questions above, a more specific pool was developed for the trainers, educators, and pioneers.

Trainers and educators
1) What motivated you to go into corporate training?
2) What is the goal of the training program?
3) How do you prepare for training?
   How do you learn the new software as an educator?
4) How is the training program structured?
   Is the training structured to resemble a university's studio curriculum?
5) Are the new practitioners monitored after the training program?
   What happens to the practitioners who are not able to apply the training?
6) Does the training enable the animator to adapt to the changes in software?

Pioneers
1) What inspired you to go into the area of computers in the early days?
2) What was your first experience with computer graphics?
3) Who were some of the other pioneers working with computers around this time?
4) Comparing the early days to present, give a brief description of the progress that has taken place in the field of computer graphics.
APPENDIX D

Mythology
Mythology helps me to look at how myths affect my beliefs, particularly, my perception of reality. I see in them an imaginative tradition about how we look at nature, history, and destiny of the world, the gods, man, and society. I tend to view myths as poetry rather than literal truth, either historical or scientific. As a symbolic way of thinking, mythology represents a poetic way of communication as I search for meanings beneath the surface. I have an interest in the similarities and parallels between myths from different cultures. The patterns that offer the explanations about the origins of life and the forces that influence the way we all look at reality. In many respects, myths are virtual realities which enter our consciousness and shape our perceptions of existence. Human beings have always invented virtual realities to give their lives meaning and purpose. Instead of a scientific explanation of phenomena, i.e., thunder and lightning or a hurricane force, I prefer a God of Thunder and Lightning or a God of the Winds. As an artist, I find this has great appeal to my imagination. I love the idea that man was formed on a potter's wheel from clay or emerged from a cosmic egg. The Egyptian God Khnum told me that he actually created the entire human race on his potter's wheel. He advised me to distrust much about scientific explanations because they do not truly offer a meaningful explanation about the origins of the Universe or the appearance of human-kind on this earth. To me it is an awesome notion to even conceive that there was once nothing but darkness or at what stage light appeared? Is it possible that matter
emerged from light or space from water? There are many Gods who have
influenced me in my work and who have offered me guidance on my
presentation of reality. The Hindu Deity, Prajapati or Brahma, who is the
Lord of Creatures, creator of the universe, father of gods, dreams and
creatures—he encouraged me to present a reality which has a dream-like
quality where I see strange distorted figures, monsters and even hybrid beings.
They change their shapes and possess magical powers. The Japanese Buddha
Areida (Boundless Light), has taught me how to use color which is not
bounded by the geometry of objects in our world, but, where color functions
more as light in a boundless 3-D space. He said it is necessary to have an aura
of infinity in my presentation of reality. The Hindu God Varuna also talked
to me about a spiritual image of an infinity that embraces and illumines. I am
not sure I understand what he means, but he has encouraged me to think
about reality enveloped in light. Varuna suggested I consider a ethereal purity
of space against a background of nothingness. Uranus, the Greek God of the
Sky, invited me to leave the earth and live in his domain. The Egyptian
Goddess, Nut, Goddess of the Sky, also told me to forget about gravity or that
we are located on a physical plane. Shadows are meaningless because they
simply keep us on the earth; besides shadows represent the evil spirit of an
underworld. I have been advised to avoid Persephone, the Greek Queen of
the Underworld, or Osiris, the Egyptian God of Death, at all costs. The
freedom and expansiveness of the sky and the air are better for what I want to
say as an artist. Psyche, the Greek God, told me my pictures should represent a
collective unconscious of myths which have become woven into my spirit.

Khnum, the Creator God, has encouraged me to be highly
experimental and not to worry about a consistent artist style. He suggests my
message will come through, irrespective of style. I should not be self-conscious about technique or innovation but to try to convey feelings about my notions of reality. When I asked him if I might be rich and famous, Khnum began to laugh uproariously. I also heard gales of laughter in the background coming from the Gods Areida, Varuna, Nut and Psyche. Then they began to chant "get real", "get real", "get real".

There is the incredible Norse God Odin, the god of magicians, who has the power to change his appearance and adopt different disguises. He explained to me how to present contrasts between order and chaos involving the nature of reality. I was also told to live and create on the very edge of chaotic systems because I can have more flexibility than if I live in the domain of orderly, linear systems. In fact now, I have more control as I gently nudge chaos into an artistic statement. The God Odin has suggested that sometimes in my images there can be a highly visible object and secondary semitransparent representations to convey echoes of time and reality. He said to be sure to include fragments of the object floating in a boundless space. (Even the American Indian God from Above encouraged me to think of the fragments as a magic lotion sprinkled into space to create people and objects). Odin has also taught me how to simultaneously show imitations of the object, creating contradictions from many points of view. I felt that the God Odin might help me so I spent considerable time with him. I tried to talk to him about my interest in emphasizing three dimensions in my work but to no avail. Later I understood his indifference when I discovered he only had one eye which I understand he lost as a consequence of his warlike tantrums. Odin, who is also the God of Wisdom, did tell me that in the field of art, there is nothing new—just different guises conveying the same ideas about human
beings and existence. Pan the Greek God of Mischief, lives in my computer. My interest in using a computer's capability to exploit new notions about creativity are very intriguing to Pan. At the same time, he takes great pleasure in tormenting me and causing mistakes so that I become confused and question my involvement with a computer. We have an interesting relationship---he deliberately corrupts my parameters and presents me with what he thinks are horrible pictures. Most of the time this is true, but, occasionally, Pan makes a mistake and I get back an amazing image. It is something I would never have predicted, and then I claim it as my own personal work. When this happens he becomes furious and shuts down the computer as his evil side comes out. Eventually Pan will relent because he really enjoys playing this game with me, knowing he wins most of the time. I must admit I do love Pan's playful attitude about art and computers. The Greek Goddess Aphrodite and the Hindu Goddess Lakshmi said they could reveal to me secrets of beauty which transcend physical beauty. However, they said to teach me about art, I needed wings to travel with them so I could fly forward and backwards through time. At this point the God from Above said he could give me wings by turning me into an eagle. I accepted his kind and generous offer and was able to accompany Aphrodite and Lakshmi and I saw many great works of art and even watched the artists at work. Unfortunately, I could not talk to them and ask any questions because I was in the form of an eagle. At each stage of the journey Aphrodite and Lakshmi, who were the only ones to understand my sounds as words, explained to me the significance and meaning of each artist's work. While the journey took us 50 years, I learned to appreciate a concept and an aesthetic which links together different styles and cultures throughout the history of art. I can now
appreciate relationships between primitive art, Giotto, Michaelangelo, Utramaro, Cezzane, Picasso and others. The experience of flying and the trip was the thrill of a lifetime and the God from Above changed me back to my original form. Both Aphrodite and Lakshmi, who represent beauty, gave me a stern warning that I am not to deal with social or political comments. The universe moves very rapidly and I should not be concerned about things which depend upon an extremely narrow focus of history. Also, I should not pay much attention to notions about interactive virtual reality as an art object because the aesthetic issues are extremely complex especially the criteria that can distinguish between playful entertainment and art. More importantly, the Goddesses told me that if I fail in my quest to achieve beauty, then, when I die, I will be banished to the underworld of ugliness. There, all of my senses will deal with hideous, repulsive, and morally objectionable images, sounds, and forms for all of eternity.
APPENDIX E
Sample Syllabus
Proposed Art Education Courses in Computer Graphics and Animation:

Proposed Instructional Context:

A. Undergraduate:

Art Education/ "The Arts, Education and Computer Technology." (open enrollment, possible BER course, lecture and small discussion groups, CTA assisted). The course reviews the brief history of computer graphics/animation and provides examples of its applications in the arts, education and training. Applications are demonstrated by viewing videotape examples. CGRG has a video library of 40 such tapes. Projected enrollment: 300 per year by January 1985.

Art Education 5 "Microcomputer Graphics in the Arts and Education" (limited enrollment). The production of graphics/animation on microcomputers. The course seeks applications of micrographics as an art form and their use in computer-based education. Projected enrollment: 60 undergraduates per year by January 1985.

B. Graduate


ART EDUCATION 652

COMPUTER GRAPHICS IN THE ARTS AND EDUCATION

Study of the applications of computer imaging for the arts and interactive educational programs.

Course Objectives:

(1) Students are introduced to and tested on the fundamentals of three-dimensional, computer-generated graphics. These fundamentals include: data generation (four methods), scaling, rotation, translation, methods of motion control, lighting models, hidden line and hidden surface, antialiasing techniques, key frame techniques, etc.

(2) Students review, analyze and discuss examples of computer-generated graphics from the major research and production laboratories. These examples are presented on videotape.

(3) Students read, analyze, and discuss major articles on the application of computing to the arts and education.

(4) Students write a concept proposal for an application of computer graphics to an area of the arts and/or education. This proposal is submitted in draft form, revised, and submitted in a final form.

(5) Students demonstrate fundamental knowledge and understanding of key concepts and analytical ability through a final examination.

EVALUATION OF STUDENT PERFORMANCE

| Classroom participation in discussion: | 25% |
| Concept Proposal (draft and revision): | 35% |
| Final Examination: | 40% |

COURSE CALENDAR (SAMPLE)

WEEKS 1-3

Basic concepts of three-dimensional computer graphics. Review of slides, production process videos and readings (Sachter) related to fundamental graphics concepts.

WEEKS 4-6

Review of artistic applications of computer graphics in filmmaking, design, and advertising. Review of artistic applications videotapes and readings.

WEEKS 7-9

Review of current research efforts in major research laboratories with focus on educational applications. Review of applications videotapes and readings.
WEEK 10

Review and discuss concept proposals.

WEEK 11

Final Examination.
SAMPLE SYLLABUS

Art Education 652.
03 credits

Computer Graphics and the Arts and Education

Art Education 795L is a seminar on Topical Issues in Art Education. This section on Computer Graphics and Art Education will address the following topics through a lecture/discussion and videotape presentation format:

-Computer imaging as an art form and the aesthetic implications.

-The computer imaging process, its development and current capabilities.

-Applications of the computer imaging process (medical, scientific, design, architecture, advertising, entertainment, etc.)

-Interactive computer imaging implications for education.

Seminar Requirements:

Attendance and participation in discussion are essential. Much of the seminar's content is presented on videotape. In the event of an excused absence from seminar, arrangements can be made to view the videotape shown at a given session by contacting Mr. Tom Hutchenson (422-3416) and making an appointment.

A five-page, concisely written proposal for an application of computer graphics to a field of your interest is required. The proposal is to have the following section headings:

I. Introduction to the Area of Application
   a. Description of current practice
   b. Advantages and disadvantages of current practice

II. Proposed Practice using Computer Graphics
   a. Scenario of the new environment, description of its features, procedures, processes, and outcomes
   b. Advantages and disadvantages of proposed practice
III. Impact and implications of the proposed practice on the problematic area and other system elements.

Proposal Drafts due: Nov. 7, 1984

Required Readings:


SAMPLE
Videotape Presentations of Computer Graphics
ART EDUCATION 652

I. Introduction to Computer Graphics Concepts

3-D Data-Generation Demo, 1982; Dr. Wayne Carlson, Cranston-Csuri Productions.


Art Education Graduate Student Animation, Ohio State University.

Key Frame Animation, National Film Board of Canada.

II. Film/Video Special Effects Advertising & Research


Omnibus Video, Inc., Demo tape, 1985, Toronto, Canada.


Cranston-Csuri Productions, 1986, CBS Electronics Project.


Cranston-Csuri Productions, Demo, 1986, Columbus, Ohio.

Cranston-Csuri Productions, Broadway Project, 1982.


Robert Abel and Associates, Los Angeles, CA, "Chicago."


III. Computer Art/Artists

John Whitney.

Kenneth Knowlton (Bell Labs).
Peter Foldes, *Hunger*, National Film Board of Canada.

Lillian Schwartz (Bell Labs).

IV. Interactive Video Games, Educational/Entertainment

TAXI, A Computer Learning Game.

Blood Cell (A Proposed Game).


Mystery Disc I & II, 1983, VIDMAX, Cincinnati, OH.

V. Medical/Scientific


Human Brain, University of California, San Diego.

Russian Ant, Robotics Project, Moscow, USSR.

Hexapod "Bionic Bug" Project in Robotics, OSU.


Kinostatistics, Department of Geography, OSU.
Title: Computer Graphics and Animation: Production I

Credit: 5 hours

Offered: Fall quarter only

Prereq: Permission of instructor and credit in CIS 222 or equivalent

I. Course objectives

The course is designed to introduce students to the production of computer graphics and animation.

At the successful completion of the course the students will demonstrate:

(1) an understanding of simple 3-D data construction with points and polygons, both built by hand and algorithmically.

(2) knowledge of compositional principles of computer graphics and animation (e.g. placement of an eyepoint within a scene to create the composition of the final image).

(3) an understanding of a computer animation system resulting in the production of a vector test and a 10-second finished animation.

(4) knowledge of the relationship of technological and aesthetic manipulations of time, space, texture, and continuity in the animation process.

II. Course Procedure and Content

To achieve an understanding of all the elements necessary to create images and animation on a computer and to transfer those images to film or slides. This includes the basics of film and animation techniques, programming, and polygonal data construction.

(1) an understanding of the computer system, including the operating system, an editor, a programming language, and certain other local utility programs.

(2) completion of tutorials on the operating system and editor in use.

(3) creation of a primitive piece of data by inputting all points and polygons by hand.

(4) creation of several pieces of data using various algorithmic data generation methods.
creation of a 'scene' using the hand-built and algorithmically built data. The scenes are to be transferred to slides.

production and evaluation of projects.

reading and discussing assigned tutorials and selected articles.

production and evaluation of projects.

III. Requirements

(1) demonstrate understanding and application of major concepts in tutorials, classwork, and projects.

(2) on-time completion of assignments.

(3) successful completion of final animation.

(4) purchase of removable storage disc(s).

IV. Evaluation

(1) quality of class participation.

(2) quality of comprehension of theoretical concepts as manifest in system usage, completion of projects and class discussions.

(3) quality of projects.

V. Grading

(1) quality of classwork-1/3.

(2) quality of assignments-1/3.

(3) quality of final projects-1/3.

VI. Required Reading

B. W. Kernighan, A Tutorial Introduction to the ED Text, Editor.

ED text editor, manual pages.


Handout on the Bourne Shell
dg – Data generation on the VT 100 manual pages
scn-scn assembler manual pages.
Handout on color with the Peritek Frame Buffer.
flat-floppy disk archiver manual pages.
Chapter 2 of Disney Animation: The Illusion of Life.
The Bouncing Ball from "Handbook of Techniques for Animation."
Cause and effects section from "Timing for Animation."
Handout on the C Programming Language.
Handout on Writing Subroutines.

VII. Recommended Readings

Get the list of recommended readings off tape (tar.A or tar.1)
Title: Computer Graphics and Animation: Production II

Credit: 5 hours

Offered: Winter quarter only

Prereq: Credit in xxI and permission of instructor

I. Course Objectives

Continued work in animation, programming and data generation. The objective is to do "straight ahead" animation using techniques utilized in xxI and shape deformation. The "straight ahead" format encourages experimentation and exploration of possible techniques.

II. Course Procedure and Content

Through discussion of progress and/or problems in achieving various effects, knowledge of the integration of computer technology and animation/image generation is increased. The emphasis in the final product should be on quality, not quantity.

III. Requirements

(1) on-time completion of projects.

(2) successful completion of a 10-to 20-second animation that shows development in the control of timing and movement in animation.

(3) successful creation of more complex data structures and the creation of stills with those objects.

IV. Evaluation

(1) quality of class participation.

(2) quality of comprehension of theoretical concepts as manifest in system usage, completion of projects and class discussions.

(3) quality of projects.

V. Grading
(1) quality of classwork-1/3.
(2) quality of assignments-1/3.
(3) quality of final projects-1/3.

VI. Required Reading

Disney Animation: The Illusion of Life, Chapter Two. Principles of Animation, Thomas, Frank and Ollie Johnson.

Timing for Animation (the whole thing).

Basic Concepts of Three-Dimensional Computer Graphics for Artists (Judy Sachter's thesis).

Timing and Movement in Three-Dimensional Computer Animation (Maria Schwepppe's thesis).

Intro. to 3D Graphics by James F. Blinn.

VII. Recommended Readings


3-D Computer Character Animation by David Zeltzer.

Twixt Here and There: Event Driven 3D Animation by Julian Gomez.

Beyond the Storyboard: A Tool Set for 3-D Computer Animation by Charles Csuri, Julian Gomez, Paul MacDougal and David Zeltzer.
ART EDUCATION 752

Title: Computer Graphics and Animation: Production III

Credit: 5 hours

Offered: Spring quarter only

Prereq: Credit in Art Education 751 and instructor's permission

I. Course Objectives

Continued work in animation, programming and data generation. Introduction to additional software. The objective is to produce animation utilizing techniques from 750 and 751. In this case the animation will be planned with a storyboard, exposure sheets, and sound. The course provides experience in planning the timing of an animation in advance, in estimating the amount of time necessary to complete a given animation.

II. Course Procedure and Content

Through discussion of progress and/or problems in achieving various effects, knowledge of the integration of computer technology and animation/image generation is increased. The technology and animation/image generation is increased. The emphasis on the final product should be on quality, but also on the ability to complete the work within the projected time frame.

III. Requirements

(1) timely completion of various stages of the project.

(2) successful completion of a 10- to 20-second animation, which shows the control of timing and movement in animation as well as ability in planning the execution of a preplanned animation.

(3) each student is required to organize information on the project for presentation to the class as a whole.

IV. Evaluation

(1) quality of class participation.
(2) quality of comprehension of theoretical concepts as manifest in system usage, completion of projects and class discussions.

(3) quality of projects.

V. Grading

(1) quality of classwork-1/3.

(2) quality of assignments-1/3.

(3) quality of final projects-1/3.

VI. Required Readings

Manual pages on:

(1) inspect.

(2) s2c assembler.

(3) document preparation.

(4) texture mapping.

(5) and numerous others.
Art Education 795L. Computer Graphics and Art Education 03 credits

Art Education 795L is a seminar on Topical Issues in Art Education. This section on Computer Graphics and Art Education will address the following topics through a lecture/discussion and videotape presentation format:

- Computer imaging as an art form and the aesthetic implication.
- The computer imaging process, its development and current capabilities.
- Applications of the computer imaging process (medical, scientific, design, architecture, advertising, entertainment, etc.).
- Interactive computer imaging implications for education.

Seminar Requirement:

Attendance and participation in discussion is essential. Much of the seminar's content is presented on videotape. In the event of an excused absence from seminar, arrangements can be made to view the videotape shown at a given session by contacting Mr. Bob Bowers (422-3416) and making an appointment.

A five-page, concisely written proposal for an application of computer graphics to a field of your interest is required. The proposal is to have the following section headings:

I. Introduction to the Area of Application
   a. Description of current practice.
   b. Advantages and disadvantages of current practice.

II. Proposed Practice using Computer Graphics
   a. Scenario of the new environment, description of its features, procedures, processes and outcomes.
   b. Advantages and disadvantages of proposed practice.

III. Impact and implications of the proposed practice on the problematic area and other system elements.
Proposal Drafts due: May 14, 1986
Drafts returned with comments: May 21, 1986
Final Proposals due: May 28, 1986

Required Readings:

APPENDIX F
Xaos Training Program Outline
Xaos Training Outline

Fundamentals of CG Production
Modeling
Space
Transformations
Rendering

Production Environment Overview
Pipeline
Hardware
Software

Production Software Training
Animation
  Basic Interface
  Modeling
  Animation
  Rendering

Image Processing
  Image Processing-Intro.
  Image Processing-Advanced
  Particle System-Intro.
  Particle System-Advanced

Image Library
  Conversion
  Display
  Paint

Data Conversion
Storage
Miscellaneous

Xaos Jobs Overview
Historical Background
Creative Direction
Technical Direction
Principles in Computer Graphics Production

Modeling

Description and Construction
Scale model
Mathematical model

Blue-print modeling
Interactive/free-form modeling
Procedural modeling

Static model
Dynamic model
    hierarchy, joints

Types
Polygonal data
    vertices, edges

Metaball data
    radius, resolution
    blobbing

Sweep data
    cross section, skin

Surfaces of revolution
    contour, axis

Patch-based data
    splines, axis

Boolean
    primitives
    operations

Space

Systems
Cartesian space
    origin, XYZ axis
Polar coordinate space
  origin, angle

Measurements
Absolute x relative coordinates

Right-hand rule

Angle measurement
  degrees
  quadrants
  radians

Vectors
Splines

Transformations

Types
Scale
Rotation
Translation

Local transformation
Global transformation

Animation
Matrix concatenation

Key-framing

Spline-based animation
Hard-wire animation

Rendering

Frame Display
Frame-buffer
Aliasing
Viewing projection
  perspective
  parallel/orthographic
Channels
  RGB channels
  Alpha channel

Surfaces
  Hidden surfaces
  Visible surfaces

Normals

Surface attributes
  ambient
  diffuse
  specularity
  transparency

Texture mapping
  projection
  spherical
  cylindrical

Bump mapping

Reflection mapping

Shading
  Faceted
    Lambert shading

Smooth
  Gouraud shading
  Phong shading

Ray-tracing

Radiosity

Lighting
  Infinite light sources
    ambient
  Local light sources
    omni indirectional
    omni directional
    spot
Temporal Shading
Motion-blur
Production Environment Overview

1. Production Pipeline Overview

   **Pre-Production**
   - Negotiation/Bidding
   - Line Production/Coordination
   - Creative Direction/Design
   - Technical Direction/R&D

   **Production**
   - Technical Direction Loop
     - Technical Direction/Supervision
     - Software Support/R&D
     - System Management/Support
   - Line-Production/Coordination Loop
     - Elements Input/Output
     - Disk Management/Archive
     - Client Feedback Loop
       - Approval Points
       - Information Feedback
   - Design & Animation Development Loop
     - Painting/Touch-Up
     - Modeling
     - Animation
     - Color & Lighting
     - Image Processing
     - Composting
     - Batch-Processing

   **Post Production**
   - Output
   - Post-House-Work
   - Storage/Clean-up
   - Post-Mortem
   - Documentation
   - Marketing/PR