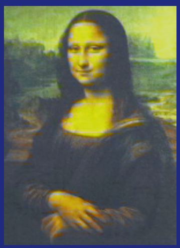
Everyone is an educator and everyone is a student.

Electronic Schoolhouse:

Educators Program | sigKIDS | Community Outreach



Jodi Giroux
The Allen-Stevenson School

Anne Richardson
StarMedia

Jill Smolin
Cinesite Visual Effects

Classroom **c**
Playground **p**
Workshop **w**

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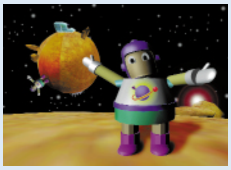


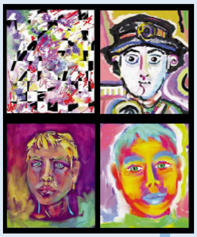
Educator

Everyone is an educator and everyone is a student.

This simple tenet is the foundation and inspiration that is the Electronic Schoolhouse. It was the visualization of this principle that led its three chairs to amalgamate three programs (Educators Program, sigKIDS, Community Outreach) to create a unique wonderland of integrated education, where knowledge sparks in every corner, and inspiration ignites during every conversation.

Education at the end of the 20th century is as multidimensional as it is challenging. The one-room schoolhouse is more evident than ever, yet its dimensions are infinite. We are a fabric of integrated circuits and interrelated topics. Students collaborate with peers halfway around the world, creating projects and establishing a lasting presence where they may not even share a common language. Educators retrieve and use tools from countries they have never visited; they scour library stacks of universities they will never see, exchange ideas with professionals they will never meet, and augment their curricula by perusing classes they will never attend. We learn tools as soon as they're built. We teach those tools as quickly as we learn them. And as soon as we learn them, we encounter students who have already constructed more tools to augment those we have barely learned.

We can choose to be overwhelmed or inspired.



For while we can be easily distracted by the technology, we should be equally compelled to remember our fundamentals, the basics that are hard-coded into every theory and provide the cornerstones of every dazzling technique. As educators and students, artists and scientists, it is vital to remember that enlightenment occurs in the smallest interactions, and transformation from the most unlikely places.

This Electronic Schoolhouse is such a place. We imagined an integrated experience where teachers could present papers in a Classroom and then walk their students through hands-on Workshops on the same topics. We envisioned an environment where students of all ages could learn the process of building a project and then explore the creation on their own in a Playground of interactive installations. We pictured a venue where professionals involved in various computer graphics industries could offer teachers and students interaction they might not be able to otherwise access. We conceived of a Library where a plethora of valuable resources, references, and publications could be borrowed indefinitely, and casual conversation could lead to collaboration and inspiration.

Through our incredible contributors, we believe we have realized our vision and we welcome you to the SIGGRAPH 99 Electronic Schoolhouse.

Student

Committee

Co-Chairs

Jodi Giroux
The Allen-Stevenson School

Anne Richardson
StarMedia

Jill Smolin
Cinesite Visual Effects

Electronic Schoolhouse Subcommittee

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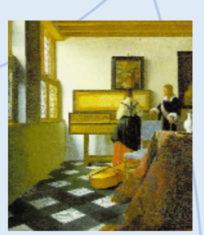

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Adele Newton
SIGGRAPH 2000 Community Outreach Chair
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Anne Richardson
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Jill Smolin
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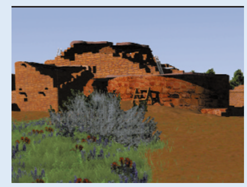

Electronic Schoolhouse Reviewers

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The 4D Virtual Museum of the City of Bologna, Italy

Classroom

See page 31 for a related workshop.

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Manuela Ghizzoni
Rosa Smurra
University of Bologna

Fernando Lugli
Centro Ricerche S.C.R.L.

Virtual

Bologna is a major Italian city. It is the largest town and the administrative center of the Emilia-Romagna region, and is located more or less midway between Florence and Venice, in the Po Valley, to the north of the Apennines, the mountain chain that separates the northern part of Italy from the peninsular part, at the northern end of several valleys linking Emilia-Romagna and Tuscany. Today, Bologna has a population of about 400,000, and it has a long historical and cultural tradition. It is known the world over for having the oldest university in Europe (dating back to about 1088) and for its characteristic architectural and urban structure. In the city center, nearly all the streets are built with arcades, known as portici, a continuous series of arches along both sides of the street forming an integral part of the urban structure. Even today, there are more than 25 miles of these arcades in the city center.

It is extremely difficult to construct a museum illustrating the history of the city inside a building, above all when there is a need to show the dynamic phases of history. New developments, periods of decline, new settlements, and changing buildings are all elements that are difficult to present to the public in a satisfactory manner. The New Electronic Museum is using computer graphic techniques to reconstruct the transformations of Bologna, so that the public can see the changes that took place, and to present the results of historical research with a high level of accuracy in terms of cartographic and architectural reconstruction.

Information technology and the information superhighway enable us to move on to a new frontier of research into urban history, making it possible to carry out a three-dimensional electronic reconstruction of the urban habitat and its historical transformations. The result will be a four-dimensional city, with the three spatial dimensions plus the temporal one.

This project combines historical research and new technology to produce results that traditional research methods could never achieve. It is therefore necessary to introduce new approaches to our work, both with regard to the methods used in historical research, and to the transfer of that research to a virtual reality environment. It must be stressed that the method illustrated is not valid solely for the city of Bologna, but rather the city of Bologna is the place where experimentation with this method is taking place. The same method is valid for all cities, whether they be ancient or modern, European, African, Asian, or American.

The Fundamental Role of Historical Research in the Implementation Phase

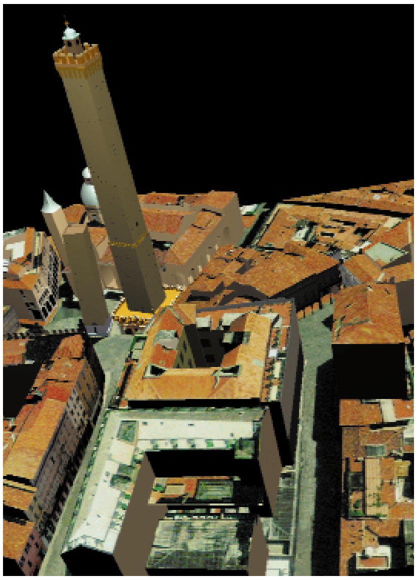
The first phase consists of historical research based on analysis of documents and identification of the cartographic sources and other useful pictorial sources. This phase is particularly complex with regard to the period (ancient and Medieval) for which no pictorial sources have been handed down to us. Precise visual representations of the buildings and urban structure no longer exist. The only available sources of information for those early periods are the records of the notaries public, government acts, property lists, and tax records.

Even the oldest pictorial records (from the Renaissance onwards) are not always easy to transpose into geometric and virtual forms. Once again, these records must be studied in depth before they can be used. It is necessary to work out why they were produced and what they were intended to illustrate in order to understand the contents and interpret them.

Autocad Modeling

Once the analysis of the historical sources (documentary, narrative, pictorial) has produced satisfactory results, the next step is the modeling phase, implemented by experts in the construction industry (engineers and architects) who have to formulate geometrical models based on the data taken from the documentary sources and combine models and materials used in the various historical periods with the building and urban components that were in existence at that time.

This is a critical phase in the reconstruction work and is preceded by a complex data-processing operation. We intend the model under construction to have a scientific rigor that distinguishes the New Electronic Museum from other products currently available on the market. In order to achieve this level of reliability, it is necessary to start from an accurate two-dimensional map, identifying the precise geographical location (latitude, longitude, altitude) of the buildings.



Four-Dimensional Navigation: the 4D Interface System

The results of the research and the modeling are entered into a virtual environment governing the "time machine."

The Use of Written Sources for Reconstruction of the City in Virtual Reality

When we reconstruct the city in a virtual reality environment, we are not only showing something that is no longer accessible. We are also examining the past by analyzing each part, showing how each element is linked to the others. The sources available to us provide a great deal of information relating directly to physical structures, such as streets, buildings and land, but they also provide much indirect information about various aspects of life in the city.

The records known as the Libri terminorum are, without a doubt, the documents that provide the most significant information about the urban structure in spatial terms. They were drawn up by teams of land surveyors and by officials appointed by the city administration on a number of occasions (1245, 1286, 1294) to lay down a series of ground markers or termini to mark off public areas in the squares, in the streets, and along the city walls from private property. They were laid down in positions that were easily recognizable, such as the corners of buildings and arcades or portici. The Libri terminorum not only provide a list of these ground markers but also a great deal of other information about the buildings. The surveys took into account the upper floors of the buildings, with overhanging beams and guttering: if there were any overhanging features, questions were asked about whether they were built over private ground.

For the purposes of our research project, the careful attention to detail of the land surveyors is of great importance. The precise measurements between one ground marker and the next enables us to see the exact relation between the various elements taken as reference points for the identification of the ground markers. These documents also enable us to locate many buildings on the city map: this degree of resolution is made possible by the care with which the various householders were listed together with their property.

Museum

The database designed to manage this documentation needs to show the buildings as the result of social, historical, and property relations over a long period of time. Most of the information in the database concerns people, structures, and places, but the contents are not simply a list of such items. We need to bring together the various components that contribute to urban development so that each person is linked to the others who are in some way related. In the same way, the buildings need to be linked up with their owners and inhabitants. The mass of data put together in this way produces the information that is the basis for the production of hypertexts and for modeling the structures that are recreated in the virtual reality environment of the New Electronic Museum.

The Map of Bologna in Perspective (1575)

For the Holy Year of 1575, Pope Gregory XIII ordered a room in his private apartments in the Vatican to be decorated with a large pictorial map (seven meters across and five meters high, scale 1:360) of Bologna, the city of his birth. It appears that this fresco served a strategic purpose for control and management of the city and the surrounding area. To be able to cast an eye over a pictorial map of the city was a way of possessing it, in material and not just symbolic terms.

This fine pictorial map of Bologna, in which topographic detail is enhanced by landscape painting, consists of a bird's-eye-view perspective in which the hypothetical viewpoint is located high up in the sky over the northeastern sector of the city.
Until recently, this map has been used to support various hypotheses about the urban development of Bologna, but now software applications enable us to move on to a qualitatively different kind of analysis of the sources.

The fresco in the Vatican is being used as the main source to produce a three-dimensional model of Bologna in the second half of the sixteenth century. To this end, there is a need to ascertain the reliability of the fresco, using scientific criteria, in order to be sure that this was a pictorial account of the city as it really was and not just a fresco based on the painter's imagination. Because of the complex changes that have taken place in the urban layout, such an analysis cannot be based simply on a comparison between the elements reproduced in the pictorial map (streets, buildings, squares) and the surviving structures. It is necessary to carry out a careful analysis of the map.

An initial analysis shows that the map has a high degree of reliability: there is a close match between the street frontages of the buildings and the measurements of the building plots in the land registry records (1833). These comparisons lead us to believe that the Vatican artist worked from a plan made in the same period that has unfortunately not been handed down to us, showing the development of the city center on paper.

Historians are able to use the fresco of Bologna as a reliable historical source, free from inventive work and flights of imagination by the artist. It is important to underline that, for the purposes of our project, the map in the Vatican is of great interest for the reconstruction of sectors and individual buildings that have undergone major refurbishment or reconstruction.

Moreover, thanks to the map's scale, it is possible to carry out a close reading of the buildings, including features of individual buildings, both civil and religious.

From Historical Sources to CAD Modeling

The city itself is a complex form. It is not an entity that perfectly conforms to elementary and standard geometric forms. It is characterized by irregular, geometric forms found in its external confines and in its complex division of streets and housing lots. In these situations, there does not exist a street that is perfectly rectilinear or a tower that is exactly vertical. Also, the dimensions and forms of habitation spaces are not perfectly subjugated in one, simple reticular form. This diversity of form provides information about the genesis of the city itself, offering hints as to how the city appeared in other times and how it expanded.

The precision of topographic operations when dealing with the necessity of reducing scale, can only be solved today with digital cartography based on CAD generating systems, which allows the possibility of overcoming the scale problem in graphic representation. The computer does not memorize the graphic nor the mathematical characteristics. Instead, it allows each mathematical element to be associated with information concerning the characteristics of the objects themselves.

In this way, the computer initiates the algorithm of representation, or in other words, "produces" the image instead of merely reproducing it, which allows the output of the machine to regenerate every time from zero.

The 4D Interface System

The interface of the prototype version of Nu.M.E., the New Electronic Museum, is designed and implemented in order:
- to provide different types of users with simple and efficient navigation tools to look back over the historical and urban development of the city from the end of the first millennium to the present day.
- to show visitors the fundamental role that historic research plays in the project.

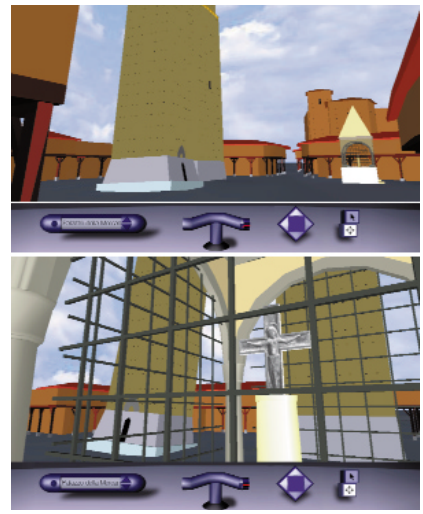
The New Electronic Museum Interface consists of a VRML browser for the 3D display and specific 4D navigation tools in order to improve management of both spatial navigation and temporal navigation.

The spatial navigation orientation tools consist of:
- A 2D orientation map of the area of Bologna reproduced in the New Electronic Museum that allows visitors to visualize their position in the virtual world with a red rectangle and the direction for viewing the city with a green rectangle. The map can be shown or hidden by means of a button on the console.
- A virtual terrain model that allows the user to visualize each virtual building considering the altitude parameter in order to measure distances and areas and to carry out simulations related to the relief of the terrain.

The temporal navigation orientation tools consist of:
- A time-bar that includes a text field showing the year on display and a bar with a cursor showing the time line. By selecting a year, it is possible to visit the entire reconstructed city.
- The sound environment by which each century is associated with a different soundtrack, that allows visitors to identify, at an intuitive and perceptive level, the period in which they are visiting the city.

Finally, the New Electronic Museum interface needs to make clear some concepts related to the historic research:
- The need to reverse the chronological order of the research itself. The visitor begins to tour the city in the present and then travels backward in time, watching existing buildings disappear into the ground or change appearance, after which the buildings that no longer exist then pop up.
- The principle that the New Electronic Museum shows only as much as the historical sources will justify. Each building is therefore accompanied by a hypertext link with a description and references to the historic sources on which the virtual reconstruction is based.

The New Electronic Museum of Bologna (www.cineca.it/visit/nume/) is supported by the National Research Council (CNR), the University of Bologna, Centro Ricerche S.C.R.L., and CINECA, the supercomputing center for a consortium of Italian universities.



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Classroom
Playground

A Creative Journey

Moderator
Victor Raphael
Artist

Panelists
Bob Goldstein
Digital Consultant

Jane Raphael
Wonderland Avenue School

"Victor Raphael @ ZZYZX A Creative Journey" was created by Victor Raphael with the support of ZZYZX Visual Systems. The CD-ROM is a virtual exhibition of Raphael's "Space Field" series that can be viewed anywhere on a personal computer. It has been accepted into the collections of The Museum of Modern Art, New York, the Bibiliotheque Nationale de France, and the Skirball Museum, Los Angeles. Beyond its artistic merits, the CD-ROM is an educational tool. Teacher Jane Raphael has used the CD-ROM in her multi-age primary school classroom.

Jane Raphael explains: "As we prepare to step into the 21st Century, educators continue to ask, 'What's worth teaching?' and 'How will learning best occur?' Information and knowledge are expanding at such an accelerated rate that what our children need to know is very different from what was needed a generation ago. 'A Creative Journey' can help educators who are asking these questions. It renders the universe a tangible miracle to students. It brings the question 'What is our place in the universe?' into focus as a point of student inquiry."

The artwork, based on NASA images from outer space, and the audio, based on plasma sounds from our solar system, send students on a personal journey into space. As they navigate through the artwork, students use technology as a vehicle for exploration. They see images of the planets, stars, and galaxies – imagery that is both awe-inspiring and provocative. One student saw rocks banging into a spacecraft, and the next moment, she was using the cursor to trace the tendrils of a spiral nebula.

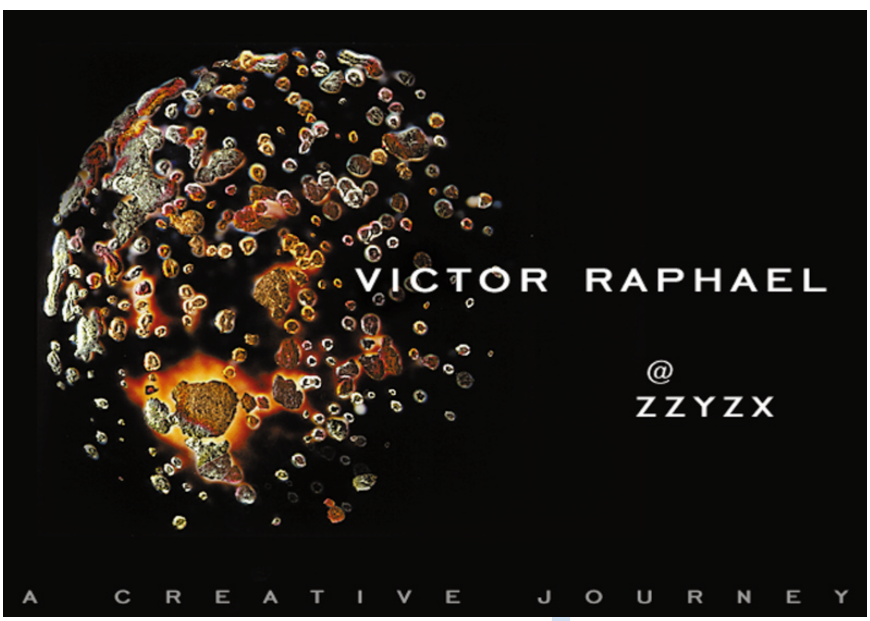
As the connection between the arts and learning becomes clear and evident, "A Creative Journey" is a tool to bring art into the classroom. Jane Raphael continues: "Viewing the artwork is the common experience that allows us to respond, interpret meaning, and make critical judgments, as individuals in a group context. When students view Victor's artwork, I raise such questions as: 'What do you see?', 'What is it about?' and 'How do you know?' The students' descriptions of what they see ranges from twisters and rainbows, to the moon, earth and stars. This talk about art seamlessly transitions into talk about science. It is in this transition that I am able to access what the children already know about the universe. The unanswered questions they bring shape future investigations into this unit of study. Children's ability to critically focus on an artwork is developed when they need to find the point of symmetry in order to interact and navigate the artwork. Using the art as a visual text to be 'read' for specific information gives support and confidence to those students whose strengths lie in visual perception."

Once students have explored the artwork and raised scientific questions about our solar system, they are able to explore Victor Raphael's studio interactively, and through the movie section, observe the artist and his creative process. The CD-ROM also explores collaborations with computer artists and technicians. As Bob Goldstein relates: "We shot video of Victor in his studio creating the 'Space Field' series and explaining the history and methods of his work. We made videos of all the technicians – digital camera operator, computer artist, programmer, QTVR artists, and Iris printer operator – to demystify the process and show other artists and students how art, science, and technology come together. Few people have seen an Iris printer, and fewer still know how it operates. As the Iris is the leading device in the fine art printing world, we thought it important to feature it."

Goldstein describes how the CD-ROM project began: "I began working with Victor Raphael, who came to me to help him produce fine art Iris prints from his Polaroid work. As Victor and I got into the process, I became fascinated with the way his images were transformed when they were digitized and viewed on a computer monitor. I was also interested in the process Victor was personally going through, seeing his art in a new way and beginning to work in the digital world. I thought that Victor represented a new breed of artist making the transition from traditional to digital art, and I proposed we document this transformation. Because we were using a myriad of sophisticated digital devices and highly talented technicians, I thought we could blend the art and science of digital imaging into an interesting 'creative journey' that would document not only an artistic process, but the entire late-20th Century digital production process as well."

Victor Raphael has a strong emotional attachment to his subject matter: "When I was a kid growing up in the 1950s, I was excited about the prospect of being an astronaut and going out into space... I think that working with these space images was a way for me to put myself out there and create my own fantasy about space. Because we live in a time where the common experience of viewing the heavens has been minimized by urban light pollution, our primal desire to connect to something larger than ourselves goes unsatisfied. Especially with young learners, the CD-ROM provides an easy entry point for students who are interested in making sense of the world."

In the opening artist statement that begins the CD-ROM, Raphael continues: "All of these images of space are new and have come into being in our lifetime... I'm depicting space as a metaphor for a micro-macro relationship, both of which offer a glimpse into infinity... I want people to slow down when they look at these images because there is something incredible about our place in the universe, when we can think about ourselves as a very small planet in perhaps endless and vast expanses of space." For students of all ages, "A Creative Journey" integrates art, science, and technology to provide an initial engagement in a compelling unit of study.



Journey

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Classroom

Art and Technology: Electronic Resources from the Getty

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Naree Wongse-Sanit
Getty Education Institute for the Arts

Anne Marie Schaaf
J. Paul Getty Museum

ArtsEdNet home page, the Getty Education Institute for the Arts' Web site.
www.artsednet.getty.edu

ArtsEdNet: A Web Site in Progress (www.artsednet.getty.edu)

ArtsEdNet began in 1995 with 250 Web pages. Today the Web site includes over 2,000 pages. In this paper, The ArtsEdNet team details the developmental process that the site has undergone in becoming an expansive and extensive Web resource.

Devoted to comprehensive arts education, ArtsEdNet offers a wide variety of curriculum resources including lesson plans and online images from ancient to contemporary times and representing cultures from around the world. ArtsEdNet also provides online professional development materials and an online community called ArtsEdNet Talk, an email discussion group with over 1,000 participants.

At its inception, ArtsEdNet consisted of materials that originated as print resources adapted for the online environment. Gradually, the team developed curriculum resources exclusively for the Web, utilizing the interactive aspects of the Internet. The four-year research and development period for ArtsEdNet is not yet complete; the demands of our audience and of this medium are constantly changing and so must the site.

Keeping in mind the audience that a Web site serves is crucial to its development. Over the years, we've devised guidelines for writing and presenting information on the Web in a manner that is useful to teachers.

Exploring the Artworlds of Los Angeles: Worlds of Art

This innovative Web curriculum resource provides lessons that tap Los Angeles' many artists, museums, community art programs, and public art. Teachers can bring LA's worlds of art into the classroom by combining use of the Internet with an interdisciplinary approach. Teachers outside LA can use these lessons to build connections between art learning and the art worlds of their own communities.

Worlds of Art comprises several lesson units designed to work together. The core unit, Understanding Artworlds, consists of four lesson plans that help students broaden their understanding of art and culture. It also includes components on exploring LA art worlds on the Internet and understanding the importance of art in other cultures. All of the lessons included were developed to correlate with the California Frameworks for various subject areas addressed.

The other lesson units, also known as multicultural units, allow students and teachers to delve more deeply into particular art worlds in Los Angeles. Three are now available: Mexican American Murals (November 1998), African American Artists (January 1999), and Navajo Art (April 1999). Each unit centers on a group of artworks found in the Los Angeles area and provides online images accompanied by multiple core and supplemental lessons, as well as worksheets and other handouts. Students and teachers can explore these art worlds, learn more about the artworks and the themes they address, and try making art that reflects what they have learned about each particular art world.

Worlds of Art is based on an approach to teaching and learning that is thematic and inquiry-based. It is part of ArtsEdNet (www.artsednet.getty.edu), the Web site of the Getty Education Institute. ArtsEdNet aims to provide K-12 teachers around the nation with quality curriculum materials based on art from ancient to contemporary times and from Western and non-Western cultures. It has been available on the Web since September 1995 and receives an average of 10,000 visitor sessions each week.

Presenting and Managing Electronic Visual Resources: The Getty Experience

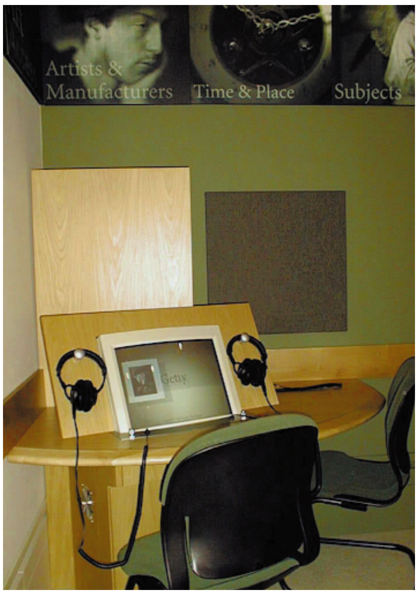
The Getty Education Institute and the J. Paul Getty Museum collaborated to produce online exhibitions utilizing the unique interactive qualities of the Internet. This collaboration focused on two of the J. Paul Getty Museum's opening exhibitions, "Making Architecture: The Getty Center from Concept through Construction" and "Beyond Beauty: Antiquities as Evidence," both of which have since closed in the galleries. Portions of these two exhibitions are still available in an online version on ArtsEdNet (www.artsednet.getty.edu), with added educational components.

Through this collaboration, the Getty has used digital images to virtually recreate elements of a physical exhibition. "Looking at the Art of Ancient Greece and Rome" on ArtsEdNet uses artwork and information from the exhibition "Beyond Beauty." The physical exhibition consisted mostly of three-dimensional sculptures. One concern was to attempt to translate these three-dimensional works onto a two-dimensional page. At the same time, because the main audience of teachers is often not able to utilize more advanced plug-ins such as ShockWave due to hardware limitations, we needed to find a simple way to accomplish this. We created "rotating" images by using an animated GIF that connects a quick sequence of several static images. For example, a statue of Aphrodite shows all perspectives (front, side, back, and other side) of the goddess in succession, giving the effect of movement around the statue. Despite the flat screen, viewers get a sense of the object's three-dimensionality.

"Trajan's Rome: the Man, the City and the Empire" on ArtsEdNet also utilizes material from the exhibition "Beyond Beauty," this time creating a unique and innovative "virtual tour" of the Forum of Trajan. Collaboration among the Getty Education Institute, the J. Paul Getty Museum, and the University of California, Los Angeles, produced a virtual reality model of Trajan's Forum based on available archaeological evidence. The video virtual reality tour of the Forum of Trajan played continuously in the physical exhibition and is now available online, along with QuickTime movies and VR stills accompanied by interviews with curators, professors, and archaeologists. To complement this technological resource, ArtsEdNet added an online curriculum unit called "Trajan's Rome: The Man, The City, The Empire." Six lesson plans explore life and culture during Trajan's Rome.

Looking at Art of Ancient Greece and Rome: an online curriculum resource on ArtsEdNet

Within Art Information Rooms located adjacent to galleries with works of art, the J. Paul Getty Museum presents information about the museum's collections in an interactive multimedia system called Art Access. Using an underlying database structure, the touch-screen system allows visitors to acquire more information on works of art and artists. Art Access is a resource for the gallery experience, not a CD-ROM history of Western art. Why would the Getty Museum supplement real objects with art on the screen? Because a database system can provide great depth of intricately layered content, well beyond the brief words on a wall label. Curators cannot be there in person for every visitor, but this virtual tour can serve as a guide at any time.

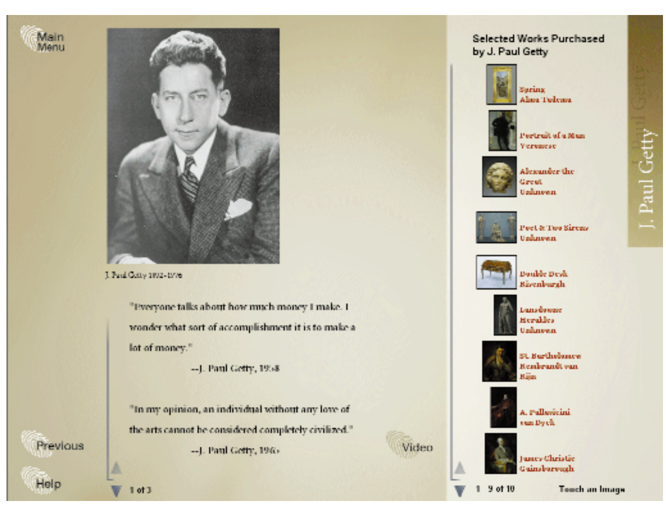


Workstation for Art Access, the J. Paul Getty Museum's interactive multimedia system, in an Art Information Room at the Museum

The structure of Art Access is based on objects. Each object record contains multiple images, informative text with hyperlinks, and links to groups. Objects also link to their artists, who are indexed by specialty, nationality, and type. Artist records can contain portraits, life dates, text, audio, and video. A variety of indexes combine works of art from multiple departments in various ways: Time and Place; Subjects, which uses language to engage a layperson; Works of Art, an index by type of object that uses vocabulary for knowledgeable visitors; and Reference, an overall listing with a visual key. Additional elements enhance the object and artist content. Hyperlinks lead to definitions for glossary terms, and presentations offer additional information on topics within indexes. Viewers who seek more guidance can turn to introductory videos from the director, curatorial tours on video, and videos of manufacturing processes.

All elements of Art Access – text, images, audio, video, and index categories – are stored in a custom-made database and retrieved from servers when a user touches the screen. With quality as the first priority for onsite use, the museum has adopted various standards for its digital resources. Having made a significant investment in these resources, the museum chose a modular database, separating content from screen design and functionality, to permit multiple uses for this information. The museum's new collection management system, AMICO (Art Museum Image Consortium), the Museum's Web site, curricula on ArtsEdNet, and in-house slide presentations already use elements of Art Access content or may do so in the future.

The production process for a complex, truly live, interactive system based on a database model differs significantly from the usual one-shot, finished publication such as a CD-ROM. Editors must pull together creation, management, storage, and delivery of high-quality modular content, while concurrently handling both the continual flow of new content and review and adjustment of existing content. Since the system is non-linear, editors must juggle the multiple, evolving digital resources – text, images, video, audio, and animation – and maintain the complex links among them in a continuing campaign of editorial and technical management.



Screen for presentation on J. Paul Getty in Art Access, the J. Paul Getty Museum's interactive multimedia system.

Art Before Technology or Technology Before Art? That is the Question

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Workshop

In 1989, AnimAction was formed with a single purpose in mind: to create a unique and innovative environment for young people, where they could experience the spirit of collaboration, develop new skills, and exercise freedom of expression, all with the ultimate goal of articulating a powerful message through the medium of animated film. AnimAction has trained thousands of students on development and production of classical and computer animation in the United States, Canada, and Europe.

AnimAction has worked with children involved in programs at: The World Animation Celebration, The Los Angeles Unified School District, LA's BEST After School Enrichment Program, LA Children's Hospital, Glendale Unified School District, The Office of Criminal Justice Planning, YWCA, YMCA, Torrance Unified School District, Long Beach Unified School District, Sweetwater Union High School District, The San Fernando Arts Council, The Light-Bringer Project, The Gene Autry Museum, The Federation of Saskatchewan Indian Nations, Sioux Lookout Zone Hospital, The Solicitor General of Canada, The Teachers Advisory Council on Alcohol and Drug Education (TACADE), and The Mentor Foundation.

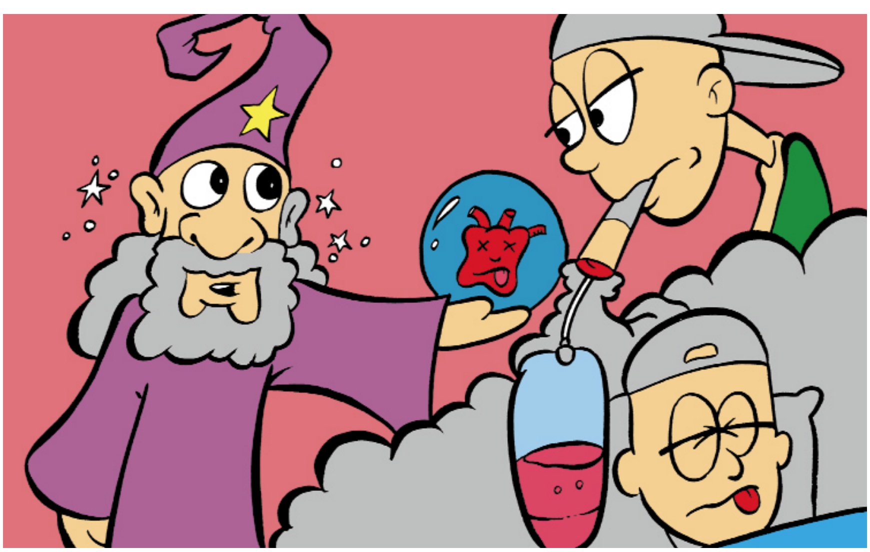
Art / Technology

Introduction

The graphic arts and animation industries have grown in leaps and bounds since AnimAction was first started, particularly the animation industry. Today more than ever, the animation industry is crying out for artists to work in traditional style and computer-generated animation. Now that the Internet is available to the general population, our world's communication system is becoming easier to traverse, and the need for technicians is becoming greater. Indeed, the whole media production world is opening up, and there are more employment opportunities for a variety of careers within the rapidly expanding fields of animation and digital production.

However, there seems to be a great crevasse between the educational world and the industry. Should we teach our kids how to work, live, and breathe computers first, whilst not seriously taking into account a solid foundation in art and the use of the pencil and paper?

Of course, the animation industry looks primarily for experienced artists who have acquired these artistic skills for a number of reasons. They are more interested in working with people who can draw and understand the flow of a line. Animation studios train these artists with the necessary digital technology, making them ready for successful employment.



Art Before Technology or Technology Before Art? That is the Question

Goals of the Program

- Introduce the classical animation process, stressing the importance of the basics and how a solid foundation in the art of animation will help in digital production.
- Demonstrate and involve all participants in a hands-on experiential workshop and give them the opportunity to take home their own products on video.
- Demystify classical animation production in the classroom (grades 5-12).

The Program

- Three hour workshop
- Ages 8-80 (presentations can be designed for a wide age range under the same roof)
- Participants are arranged in groups of up to four people, as small production teams. Each team works together throughout the workshop. From the very beginning, this introduces and builds the teamwork.
- From this launching point, we work through every stage of animation production with the goal of producing up to 10 seconds of animation. Each team takes on the challenge of producing a short film based on the theme: a whimsical look at a digital animation artist compared to a classical animation artist.

Each animation stage is covered:

- Importance of the story concept
- Character development
- Timing
- Storyboarding
- Production
- Color
- Filming

Methodology and Quotes

AnimAction's staff consists of artists and students of scriptwriting and animation. We're a very young-minded company made up of extremely curious minds. In this workshop, we demonstrate the endless possibilities of peer education and how it inspires us all as we work together experiencing each other's talent.

AnimAction staff artist Esdras Varagnolo, independent 3D animation student, and SIGGRAPH member, says: "Working with kids has improved my improvisation ability and constantly makes me look back at the basics for inspiration. Digital production is a tool used as an enhancement. The real strength is in the art!"

AnimAction staff artist Wade Bradford, English masters program, California State University, says: "I get to discover brand new styles and fresh story concepts working with kids."

AnimAction staff artist Brigitte DiSalvo, student at Santa Monica College says: "Working with kids has improved my timing and conceptual creative approach. It's also great practice, and somehow I seem to work faster now. A solid foundation in art is essential as the computer is only a tool. Creativity comes from within."

The Atmosphere: Incorporating Interactive Multimedia into the Classroom

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Classroom

The Atmosphere is an interactive multimedia project that I did while I was a graduate student at Rensselaer Polytechnic Institute. The title comes from the Lutgens and Tarbuck textbook used in an introductory atmospheric science course at the State University of New York, Albany. This course is offered to non-science majors to fulfill a distribution requirement. Most of the students in the class find math and science very difficult and are unmotivated to study the material. So a multimedia application for this class serves two purposes: to explain difficult material and to motivate students to learn the material.

This project was a collaborative effort. A classmate worked on the project with me. She is more skilled at graphic design, while I am more skilled at programming. We also enlisted the help of two graduate teaching assistants in the Atmospheric Science Department, who were responsible for this class. They were our content experts. They identified topics that were especially difficult for students to grasp through lecture and readings, and gave us books and lecture notes that explained these concepts for us.

My partner and I wrote scripts based on this material and worked with the teaching assistants to ensure that our text was technically accurate. Then, we illustrated the scripts and motion through simple storyboards. These are just pencil and paper stick-figure diagrams that roughly show the illustrations that appear in the scene, and use arrows to indicate motion. Again, we met with the teaching assistants to review the storyboards to make sure we were still on track. Next, we found clip-art illustrations and built our scenes inside our tool, Asymetrix Toolbook. We used arrows to represent the atmosphere, and used Toolbook's hide and show commands to "move" the arrows to show the atmosphere's motion. In another scene, we used Toolbook's motion recorder to move an object from one point to another.

When we put it all together, we showed the application to the teaching assistants and their professor to get their feedback. We also asked co-workers who had never taken the class to try out our program and let us know what they thought about its navigation, layout, and content. Everyone was pleased with the program. Most everyone found the navigation intuitive. Many suggested that we add a "back" button, which we did. One reviewer suggested that we add a quiz at the end, in a future release.

We packaged the program on two diskettes and gave it to the teaching assistants to distribute to their classes as optional materials to supplement lectures. They reported that many students used the program and conveyed that it did help them better understand the concepts. The teaching assistants then began to use the program in class as part of the lecture. The professor did not have to wave his arms around any more to describe precipitation processes. Students could now watch precipitation in action.

Our process can be summarized in four major steps:

- Planning (10%) — audience analysis, anticipated use
- Design (40%) — script writing, storyboarding
- Development (40%) — drawing illustrations or finding images, videos, and sound, putting the pieces together in the authoring tool
- Testing (10%) — reviewing the final piece with anticipated users, gathering feedback, incorporating feedback into future releases

Animation is not a technique for film studios or design students only. However, it is time-consuming. We spent about 10 weeks working on The Atmosphere, part-time. The professor and teaching assistants wanted to incorporate multimedia into the classroom, but they didn't have time to develop the application while also teaching their classes. My partner and I had the time, but were not experts in atmospheric science. Because the teaching assistants were willing to spend a little time with us to review our work along the way, we were able to form a successful collaboration. After this project was completed, the professor realized the power of using multimedia in the classroom. He has asked his teaching assistants to find more video and animation to incorporate into lectures. A large volume of educational material is available free from the World Wide Web.

Interactive

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Playground

City@Peace

City@Peace, sponsored by the Community Mediation Program in Santa Barbara, California, brings together a diverse group of teenagers, age 13 to 19, from all socio-economic and ethnic backgrounds to promote peace and cross-cultural understanding through the performing arts. Assisted by professional artists trained as mediators, the teens explore conflicts in their lives and use improvisational theater techniques to write, produce, and perform original musical plays. Through collaboration with the professional artists (writers, actors, directors, visual artists, dancers, composers, musicians, poets), the teens grow in self-esteem and become productive (rather than destructive)members of their communities. They also invite an ever-expanding audience of their friends, families, extended families, and community supporters to enjoy their work.

This year, City@Peace adopted interactive, computer-generated sets to replace traditional props and backgrounds. The computer imagery shows physical locations where the action takes place (for example, in homes, on the streets, etc.) The image-processing capabilities are also used to show not only reality, but how the reality might feel. The German Expressionists called this "Theatre of the Mind."

ColorWeb

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Playground

The ColorWeb installation is a subset of Web-based materials created in the Exploratory Project at Brown University. An exploratory is a computer-based combination of an exploratorium and a laboratory that embodies an approach to learning by experimentation and investigation. It provides multifaceted, interactive microworlds that model objects, concepts, and phenomena, and that exhibit appropriate behaviors when interacting with students.

Our current implementation embeds Java applets in a hypermedia framework that (a) provides an immediate context for both the individual applet and for the larger conceptual frame of reference, and (b) enables students and teachers either to work within the framework provided or to place the applet in an environment of their own choosing.

The first set of exploratories on this site teaches basic concepts in additive and subtractive color mixing. These modules are being used in our introductory computer graphics course as classroom demonstrations, in assignments, and for self-directed learning. They are appropriate for a wide audience and assume no prior knowledge of color theory or computer graphics. The second set is designed to develop an intuitive feeling for the signal processing aspects of color perception and has been used by teachers around the world in their existing curricula. These exploratories are appropriate for a general technical audience.

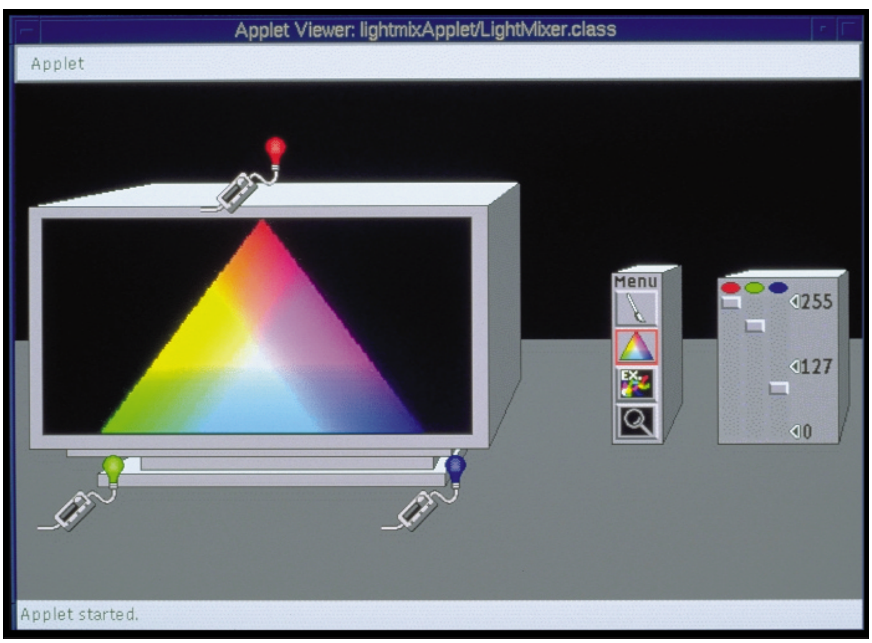
Text for the color mixing applets is from Anne Morgan Spalter's recently released text *The Computer In the Visual Arts* (Addison-Wesley).

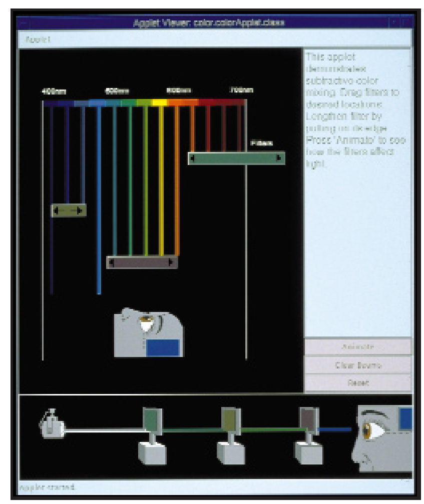
Text for the signal processing color applets is by John Hughes.

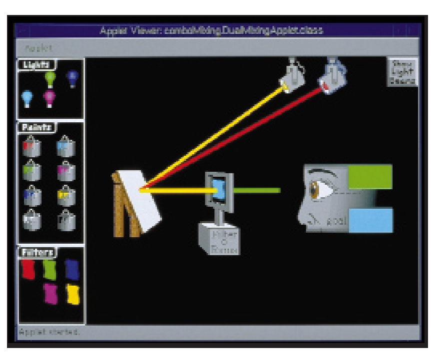
The signal processing color applet suite was developed by John Hughes, Adam Doppelt, and Jeff Beall.

Color Mixing Applets were brought to Java Platform 2 compliance by Robert Benjamin George.

Exploratory Project Leaders
Andries van Dam
Rosemary Simpson
Anne Morgan Spalter
Brown University







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Classroom

Computer Camp: For Girls Only!

Abstract:

A Web-based computer camp for girls only (7th - 10th grade) was offered during the summer of 1999 in the Philadelphia region. The campers learned HTML and JavaScript programming in order to understand basic computer concepts, while enjoying individual creative exploration and developing Web pages. The female orientation was intended to assist in thwarting the image of computer and math-related activities as male dominions. 2D and 3D graphic design, as well as interactivity and human-interface concepts, were emphasized. Programming topics included: language syntax, functions, block structure, sequential and iterative statement sequences, and variables. Computer fundamentals (such as word processing, and basic understanding of hardware components) were summarized. Students were assigned female mentors who communicated with them via email and chat rooms during the camp week. The goal was to have each girl create a personal Web page.

Camp

Description

Computer camps have been traditionally viewed as a haven for sallow-faced, antisocial, male teenagers who prefer to bask in the glow of a terminal rather than in the summer's sun. Often, this male orientation is enhanced by promotional materials that emphasize activities like "hacking" and "Dungeons and Dragons" in addition to traditional programming. Although some of the camps are better than others in attracting females, it is a matter of serious concern that they may be among the factors contributing to the early perception of computer programming as an inappropriate career choice for females. Even worse may be the adverse impact that the reduction in hands-on recreational computer time has on the ability of females to compete in higher-level programming courses as they proceed through the curriculum. These assertions find support in studies indicating that although males and females elect high school computer courses in equal numbers, only a third of the bachelor's degrees in computer science and computer engineering are issued to women. This disparity begins as early as the freshman year, when about half of the qualified males choose scientific majors, with only a sixth of the qualified females making similar selections.[1]

In an effort to reverse this trend, a number of organizations have attempted early intervention programs. One of the more notable of these is the Math Options program, now in its ninth year at Pennsylvania State University. This project targets seventh-grade girls, who are brought to college campuses to attend a day of activities, panel sessions, and workshops led by women who have chosen math-related careers. There, the girls are given an opportunity to communicate one-on-one with the women about their professions and lives. Follow-up sessions and mentoring relationships are also provided. This project has met with tremendous positive approval, and serves many hundreds of girls each year.[2]

Having been involved with the Math Options program since its inception, I wanted to extend this concept within the computer camp scenario. One of the locations expressing interest in offering this program was Mercer County Community College (MCCC), a suburban campus in central New Jersey serving a diverse student population. Among the many non-credit offerings is a group of summer courses called Camp College for junior high and high school students. For a number of years, MCCC has offered various week-long computer camps entitled Computer Hackers Workshops, which emphasize programming in the Pascal and C languages. The project goal is development of a computer game. Interestingly, to the best of the program directors' recollections, not a single female had ever applied for admission to any computer camp session. Clearly these demographics indicated that something was amiss.

The first step, therefore, was to develop a theme that might better attract the large untapped market of young female computer users. The Internet and World Wide Web seemed to promise a viable educational scenario, since its multimedia presentations, timeliness, and easy accessibility attracts both girls and boys, yet its verbal orientation, particularly in chat sessions and via email, provides an especially strong female appeal. Also, the slight edge in verbal skills among girls of high school age possibly makes them better "surfers" than boys.

Penn State chose seventh grade as its target age group for the Math Options program because, at that point, the sex-based math and verbal differentiation is not yet as noticeable. Our camp would include students between 7th and 10th grades, since that was currently a successful age group for the male attendees. Since same-sex schooling has been shown to enhance participation and learning by females in male-dominated subject areas (such as mathematics and science), it was decided to offer the Web-based camp for girls only. This labeling in the promotional brochure was intended to further attract the attention of female students and their parents.

A few years earlier, I co-developed a Web-based "Introduction to Computer Programming" course at Drexel University, aimed at college freshmen.[3] This course used HTML and the JavaScript language to teach such concepts as language syntax, functions, block structure, sequential and iterative statement sequences, and variables. Computer fundamentals (such as word processing, and basic understanding of hardware components) were summarized. Good human interface design and interactivity were emphasized, through the inclusion of tables, forms, and hyperlinks in Web pages. Students were provided with software tools for 2D graphics, and they were encouraged to explore use of original or customized imagery in their Web presentations. Some of the more advanced students surfed for animations and other code that they linked to or modified and included directly in their pages. The materials developed for this introductory course were simplified somewhat and used for the programming training portions of the computer camp.

Prior work for the graphics portion of the computer camp was based on my earlier collaborative effort involving the Franklin Institute Science Museum in Philadelphia and the Community School of Music and Arts in Mountain View, California. Here, cartoonist Mike Mosher instructed students to develop images that depicted their fears. These drawings were then enhanced with sound and 3D graphics in order to form a kiosk-style display. This successful exploration with evocative feelings should transfer well into the Web modality.[4] The Franklin Institute, which serves nearly a million visitors each year, is currently involved with the National Science Partnership for Girl Scouts and Science Museums. Girl Scouts in regional clubs (from Maine to Virginia) have the opportunity to participate in educational programs at the museum, including overnight camp-ins and mentoring sessions by women in science-related careers. Illustration 1 shows a recent lecture/demonstration about Web programming to a group of Cadettes and their troop leaders.[5]

The Girls Only Computer Camp had as its goal that each participant develop her own original Web page, from scratch (using a non-WYSIWYG editor), around a personal theme. The campers began the week by learning how to use the browser and search engines in order to surf the Web for specific topics (in a scavenger-hunt fashion). The girls were directed to specifically female and kid-oriented sites and permitted to explore for items of their own interest (parental control software was used to insure some level of safety). The campers were given access to chat rooms, email, and digital whiteboards, in order to facilitate cooperative work within the group.

Each camper was assigned an adult female mentor, similar to the Math Options scenario, who greeted her mentorees electronically and remained available for email consultation throughout the week (and possibly also after the camp was over). Various hardware and software tools (including 2D and 3D graphics, digital still pictures, animated videos, and audio) were explored for development of multimedia presentations. While the students began to storyboard their concepts for their Web pages, they were provided with small programming tasks in HTML and JavaScript that taught them the language basics. At the end of the camp week, the Web pages were mounted, and the students and their mentors had an opportunity to look at and interact with each others' work.

The collected set of pages was posted on the Web. Results of the program to date are reviewed in a Classroom presentation, including the course syllabus, examples of training materials, and student work.

Senior Girl Scouts and their troop leaders at the Franklin Institute Science Museum attending a lecture/demonstration by Rebecca Mercuri on careers in Website development.

Photo by Ed Wagner, Franklin Institute.

References

1. Statistics from the Computing Research Association's Taulbee surveys.
2. Math Options can be reached by contacting: Alice Sayles, Penn State Abington, 1600 Woodland Road, Abington, Pennsylvania USA 19001-3990, aws5@psu.edu, www.abington.psu.edu/MathOptions
3. Report presented at ACM SIGCSE '98, see proceedings.
4. For "Fears" information and photos see: www.ylem.org/artists/mmosher/fears.html
5. Information on the National Science Partnership for Girl Scouts and Science Museums can be found at: sln.fi.edu/tfi/programs/nsp.html

Creating 2D Animation

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Classroom

Digital Compositing and 2D Animation

Compositing and 2D animation is an exciting field for digital artists, effects editors, and designers. There are many opportunities in both the broadcast video and feature film markets for visual effects artists. Today more than ever, there is an increasing need for people with that special blend of creative and technical skills. Not only does one need to understand the basic "tools of the trade," which can include a variety of software, one must also be aware of the visual nature of the process.

Remember, the bottom line is that all the technical considerations are unimportant when confronted with the question: "Does it look right?" Obviously this is a subjective judgment, and a good compositor able to make these decisions will always be in high demand.

What is a Composite?

Compositing is simultaneous multi-layering and design for moving pictures. It is the digital blending of a background plate and one or more foreground elements to create one seamless, well-integrated film image. Modern designs often use many techniques together, such as painting, retouching, rotoscoping, keying/matting, digital effects, and color correction as well as multi-layering to create complex animations and opticals for promotions, title sequences, and commercials as well as program content. Besides the creative element, there are other important applications for compositing such as image repair, matte painting, and wire removal – especially in motion pictures. The artist and the equipment can be crucial, especially where seamless results are demanded.

Digital Compositing Tools

The tools used in the process of creating 2D animation and compositing include:

Paint programs
Color correction utilities
Warping and morphing tools
Matte-extraction software
General-purpose compositing packages

Basic Terms

Elements
Elements are your images. You may also commonly hear elements referred to as "layers." A subset of elements, called "plates," usually refers to original scanned sequences. Intermediate elements generated during creation of a composite are not referred to as plates, but as "precomps."

Mattes
A matte is an image designed to control the transparency and opacity of another image. Mattes are used during compositing when we only wish a portion of one image to be included in the output image. You may also hear the term "mask" used when referring to mattes, and in general the two terms are usually interchangeable. "Mask" is more common when specifying an image that is used to control or limit a color correction (or some other form of image-processing) on another image.

Matte Generation

There are many different types of mattes, and there are many different methods used to generate mattes for compositing. This process, particularly when automated, is also referred to as "matte extraction" or "pulling a matte."

There are two approaches we can take to generate these mattes. The first is hand-drawing a matte for the object in question over every frame of our sequence. This is still occasionally done, but only after all other options have been exhausted, since the process of hand-drawing a matte for every frame of a sequence is time-consuming and error-prone.

One slightly less brute-force method of generating a traveling matte involves the use of splines to "rotoscope" basic outlined shapes for an object. The rotoscope artist can specify certain key shapes, and the software will smoothly interpolate any in-between frames. Unfortunately, objects that move or change shape a great deal may end up needing a key shape defined for every frame anyway!

There must be a better way, you say, and there is. Instead, we rely more on procedural techniques, where some initial parameters are determined that are capable of extracting a matte, and then software is allowed to apply these same parameters over a sequence of images. Some of these methods include The Color Difference Method, which involves photographing the subject in a manner that greatly simplifies the extraction of a matte.

The Color Difference Method requires shooting the foreground object we wish to isolate in front of a uniformly colored backdrop. Any color for the backdrop (or "backing") may be used, as long as the foreground is essentially devoid of this color. The term "color difference" refers to the difference in color between the foreground and the colored backing.

The most common backing colors are blue and green, and the choice of which to use is generally determined on the basis of the subject's colors. If someone says that the subject must be wearing a blue shirt, then typically a green-screen shoot would be dictated. Generally, tests are done if the choice is not obvious. The process of extracting a matte with this method is known as "keying," and the extracted matte can be referred to as the "key." The software used to key something from its background varies in complexity and capabilities.

There is also a method of creating a matte known as "difference matting," where a frame of the scene without the subject is subtracted from a frame with the subject. In theory, all you are left with is the subject. In practice, slight lighting differences, shadows, and grain make the difference between the two images unpredictable. Difference matting is sometimes the only solution available, and it is actually a very useful first-pass that can then be cleaned-up by hand.

Even the best tools can have problems with certain images, and real-world situations often deliver to the compositor plates that are less than perfect in terms of evenness, graininess, and absence of objects that are not intended to be seen in the final composite. To help deal with these, one almost always creates garbage-mattes around the subject. These are loose-fitting shapes designed to quickly remove problem areas from the scene.

Several of the techniques mentioned will often be used in conjunction with one another, combined until as flawless a matte as possible results.

Image Tracking and Stabilization

When photographing an element to be used for visual-effects work, one sometimes has the ability to specify that the camera be unmoving, or locked-off, for the duration of the shot. However, it is often not possible, or even desirable, to do this. Multiple shots without camera moves can become boring and lifeless. In situations where the need arises to composite elements that were shot without identical camera moves, one must resort to tracking. Tracking is the process of selecting a particular region of an image and determining that region's movement over time (on a sequence of images). The data are stored as a series of moves or positions and then applied to one or more images.

There are a variety of situations where tracking can be used. One reason would be to "stabilize" the sequence you are working on. Another reason would be the need to synchronize the movement of an object you are adding to the scene, with something already in the scene. (The object in the scene may be moving, or the camera may just be moving relative to the object).

Preparation of Elements

The best composites are those whose elements were planned and photographed with the explicit intention of creating a composited image. While this may seem like an obvious, elementary statement, you'd be surprised at how often it is ignored in the real world. In just a bit, we'll look at what can be done to help fix improperly shot plates, but first, let's look at some things that can be done to make everyone's lives easier.

Matched Lighting

Whether you are planning to integrate elements shot with bluescreen or synthetic CG images, or are just soft-splitting two plates together, it is critical that the different pieces look like they were lit with the same lights. Lights should hit the objects in the scene from the same angle, have the same apparent intensity, be of the same color, etc.

Matched Cameras

Almost as important as the lighting is the synchronization of the camera for all elements. Be aware of the camera's positioning relative to the subject and the height of the camera from the ground plane, and ensure that the same size lens is used when photographing all plates. If your camera moves throughout the shot, either plan on shooting it with a mechanical motion-control move (a device that allows the camera to repeatedly execute the exact same move) or be prepared to do a lot of post-processing tracking to try and duplicate the move.

Film Stock
If possible, shoot all elements with the same type and speed of film (and expose and develop them similarly). Different film stocks have widely different grain characteristics, and the discrepancy can be obvious.

Element Repair

Fixing Elements
The usual situation in this business is that by the time you receive the elements for your composite, there is no longer an opportunity to re-shoot anything to correct faulty plates. At this point, your only option is to manually fix the problems. The following section lists potential and common pitfalls and gives a few solutions. Remember, every shot has its own problems, and the true test of a good compositor is the ability to come up with efficient and creative solutions to these issues.

Wire Removal
It's very common for visual effects to be mixed with practical effects that require things like gag-wires, harnesses, ropes, and other mechanical devices. It is not always possible to fully hide these items from the camera, so digital effects may be needed to remove them. There is limited commercially available software for wire removal, and the general consensus is that this software works well on the easier situations, but the more difficult shots are still going to be done at least partially by hand.

Plate Instability
As mentioned earlier, tracking software should be used, either to stabilize the plate or to "bounce" the new elements to match the background.

Mismatched Lighting, Cameras, Action
Trying to tie together images whose lighting doesn't match can be one of the most frustrating tasks a compositor can undertake. Troublesome highlights on objects can often be decreased via specific color-corrections and masking. When your A and B plates were accidentally shot from wildly different positions or with different length lenses, you may need to compensate by moving and scaling the various elements relative to each other. Even the timing of the action may not initially work correctly. Not only can this be dealt with by "slipping" the synchronization between the plates (so that frame 1 of element A is combined with frame 30 of element B, for example), but you can also adjust the speed of action by dropping, duplicating, or averaging frames.

Hand Painting
Ultimately, for certain problems, there may be no other solution but to hand-paint the offending area, possibly on every frame. This is usually somewhat of a last resort, but the fact remains that it is a totally valid and acceptable solution. Sometimes you may be able to hand-paint a fix on a single frame and then use tracking and warping tools to apply this fix to the rest of the sequence.

The Final Touches
The more time you spend compositing, the more you'll learn about what things are important in order to fully integrate the elements. There are a number of techniques (and several tricks) that can be used to trigger the visual cues the eye is accustomed to seeing. There are also a lot of common problems that can be easily addressed if they are identified. First and foremost, a good compositor should understand how a real camera behaves. You will often need to mimic artifacts and characteristics of shutter, film, and lens. Many of the items mentioned below are related to this issue.

Blur Levels
It is rare that every element in a scene is in sharp focus. Depth of field dictates that objects farther or closer than the focus point will grow more and more unfocused. Determine the distance your element should be from that focus point and blur accordingly. This focus relationship can change over time (rack focus). Be sure to match the animation timing as closely as possible.

Also, keep in mind that a moving object, when recorded on film or video, will have "motion blur." This is due to the distance the object moves while the film is exposed (or the video-camera is recording). If you wish to place a moving object into a scene, and that movement is something that you created (either as a 3D element or with a 2D transformation), you should plan on motion-blurring your element. Most high-end systems allow motion-blur to be added to a 2D move or rendered with the 3D element.

Lens Flares
In the real world, when a bright light source shines directly into a lens, you will get a flare artifact. It is often desirable to duplicate this flare when creating an image that has bright light sources that were not present in the original elements. Be careful with this effect, as it has become over-used in much of the CG imagery being created these days.

Film Grain
Another extremely common mistake with adding pure CG elements to a scene is to ignore the amount of grain that the rest of the plate has. The CGI element will consequently appear far too "clean." In general it's much easier to add grain to an element than it is to remove it, so for this reason effects photographers try to use the least-grainy film they can get away with.

Interactive Lighting
If your background scene has flickering or inconstant lighting, (and your foreground plate doesn't), you will need to do your best to match the background. In some cases it may be as simple as adding a fluctuating brightness effect that is synchronized to the background. In other situations, you may need to have articulated mattes controlling the light so that it only falls on certain areas.

Edges
Examine the quality of the edges of objects that are already in the scene and try to match them as closely as possible. Edges can be sharper or softer depending on the amount of backlight an object is getting or how out-of-focus it is. Be particularly aware of how edges are behaving over time. What looks acceptable on a still frame may "chatter" in the moving sequence.

Shadows
A common novice mistake is to forget the fact that an object should cast a shadow (or several shadows). Many methods of extracting an object from its background do not allow the object's shadow to be brought along. In this case, you'll need to create a shadow yourself. It is often acceptable to simply flop the matte of the foreground element and use it to darken a section of the background. Remember to match the rest of the shadows in the scene, in terms of size, sharpness, and density.

Black Levels
Black levels in the elements you add should match the background plate. This is probably the most often-violated compositing rule, particularly when integrating CGI imagery with live-action. Rarely are the darkest parts of a scene pure black, and if you want to add something new to that scene, you should make absolutely certain that the darkest parts of your new element aren't any darker. An excellent trick for ensuring that your element's levels are matched to the background is to adjust the monitor brightness to high and low extremes. This will help to bring areas that the human eye is less sensitive to into a range where differences become more obvious.

Camera Movements
The nature of effects photography often requires that the elements of a composite all be shot with an unmoving, locked-off camera. While this makes for easier composites, it doesn't really make for interesting (or believable) cinematography. Fortunately, it is possible for the compositor to add camera moves after the plates are shot. This move may be as simple as a nearly imperceptible camera shake, or as complex as a tracked, 3D match-move.

Atmosphere
Often there may be fog, smoke, or haze in the scene you're wishing to integrate with. The farther away from the camera your element is supposed to be, the more atmosphere would need to be added. Again, examine other elements in the scene that are at the same distance and try to match their levels. If the atmosphere in a scene is very uniform, you can probably get away with just decreasing the contrast in your element and adjusting its color. With more distinctive mist or smoke, you may need to use a separate smoke element and add it in explicitly.

Rendering
Last, but not least, you have to render your animation. The computer will render each frame in turn, each comprised of various operations to achieve the desired effect. The rendering may take minutes, hours, or days depending on the effect's length and complexity and, most importantly, the speed of your computer.

Parting Thoughts

Finally, remember that every person who views an image has a little expert he carries around with him. This expert, the subconscious, has spent a lifetime learning what looks "real." Even if, consciously, the viewer is unable to say why a composite looks wrong, the subconscious can notice warning signs of artificiality. Beware.

Special thanks to Ron M. Brinkmann for allowing me to excerpt his Digital Compositing SIGGRAPH paper.

Creating 3D Animation

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Classroom

3D computer animation has become wildly pervasive throughout our media, ranging from Saturday morning cartoons to high-end feature film creatures and effects. What may not be obvious, though, is just how these effects were created. For those seeking an awareness of the field, this presentation covers the basics of the 3D artist's production tasks.

Overview

1. Cinematic special effects can be seen as the creation of fictional events.
2. We are experiencing a shift from manual (practical) effects work to electronic digital techniques.
3. The most successful work is a result of combining the two approaches, capitalizing on the strengths of each.
4. 3D software applications are primarily used for creation of character elements, props, effects, or environments.
5. 2D software applications are primarily used for assembly and enhancement of individual elements, both digital and practical.
6. 3D software generally appeals to "object-builder" personality types, whereas 2D software appeals to "image-maker" personality types.
7. The key to mastering this medium is comfort and understanding of computer technology. Presently this is a heavily technical enterprise.
8. Always remember: the act of drawing is primarily visual and secondarily technical. Digital media are no different, but they demand more technical discipline.

Sample 3D Production Workflow

1. *The Modeling Phase*
   A. Modeling typically accounts for 20 percent of a project's schedule.
   B. Modeling requires the skills of a sculptor or architect.
   C. Modeling involves creation of wireframe 3D geometry.
   D. The geometry defined is typically NURBS (freeform deformable surfaces) or polygons (point meshes).
   E. 3D applications can import EPS or CAD file types (vector-format data).
   F. One can build from sketches, measured drawings, video frame captures, or 3D scans.
   G. Modeling requires a good feel for 3D spatial visualization.
   H. Character modeling is one area of specialization for artists.
   I. Hard models, such as vehicles and props, are another area of specialization.
   J. Efficiency of modeling is very important, to allow ease of production later on.

2. *The Lighting Phase*
   A. Lighting typically accounts for 20 percent of a project's schedule.
   B. Lighting requires the skills of a photographer, director of photography, or gaffer.
   C. Lighting involves placement and adjustment of various light sources.
   D. CG light types can be spotlights, point lights, ambient lights, or directional lights.
   E. CG lighting is presently a crude simulation of real-world lighting complexity and subtlety.
   F. An emerging more realistic lighting paradigm is that of radiosity calculations.
   G. Lighting can have a multitude of approaches, such as theatrical stage, studio, architectural, cinematic, product, and character.
   H. Character lighting is an area of specialization for artists.
   I. Hard model lighting, such as vehicles and props, is another area of specialization.
   J. Efficiency of lighting is very important, to allow ease of production later on.

Recommended Bibliography

Film Architecture: Set Designs from Metropolis to Blade Runner, Dietrich Neumann, Prestel

Digital Filmmaking, Thomas Ohanian, Michael Phillips, Focal Press

The New City, Lebbeus Woods, Simon & Schuster

American Cinematographer Manual, American Society of Cinematographers, The ASC Press

Cinematography: a Guide for Film Makers and Film Teachers, J. Kris Malkiewicitz, Van Nostrand Reinhold

Special Effects Cinematography, Raymond Fielding, Focal Press

The Language of Visual Effects, Michael J. McAlister, Lone Eagle Publishing

3. *The Texturing Phase*
   A. Texturing typically accounts for 20 percent of a project's schedule.
   B. Texturing requires the skills of a painter, illustrator, or photographer.
   C. Texturing involves creation and application of images or surfaces onto the modeled geometry.
   D. Texturing is intrinsically related to the lighting of surfaces.
   E. Texturing can be designed or computed procedurally.
   F. Texturing is the key to establishing scale, age, and weathering of surfaces.
   G. Texturing can replace the modeling of 2D surface detail.
   H. Character texturing is an area of specialization for artists.
   I. Hard model texturing, such as vehicles and props, is another area of specialization.
   J. Texturing relies heavily on Photoshop or similar applications.

4. *The Animation Phase*
   A. Animation typically accounts for 20 percent of a project's schedule.
   B. Animation requires the skills of a classic animator or choreographer.
   C. Animation involves establishing the motion and performance of geometry, effects, lighting, and camera moves.
   D. Animation deals with working with abstract motion curves within graphs.
   E. Animation is a lifelong art and education, requiring many years of training.
   F. Character animation is an area of specialization for artists.
   G. Effects animation, such as explosions or dust effects, is another area of specialization.
   H. Camera animation is yet another area of specialization.

5. *The Rendering and Output Phase*
   A. Rendering computation typically accounts for 20 percent of a project's schedule.
   B. Rendering computation places a very high demand on hardware, such as CPU cycles.
   C. Rendering computation requires distribution of frame processing over a large network of machines, with most rendering done at night.
   D. Rendering computation requires massive amounts of hard-drive storage and RAM.
   E. Back-up of the resulting data is also a large task.
   F. Once frames are complete, they need to be put onto videotape or film.

6. *Possible Hardware and Software Routes*

   A. SGI/UNIX Platform Route

   Highest quality, professional level software. Has the ultimate flexibility and capability.
   - High-end: 300mhz R12K Octane MX2 with Maya Infinity
   - Mid-range: 195mhz R10K Octane SI with Maya Complete
   - Entry level: 195mhz R5K O2 with Animator

   B. Mac Platform Route

   Easiest interface, good media capabilities. Common in graphics communities.
   - High-end: 300mhz G3 PowerMac with Electric Image
   - Mid-range: 200mhz G3 PowerMac with Lightwave
   - Entry level: 200mhz G3 PowerMac with Strata3D

   C. PC Platform Route

   Good price/performance ratio. Becoming on par with Unix/SGI.
   - High-end: Quad 533mhz P3 NT box with Softimage Extreme
   - Mid-range: Dual 450 mhz P2 NT box with 3D Studio Max
   - Entry level: Single 400mhz P2 box with Lightwave

The Creation of the Nu.M.E. Project

See page 8 for a related classroom presentation

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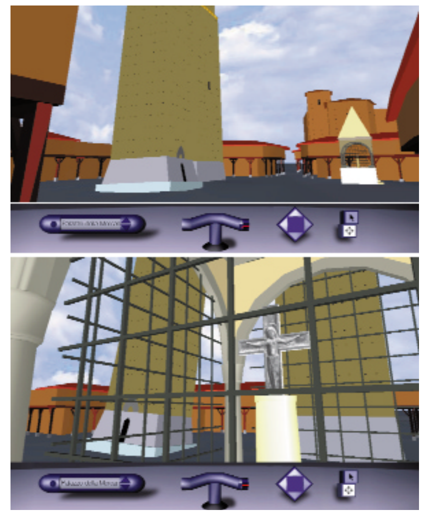
Playground
Workshop

The methodology of the Nu.M.E project, as presented in the Classroom Panel "The 4D Virtual Museum of the City of Bologna", is based on the virtual reconstruction of Medieval and Renaissance buildings and streets. This workshop presents the 4D navigation and graphic processing phase of the project.

In the new millennium, the world will be increasingly connected by high-bandwidth links that will allow the virtual visitor, seated in front of a monitor anywhere, to take the New Electronic Museum's electronic tour of the Medieval streets of Bologna. Visitors will be able to look up at the Garisenda tower, as Dante did, and be impressed by the gathering clouds above, go up to the top of the Asinelli tower, admire Piazza Maggiore as it appears today or as it appeared in the 13th century, see the urban settlement where the oldest university in the world was founded, and walk under the portici today or in the past. They will be able to choose any street or period, in the hope of being able, sooner or later, to see this extraordinary city in real life.



Implementation Phases and the Time Machine
The results of the research and the modeling work were entered into a virtual environment governing the "time machine." Modeling techniques made it possible to reconstruct buildings that are no longer in existence. The navigation system enabled views of historic elements that are no longer in existence and removal of items that were not yet in existence during a given period.

A "time machine" in the program's tool bar allows visitors to select a historical period for an electronic walk through the city of the past. Visitors can access views of Piazza di Porta Ravegnana with the Asinelli and Garisenda towers and the surrounding streets, the Chapel of the Cross (fourth-18th centuries), three medieval towers that were demolished at the beginning of the 20th century, Piazza Maggiore, and the interior of the basilica of S. Petronio.

Coordination of the Working Environment
At this stage of the project's development, various groups are working in parallel, coordinated by means of a "shared environment" that enables them to exchange information among themselves. The Nu.M.E. Cooperative Open Environment is used to gather the data from the various laboratories and download it for processing.

The work presented in this workshop is only the tip of the iceberg of a great scientific enterprise with sophisticated software applications that the "visitor" cannot see, but which are the basis of the final product. Every mark, drawing, and movement is derived from in-depth historical research, since it is the quality of the historical research, over and above the software applications, that makes the difference between a multimedia product of a purely commercial kind, of which there are many on the market, and the New Electronic Museum project.

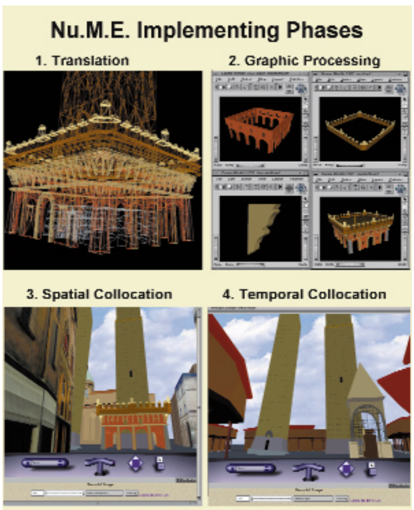
Four-Dimensional Navigation as a Summary of Historical Research.
In order to provide the visitor with the scientific information on which the product is based, every building, every urban sector, and every single item is accompanied by the sources on which the vector model is constructed and which make the three-dimensional navigation possible. These sources may be called up on the screen at any time during the electronic tour. One advantage of this electronic museum is that it is accessible at all levels of competence and knowledge, and visitors can make their own personal interpretation of the materials.

The project is both an instrument of scientific research and a new means of disseminating scientific knowledge (in this case, about urban history and cultural and conservation studies), and, at the same time, a means of stimulating interest in applications of technology that are likely to see further development.

Implementing the Nu.M.E. Project
The idea of making the Nu.M.E. or New Electronic Museum project accessible on the Internet (www.cineca.it/visit/nume/) arises from the need to facilitate interaction with historical researchers, to reach a greater number of users, and, of course, to publicize the project. For this reason, we chose to implement Nu.M.E. with VRML and Java that also make it possible to develop dynamic and interactive 3D environments in a portable, standardized, and platform-independent manner.

Briefly, the implementation process of the Nu.M.E. project consists of progressive introduction of 3D models of buildings in the virtual 4D city model. This process can be subdivided into four phases. During the translation phase, the CAD model of a building must be translated into VRML2 format, which requires modifying some characteristics of CAD solid modeling:

- To maintain only the surface information to be used in the VRML representation.
- To introduce a hierarchy among the different components that constitute a building, so that during the graphic processing phase it is possible to process them individually and to reproduce their temporal development, if required, separately from the rest of the building.



During the graphic processing phase, the VRML files are processed in order to make them photo-realistic. In order to improve performance in terms of download time and frames per second, we simplified construction of individual 3D architectural elements (roofs, portici, columns, etc.) with the use of photos as texture to be applied to them in a level-of-detail technique. It is necessary to strike a balance between a lot of details for maximum realism and quick drawing for maximum interactivity. Moreover, the Nu.M.E. project has a great variety of potential users (for example, historical researchers, urban planners, virtual tourists, etc). Clearly, historical researchers need a more detailed 4D visualization than virtual tourists, who probably give preference to speed of access rather than to careful reproduction of too much detail. So we developed two models: high-resolution and low-resolution, characterized by the different resolutions in which 3D models and multimedia data are stored, but with the same interface. The high-resolution model may be used by accessing Nu.M.E through a LAN connection or a visualization in a local environment. The low-resolution model is accessed via a remote connection to the Internet.

During the spatial collocation phase, the VRML model of the building is placed in the area of the city recreated in the Nu.M.E. project, considering only the spatial coordinates, eventually moving and rotating it in order to place it in the correct position. Recently, we introduced the option of visualizing a 3D model of the area, in order to place the buildings also at the correct altitude. The temporal collocation phase consists of positioning the building in the temporal dimension. Each building is identified by: the VRML model created during the previous three phases, properties that vary with the passage of time, and the historical sources underlying the four-dimensional reconstruction of the building. From the implementation point of view, we associated each building to a set of different files:

- building.wrl: the VRML model created during the previous three phases.
- building.db: the text file that describes the properties of the building that vary over time (defined by the dates of construction, alteration, demolition, etc.).
- _building.wrl: this file allows the user to select the VRML file (building.wrl) to visualize a specific hypertext document (building.html).
- building.html: this file allows the Nu.M.E. visitor to examine each building individually, together with the historical sources that were used for its reconstruction. It consists of two HTML frames visualizing respectively:
  - fonti_building.html: a hypertext document that describes the historical significance of the building citing the sources used to collocate it on a time scale, visualizing its changes from 1200 to the present.
  - building_bis.wrl: a high-resolution VRML model of the building isolated from its context. In this model it is possible to add light-spots to enhance some components and specific viewpoints.

In each phase, a constant exchange of information is required among partners located on separate sites with different platforms and different computer skills. We therefore implemented the Nu.M.E. Cooperative Open Environment, which provides all the partners with remote access and updating of all the archive data, building by building and period by period, which is simpler than interacting directly with the entire virtual environment.

Recently, we have begun to design a new immersive physical access to the Nu.M.E. scenario in order to prepare a virtual theatre using technologies such as Reality Center SGI. There is reason to believe that the virtual theatre could be the natural development of our high-resolution model, and that it could provide a public venue for the New Electronic Museum to be seen by groups of visitors.

Creative Programming: Merging the Artist with the Computer Programmer

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Classroom
Playground

The Creative Programming program at the University of Gävle is unique in its approach to education and selection of students. It aims to give opportunities to highly creative and intelligent people to experiment and enhance their abilities in the world of digital media by combining their skills from other areas.

The area of multimedia systems and digital media itself is becoming increasingly important. There is a shortage of people with the required educational background who can design systems in this new medium, in research terms, as well as in visual development and implementation. The skills involved in creating software applications have expanded from traditional programming to include creative skills, such as graphic design and writing interactive narratives and storyboards. Research also plays a very important role in design of systems and implementation of new techniques yet to be utilized in current technologies. Universities with traditional computer science programs must now examine the need for these new multidisciplinary skills. The skills required to develop applications using the new medium are essentially varied depending on the end result. Several applications will require a programming, logical approach as a solution, whereas others will require a creative, visual solution to the problem.

The Creative Programming program looks at both the technical and aesthetic issues involved in current digital media. Education is in the form of lectures and practical sessions with skilled instructors from industry or academia. This keeps the students up to date with what is happening in industry, as well as the latest developments in research. The program helps students to combine existing skills with the technological skills needed in this area, enhancing their knowledge both technically and analytically.

Applications are examined by a jury of experts in the area of digital media, both from academia and from industry. A previous Creative Programming student is also included in the jury to provide a student's perspective. The applications include samples of art-work. The jury reduces all the initial applications to 30 possible candidates, who are then invited for interviews.

The interview generally involves an examination of the applicant's intellectual ability, creative ability, skill at handling a computer, creative thinking, and sociability. One element of the interview stage is the use of Raven's Advanced Progressive Matrices (APM) to indicate the analytical and logical ability of the applicant. It is one of the most well-examined tests of general intelligence. It is nonverbal, and it has very good psychometric properties, normalized against lots of populations with different cultural and educational backgrounds. The advanced version of the APM used in this process is designed for people of above-average intellectual capability. The test-retest reliability is over 0.93 for age 30 and under. The test is used to evaluate the logical, intellectual capacity of those very artistic applicants who have no experience in traditional computer science. As APM is a very good predictor of academic success, it can also be used to raise the confidence of the applicants.

Social and emotional competence are also judged in the interview, to make sure that an open and dynamic group process is promoted by the students accepted. Creation of this group dynamic is also the rationale for selecting a good mix of gender, age, and artistic and computational profiles into the group. In this way, the most crucial conditions for merging the artist with the programmer are met.

This new digital media program provides a place where programmers who have artistic skills and artists who have never approached a computer can learn and improve themselves. In this lab environment, different cultures experiment with new techniques and use each other as references both technically and aesthetically. Those who are familiar with computer programming educate the artists in some aspects and in return receive aesthetic criticism and tutorage.

The educational process concentrates on theoretical aspects of multimedia, design and cognition, computer graphics, modeling and animation, aesthetics, and media issues. The practical side generally involves reinforcing the theory but also acts as an avenue for the students to enhance their creativity. Industry involvement is also crucial, so the students often find that their work has a real-world purpose. Guest lectures from industry, some not directly associated with digital media but affected by its presence, allow for intellectual discussion groups to develop between creative students and the industry of which they so often have misconceptions.

Creative

Jeremy Sutton
Portrayals

Developing Creativity: A Curriculum Based on the Use of Computer Graphics Technology

Classroom
Playground
Workshop

Computer

This curriculum addresses the needs of people who have access to personal computers and are excited by the idea of harnessing their computers as creative tools. The objective is to empower students to explore and expand their creativity using the powerful computer graphics technology now available.

Through carefully structured assignments, students:

1. Master a powerful paint program used in combination with a pressure-sensitive graphics tablet.
2. Expand their artistic, creative, and perceptual boundaries.
3. Gain knowledge, skills, and confidence that can be applied at a personal or professional level.

Media

A number of exercises, such as those using scripting, take advantage of the unique capabilities of digital media. Other exercises can be applied to "traditional" or "natural" (non-digital) media as well as digital media. Direct tactile experience using "traditional" media helps students realize the full potential of the digital tools that emulate "natural" media.

Modality

This curriculum can be taught by an instructor in a computer classroom or online, or followed by an individual independent of an instructor. The structure presented here, and the delivery tools described (workbook, hand-outs, assignment instructions), can be adapted to suit each specific teaching situation.

My experience with all three modalities (classroom, online, and individual) has led me to value the benefit of direct, in-person, student-teacher and student-student interactions. An instructor can motivate, encourage, energize, cajole(!), challenge, and stimulate students, as well as resolve problems quickly. Students learn from each other, from seeing how others apply the tools and solve problems. Collaborative exercises teach students to let go of the need for total control, let go of treating their brush strokes and materials as "precious," and learn to work from other people's brush marks.

A classroom setting offers the opportunity for full use of the curriculum. When the curriculum is applied in an online class, or by an individual, the collaborative exercises are omitted.

Structure

The Big Picture
I start with the big picture: the map. Students are given an overview of the course and the objectives. I break down the curriculum into easily digestible parts so that no single part seems insurmountable.

The Tools
The primary digital tools are Painter software and a graphics tablet with pressure-sensitive stylus, on a Macintosh or Windows computer. There are two software options with the curriculum. The simpler option is Painter Classic, which is bundled with many Wacom tablets. Painter Classic is suitable for institutions and individuals with a limited budget who are not interested in a versatile and powerful professional-level graphics program.

For the professional user, the software is MetaCreations Painter 5.5 Web Edition (or the latest version of Painter available).

Mastering the Technology

The students' first step is getting to know and understand the tools. This is more than being able to recite a manual or point at things on the screen and know what their function is. It's about developing a deeper, intuitive sense of the way the tools work, how to approach a task, the way to make any job easy and fun and efficient. I place great emphasis on strategy; not just explaining what things are and where they are, but the series of questions students can ask themselves that naturally lead to an elegant solution. I emphasize building up good habits so that application of effective strategy becomes second nature, like the muscle-memory of a trained dancer. One of the hardest challenges in technically mastering a program like Painter is letting go of old habits and behavioral patterns.

By necessity, this section of the course is more technical and less creative. Class exercises for this section are based on experimentation and familiarization, diving in and trying out brushes and art materials, getting a feel for the variety of looks and effects at the user's disposal. This section is like getting your hands used to playing the piano keys without needing to look and think. It's the necessary hard work that needs to be put in before you can play beautiful music.

The focus of this curriculum is learning expressive creativity by hand using a (digital) paint brush. The lessons learned can be applied to other areas of computer graphics such as photographic manipulation, Web design, and animation.

Embracing Chaos

Students dive into their greatest fears: making a mess, using wild colors and wild brushes, experimenting, purposely creating chaos, using gestural movement and expression in their brush strokes (see the examples in Figure 1). Students are encouraged to enjoy the process and not worry about the end product. I want them to push all their creative blocks: the emotional resistance they may have to embracing chaos, the urge to create something "pretty," inhibitions against using the whole canvas, and the full dynamic range of the materials at their disposal. This stage involves letting go of the need to be in total control and knowing what the final result will look like. This is the moment of liberation, of being given permission to forget every "rule," every "should," every "can't." In this section, students develop vitality and energy. They experiment with brushes and materials unencumbered by the need to create something that "looks right" or resembles something.

Stillness, Connection, and Visualization

Having prepared a canvas for paint, the students take a step back from the world of technology, pixels, and programs. They select a subject to paint. They place the tablet on their laps and rest their hands, palms down, on the tablet. They close their eyes and take a deep breath. They let go of all the worries and tensions from the day. They listen. They become aware. Awareness of self is the starting point for observation.

Students open their eyes and look at their subject (this curriculum is based on drawing from the live subject). They observe carefully, being aware of what their reaction is to the subject, what stands out, what moves them. This is the moment when the composition begins in the students' minds. They begin to visualize the finished picture. Details are not important at this stage. It is more a matter of tuning in to their subject and visualizing the picture they are about to create, setting a visual goal in their minds.

As they observe their subject, the students rest their finger tips on the tablet, following the subject's contours like invisible brushes. In this stage, students make the tactile hand-eye connection between the subject they are observing and the physical interface with the computer.

The Art of Seeing
Students are encouraged to observe with great care, to differentiate between what they "know" is there and what they actually see.

Figure 1
Student work (by Lesley). Clockwise from top left - Embracing Chaos, After Picasso, Self Portrait with Wild Colors, First Self Portrait.

Visual Vocabulary
The exercises here build vocabulary that can communicate the impression of a 3D solid form on a 2D canvas. Every mark on the canvas affects and is affected by other marks on the canvas. It is the relationship among all these marks that collectively gives the impression of form and that determines the expressive power, beauty, and impact of the picture.

Throughout this section, students are encouraged to take risks, to push themselves and go for "overkill," to exaggerate. This course is a laboratory for experimentation. If you're going to make a gesture, make it big and bold.

Style
Students create paintings in the style of other artists, paying attention to the way different artists have applied their paint and achieved different effects (see the Picasso-style example in Figure 1). I encourage students to experiment, emulate others, and ultimately develop their own individualistic styles.

Transformation and Variation
Students experiment with transforming and recycling images, or portions of images. They learn to celebrate impermanence and change rather than be afraid of it.

Order from Chaos
This is where all the elements come together. Students learn to transform chaos into order through intuition, visualization, and observation. This is the final stage of creative realization, where contrasts are brought into harmonic balance. This is where the stillness, connection, and visualization exercises come to fruition. The circle is closed as the seeds sown earlier now make their influence felt (see Figure 2 for examples of student work).

Students complete the creative process by closing their eyes, breathing deeply, and returning to the peaceful, aware state they entered at the beginning of the curriculum.

Final Touches

Practical matters are covered such as:
- Determining canvas size
- Creating backgrounds
- Deciding when a painting is "finished"
- Frames and borders
- Preparing files for output, display, and storage
- Archive and documentation
- Output, mounting, and display issues
- Copyright protection

Delivery Tools

The primary delivery tool of this curriculum will be a hard-copy workbook that contains the course description, background reading, and assignment instructions, supplemented by additional handouts that contain topical reading material. Teachers can adapt the workbook and handouts to suit their own teaching styles and circumstances. There is a substantial amount of material that could be covered, much more than there is usually time for in a regular class or workshop. Instructors will need to exercise their own judgments in selecting the portions of the course most suited to their needs and those of their students. Teachers may wish to take out specific exercises, change them slightly, or add their own. I see this as a living document, not as the final word.

Summing Up

This curriculum combines the teaching of computer graphics skills with a creatively challenging arts program. It addresses two questions:

1. How do we bring more creativity and art into our computer laboratory?
2. How do we bring computer technology into our fine art classes in a relevant and effective way?

This curriculum is not an attempt to merely duplicate a traditional art class using digital media. It brings together the mutual benefits and strengths of both worlds, the technological and the creative, in a manner that is exciting, stimulating, and educational.

Figure 2
Order from Chaos, Student work
The left-hand pictures are the initial images, and the right-hand pictures are the final results. Top two images by Lesley, bottom two images by Lois.

About the Author

Internationally recognized award-winning artist and educator Jeremy Sutton is a graduate of Oxford University, author of *Fractal Design Painter Creative Techniques* (Hayden Books 1996) and *Total Painter* (Total Training video course 1998), and a former faculty member of the Academy of Art College and San Francisco State University. He teaches computer painting seminars and runs an online digital portraiture course.

Resources

See www.portrayals.com for a list of useful resources plus Painter tips and many examples of Jeremy Sutton's and his students' artwork.

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Classroom
Playground

Digital Design Education at UCLA

Moderator
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Panelists
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A panel of educators discusses the digitally oriented curriculum of the Design Department at the University of California, Los Angeles, and presents examples of student work.

The UCLA Design Department completely revised its program three years ago to incorporate digital technologies. Every attempt was made to maintain the core studies needed for a well-rounded designer while fully engaging the possibilities offered by new digital media and technologies. Preparation of the new curriculum involved several challenges, including:

- How can a liberal-arts based design education best prepare students for future work with newly emergent technologies and media?
- What is the best balance of theory and studio work, of conceptual to professional work, of hand-to-computer exercises?
- How does one teach with new technologies without spending too much time just learning software?
- Hardware and software acquisition
- Space planning
- How to reconcile the "computer room" mentality with the studio environment so common to art and design programs.

The panel illuminates these issues for educators who are interested in incorporating the new digital technologies into art and design programs. The presenters were all engaged in design education long before the emergence of the computer and are aware of the issues common to all programs facing the transition to digital technologies. They candidly discuss which aspects of the curriculum seem successful and which still might need refinement, and they offer predictions for the direction of digitally based art and design programs.

Drawing & Learning

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Classroom

A number of London-based art and design institutions are in the process of developing a family of products which address the important subject of drawing. The focus of the project will be fundamentally and crucially concerned with the process of developing visual literacy in students.

In 1995-96, almost five percent of higher education students in the United Kingdom were in art and design. If related subjects with a clear interest in drawing such as architecture, engineering, and technology are included, the total rises to almost 16 percent.

Drawing is central to all that is produced within the broadest spectrum of art and design. It is the core around which the conceptual and intellectual development of students takes place. By the end of this three-year project, the proposed outcomes will be a set of fully tested, quality assured, inter-related interactive multi-media (CD-ROM, video, and Internet) products covering the important subject of drawing. The products will provide an extremely valuable teaching and learning tool for use throughout education. They will enable students to develop as independent learners while also providing a much needed, innovative and cost-effective teaching aid to support hard-pressed teaching staff. The University of Glasgow Evaluation Group will oversee the process of production, testing, and delivery.

The project will address this problem by producing a set of computer-based resources which will have wide applicability to the subject of art and design and related subjects. This applicability will also extend across a range of levels. The products will be readily integrated into the teaching and learning practices within higher education and will reduce the amount of costly lecturer time presently expended on this.

The consortium partners are: The London Institute; University of Brighton, Faculty of Art, Design and Humanities; Falmouth College of Arts; Ravensbourne College of Design and Communication; Surrey Institute of Art and Design; and University of Ulster, Faculty of Art and Design. The consortium is seeking funding of £300,000 over three years. The consortium represents a large part of the total art and design activity in the higher education sector. The subject expertise which is available to support the project is formidable. The consortium partners have significant experience in the management and delivery of complex publicly funded projects.

Learning

Introduction

The growth in higher education student numbers and in the diversity of their nature, e.g. mature students, has placed continuing strain on teaching resources. The skill base of students is more varied than ever before. It is increasingly difficult to cosset students through the development of the essential skills of drawing because of increased student numbers and obvious cost constraints, yet it is necessary to ensure that student expertise and skill in this particular area are well developed.

Drawing is central to all that is produced within the broadest spectrum of art and design. It is the core around which the conceptual and intellectual development of students takes place. Drawing allows individuals to learn to look, to record what they see, and is used to develop thought and ideas for artwork and for design, in both two and three dimensions. Furthermore it is a language capable of emotional and formal expression and communication with others, in fine art, design, and fashion, as well as in architecture and engineering. There is a rich history of drawing as part of the history of art and design as well as the history of architecture, and of technology, in relation to European and world cultures.

The working titles of the initial products will include: Ways of Looking; Perceptual and Conceptual Approaches to Drawing; Measured Drawing Systems; The Use of Perspective, Scale, and Tonality; Using the Computer as a Drawing Tool.

Aims

- To develop computer-based products which will be of significant value in providing cost effective support to students of art and design.
- To develop a family of related products which exploit the diversity of drawing.
- To enable partner institutions, either individually or in conjunction with each other, to develop an aspect of drawing.
- To produce products that will build into a comprehensive coverage of the subject of drawing and be of significant value to education.
- To subject product development to clearly defined standards covering platform, scripting, delivery, and dissemination.
- To adopt a regime of stringent editorial management, ensuring quality of content and consistency of presentation.

Objectives

- To produce computer-based products which will emphasize the development of observation, skill, and accuracy.
- To produce products which will emphasize the understanding of form and space.
- To produce products which will improve the ability to utilize software applications for 3D modeling and will enhance the teaching of formal drawing systems such as projection and perspective.
- To publish teaching materials through CD-ROMs and other media, marketed within and beyond the educational sector as valuable learning resources for a wide range of applications for which the understanding of drawing is intrinsic.

Education Delivered Through Storytelling: Using Virtual Reality as an Educational Tool

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This use of virtual reality for delivery of education through a storytelling motif is presented by a collaborative group of educators. The project environment allows children to interact directly with a 28-foot curved virtual reality world, which at scheduled times is a huge interactive computer screen offering educational vignettes, and other times runs in demonstration mode. The choices being considered for availability to the students using the VR motif range among the following educational programs utilizing the Panoram Technologies image stitching and projection system:

- A visit to the North Carolina Outer Banks, sounds and estuaries, with information on the troubled water situation that threatens the wildlife nursery.
- A visit to the Civil War vessel SS Monitor, sunk off the North Carolina coast.
- A visit to the pirate ship Queen Ann's Revenge.
- A visit to a museum without walls housing the largest collection of African art outside the Smithsonian Institution.
- A visit to the history of North Carolina pottery.
- The folklore of Lapland.
- A wild ride on a snowmobile through the great northern woods of Lapland.
- A history of the Cold War and pursuit of the elimination of nuclear weapons, featuring past SIGGRAPH Computer Animation Festival works ("Nuke the Duke" and "Wag the Flag," for example).
- A story about the plight of endangered species in "Save the Animals."
- Health education

Storytelling

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Workshop

Educators Workshop in 3D Computer Graphics

"If Walt Disney were alive today, where would he be?"

"Probably brushing up on his computer skills!"

This excerpt from a recent article in the "Toronto Globe & Mail" sets the stage for this workshop. The reporter interviewed a number of educators as well as production managers and technical directors in the film industry and included many quotes, such as:

"Today's major animation studios and boutiques are insisting that employees be hybrid artists - individuals possessing both Bill Gates' technical proficiency and Vincent Van Gogh's artistic flare. It is a recent phenomenon that animators can not afford to ignore."

Fueled by Hollywood's demands, educational programs have begun to surface at a number of colleges and universities to help provide students with the skill sets necessary to meet these demands (both computer-related and technical). Many artists and would-be animators are now investing a lot of time and effort in seeking out educational programs that will allow them to learn and develop these skills.

But why wait until the college and university years to introduce this technology to hungry, creative minds? Why not introduce this technology at a much earlier stage so it can grow, develop, and mature prior to the time when one has to make career decisions?

A decade ago, general computer skills were introduced only at the college and university level, largely because of the high cost of computer hardware and software, and the relatively low budgets at the public school level. Today, with the availability of lower cost hardware and software, and in many cases donated software, kids have access to computer technology at a very early age. We now have young adults entering post-secondary programs who are fully prepared to study computer skills and applications at a much more advanced level. As a result, they have very bright futures ahead of them, in positions that are not only challenging and creative but very lucrative as well. These graduates are now designing the software of the future and creating award-winning effects in the movie industry.

Today, we recognize that this integration of computer technology into the classroom has been a great benefit, not only as a teaching tool but also as a doorway to creativity and exploration. Simply put, it's fun as well as challenging. And it is this combination of fun and challenge that keeps these students motivated and eager to learn and grow.

This workshop introduces educators to the world of high-end 3D computer graphics technology and demonstrates how easily it can be integrated into the curriculum and classroom at the public and high school levels, using real software that is recognized for its abilities to create photo-realistic models, award-winning special effects, and truly believable animation. It utilizes some of the most innovative and flexible software available in the market today: Houdini, from Side Effects Software. The technology is described in lay terms as participants work through a real-life model project. Full course notes on the guided exercise are provided for all attendees.

The Scenario

A designer has an idea for a spiral staircase for an architectural design presentation to a client. The designer is a bit sketchy on the design but he does know the rise, the number of treads necessary, and the degree of rotation that the staircase must travel through. He is looking to the computer designer for a few ideas. He needs to see a prototype, but he also wants a considerable amount of control over design changes.

Workshop participants build the spiral staircase using a number of mathematical and interactive manipulation techniques. Materials and appropriate lighting are applied for final presentation of the prototype to the designer.

Exploratories: An Educational Strategy for the 21st Century

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Classroom

What computer-based learning environment will students of all ages be immersed in five, 10, or 20 years from now? And how can we best prepare for learning and teaching in that environment? These questions may be partly answered by obtaining a deep understanding of Web-based (or whatever succeeds it) interactive learning that engages a broad range of human capabilities.

The Exploratories project, an interactive Web-based educational research project at Brown University, uses the introductory undergraduate computer graphics course as a testbed to address the following challenges:

- What goes into effective interactive Web-based learning modules?
- How can such tools be most effectively deployed?
- What categories of the learning environment can benefit most from this approach?

Exploratories

An exploratory is a computer-based combination of an exploratorium and a laboratory that embodies an approach to learning by experimentation and investigation, in the tradition of Kay[1] and Papert.[2] It provides multifaceted, interactive microworlds that model objects, phenomena, and concepts, and that exhibit appropriate behaviors when interacting with the student.

Our current implementation embeds Java applets in a hypermedia framework that (a) provides an immediate context for both the individual applet and for the larger conceptual frame of reference, and (b) enables students and teachers either to work within the framework provided or to place the applet in an environment of their own choosing.

For example, one set of exploratories, which develops an intuitive feeling for the signal-processing aspects of color vision,[3,4] has been used by teachers around the world within their pre-existing curricula. Another set of exploratories, which teaches basic concepts of additive and subtractive color mixing,[4] is being used in our computer graphics course as classroom demonstrations, in assignments, and for self-directed learning.

Project Context

The context of the Exploratory project both reflects and reinforces the flexibility of the project approach described above. Because the Brown Computer Science department has long-standing programs for undergraduate research and teaching assistantships, our resources include eager young developers who combine imagination, energy, and intelligence with a sound technical base. These students work under the guidance of faculty, staff, and older students who provide domain and development expertise. The constraints include the heterogeneity of student-developer experience and platforms, the multiple ways in which we use the exploratories, and the episodic (and sometimes unpredictable) nature of undergraduate availability.

The Design Strategy Handbook

The ultimate goal of the project is to understand the patterns, in Alexander's sense[5] that underly effective Web-based interactive education and to transmit that understanding through an interactive, Web-based Design Strategy Handbook that is itself an example of what it teaches. This handbook will present the results of our research in the form of guidelines, rules-of-thumb, worksheets, and patterns to guide teachers and educational material developers through a process of analysis of their context, needs, and resources; development of strategies and plans; and finally deployment of effective, finely tuned materials.

Exploratories

Handbook Topic Examples

We are currently mining our own experiences as well as those of other Web-based educational project designers[6,7,8] for patterns in the areas of user interface design, pedagogy, interactivity, Web-based information structure design, and component-based software. Our initial analysis has focused on optimal applet granularities[9] and on the process through which we develop user interface widgets.

Granularity

Granularity, by which we mean the conceptual scope of an exploratory, has significant impact on the rest of the design process; fine granularity usually leads to multiple, single-featured applets, whereas coarse granularity tends to produce complete applications that demonstrate several related ideas. We have found that the fine-grained approach has many benefits for reducing development costs, enhancing reuse, and supporting flexible teaching and learning strategies.[9]

User Interface Widgets

As an example of the process of developing user interface widgets, we have documented the entire sequence of decisions, results, and analyses involved in deciding what kind of widgets to use to represent vectors for a set of basic linear algebra exploratories. This documentation will be exploited later in looking for patterns of effective UI design for different categories of exploratories, and is part of the very preliminary version of the Design Strategy Handbook.

Future Work

The fluid, asynchronous, fragmented, and open nature of the Web as an environment forces us out of the fixed formats we have been used to in our classrooms and labs, and provides invaluable experience in rethinking educational goals, strategies, materials, place, time, and space. Our hope is that some of the patterns and strategies we develop in response to this environment may prove flexible enough to provide a foundation for working with the radically changed environments that students, of all ages, will be immersed in five, 10, or 20 years from now. To further this goal, we will: extend our testbed to other courses in computer science, the sciences, and the humanities; continue to investigate the work of others in this area;[6,7,8] and explore adaptations of our current work to semi-immersive environments, such as the Responsive Workbench, and fully-immersive environments, such as the Cave.

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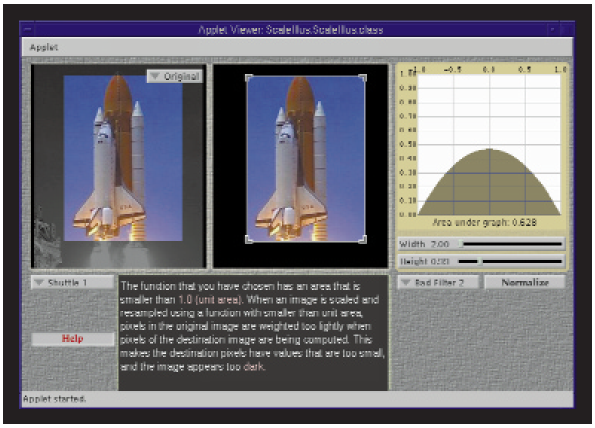
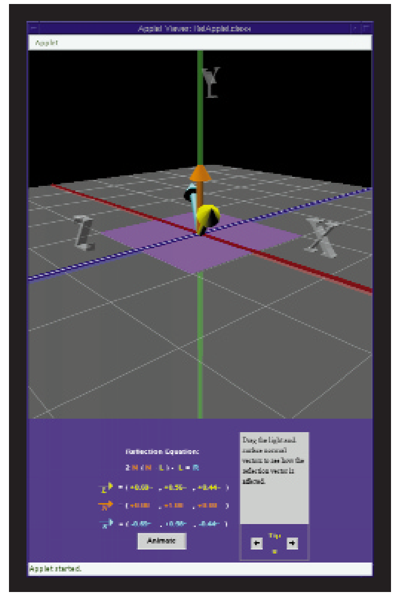
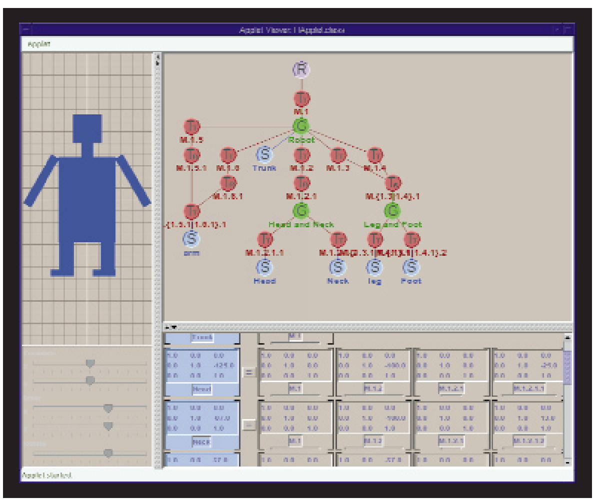


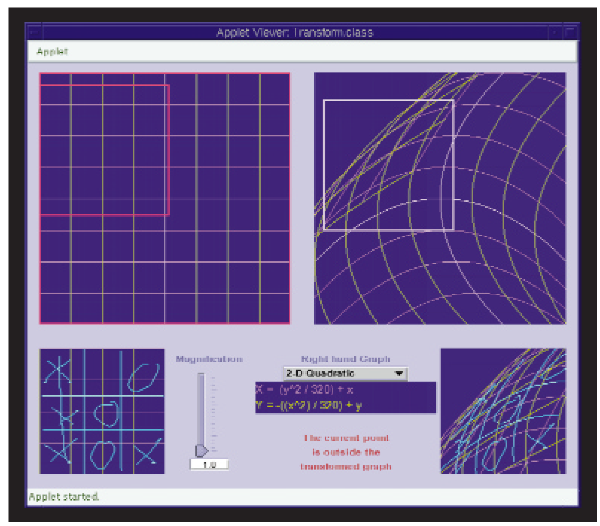
Scaling and Filter Shapes



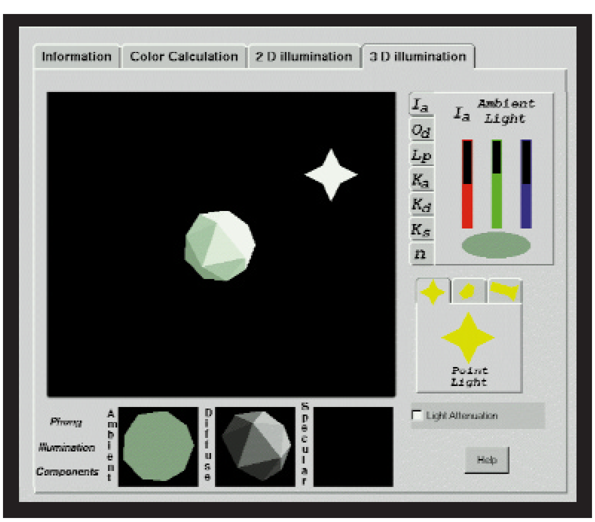
Reflection Equation



Scene Graphs



Coordinate Transformation, 2D Quadratic



Phonge Illumination

Halftoning

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Playground

FELIX 3D Display

Implementation of a "holodeck-like" display device is a long-held dream of researchers in computer graphics and interactive techniques. The FELIX 3D Display represents another step towards this goal. Projected spatial images occupy a physical space of full height, width, and depth. The system can be viewed by any number of spectators from almost any angle in the room without cumbersome goggles. The images are created within the physical world of the observer, in contrast to virtual reality systems where the observer is placed within the virtual environment of the non-physical image space. Thus FELIX provides an important new option for team tasks and tasks requiring many simultaneous views of multi-dimensional data. Entertainment, air traffic control, molecular design, or computer-aided design are only a few examples of potential applications.

In the FELIX system, a two-dimensional pattern is generated on a passive projection screen. A rotating helix sweeps out a cylindrical envelope (frame rate is 20 Hz), providing a volumetric display medium through which scanned laser pulses are projected. The hitting laser beam is scattered from the rotating surface, which generates a visible light spot (voxel). The spatial position of the emanating voxel within the display is determined by the momentary location of the laser beam's intersection with the rotating helix.

Vector Graphics

The vector graphics are projected with galvanometric scanners. Colored images are realized by combining red, green, and blue lasers. Separate modulation of each component enables additional color mixing.

Random Access Graphics

In the random access approach, raster images are generated. But only the volume pixels (voxels) to be displayed are scanned, saving data resources. For this mode, a high-speed acousto-optic deflector is used. The advanced software concept is capable of displaying wire-frame graphics in standard data formats within the FELIX 3D Display. The resolution is about 10,000 voxels at 20 Hz.

The FELIX 3D Display project team has evolved from a scientific working group of students and teachers at the Vincent Lubeck High School in Stade, Germany. This group works together on projects that range from development of a cyberbike to multivision projections through development of the FELIX 3D Display. All these voluntary activities are aimed at combining aspects of science and art.

Despite minimal financial resources, the group has achieved considerable results. Since 1983, the FELIX 3D Display team has been working on various 3D display techniques (stereoscopy, holography, multiplanar displays, etc.) in collaboration with the Institute of Flight Guidance and Control at the Technical University of Braunschweig, which led to development of innovative volumetric 3D display concepts.

FELIX

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Figures of Speech

Speech

What do you get when you put a group of 3D computer animation students together with an animation instructor and a great concept? Figures of Speech, an eight-minute animation that humorously depicts interesting colloquialisms of various origins. Imagine really seeing what happens when the "cat's got your tongue" or what it might be like when "it" really hits the fan.

Overview and Concept Development

The English language is full of creative associations from diverse origins. These catch phrases and colloquialisms are obvious because they translate poorly into other languages. The sheer volume of commonly used English figures of speech is quite remarkable. Choosing a commonly used figure of speech and successfully depicting it in a non-obvious manner is quite a task.

Figures of Speech follows the process of preparing a body of student animations in a form and quality suitable for screening at festivals and contests. Teaching an individual to reach an applied understanding of 3D computer animation is a delicate balance of several skill sets. Teaching an individual to animate, problem-solve, and specialize, as well as tell a story, is critical in an industry that expects high-caliber work. A mix of correct schooling in classical technique, practical use of newly introduced animation tools, story and concept development, and multiple critiquing sessions is necessary for a successful performance.

Real World Critiquing

Instructors will find it helpful to integrate the client/art director/producer relationship in the classroom. There's a feedback loop that's essential to producing good work. It is extremely useful to show students the ropes using a real-world approach. The limitation of this experience (as opposed to the real world) is that the student completes the work from start to finish.

In a small studio, the critiquing begins almost immediately. The same is true in the classroom. Ideas are deemed feasible or not, and the scope of the project is limited to an attainable amount of work. Multiple critique and feedback sessions are essential to push students beyond their current aesthetic and practical understandings of animation.

In the real world, you get feedback from the client, who expects a product to be developed on time and on budget. The producer's role is to see that the work is done according to plan and that resources are properly allocated. The art director oversees the aesthetic of the project. As an instructor, you get to play all three roles. And critiques are done with all three job descriptions in mind.

The feedback loop is started from day one of the project. A log of the feedback from each of the critiques helps students logically address suggested changes. During the second critique, a preliminary grade is awarded. Students can elect to make the additional changes before beginning their final render. A grade is given based upon completion of those changes. The final render delivery date is set, and students are penalized, or graded-down, if the deadline is not met.

The Future in Computer Graphics Education

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Classroom

Moderator
Mike McGrath
Colorado School of Mines

Panelists
Werner Hansmann
University of Hamburg

Dena E. Eber
Bowling Green State University

Judith R. Brown
University of Iowa

Jose Carlos Teixeira
University of Coimbra

This panel presents recommendations for the future of computer graphics education developed at the Computer Graphics and Visualization Education Workshop (GVE 99), co-sponsored by Eurographics and SIGGRAPH, 3-5 July in Coimbra, Portugal. The GVE 99 workshop brought together many of the leading computer graphics educators from around the world to consider the future of computer graphics education. Their recommendations will influence many ongoing efforts in developing curricula, including a developing ACM/IEEE computer science curriculum study and a new effort in creating curricula for computer graphics in engineering. More information on GVE99 can be found at: http://www.ccg.uc.pt/GVE99/

The focus for GVE 99 was two-fold:
1. Teaching computer graphics and visualization.
2. Using computer graphics and visualization for education.

Participants in GVE 99 were selected from position papers reviewed by a distinguished international program committee. While some participants were invited to expand their position papers into papers to be presented at the workshop, considerable time was spent in organized discussions of future directions in computer graphics and visualization education. The recommendations and predictions from the workshop were distributed at both SIGGRAPH 99 and Eurographics 99 as part of the joint celebration of SIGGRAPH's 30th year and Eurographics' 20th year.

Panel topics include:
- Hardware and software technology for educational workstations.
- Tools for educational applications.
- Cognitive aspects of visual teaching and learning.
- New teaching paradigms such as interactive classrooms, tele-immersion, and networked tele-collaboration.
- Developments in specific academic areas such as computer science, engineering, and art.

Panel Chair

Michael B. McGrath
Colorado School of Mines
Position Statement: Engineering Education in the Future

The practice of engineering has been radically changed by graphical tools that model the real world and allow interactive simulation. The challenge will be to develop teaching, instructional materials, and curriculum, that will take advantage of these tools. The emphasis in engineering will be on using graphics in education.

Panelists

Werner Hansmann
University of Hamburg
Position Statement: Computer Science Education in the Future

It can hardly be imagined that there could be any discipline that has no need whatsoever for graphics as a powerful means of communication. There is an increasing demand for graphical tools to become more and more sophisticated. Hence the challenge for computer graphics curricula (mostly as part of a general computer science education) is to provide appropriate foundations that will enable future developers of graphical tools to meet that demand.

Education

Dena E. Eber
Bowling Green State University
Position Statement: Educating Artists in a Digital Medium

Against all odds (and budgets), computers have recently emerged on the scene in university art departments across America. As part of this rapid change, unique digital art forms are taking shape. From imaging, digital painting, and 3D modeling to interactivity, video, and 3D animation, graphic technologies in the arts have the power to be an expressive medium, thus forging new educational and aesthetic concerns for computer art educators. Among many issues, three emerge as paramount. Art educators must:

1. Provide a balanced curriculum that includes traditional art, a computer art focus, and computer science.
2. Teach beyond what I call the "wow" factor.
3. Help students use the technology to express themselves through works of art.

Judith R. Brown
University of Iowa
Position Statement: Enabling Educational Collaboration

Tele-immersive collaboration can provide new learning experiences and insights by bringing together educators and students from remote locations in a shared virtual space. The visualization lab has long been the crossroads between research and education. As virtual reality technologies have recently enabled scientists to better understand their data through immersive exploration, so are these technologies enabling students to better understand new concepts. Inter-university student explorations are an exciting new way to learn. Enhanced computer graphics and tools for interaction, along with high-performance networks, enable a shared learning environment.

Jose Carlos Teixeira
University of Coimbra

The emergence of multimedia technologies and tools, the Internet, and the huge volume of educational information require new skills both for educators and students. Therefore, computer graphics is a crucial ingredient for the new generation of computer-supported learning material. In recent years, different approaches have been developed to answer technological and pedagogic challenges in education and training. It is important to review issues considered in some specific educational projects and apply them to different learning scenarios.

A similar panel is scheduled for Eurographics 99 in Milano, Italy, in September, for dissemination to and input from Eurographics educators.

Get a Job! A Recruiter Tells You What You Need to Know

Pamela Thompson
Pamela Thompson, Recruiter
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Classroom

What does it take to get a job at a visual effects, traditional animation or interactive company? This course presents the keys to opening the door to interviews, how to put your life on a one-page resume, and how to showcase your talent in a three-minute-or-less demo reel.

Resumes
If yours doesn't work, neither will you. As a recruiter and career coach I have seen literally thousands of resumes. On a slow day, I get three or four; so here is what bugs me the most:

Issue #1 - No phone number, wrong phone number, wrong area code, hard-to-find phone number, hard-to-read phone number.

Issue #2 - Name missing. Yes it has happened! But if I have a phone number, I can call it and leave a message for the person, so this gets the #2 position.

Issue #3 - Resumes with a type face that is impossible to read – too small or too ornate. Huge blocks of type that are a challenge to read.

Issue #4 - Hiding your skills. Don't make anyone read through a big paragraph to find your specialized skills such as C++ programming or knowledge of Alias. Highlight your skills under a separate heading.

Issue #5 - Resumes with multiple pages. If your resume is more than one page, put your name and phone number on each one.

Issue #6 - Resumes that fail to tell me who you are, what you know (skills), what you've done (accomplishments), and what you want to do (objective or goal). If you are changing careers, focus your resume on the job you want rather than the job you have.

Issue #7 - Paper that doesn't copy well. Test your resume. Copy it and make a copy of the copy. Surprised? Orange and dark blue paper turns black. Marbleized paper makes your resume look like someone poured coffee over it.

Issue #8 - Graphics or artwork on a gray scale behind the type. After doing the copy test, you'll find those beautiful graphics in the background are now some of the ugliest stuff you've seen on paper and what's more, you can no longer read your phone number or name, which looked so crisp in front of the graphic on the original. If you want someone to get a sample of your graphics include it on a separate page with your name and phone number.

Issue #9 - Typos and spelling mistakes. Proofread and ask a friend to proofread.

Here are several tips for a better resume:

1. List your skills and be specific.

2. Many companies scan resumes into computer databases. Select a font where the lower case l and number one are different enough that the computer won't confuse the characters.

3. If you have email, put your email address on your resume.

4. If your resume shows a variety of jobs, make sure you have an objective at the top that indicates what job you're seeking.

5. Review your resume every six months to update your skills and accomplishments.

Portfolios and Demo Reels

If you are an artist, it is essential that you have an outstanding portfolio and demo reel. The first step is to determine what your strengths and interests are. What kind of work are you suited for? There are many different jobs for artists, from animators to modelers to graphic designers to Web site developers to interface designers. You need to figure out what you like to do and what you are really good at. Assess your skills. Make sure your demo reel reflects the very best you can do and keep it short. Make them want to see more. Make sure the demo reel and portfolio are relevant to the job you want. If you want a job as a character animator, don't show only compositing work on your reel.

The purpose of the resume, portfolio, and demo reel is to get you an interview with someone who can hire you. Prepare your marketing materials with care. Have others take a look at them and give you feedback before you send them out.

For artists, a demo reel and portfolio are more important than a resume.

Your demo reel should:

- Be no longer than three minutes. It can be much shorter.
- Show variety
- Contain only your best work
- Be dynamic
- Be irresistible
- Be labeled with your name and phone number and email address if you have one. Include slates on your reel with this information in case the label falls off.
- Be a VHS cassette in NTSC format. This is the format almost all companies can deal with in the United States. If it's a PAL tape, be sure the company has a way to view it.
- Be representative of your recent work and show your skills and talent
- Be of high caliber and quality

Put the very best segment first. Include slates on the tape or a written outline that describes each scene and what you did for that segment. Remember, your audience sees lots of demo reels and portfolios. Keep it moving.

If you must have your work returned, include a self-addressed stamped container for return. Never send your only copy to anyone.

If you have worked on an interactive project and want to submit your portfolio in a digital medium such as CD-ROM, call the company before you send it to be sure they have the appropriate equipment to view it. Include a breakdown of how each piece was done and the constraints of production.

A portfolio of life drawing, illustration, photography (if you are interested in lighting), sculpture (if you are interested in modeling), character design, or color design is a big plus. Many aspiring computer artists today have no foundation in fine art, and the lack of training in aesthetics limits their capabilities. It's easier to train someone to learn a software package than to learn to draw. If you have a fine art background, include some of the work with your reel. Portfolios should have no more than 25 pages of work, and remember to include only your best work.

Whether you submit a demo reel, CD-ROM, portfolio, or all three, remember to always include a resume with it.

Networking

I recently got a message in a fortune cookie: "A wise man knows everything. A shrewd one, everybody." That message is the essence of networking. As an independent recruiter, I have found that no matter what you do in the entertainment arena, networking is key.

Here are some networking tips to try out at the next function you attend:

- If you have trouble getting started, think of it as a game. Make a goal of meeting at least two people at the next party or meeting you attend. Years ago, I went to a party with three friends, one of whom issued us all a challenge: meet five people. Instead of hanging around together, we went off in all directions and reported back the results. We had all met five different people, so now our network had expanded by 20!
- If you are painfully shy, go to events with someone who is good at networking. He or she will take you around and introduce both of you to someone new.
- Listen and learn. Force yourself to eavesdrop on a group. Learn their names.
- If you forget someone's name, admit it and reintroduce yourself. If you dread doing that, if you have a friend with you, reintroduce yourself to the person and then introduce your friend. Then pause so the person can introduce himself.
- Be prepared to meet people, follow up, and keep in touch. Bring plenty of business cards and exchange them with everyone.
- In a group made up of strangers and acquaintances, talk to someone you don't know. Once you introduce yourself to a stranger, he or she is now an acquaintance and could be part of your network.
- You have something in common with everyone. Make it your goal to find out what it is. This is fairly easy to do especially at SIGGRAPH 99. Everyone here has a common interest.
- Never whine, gossip, or speak badly of a fellow artist or employer. Be nice to everyone. It's a small world, especially in the entertainment industry.
- Prepare for meetings by reading the trade journals or the program. Read the bios of the speakers who do the presentations before you attend the meeting. Find out about the people you are going to meet. Do your homework. It'll be easier to speak to people if you know something about them.

- You don't have to wait for an event to try networking. Form a relationship with people in charge. Go to lunch with the boss. Network with people on other projects at your company. Network with people from other companies, too. Your next job may come from one of them.
- Be positive and flexible. Be a team player.
- There is no such thing as a small job. Do your best on every job you get and your circle of fans will grow.
- Everyone, yes, everyone is a potential job lead. Don't keep what you want a secret. Tell people what you are looking for. Ask them for help.
- The most important thing about networking is you must be prepared to give before you get. Find out what you can do for someone else. Perhaps someone is having back trouble (not uncommon in the animation industry!), and you know a good chiropractor or acupuncturist. Be ready to lend a hand, and hands will reach out to help you when you need it.

Whenever you attend an industry conference, trade show, or an association meeting or software user group, make a goal of meeting at least five people. Networking is one way to market yourself for jobs that may never be advertised. Build on these relationships.

Interviewing

Before you go for your interview:

- Research the company's products or services.
- Find out what their reputation is. Larger companies will have publicity materials. Study their press releases.
- Look for people in responsible positions that you respect.
- Determine the long-range prospects of the company by looking at their goals and target market.
- Look for a company that is growing.
- If it is a publicly traded company, check it out on the stock market report.
- Most importantly, look for opportunities to learn from exceptional people.

This research will pay off when you finally get an interview. You will impress them by your knowledge and enthusiasm for their company. Everyone wants to find someone who will fit in, and this research will help you convince the interviewer that you do.

After you get one foot in the door, how do you get both feet in and stay in? Interviewers want to answer three basic questions:

- Can you do the job?
- Will you do the job?
- Will you fit in with the other people at the company?

To get answers to these three questions, they may ask you many other questions. If you can convince the interviewer that you have the skills, (can you do it?); the willingness (will you do it?); and flexibility, and that you are a team player (fit), chances are you will get a job.

The last question (fit) is often the one that makes all the difference. If you have done your homework and research, you will likely be the one they believe will fit in. You know the other companies that do the kind of work they do. You know the company's work and something about the company's history and the key people. And you can speak with confidence.

But only one of the key factors in getting a job is the fit. The other is willingness. Attitude is of paramount importance, particularly in the computer graphics industry. There is little room for arrogance or a prima donna attitude. You are working closely with many personalities under often strict deadlines, and being a team player is essential to keeping a job and sustaining your career. So convince them that you can do the job, want the job and are willing to do it, and that you will fit in, and you will be getting an offer soon.

Once you get that job, remember to network, keep your resume, portfolio and demo reel up to date, and do the very best job you can every single day.

The Author

Pamela Kleibrink Thompson is an independent recruiter, career coach, and management consultant for clients such as Walt Disney Feature Animation, Digital Domain, Fox Feature Animation, Dream Quest Images, and interactive companies such as Lucas Learning, Activision, and Hollywood On Line. Thompson's adventures in animation include setting up a studio from scratch, hiring and managing a crew of 100 artists, creating and staffing a 3D art department, producing award-winning video games, commercials, creating and producing the 1998 Career Boot Camp, and co-producing the 1999 Career Boot Camp.

Thompson regularly speaks on career issues and consults with colleges and universities to design animation training programs. Her production credits include "The Simpsons," "Family Dog," and "Bebe's Kids." Thompson worked on the computer animated film currently running at Epcot Center's Universe of Energy Pavilion, which is possibly the longest continuously running computer animated film ever. She was recognized in February 1999 by Animation Magazine as one of the top recruiters in her field. Her articles on animation and business have appeared in over 40 periodicals. A member of the Academy of Television Arts and Sciences, Thompson is currently the subcommittee chair of LA SIGGRAPH and is active in Women in Animation and ASIFA.

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Going Farther in Less Time: Responding to Change in Introductory Graphics Courses

Moderator
Rosalee Wolfe
DePaul University

Panelists
Steve Cunningham
California State University, Stanislaus

Scott Grissom
University of Illinois at Springfield

Lew Hitchner
California Polytechnic University

The field of computer graphics has matured greatly since the formal statement of the introductory undergraduate course was created for ACM/IEEE Curriculum 91, and courses must change accordingly. This panel will describe a philosophical basis for the changes and gives some examples of courses that are responding to that change.

Introduction

The panelists all teach computer graphics at medium-size institutions and teach courses whose details vary rather widely. However, all have addressed the changes in the field, and their discussions of their choices illuminate how the changes in the field are reflected in course design. The panel shows how several recurring themes appear in the courses.

One of the goals of the panel is to lay out an early form of a philosophy for the introductory graphics course. We hope that this philosophy will evolve into a basis upon which instructors can develop courses that fit their local needs while reflecting the changes in the field. Fundamentally, the philosophy is:

1. Computer graphics is inherently 3D and courses should be also.
2. The fundamental subject of a computer graphics course is geometry and how it is expressed in computational terms. Thus, geometry is a major part of the introductory course. Geometry is expressed in terms appropriate to the field, such as coordinate systems, transformations, and surface normals. The basic shape is the triangle. The mathematics of curved surfaces is typically treated in a more advanced course.
3. Computer graphics is intrinsically visual, and even the most technically oriented graphics practitioner must be aware of the visual effects of algorithms. Unlike other areas of computer science, algorithms must be considered not only for time and memory usage, but also for their visual effect.
4. Besides geometry, computer graphics is about light and surfaces, and about developing algorithms to simulate their interplay. Courses need to include material about light and surface properties, and about the distinction between the ways various algorithms present light and surfaces visually.
5. Computer graphics has matured to a state in which there is a small number of high-level API's that support all the fundamental concepts needed for early work. Courses should be built upon this high-level approach.
6. Computer graphics should be interactive. Courses should include interactive projects and cover event-driven programming. Because this explores new possibilities in curricula for computer graphics courses, this panel is designed to spark discussion and encourage involvement in this process.

Panel Members and Position Statements

Steve Cunningham

Steve Cunningham has taught at California State University, Stanislaus since 1982. He has worked in computer graphics since he developed a graphics-based general statistics laboratory in 1976-78. He has worked with SIGGRAPH since 1983 as chair of the Education Committee, chair of the SIGGRAPH 91 Educators Program, Director for Publications, and currently as Chair of the organization. He has presented two SIGGRAPH conference courses, co-authored books on user interfaces and electronic publishing, and co-edited two books on visualization and one on object-oriented computer graphics.

"In the late 1980s I contributed to Curriculum 91 by reviewing its recommendations in computer graphics and user interaction. As part of that review, I wrote the computer graphics course outline in that curriculum. However, the field has changed substantially and our graphics courses must keep up. I changed my introductory course to become fundamentally a course in computer graphics programming based on OpenGL. This

change showed me that students could succeed with less computer science preparation when they use a capable API. This makes the course accessible to more students, and I have begun to orient the course towards students in the sciences. I am now developing materials for such students. It is still important to offer a computer graphics fundamentals course, particularly for students who want to pursue a graphics career. Because the fundamentals course builds on students' OpenGL background when it is a second course, it can cover significantly more material than when it is the first graphics course."

Scott Grissom
Scott Grissom has been teaching at the University of Illinois at Springfield since 1993. He graduated from The Ohio State University with an emphasis on computer graphics and human-computer interaction. He is editor of the Visualization Resource Center, a collection of peer-reviewed teaching resources for computer science. He teaches Data Structures, Computer Science II, Object-Oriented Design, and Human-Computer Interaction in addition to the Computer Graphics course.

"We only offer one undergraduate course in computer graphics. So I try to expose students to a wide range of computer graphics. I have been using C++ and OpenGL for three years. I want students to create interesting and motivating images as early as possible. Using a high-level API allows them to do that. Towards the end of the semester, I briefly introduce concepts of ray tracing and have students use POV-Ray to render an image. POV-Ray requires an understanding of lighting models, view manipulation, and texture mapping, and is available on all platforms. The final project involves an interactive application on the Internet using JavaScript, CGI, VRML, or Java."

Lew Hitchner
Lew Hitchner has a varied background in applying computer graphics and virtual reality in academia, industry, and research. His PhD is from the University of Utah. He taught at the University of California, Santa Cruz for five years and currently teaches at California Polytechnic University. He has worked as a researcher for NASA, in industrial R&D, and as a private consultant in graphics and VR. His teaching experience includes introductory CS1 and CS2 and all levels of computer graphics courses (intro through graduate courses).

"The Cal Poly introductory computer graphics course is a practice-oriented curriculum that combines fundamentals with intensive laboratory exercises and programming assignments. Students learn to apply fundamentals through programs that use two high-level API's. Our one-quarter course covers 3D geometry and transformation basics, event-driven interaction, hierarchical modeling, camera and lighting equations, and rendering techniques (visible surface, texture mapping, etc.). Students use a high-level API in all assignments (Open GL and Open Inventor)."

Rosalee Wolfe
Rosalee Wolfe has taught graphics and human-computer interaction at DePaul University since 1987, after graduating from Indiana University. She served as the SIGGRAPH Educators Program Chair in 1996 and 1997. She has edited several SIGGRAPH Slide Sets and the Seminal Graphics book published in 1998. In addition, she is the education columnist for Computer Graphics and currently serves on the SIGGRAPH Education Committee.

"We have two introductory computer graphics courses. Computer Graphics Survey covers the entire discipline and uses high-level packages (Rhino, POV-Ray) to teach topics from the areas listed above, and to teach animation. This course is often referred to as the seduction course, because students taking this course often decide to embark on additional courses in graphics. The second course, Computer Graphics I, uses C++/OpenGL as a platform. Students are given a crippled wireframe browser, to which they add transformations, hidden surface removal, shading, texture mapping, and interactive elements. Although both are entry-level courses, many find that the survey course helps them when they take Graphics I.

change

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Workshop

Hands-On Animation

Introduction to Animation using Maya 2.0

3D animation is an important subject in the film and video market. Everyone wants to animate or have some form of 3D animation in their productions. There are numerous tools available in the production environment for 3D animation, and they all work from similar concepts. In this session we will look at how one software system (Alias|Wavefront's Maya) handles the concepts of animation.

Maya Overview

Maya's Architecture

- A brief look at how objects are defined in Maya with nodes and attributes.
- Use of the dependency graph view to look at the relationship between nodes.

Animation in Maya

To animate something is to bring it to life. A simple cube can be considered a character and brought to life by a good animator. The animator is able to give it personality by carefully animating the cube's movements with subtle nuances. We no longer see the cube as an inanimate object but as a character with personality. In Maya, there are several different ways in which you can animate your scenes and the characters who inhabit them. In this session we concentrate on the basic tools used for animation.

Keyframes

To understand keyframes, you need to look at time. Within Maya, you are able to define what time is by using a frame rate. A certain number of frames will define one second of time (for example, 30 frames per second for video). Once you have defined your frame rate, you know how many frames make up a second (in this example 30). This is important because a keyframe is a key set on a specific frame. The key is specific information about the object that is held at that frame, such as position, scale, and rotation. At a different frame, the key can hold different information. If you wanted an object to move from position A to position B in one second, then you would put one keyframe on the object at position A, frame one and a second keyframe on the object at position B, frame 30. The system now has two keyframes that define the object's position at two different times. Since the positions are different from the first frame to the second, when the system moves to frame two, the object starts to move. As you progress through the frames, the object will continue to move until it reaches the position at frame 30 defined by the keyframe. When this animation is played back, the object moves from position A to position B in one second. The tools we will be looking at are:

- Set key
- Auto key
- Set breakdown

Editing Keyframes

When animating, you will generally take a first pass at an animation by blocking out positions. This is a rough first pass of an animation, setting initial keyframes to establish positions of your objects. Once you have established initial positions and keyframes, you will need to spend time editing them by moving keyframes and inserting new ones. There are a number of tools and windows that can help you when it comes to editing keyframes:

- Time slider
- Graph editor
- Dope sheet
- Curve tangents

Hierarchical Animation

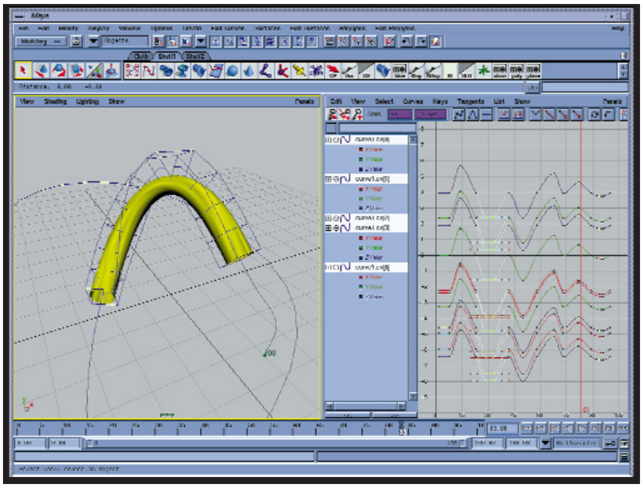
Hierarchical animation is used to add secondary animation to an object. For example, if you animated a bouncing ball, you might want to introduce some squash and stretch as well as some rotation. If you were animating a car, you would want the tires to rotate and the engine to run. To make these examples work effectively, you need to use a hierarchy.

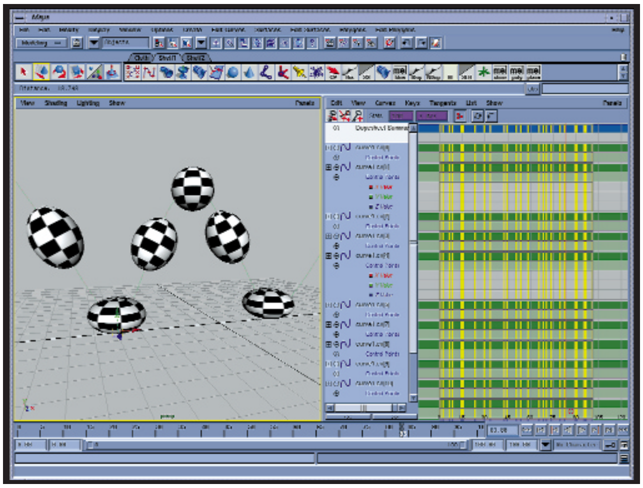
Set Driven Key

This is a powerful tool that lets you connect the animation from one object to another object or objects. You can quickly set up an animation where you keyframe one object and use that keyframed motion to drive the movements of one or more objects.

Path Animation

Another important animation tool is the path tool, which allows you to define the motion of your object by using a path. First you need to draw a curve defining where your object will travel, and then you use the path tool to attach the object to that curve (for example, a car on a roller coaster). To further modify the animation of the object, you would then modify the curve and the keyframes generated along its path.





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Hands-On Universe: Teaching Astronomy with Java-Based Image Processing Tools

Playground Workshop

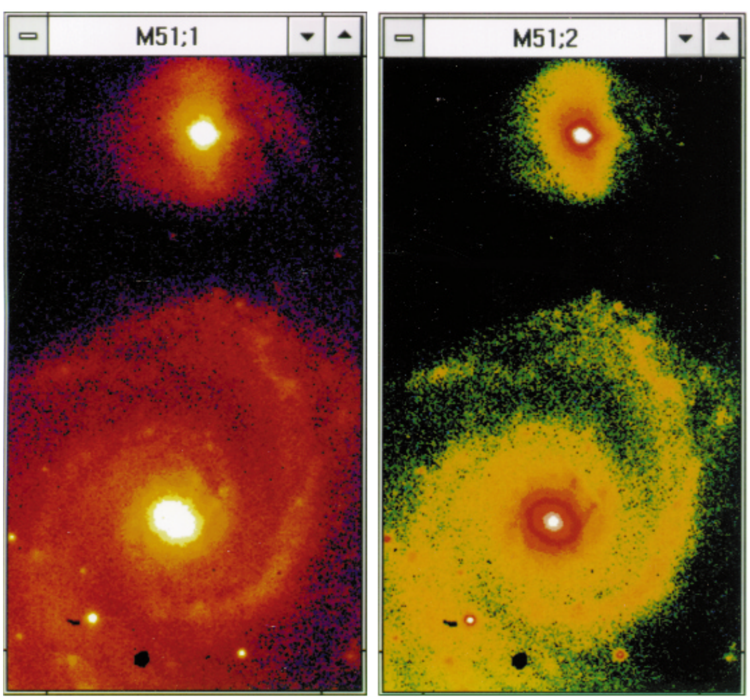
Presenters
John Refling
Carl Pennypacker
Lawrence Berkeley National Laboratory

The goal of the Hands-On Universe Project is to teach observational astronomy and related science concepts within a collaborative and stimulating learning environment. This environment is enhanced by appropriate software tools and professionally produced curricula. The software tools consist of Web-based image processing, visualization, and computer graphics programs that provide various forms of image enhancement, qualitative and quantitative data extraction, and analysis functions.

The project goes beyond the traditional static classroom approach to teaching by providing a networked environment in which students interact with other students around the world. They can have their questions answered by professional astronomers and scientists who are participating in the project. They can also participate in collaborative research with other institutions.

A key feature of this project is the use of networked, automated, research-quality telescopes. Via the Internet, participating students can make personal requests for a telescope to take an image of a particular feature in the sky. The students' request for images is the first important step in their subsequent application of the computer image processing tools and astronomy fundamentals. This step is crucial, as it provides a sense of ownership of the image, which in turn increases the students' interest and motivation in performing scientific investigations on the image. Since each image is unique, and since the universe is changing over time, there is a possibility that the image contains astronomical features that have never been viewed before, even by well-funded research institutions. This potential for discovery also enhances the students' interest in learning and participating in the project.

In addition to the networked research-grade telescopes, the underlying technology consists of remote and local file servers that provide archived data and number-crunching capability in response to interactive requests from the participant, and Java-based graphics terminals that provide an interactive visual interface between the user and the rest of the system via the World Wide Web.



The main focus of this Electronic Schoolhouse workshop is to examine the project's Web-based image processing tools, which visually manipulate and analyze astronomical images, and to explore the curricula that accompany the software. Specific subjects include: CCD camera fundamentals, image enhancement, visualization and extraction of measurements from the image (for example, measuring feature sizes on the Moon), exploring photometry, correlating orbits of objects with their visual images and the underlying orbital mechanics principles, and studying changes in objects in the sky.

In the most compelling demonstration of the project, the workshop demonstrates how students in rural America were able to use the software to detect a minute change in images of the sky over time, leading to their discovery of a supernova. They are currently collaborating in a search for comets.

High-End Interactive Media in the Museum

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Classroom

This paper examines the issues involved in the use of high-end interactive media, computer graphics applications, and virtual reality technology in museums. As museums adapt advanced digital media for use in exhibitions and public programs, new relationships develop between the audience, the venue, the virtual representation, and the real object or fact. While use of state-of-the-art technology can effectively shape how museums deliver public education, issues of high cost and maintenance of such technology, larger and diverse audience throughput, and difficulty in content development present important drawbacks. Both the benefits as well as the problems caused by deployment of technology in the museum will be analyzed. Examples will be presented of special museums worldwide that use technology in innovative ways for educational and artistic purposes. Particular focus will be given to presentation of the projects created by the Foundation of the Hellenic World, a cultural heritage institution in Greece, which uses immersive virtual reality, VRML, and 3D graphics for reconstruction of archeological sites, historical interpretation, and education.

Technology in the Museum

Recent technological developments have provided designers with new tools for introducing media into the museum setting. Many museums are now beginning to utilize more recent information technology for internal and external organizational purposes, while more and more interactive exhibits are incorporated into galleries in order to enhance the visitor experience.

Museums realize that they are one among many components in a panoply of cultural amenities and that computer technology can help them quantitatively and qualitatively expand, deepen, and enhance the museum experience for their visitors. A growing number of museum educators regard new media as tools that can offer unparalleled opportunities for learning. Through educational Web sites and CD-ROMs, museums have enhanced their role as providers of informal education. Educators respond to such efforts favorably, as they provide alternatives to restricted curriculum material and allow for more exploration and ownership of the learning process. Finally, museum visitors, especially non-frequent and novice audiences, appreciate and benefit greatly from additional forms of information that make the museum a more accessible and attractive place for them to spend time in.

What are the most common ways that media technology is used nowadays in the museum? One can broadly define the following ways that museums incorporate media in their daily function:

- Audiovisual media used for passive presentation in an appealing way. This, for the most part, consists of video presentations on simple monitors or wall projections in special rooms intended to cover needs in public spaces where staffing is minimal.
- Guided presentation with the help of audio guides, video projections, and other means to accompany visitors throughout their tours, offered as alternatives to the popular tours usually given by museum docents.
- Interactive browsing stations with information on museum collections and educational programs (usually kiosks with "press-a-button," easy-to-learn interfaces).
- Environments that provide opportunities for direct creation or production, take-away experiences, interactive experiences, and innovation.

Current museum theory and practice suggests that technology, as incorporated in today's exhibitions, should generally evolve through two successful formats: inquiry-based guided tours and interactive hands-on exhibits. In this paper we focus on the latter types of technology use, particularly on interactive media that move beyond the point-and-click of common multimedia and information stations. These media may include interactive installations, simulation environments, interactive film, large format theaters or small-scale exhibits, and virtual reality. The explosive development of information technology and the increasing confidence on the part of the museums to

Interactive

incorporate it in their setting has encouraged many institutions to adopt these sophisticated technological means, innovative environments, and equipment.

Of particular interest to museums is the use of virtual reality (VR) displays and computer-generated interactive experiences that aim at allowing visitors to travel through space and time without stepping out of the museum building. The potential to transcend the physical location of the built environment and the growing sense of the educative function of the museum juxtaposed with commercial pressure has led museums to consider virtual reality as a necessary component in the arsenal of tools to educate, entertain, and dazzle. Although virtual reality suffers immensely from media hyperbole and thus has not lived up to its promises, development of VR systems has matured enough to find its way out of the research realm and into public settings. Introduction of projection-based VR systems has shifted the format from the one-person VR experience with bulky headsets and equipment to the slimmed down, more comfortable visual displays for multiple simultaneous participants.

Multimedia and Internet Stations in a Museum Café

Issues and Challenges

Introduction of high-end or virtual technologies in museums runs up against a number of issues that must be considered. Specifically, high-end technology in the museum must take into account the physical context of the public space, support the conceptual and aesthetic standards of the exhibition or learning purpose, and be functional and accessible to its intended audience.

Whether it's the novelty of interactive technology and virtual reality exhibits or the compelling nature of the applications themselves, visitors flock to museums to see things that are new and cutting edge, even if the content remains relatively unchanged. This generates added worries for museum practitioners, who must design keeping their educational role in mind, yet provide the added novelty, accommodating an increasing range of educational experience, and enhancing their visitor demographic.

Attention can be focused on the following set of issues that previous experience has led us to recognize as the more critical ones in the process of introducing highly interactive technologies in public spaces:

1. Bring technology into context.

Technology in a museum exhibit can not stand alone. To serve museum needs, it must address the specifics of venue and audience, and be used in the context of the total museum experience. The physical context provided by the museum as a public space, the exhibit in its entirety, and the interaction with the exhibits, the other visitors or the museum staff are all important parts of the museum whole. The best media are integrated architecturally and conceptually into an overall exhibition narrative and created directly for the spatial and thematic context of the museum itself. Effective deployment of technology relies upon the degree to which it can be thoroughly embedded in its context of use, including the ordinary, practical competencies of those who are to work with it.

Museum visitors vary in age, level of education, interests, and learning styles. To address these differences, good exhibit design recognizes the social activity and nature of museums by providing space for more than one person to get involved and by developing exhibits and media experiences that often serve as prompts for social interaction. Media productions in the museum should not come into conflict with the natural, often non-linear, ways a visitor interacts with the museum space. The multi-modal nature of interactive technologies provides ideal opportunities for development of flexible tools for both group and personal experiences.

2. Technology must be seamless.

A well-designed environment is one that is consistent, predictable, and transparent. New media tools are just elements to enhance the educational, informational, or aesthetic goals of any given exhibit and should be seamlessly incorporated. We do not want the media experience to seem like an add-on, an extra to the exhibition, but an integral part of it. Hence, the technology should be designed to "disappear" during the experience. It should be non-obtrusive. Projection systems and computer equipment, for instance, can be hidden from view and acoustically isolated. Visual cues associated with the projection surface or other equipment can be minimized.

3. Provide immediate feedback yet prolonged engagement.

Donald Norman identifies four principles of good design that can be applied to an information environment to make it self-explanatory and not frustrating: visibility, a good conceptual model, good "mappings," and feedback. The format of a typical museum experience involving technology is inevitably controlled, structured, and brief. Hence, responsiveness and feedback are particularly important in museum media settings where we encounter only brief interactions, even in structured events. Users of multimedia installations expect a response immediately; otherwise they walk away. This may be more difficult with highly interactive environments where interactivity is not easily controlled. Experiential-based installations and participatory environments must demonstrate different strategies to include and involve the observer in the events on a long-term basis. Advanced forms of interactive technology, such as virtual reality, allow us to tie together the time and space-breaking nature of interactive media with the time and space-bound nature of the site-specific museum environment. The key is to provide immediate responsiveness and then prompt for deeper involvement on the part of the user.

Overall, experience using virtual reality with large groups of children has shown that the effect can be much more powerful if it possesses two important attributes: an interacting mentor and long-term engagement with the learner.

4. Design with content in mind and involve the experts.
In many cases, high-end technological innovation often creates the suspicion of high cost and low content. Current applications seem unable to step out of paradigms created by other media. "Old media" do not always translate gracefully into new media environments, producing, in many cases, outcomes that seem fragmented. It is also often the case in advanced media environments that novelty overshadows content. Technological developments may often be associated with disappointing gains for users whereas compelling content will most likely engage the visitor no matter what the form of presentation may be.

As a result, most educated audiences are skeptical regarding the added value and appropriateness of advanced technology applications in the public domain. Based on the above, it is important to use the involvement of content experts when designing interactive and virtual environments. As difficult as it may be for educators, artists, designers, archeologists, historians, architects, doctors, scientists, and technicians to speak the same language, it is nevertheless essential for creation of sound and complete environments. Collaboration must definitely take place amongst those who are concerned with how things work and those who are not concerned with the technical details but with what is delivered to the public.

The designers of new media must understand the medium to achieve the perfect blend of form and function. They must attract visitors, and they must meet expectations both in terms of their innovation and their delivered content. Questions should be asked regarding the underlying principles that are guiding the development of content, and conventions should be set for structuring and delivering this content. The museum must provide the best combination of technological innovation and educational content and create a shared critical context within which to understand the work aside from understanding it technically.

5. Be concerned about physical and accessibility issues.
Clearly, an important point of particular relevance to high-end technology is usability. Public viewing must be considered in the context of hundreds of people who will visit a site each day, more so if the site is set up for visitor interaction. Practical issues and problems are especially apparent when the apparatus is not designed with novice or special users in mind, as is the case with most experimental high-end computer technology. In the case of virtual reality, for example, it is common for most systems to cause motion sickness; active stereoglasses are too large for small heads, too fragile, and too expensive for use by excited visitors, let alone a child. Children must use both hands to operate hard-to-use interaction devices, hold the stereoglasses with special ties, or even deploy support systems to stand up higher in order to achieve the correct viewing angle.

Issues of high cost and maintenance of advanced technology, larger and diverse audience throughput, and difficulty in content development present important drawbacks for public venues. Prohibitive costs of such technologies and concomitant inaccessibility, staff development, operation, and maintenance can find no place in dwindling museum budgets overwhelmingly dominated by human resource costs.

Good sight lines, ample seating where applicable, comfortable viewing for extended periods, good field of view, and ergonomics are some of the issues that must be addressed when designing a unique, high-end environment. The interactive experience must also have an easy-to-learn and simple-to-use interface that is accessible to a wide range of skill levels and requires virtually no visitor training.

In brief, accessible new media must be characterized by:
- Attractive designs
- Rugged engineering
- Accessibility
- Practical maintenance

Despite the above issues, there are ambitious and significant efforts taking place in museums worldwide that have used high-end technology to complement their exhibitions. Some examples of innovative media use in museums are mentioned below.

Innovative Examples of Media Museums and Museums Using Media

Science museums, hands-on children's museums, large "edutainment" venues, and recreation parks have traditionally embraced new media first. Museums such as the Exploratorium, the Tech Museum of Innovation, or the Computer Museum in the United States employ fascinating and sophisticated interactive installations and have been presenting up-to-date results on the creative use of technology.

Aside from existing museums that have employed higher-end technologies, a new form of museum has emerged, as exemplified by a growing number of media museums worldwide such as the Ars Electronica Center in Austria, the ICC center in Japan, and the Center for Art and Media (ZKM) in Germany. These are new types of museums devoted to depiction and presentation of new media, or "productive media art museums," a term coined in ZKM's mission statement. They are true pioneers in the use of high-end interactive technologies open to the public. The Ars Electronica Center, for example, was the first museum worldwide to install and open to the public a CAVE, an immersive multi-person virtual reality room, where high-resolution, 3D video and audio are projected on three walls and the floor.

In the more traditional fields of fine arts, archeology, and history, there are hardly any museums that have moved beyond multimedia presentations (which are usually placed outside their main exhibition galleries). Unique is the case of the Foundation of the Hellenic World (FHW), a non-profit cultural institution in Athens, Greece. The foundation's mission is to preserve and disseminate Hellenic culture, historical memory,

Acknowledgements
The Foundation of the Hellenic World is a privately funded, non-profit cultural institution based in Athens, Greece. The authors wish to thank the staff of the museum, who have worked hard to achieve its innovative interactive programming and vision.

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and tradition, as well as project the contribution of the Hellenic spirit in the development of civilization. Its main plan for operation is the use of advanced technological methods to promote this understanding of the past, as a point of reference for shaping the present and the future. The foundation is housed in a large innovative museum/ cultural center on an old 18-acre industrial plot in Athens, where historical exhibits on all periods of Hellenic culture are presented using the latest audiovisual technology.

Consistent with the foundation's decision and commitment to use state-of-the-art technology, normally found only in research labs, is the plan to develop a type of "VR center" focused on the cultural domain. Not only is this blend of the traditional with the most advanced unique as far as museums are concerned, it is also a one-of-a-kind endeavor for Greece.

Specifically, the Foundation of the Hellenic World's high-end technology endeavors involve immersive virtual reality. Generally, VR technology in FHW functions in two basic ways: as an educational/entertainment tool and as an instrument of historic research, simulation, and reconstruction. Examples of applications include an educational environment related to traditional Greek costume throughout time and reconstruction of and a journey through the ancient city of Miletus by the coast of Asia Minor, as it was in antiquity. Guided by a virtual "time-machine," our travelers are able to explore the city as it unfolds through time, and experience the life of its architectural glory, its people, and their customs, habits, and way of life. To present such projects, the Foundation has purchased a roving immersive projection table, the ImmersaDesk. This virtual reality environment "on wheels" has the ability to move about the museum campus. It thus enables creation of a truly flexible virtual reality setting for the museum and allows for customization of the virtual reality exhibit to any current exhibition or program.

While this type of setup can afford unique educational and recreational opportunities, equipment of this kind is inevitably in an experimental stage and suffers from a number of drawbacks in terms of usability – essentially, many of the practical problems mentioned above. The roving nature of this particular virtual reality system is a relative advantage as the equipment is fragile and requires special handling; once installed, the virtual reality equipment requires a specially designed place where metal structures are not present. The display system must be designed to withstand breakage, short attention spans, greasy fingers, and large numbers of visitors. The special glasses are expensive and can break easily as their sizes are not made to fit everyone's head. Equipment must be placed out of reach yet remain accessible to the technical staff. Finally, experienced guides who have both technical skills and museum education background are always required.

The above efforts set standards in the direction of technology use in informal public settings, yet the contours of the new media landscape are just now becoming visible. No one yet knows what will be successful or how visitors will ultimately use and interact with these emerging technologies. We must, therefore, continue to see that the insights gained through experienced use are adequately translated into the public space and are both inquisitively and critically examined.

How to Marry an Éclair: Anatomy of an Animated Tale

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Playground

This Playground exhibit demonstrates how a unique, cross-age, multicultural, and, most importantly, cooperative learning environment allows for producing well-prepared animation artists as well as production of animation itself that is tremendously engaging (and fun!).

For the computer graphics student, having a strong drawing and traditional animation background provides the strongest possible foundation for developing a career in computer animation. Conversely, computer animation experience is critical to the learning needs of traditional animation students. Therefore, the Abram Friedman Occupational Center gears its program toward the holistic integration of both disciplines to provide learning for students who are concentrating solely on a career in one or the other.

This exhibit shows how traditional animation and computer animation classes collaborated to produce an animated short. The exhibit emphasizes how computer animation techniques for producing such things as lighting, environments, and particle systems were married with traditional 2D techniques such as hand-drawn character animation to produce a seamless animation that highlights the best qualities of both.

All steps of the collaboration are demonstrated, from developing the story in discussion to how it was storyboarded on paper, from building and animating characters using computer animation to more traditional techniques that utilize paper, cels, disks, pencil test machines, and animation stands. The use of pencil test machines, scanners, and computers to create animation tests for characters, backgrounds, and environments will also be demonstrated. How the students rendered scenes, edited, and assembled footage to develop a final product will also be shown. Team building will be demonstrated and discussed, as representatives from each class "walk and talk" observers through the exhibit. The exhibit also includes a documentary showing how the animation was made.

This exhibit is an opportunity for students to talk about both the learning experience and how it prepares them for work in the industry, whether they are computer graphics artists or traditional animators.

Animated

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Classroom

Incorporating Principles and Examples from Art/Design and Film/Video into a CS Computer Graphics Course

Introduction

Computer graphics is one of the most technology-dependent areas in computer science. Creating and storing realistic 3D images and animations requires substantial processing speed, main memory, disk space, and graphics display capability. Fortunately, we are in a field where incredible advances in these technologies are an accepted fact. Thus, I have changed my course constantly over the past few years.

A non-technology change that I have made is to incorporate established principles from art/design and film/video and into my computer graphics courses. Artists have been producing images for purposes of visual communication for over 10,000 years. They have established a rich set of principles and guidelines for image composition and have worked out many of the problems that have been faced in computer graphics. Similarly, film has a history of over 100 years and has added extensions and modifications to the art principles. Our computer science students can benefit from exposure to these principles. In addition to teaching them algorithms, we should teach them some of the aspects of visual communication. I also think that they would benefit from exposure to examples from art that illustrate some of our core principles.

In this paper, I will briefly describe the particular environment in which my course is taught and the changes within my course over the past several years. I will discuss how these principles and examples from art/design and film/video can be incorporated into a computer graphics course. Most of the examples given below are in HyperGraph, which is available in the Curriculum and Materials portion of the ACM SIGGRAPH Education Committee Web site (www.education.siggraph.org).*

Background

Georgia State University is primarily a commuter university with approximately 24,000 students, many of whom live 30 to 45 minutes away from campus. The undergraduates have a sound mathematical background and are familiar with vectors and matrices. The prerequisites to the first graphics course include the first three computer science courses, covering programming principles and data structures in Pascal and Ada.

Many of our students work part time or full time. Almost all of the students have their own machines; almost universally these are IBM PC compatible machines. This leads to several constraints. First, I cannot force the students to use Java, C, or C++. Second, it would not be fair to the students to require them to spend a large amount of time on campus. They should be able to do most of the work at home.

Although the course material and teaching methods change every time I teach the computer graphics courses, my objectives have not significantly changed. These objectives include both computer graphics and non-computer graphics issues. The graphics objectives are that the students should learn about graphics systems, algorithms, and the process of creating graphical images. I have emphasized 3D graphics and the 3D graphics pipeline for several years, although I still cover 2D graphics algorithms. Although I cover different modeling methods, an emphasis has been on different image synthesis techniques.[1] Perhaps this is because of my background in physical science, whereas someone who has a background in mathematics might tend to emphasize modeling techniques.

I have changed the projects for the students over a period of years, always adhering to the constraints mentioned above. Initially, I had students develop a scanline graphics system that culminated in display and manipulation of a simple 3D faceted shaded object such as a parallelepiped. Then GSU obtained a license for the RenderMan development system, and I began using this in my courses, in addition to the programming projects.[2]

As computers became faster (with the introduction of the Intel 386 chip) it became feasible to teach ray tracing. Students developed a ray tracing program over the course of the quarter. I still used RenderMan, since I wanted the students to be able to compare scanline graphics images with ray traced images.

With the advent of VRML, I switched from RenderMan to VRML.[3] Unfortunately, I have found that I need to periodically change my assignments as the students tend to copy the previous year's assignments. Over the past year, I have used Larry Gritz' s Blue Moon Rendering Tools (BMRT) program. This freeware package adheres to the RenderMan interface specification and creates both ray-traced and/or radiosity-based images. So, instead of writing a ray tracer from scratch, my students create Renderman RIB files and then use BMRT to render the images. This allows them to compare a system designed for high quality image output using global illumination methods (BMRT) with a scanline system designed for interactive speed (for example, VRML).

GSU has recently revised its computer science curriculum so that the first programming courses are in Java and then C++. This means that in the near future I will be able to explore the use of other tools for programming assignments, such as OpenGL and Java3D.

My courses have also been changed in that I have incorporated principles from other, related fields. This is the primary topic of this paper and in the next few sections I will give examples of how I have done this.

Image Composition and Graphics Design

Our students are going to be creating graphical user interfaces (GUIs), Web pages, and computer images. Therefore, it is important that they understand some of the basic principles of design and image composition. A human computer interaction (HCI) course might discuss these topics, but HCI courses usually emphasize cognitive aspects rather than the visual display aspects of interfaces.

Some of the image composition topics that I cover include the following:

- General concepts such as: line and contour, value, shape, texture, space (both positive and negative), color
- Unity and harmony
- Ways to achieve emphasis: contrast, tangents, isolation, shape, motion
- Ways to achieve balance including the concept of visual weight: value, color, shape, texture, position, eye direction
- Scale and proportion
- Repetition and rhythm

These can be somewhat specific to Web design[4] or they can be more general.[2,5,6,7] Scene composition is implemented in computer graphics by the choice of a virtual camera placement, orientation, and field of view. However, there are other aspects of camera usage that we can learn from film by looking at the purpose of different types of camera shots. For example, what is the purpose of a long shot versus a close-up? What are we trying to accomplish with these different types of camera shots?

P. Turner presented some similar ideas in the context of an art computer animation course at SIGGRAPH 98.[8] For example, depth of field can be used to shift the emphasis from one character or area to another. In this first scene, the creature and Debbie are having an innocent conversation, with the center of focus and attention on them. Next, we switch to focusing on the evil alien as he covertly observes their conversation. (Both images are on the Conference Abstracts & Applications CD-ROM)

Lighting Considerations

In discussing the lighting of computer images, I use the example of lights from film and video,[9] and how these principles can be applied to computer images.[5,10] The different types of lights used in film (key light, fill light, etc.) are discussed. Then the kinds of lights available in CG systems, (point lights, distant lights, spotlights, etc.) are defined, and we discuss how we can use the CG lights to emulate the real lights used in film. The importance of lighting for scene composition and emphasis, is covered. We also discuss how different types of lighting can create different types of moods or emotional impact.

Illustration 1
Here is the first ever painting *(Trinity with the Virgin, St. John and Donors)* done in perspective by Masaccio, in 1427.

Using Examples from Art to Illustrate Computer Graphics Concepts

There are several places in my computer graphics courses where I incorporate examples from art. I do this to illustrate to the students that these are not really new concepts, but are problems that were long ago solved by artists. Here are some examples of this.

Perspective
The architect Filippo Brunelleschi discovered linear or scientific perspective during the Italian Renaissance.[2,11] This allowed artists to use geometric methods to project a 3D space into a plane. Massacio was the first painter to use this technique, and I use his painting, along with other examples from art, as shown in illustration 1.

Two other examples I use (with the images on the CAA CD-ROM) are as follows: a painting (The Piazza of St. Mark, Venice) done by Canaletto in 1735-45 in one-point perspective; a painting (Sunlight in a Cafeteria) in two-point perspective by Edward Hopper (1958).

Another example illustrates how well-known classic CG images were inspired by art. The environment depicted on illustration 2 was inspired by the painting Lady and Gentleman at the Virginals, by the 17th century Dutch painter, Jan Vermeer. Illustration 3 is the original, painted in 1662-65. Vermeer is well known for the depiction of light in his paintings. A modified radiosity solution was ray traced to produce the specular highlights on the floor. The image is from the 1987 paper "A Two Pass Solution to the Rendering Equation: a Synthesis of Ray Tracing and Radiosity Methods" by John R. Wallace, Michael F. Cohen, and Donald P. Greenberg. The image appeared on the cover of 'Computer Graphics: Principles and Practice' by Foley, van Dam, Feiner, and Hughes.

Contrapposto
Another example is in the modeling and posing of human figures. Here we can use examples from sculpture. Early sculptures of human figures, while anatomically correct, appeared stiff and unnatural. The classical Greeks progressed to where they were able to model the human form in a nonsymmetrical, relaxed stance that appeared much more realistic. This is described by the Italian word "contrapposto" (counterpoise). This technique was lost during the Dark Ages and rediscovered by Donatello during the Italian Renaissance. All images can be viewed on the CAA CD-ROM; they are from Mark Harden's art archive.[12]

There are three examples that I use (with the images on the CAA CD-ROM): here is an example of Egyptian sculpture from about 1920-1880 B.C.[12] Notice the unnatural stiffness of the figure. Here is an example of Greek sculpture from about 440 B.C. Notice the nonsymmetrical, relaxed stance, which appears much more natural. Here is Donatello's David from 1444-46. As with the Greek statue above, it is relaxed, nonsymmetrical, and realistic.

Conclusion

Going beyond a computer graphics course that is purely algorithms by teaching computer science students aspects of visual communication, imported from other but related fields, is something we should seriously consider. Our students benefit from an exposure to elements of art history because they see that artists, painters, sculptors, and filmmakers have encountered and solved many of the same problems that we find in computer graphics.

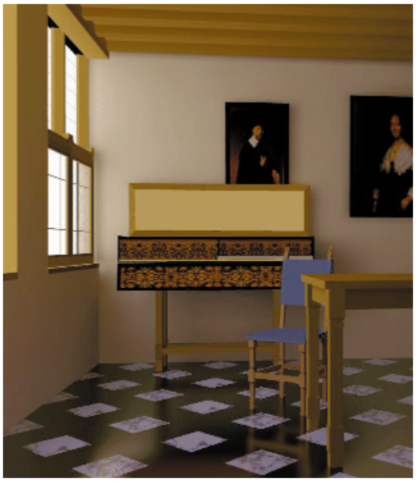

Illustration 2

Illustration 3

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*A more extensive version of this paper, with more images, is contained on the Conference Abstracts & Applications CD-ROM.

Integrating Art and Technology in a Statewide Curriculum

Classroom

Panelists
Taylor Gutermute
California Department of Education

Lynn Hickey
Los Angeles Unified School District

John Hughes
Rhythm and Hues Studios

Alan Warhaftig
Fairfax Magnet High School for the Arts

Integrating

This panel discusses issues related to how and why arts instruction in California public schools can be supported with contemporary technologies to enhance students, learning and achievement, and their preparation for life after graduation. The discussion includes the unique issues and concerns of a classroom teacher and the Visual Arts Specialist in the Los Angeles Unified School district, the Arts Education Consultant for the California State Department of Education, and the President and CEO of Rhythm & Hues, Inc. They review the findings of the State Superintendent's Task Force on the Visual and Performing Arts published in "Artswork: A Call for Arts Education for all California Students." The Task Force stated the following overarching goal for arts education:

All students in California public schools will have high-quality arts education programs from pre-kindergarten through grade 12. All students will:
- Develop and demonstrate literacy in and through dance, music, theatre, and the visual arts.
- Participate in arts-related school-to-career experiences.
- Have access to the arts through a variety of educational experiences and technologies both in and out of school.

Opportunities and constraints experienced by teachers in the Los Angeles Unified School District provide case studies for the panel discussion.

Lynn Hickey
Visual Arts Specialist, Los Angeles Unified School District

With graduate degrees in the visual arts, education, and school administration, Lynn Hickey has been involved as a visual arts teacher, school administrator, provider of professional development programs, program developer, and advocate for the use of educational technologies in the Los Angeles schools, the California Department of Education, and several campuses of the California State University.

While developing aesthetic sensibilities, an arts education in the new millennium must further students' abilities to participate in an information age and within a global economy. Through a sequential visual and performing arts curriculum supported by contemporary technologies, students must learn to:
- Communicate effectively using a variety of symbol systems.
- Understand people and traditions in a diverse and complicated world.

Taylor Gutermute
Consultant, Visual and Performing Arts, California Department of Education

Taylor Gutermute does developmental work in the visual and performing arts, most recently coordinating the development of the Visual and Performing Arts Challenge Standards. She serves as a liaison to the arts education field both statewide and nationally.

Arts education in California public schools has traditionally focused on the disciplines of dance, music, theater, and the visual arts. For each of these disciplines, arts educators are asked to include four components in their curriculum: artistic perception, creative expression, historical and cultural context, and aesthetic judgment. At this moment in time, with the onset of new technologies, arts educators are asking and are asked questions such as: Who teaches computer graphics? Is video production visual arts or theatre? How do teachers who have taught traditional visual arts techniques get training in new technologies? Is the funding available to purchase necessary equipment for art teachers or those in traditional career education programs?

While these questions appear mundane, finding answers will help to get effective programs implemented. The recent California Arts Task Force report, *Artswork*, emphatically requests that there be an "updating of the arts" to embrace the field of computer graphics and interactive techniques.

John Hughes
President and CEO, Rhythm & Hues, Inc.

Rhythm & Hues produces animated visual effects for feature films, theme park attractions, music videos, commercials, and interactive video games. In 1995, Rhythm & Hues won the Academy Award for Best Visual Effects for "Babe."

The K-12 educational environment is challenged to prepare a literate populace, one that can appreciate the visual and performing arts as well as participate in a variety of businesses and industries dependent upon communicating with digital media. It has been demonstrated that students in schools with a strong emphasis on the arts experience greater meaning, excitement, and depth in what they learn. They are more motivated, engaged, and eager to learn. Even if they do not envision themselves in an arts-related career in the future, all students can experience the joy and inspiration of the arts, understand the connection of the arts to their lives, and appreciate excellence in the arts.

Most specifically, we have very particular needs in my industry, for example, for people who are knowledgeable about history and culture and have the ability to draw, design, and communicate ideas using digital media. Industry leaders have both ideas and the responsibility to share them with the education community. Together, for the benefit of all, we must re-conceptualize the components of a quality arts education and ensure its delivery to all students.

Alan Warhaftig
Fairfax Magnet High School for the Arts

Alan Warhaftig teaches American literature and first-year algebra at the Fairfax Magnet Center for Visual Arts. A graduate of Stanford University, where he majored in Social Thought and Institutions and specialized in Caribbean Studies, Mr. Warhaftig has been deeply involved in technology, arts, curriculum, and professional development issues in the Los Angeles Unified School District. As co-chair of the Technology Focus Group, he wrote two widely-disseminated Discussion Papers reflecting his concern that the value of computers and the Internet for K-12 education has been wildly overstated and expressing his doubt about the institutional ability of schools to cope with technology's costs and other complications.

K-12 visual arts education in the new millennium will still require foundation training along the lines of that offered at the Fairfax Magnet Center for Visual Arts, where ninth and 10th graders take introductory classes in drawing, sculpture, photography, and computer graphics. In 11th and 12th grade, they take more advanced courses in these areas. Computers are part of our training, but it's inconceivable that they could substitute for training in the other areas without damaging the development of our student artists.

As a teacher of American literature, my job is to teach students to read critically. We closely study challenging works. Writing follows reading, and in my classroom writing is about clear expression of ideas. Technical issues are important but secondary. My most precious resource is instructional time, and I would regard the introduction of computers in my classroom as a distraction.

There are certainly valuable uses for computers and the Internet in K-12 education, and a sensible approach would be to identify these excellent uses, on a grade-by-grade, course-by-course basis, and teach teachers how to use technology to improve curriculum delivery. This should happen before schools spend huge sums on technology that they are not sure how they'll use.

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Classroom

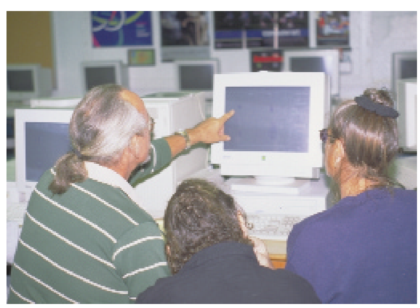
The Integration of Graphics, Video, Science, and Communication Technologies

Panelists
Thomas D. Cauffield
Glenn Dame
Kevin J. Meehan
Robert Wickman
Forest Hill Community High School

At Forest Hill Community High School in West Palm Beach, Florida, a unique program that integrates technology, science, video, and the graphic arts has been developed to provide students in grades nine through 12 with employment skills for the information economy. This modern multimedia school-to-career academy blends the skills of students and teachers with diverse multimedia interests to provide real-world experiences that support local government and international environmental issues.

As part of a Sister City project between the City of West Palm Beach and the Tzahar Region, Israel, the students at Forest Hill Community High School are developing an international Internet site that will allow science students, teachers, government officials, university personnel, and environmental scientists and engineers to share data, graphics, video, and artwork about the South Florida Everglades and the Hula Valley in Israel. This international project uses student and teacher talent in the following engineering and graphic application skill areas: Microsoft NT, 3D Studio Max, HTML, XTML, Painter, PhotoShop, PageMaker, Frontpage, Macromedia Authorware, Dreamweaver, linear and nonlinear video editing, and environmental science.

FHCHS graphics and engineering students work together with 3D Studio Max.



West Palm Beach community members study graphics and video editing in an evening program at Forest Hill.

Students prepare video title pages and graphics for their Web site (www.fhchs.com).

The Interactive Learning Environment

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Playground
Workshop

Presenters
Stephen Detwiler
Elizabeth Padilla
California State University, Chico

Jonathan Hendryx
Arizona State University

Introduction

Storytelling is an effective educational medium. Imagine the possibility of having a conversation with someone who has been dead for almost 100 years. Imagine the tales and everyday life stories this person could tell. Imagine seeing that person's world and being free to explore it. Now, give this experience to a classroom of students and watch them become active learners without them even knowing it. They will be enthralled with the possibilities set before them. The Interactive Learning Environment (ILE) is designed to do just this.

For our first application, ILE focuses on the fourth grade-classroom. Students study California through a local landmark, the Bidwell Mansion in Chico, California. ILE allows the learners, both teacher and students, to explore the mansion through computer-generated, 3D environments. Integrated lesson plans support the curriculum required of a fourth grade classroom.

The Theory Behind the Educational Method

ILE merges group work and traditional individual learning methods into a process called communal work. In this approach, group development is based on individual knowledge and participation. Communal work can be surprisingly helpful, enlightening, and beneficial to all students. The key to success is finding a way that not only works in theory but in the classroom as well. A good group allows for all levels of learning and a shared goal, yet the learning and the objectives should also be individual. The work of a group should be stronger, and the goal should be harder to reach than one person alone could achieve. It becomes pointless to have a set of minds working for a goal that one alone could do. It is essential all the members work toward the goal and share the information they have accumulated. The connection of group members must ensure that competition for the best answer and superiority over other members is eliminated.

With ILE, learners reach out to others and interact, not only with their groups, but with computer-generated people as well. The people the learner comes into contact with allow information to pass from one person to another, making the learning experience a two-way exchange. The learner can then become not only a receiver but also a transmitter.

ILE is not a replacement for the classroom. Children will not be placed before a screen and asked questions and lectured to by an electronic teacher. ILE is a tool for implementing all the functions for learning. Students are able to walk away from the machine and apply the knowledge that they have gained to the other activities that correspond to a themed learning unit, whether it is history or chemistry.

The classroom environment is not regimented by ILE. It should still reflect the teacher's own style. ILE is just another component, an extension of learning through hands-on experiences such as field trips and museums. These are ways to expose children to art, history, and other elements of cultures. ILE immerses learners into the environment, giving them a deeper understanding and comprehension.

Interactive

Environment

The Technical Design

From the beginning, ILE has been designed to work on various types of computers. Recognizing that not every school can have the latest and greatest computers, ILE automatically adapts itself to the machine that is currently running it. The program was built using industry-standard technology components. The 3D content is streamed from an ILE geometry server to a Java applet on the client and then rendered to the screen via Java3D. By tracking each client computer's performance, the server only sends as much information as the client can process. The geometry server streams the geometry in levels of detail, and the client only processes as many polygons as it can handle at a given time. By this method, the client workstation determines how detailed the environment will be.

ILE is a multi-user system. A primary goal of ILE is to ensure that students are not isolated from each other. Allowing multiple students to explore the shared environment has several advantages. Students can share their experiences in real-time. Also, students can move in groups and interact with the environment together. Students can talk with each other through a text-based chat system, and the teacher can talk with them to give advice or ask questions. When students enter an environment, they can be assigned to a group by the teacher and given a task to complete. Their progress is tracked by the server and can be monitored by the teacher at anytime.

Each student's progress is stored on the server in a database. By accessing each student's performance, the system can also recommend different areas that they should explore and study. Messages from the server are delivered in a variety of modes. Some messages come in textual form, but the goal is to have all messages come from computer-controlled characters that approach students to ask questions or give advice.

The Windows NT-based server is an open, object-oriented system. Topic modules can be loaded onto the server, allowing any number of subjects to be presented. New technologies can be added in the future without having to modify the older code. The multimedia content is obtained through Triadigm Technology' s FutureArts server. The text, images, audio, and video are stored in a database and extracted as needed. This allows ILE to present information to students in various forms. By tracking student performance based on presentation method, the server tries to give information to students in the way they learn best. For example, a student who seems to learn better by reading will be given textual descriptions first. Audio narration is provided for students who appear to learn best by listening. The ILE server uses TCP/IP network protocols, so it can reside locally or be accessed remotely via the Internet. By providing an open and versatile system, ILE can be adapted to many different learning environments.

Conclusion

Integration of computers into classroom can increase the learning potential of a student. Computers can provide immediate feedback on student progress and allow a teacher to better monitor progress. The Interactive Learning Environment is a step in the right direction, toward more than Internet workstations. Computers become tools for cognitive development and support participants in a rich learning environment.

Introduction to 3D Concepts for Teachers

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Workshop

The Process

Though it may appear to be filled with complexity, there are no great secrets in the fascinating world of 3D animation. To put it into familiar terms, to produce successful 3D animation, you must visualize the computer and your 3D software as an empty soundstage and complete seven basic steps:

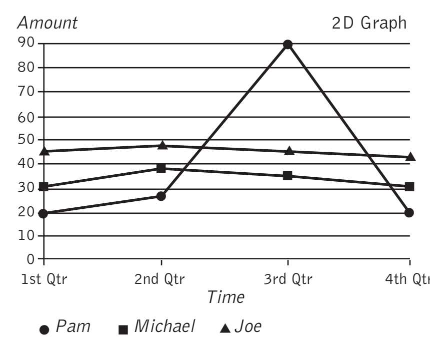
Script/Storyboards
The more time and energy you invest in planning and preproduction, the more successful the final product will be. A good script and finely detailed storyboards can work wonders in communicating the director's vision to an animation team.

Modeling
Modeling is the process of "building" the geometry in a 3D package. Models are defined in terms that allow the software to simulate the sets and characters that populate the scene.

Materials/Textures/Lights
Completed models and characters appear to be constructed of gray (or blue, etc.) cardboard. Applying materials and textures to models is the process of defining the surface characteristics of those models. Are they red? Are they shiny? Are they made of plastic or metal? Are they smooth or rough? Do the walls have wallpaper? Materials and textures are vital in making the 3D environment "real." So is lighting. Just as in theater or live-action filmmaking, lighting can make or break a mood. Properly defining lights, placing them, and creating realistic shadows is just as important in the 3D world.

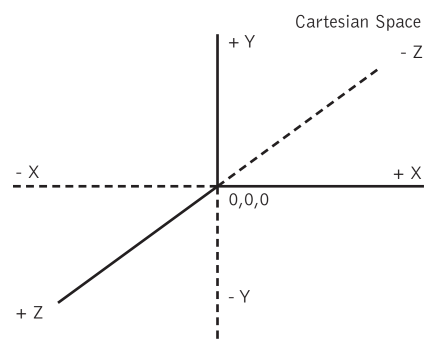
Animation
By definition, animation is the process of presenting a series of still images in succession so that the viewer perceives continuous motion. In 3D, animation is the process of adding motion or change to the scene and saving it. With current software, most elements in a scene can be animated: objects, characters, cameras, lights, materials, and effects.

Rendering
Because animation is the sequential display of still images (30 images per second for video, 24 per second for film), the 3D environment built on our virtual sound stage must be converted to 2D images. This process is called rendering and can be extremely costly in terms of time and computer resources. The more complex a scene, the longer it takes to render a frame. Because of this, all previous steps in the 3D process are executed with rendering in mind.



Compositing
3D work is frequently created for use in a 2D scene. So compositing, or combining two or more 2D images to create a new image, is a part of completing a 3D sequence. For instance, 3D F-14 fighters might be composited over live-action footage of the California desert.

Output
After it is rendered, a sequence must be output to a medium for distribution such as film, video, CD.



3D Space

Global Space
In a 3D program, you are working in 3D space based on a system called the Cartesian Grid. Cartesian space is defined by a series of axes and planes.

When you are working in 2D space (for example, on a 2D image or a graph), the space is limited to, and defined by, two directions; left to right, and up and down. These directions, or axes, are usually defined as X and Y. In the example on the previous page, the X axis (left to right) displays the time and the Y axis (up and down) displays the amount. Each of the axes are divided into even segments, making it possible to determine an exact amount at a specific time.

This system is the basis of Cartesian Space, with the addition of a third axis to define depth. Although axis definitions may vary from one program to the next, most computer animation systems define left/right as X, up/down as Y and forward/backward as Z.

All three axes continue past their intersection, defining a 3D space that is infinite. The intersection of the three axes is referred to as the global or universal origin or center, and the numeric designations for each axis begin at this point. The center is at zero for each axis: X0, Y0, and Z0 or 0, 0, 0.

With this system it is possible to define exactly where in 3D space a specific point lies (for example, X3, Y4, Z5), making it possible for computers to simulate 3 dimensions.

Local Space
Cartesian Space is the entire space in which the computer creates your simulated environment. The origin, or center, of that space is the global center. As the global space has a center, so does each object in your scene. This is the local center. The local space is the area that is inhabited by the object.

The Building Blocks

3D software packages define and manipulate simulations of shapes using the mathematics of shapes, or geometry.

Polygons
When you can define specific points in space, you can build models. Defining two points in space gives the coordinates to draw a line. If you continue to define points (control points or vertices) and connect them with lines, you can, with a minimum of three points, build a polygon. A polygon with a surface, or face, is the primary building block of polygonal modeling programs. Together, multiple polygons build a 3D model. To help organize the large numbers of polygons in complex models, programs commonly define the model as a mesh, or grid, of polygons.

Splines and Patches
Because polygonal modeling cannot recreate curved surfaces, researchers developed the curved line, or spline. Splines are curved lines with control points, or vertices, that determine the shape of the curve. How the vertices affect the curve is determined by the type of curve you have drawn. With splines, curved surfaces or patches can be generated. The shape of the patch can be changed by editing the control points.

Primitives
Specific 2D and 3D shapes that are so commonly used in 3D can be created automatically. Referred to as primitives, these shapes include such objects as cubes, spheres, cylinders, squares, circles, toruses, cones, and grids. Since so many objects are comprised of these basic geometric shapes, primitives are very useful starting points in modeling.

Transformations

When working with 3D geometry, you frequently edit an object to get the model you want, or you change it to create motion. There are three basic changes, or transformations.

Scale
Scaling changes the size of an object. It is expressed in terms of a ratio of the new size in relation to the original size of the object (for example: the cube is now 2.75 the size of the original cube). As with everything else in 3D animation, the changes are made in relation to the X, Y, and Z axes.

Rotation
Rotation changes the orientation of the object around the X, Y, and/or Z axes. Rotation is expressed in degrees and, like scaling, the changes are made in relation to the axes.

Translation
Translation changes the location of, or moves, an object. Translation is expressed in units (inches, miles, kilometers, or the default unit of the software with which you are working) and, as always, is in relation to the starting location of the object along the axes.

Although there are more sophisticated processes for building models or making motion for animation, all changes to the geometry of an object are based on scale, rotation, and translation. You may be rotating only one surface of an object, translating the points that control the shape, or scaling just part of your model, but all changes are based on the major transitions.

Summary

So now you know the basics. Armed with this foundation, you can begin to understand and work in the 3D computer animation world.

Have fun!

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Classroom

CGI (Computer Generated Images) – 3D computer animation

CGI creates the entire image in the computer. A true 3D model of an object is built in the computer, the object is animated, then the computer "renders" the object (computes the finished image). This technology permits creation of virtually any imaginable image without the practical constraints of the real world – a huge advantage in the world of special effects.

The types of objects that can be created fall into several categories. Character animation is where a character of some kind is created and animated, such as the T. Rex in *Jurassic Park*. Effects animation is used to create computer versions of snow, rain, tornadoes, tidal waves, and other effects. Props such as spaceships and fighter planes can also be created and animated. Even entire virtual sets can be created and live action actors placed within them.

The first step is the modeling process, where the 3D shape of the object is created. Points in 3D space are defined, then they are connected together to describe a surface. When finished, the "wireframe" view of the object shows the object's shape and can be viewed from any angle.

The next step is the surface attributes: color and texture. Texture maps can be applied to the surfaces that give the look of a painted surface. Bump maps give the surface texture. Environment maps create reflections of the environment on the surface of the object. There are other types of maps that can be applied in combination until a very realistic surface is built up.

Lighting is achieved in ways similar to the real world. Several computer "lights" are placed within the scene to illuminate the object. Of course, the rules for the computer lights are much more generous than the rules for real lights. Computer lights have no real world limits and can do remarkable things like shine through walls or maintain full brightness without dimming over distance if the artist wishes them to. While one artist is working on the surface attributes and lighting, a 3D animator can be working on the animation of the object.

There are basically three types of animation methods. Keyframe animation is where the object is "posed" at a few key frames in a scene, then the computer interpolates all of the in-between positions for each frame of the scene. Motion capture uses live actors wired up with sensors so that a computer can track the position of multiple body parts simultaneously. This captured motion data is then fed into the computer character, which duplicates the moves. Procedural animation (sometimes called "dynamics") uses rules and math formulas to describe some action, such as falling snowflakes. Each flake is given a falling rate of speed, a wind factor, and a turbulence factor, then the computer figures out the motion of each flake individually.

The final step is rendering, where the finished image is computed. The computer combines all the information from the shape of the model, the various surface attribute maps, the lights in the scene, and the object's animation, locates the camera's position, then renders the scene as seen by that camera. This is the most compute-intensive part of the job. Using very powerful computers, render times of several hours per frame are not unusual. Typically, each object in the scene is rendered separately, then combined afterwards in a compositing operation.

Compositing

Compositing is the process of combining pre-existing images, or elements, into a single picture. The background might be a live-action scene, the character might be a live-action actor shot on a greenscreen stage, and a prop such as a car might be created with CGI. Regardless of how the elements are created, it is the compositing operation that puts them all together and color corrects them to look right.

When compositing one element over another, the foreground (top) element will always require a matte layer that tells the computer which parts of the foreground image are kept and which parts are thrown away. These mattes can be created several ways. With a greenscreen (or bluescreen) shot, the computer creates a matte from the green part of the screen. CGI images, however, are rendered with a matte automatically so that the compositor does not have to create one. When all else fails, a matte can be painted by hand (a "roto" matte), but this is slow, expensive, and difficult to do well.

In addition to combining and color correcting the various elements into a finished picture, compositing can add some special effects tricks of its own. Two-dimensional animation can be used to rotate, scale, or move elements around the frame. Elements can be "cloned" and multiple copies placed all around. Images can even be warped, and warped images can be morphed.

Paint Systems

Computer paint systems have a variety of important applications in digital effects. Matte paintings, which are entire background scenes that are typically painted on a large piece of masonite and then filmed, are more and more often created on computer paint systems such as Adobe Photoshop. Frame fixes can also be done, where small defects in individual frames of the film are touched up by hand. Done on a large scale, these frame fixes become entire film restorations. Wire removal, where the paint system is used to paint out supporting wires, rods, or robotic armatures, is another very important application.

Digital Ink and Paint

All feature film and most broadcast animation is painted, composited, and filmed digitally. The actual animation is still drawn on paper, but the paper drawing is then scanned into the computer, and from that point forward the entire process is digital. In addition to the character drawing, there is a second drawing called a "tone layer" that outlines the highlight and shadow areas of the character. This tone layer is painted as a mask, which is then used by the computer to highlight and shade the painted character at compositing time. Backgrounds and overlays are usually painted conventionally, then scanned into the computer for camera moves and compositing with the animation layers.

Input

Digitizing film into the computer is done with a machine called a film scanner. These are very large and expensive machines ($100,000 and up) that typically digitize the film at 2048 pixels across and 1556 scan lines down. Scan times are in the range of two to four frames per minute, and the file size for one frame of film will be about 10 megabytes. Large digital effects studios usually own their own film scanners, while smaller companies take their film to be scanned at service bureaus and get the digitized film back on data tapes.

Digitizing video is considerably simpler, especially since most video formats today (D1, D2, DigiBeta) are digital formats to begin with. The videotape is loaded into the appropriate videotape player, which sends the digital video data to a DDR (Digital Disk Recorder) in realtime. A DDR is actually just a high-speed, large-capacity disk drive with some video circuits. From the DDR, the video data is transferred to the workstation over Ethernet. The video frames are 720 pixels by 486 scan lines, and each frame of video is about 0.7 megabytes in size. Most studios have their own DDRs and tape decks, but any video post-production house will do the transfer for a fee.

Output

Outputting the digital film data to 35mm film requires another large and expensive machine called a film recorder. There are two basic types of film recorders, laser and CRT. The laser film recorders read the digital data and "burn" the image directly onto the film with three colored laser beams: red, green, and blue. The laser film recorders are fast, very high quality, and expensive. The CRT film recorders place one color "channel" at a time, for example the red channel, on a black-and-white CRT with a red gel in front of the lens. The red layer of the film is exposed, the film is NOT advanced, then the green and blue channels are exposed. When all three passes are complete, the film is advanced to the next frame. The CRT film recorders are slower, lower quality, but cheaper.

Outputing the digital video back onto video tape is done with the same equipment used to digitize the video in the first place. From the workstation, each video frame is transferred to the DDR. When the entire shot is on the DDR, the videotape deck is rolled and the DDR dubs the shot onto the video tape in real-time.

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Math

Introduction:

Behind all great (and not so great) computer graphics images and/or animations stands a great lady. Her name? Mathematics. Whether it is a spline or parametric equations that generate the curve, the various geometries that provide the illusion of 3D, or the vector theory used in reflections, rotations, and shading, just about all aspects of a computer-generated image rely on mathematics. This paper discusses some of the different mathematics used in generating graphics images, from basic Euclidean geometry to the basics of spline interpolation. We begin with an overview of the simpler concepts in computer graphics: line drawing and transformations. In section 2, we examine how the illusion of 3D is created. In section 3, we examine the mathematics involved in lighting our scene. And finally, in section 4, we examine creation of objects that do not have a simple geometric representation.

Section 1: The Basics

Computer graphics techniques have always relied heavily on mathematics for their implementation. Simple line and conic drawing algorithms[1,2,3,4] show the importance of a thorough understanding of basic algebra, geometry, and multivariate calculus. Calculus? Yes, gradients are used to determine vectors perpendicular to the tangents to conics other than circles. This is used when determining which pixel to "turn on" to create the most realistic-looking curve. Even pattern filling and line clipping rely on these basic concepts. Then, of course, clipping requires knowledge of the widowing system and coordinate systems in general. So we're back to geometry again. When creating an object to be represented, a mathematical model representing this object must be created. Whether it is a simple 2D or 3D geometric figure, or a more complicated curve or surface, each object must have a mathematical representation. This representation is given in "real-world" coordinates: real values for which the mathematical model is valid. To create the graphics image to represent our object, we must change the real-world coordinates (window or user coordinates) of our object to the normalized device coordinates and/or the viewport coordinates. This change requires what is commonly referred to as a window-to-viewport transformation. This transformation of user coordinates (x_{user} ,y_{user}) to normalized device coordinates (x_{norm}, y_{norm}) is a simple linear function that is a combination of scaling and translation:

$$x_{norm} = \frac{x_{user} - w\_x\_min}{w\_x\_max - w\_x\_min}(v\_x\_max - v\_x\_min) + v\_x\_min \qquad y_{norm} = \frac{y_{user} - w\_y\_min}{w\_y\_max - w\_y\_min}(v\_y\_max - v\_y\_min) + v\_y\_min.$$

Here, w_x_min, w_x_max, w_y_min, and w_y_max, are the minimum and maximum window (user) coordinates in the x and y directions, and v_x_min, v_x_max, v_y_min, and v_y_max are the minimum and maximum viewport coordinates in the x and y directions.

Once we have the ability to represent our object, we may wish to change its position or size or inclination. Each of these transformations of an object, whether it is a translation, rotation, or scaling is accomplished with the assistance of vectors and matrices (linear algebra). These 2D transformations are given on the Conference Abstracts and Applications CD-ROM as Exhibit 1.

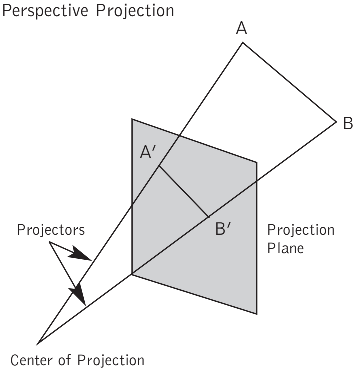
To rotate about a point other than the origin, say point P, we first translate P to the origin, rotate the object, and then translate back.

In order to treat all three transformations equally and to be able to easily compose them, we extend our 2D object to a 3D representation, by creating what are known as homogeneous coordinates: $(x, y)^T \rightarrow (x, y, 1)^T$. This is done so that the different functions that are to be applied to our object (or primitive) can be composed into one matrix transformation, and this one transformation is applied, rather than incurring the cost and time of applying the separate transformations to the object. The individual transformation matrices are given on the Conference Abstracts and Applications CD-ROM as Exhibit 2.

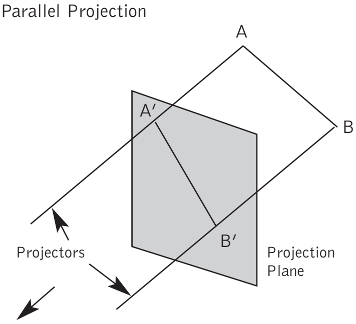
When working with 3D objects, we simply extend our 2D ideas to 3D. These transformations are applied to similar homogeneous representations: $(x, y, z)^T \rightarrow (x, y, z, 1)^T$. These forms are given on the Conference Abstracts and Applications CD-ROM as Exhibit 3.

Finally, to handle the generic case of rotating by an angle θ about an arbitrary direction given by the line segment beginning at $P_1 = (x_1, y_1, z_1)^T$ and ending at $P_2 = (x_2, y_2, z_2)^T$ we apply a composition of transformations. Set $(a, b, c)^T = P_2 - P_1$ and $L = \sqrt{a^2+b^2+c^2}$ and $p = \sqrt{b^2+c^2}$. Step 1: Translate the line and the point to be rotated to align with the z-axis. Step 2: Rotate the line around the x-axis until it is in the xz plane. Note that right-triangle trigonometry is used to determine the values for cosine (c/p) and sine (b/p). Step 3: Rotate once more to put the line on the z-axis. Step 4: Rotate through the desired angle θ. Step 5: Reverse steps 3, 2, and 1 to place the point back to its relative position.

Figure 1
Perspective Projection



Parallel Projection



Section 2: It's All an Illusion

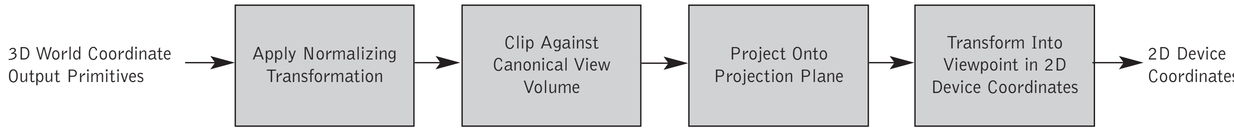
The idea of trying to present the illusion of a 3D picture on a 2D surface had its beginnings in the Renaissance. The painters of the period utilized the idea of a "point at infinity" to represent the place where parallel lines seem to intersect. Mathematicians, in their attempts, to prove Euclid's parallel postulate developed non-Euclidean geometries[5,6] – geometries that do not assume one or more of Euclidean Geometry's postulates – provided firm mathematical foundations for this idea of a "point at infinity." When we attempt to represent a 3D object on a graphics device, we are utilizing these concepts. There are two types of projections that are commonly used to create these representations: perspective and parallel. If the distance from the center of the projection to the projection (or view) plane is finite, then the projection is perspective; if the distance is infinite, the projection is parallel. Perspective projections do not preserve angles and distances, while parallel projections do. Figure 1[7] provides an illustration of the two basic projection types. Since it is the perspective projection that creates the more "realistic" representation, the illusion of 3D, it is this projection method that we will discuss here.

We start by assuming that the projection plane is perpendicular to the z axis and is located at $z = d$. The center of projection is at the origin. To determine the projection $P_p = (x_p, y_p, z_p)^T$ of a point $P = (x, y, z)^T$ we use similar triangles to get $x_p = x/z/d$, $y_p = y/z/d$, and $z_p = d$. The division by z causes the projection of more distant objects to be smaller than that of closer objects.

A more general formulation was developed by N. Weingarten.[7] We summarize this formulation here. We still assume that the projection plane is perpendicular to the z axis and is located at $z = z_p$, but now the center of projection is a distance Q from the point $(0,0,z_p)^T$, the intersection of the projection plane with the z axis. If the normalized direction vector from $(0,0,z_p)^T$ to the center of projection is $(d_x, d_y, d_z)^T$ then it can be shown that the projection P_p can be computed by a simple matrix product. This formulization is given in Exhibit 5 on the Conference Abstracts and Applications CD-ROM. This matrix transformation provides a one-point perspective projection. The vanishing point (or the point at infinity) is given by $(Qd_x, Qd_y, z_p)^T$.

There are many variations of this type of projection; for example, those that allow for multiple vanishing points. A summary of the mathematical effort required to transform a 3D world coordinate into a 2D device coordinate is given in Figure 2[7].

Figure 2



Section 3: A Little Light on the Subject

When considering the lighting of a scene, one must consider the interaction of light with the surface of an object in the scene and model this interaction. One must consider the light emitting sources (a point source or distributed source) as well as the light reflecting sources (ambient light or background light). There are also two types of reflection to be considered: diffuse and specular. In diffuse reflections, incoming light that is not absorbed is reflected off the surface in random directions, while in specular reflections the light reflects in a nearly fixed direction without any absorption.

In order to compute the overall illumination of a given point $P = (x, y, z)^T$, we need the following information:

1. The direction of the light source L (there could be more than one)
2. The normal vector N
3. The reflection vector R (there could be more than one)
4. The viewing vector V

If $S = (S_x, S_y, S_z)^T$ is the position of the light source and $E = (E_x, E_y, E_z)^T$ is the position of the eye, then L = S - P and V = E - P. Each of L and V must be normalized, i.e., made to have length one. The computation of N and R can be complicated depending on the type of surface. N and R must also be normalized. Once L, V, N, and R have been determined then $\cos\varphi = L \bullet N$ and $\cos\theta = V \bullet R$ and the Phong[8] model of illumination can be computed by[9]:

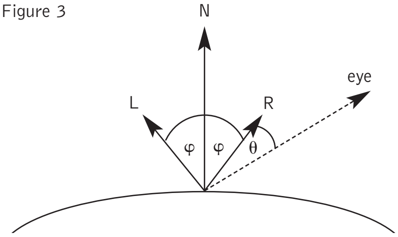
$$I_* = I_{a*}k_{d*} + I_{p*}(k_{d*}\cos\varphi/d + k_s\cos^n\theta)$$

where

- $*$ = r, g, or b (for red, green, or blue)
- I_{a*} = intensity of ambient light for $*$
- k_{d*} = diffuse reflectivity of $*$
- k_s = a constant that estimates the specular reflection coefficient ($0 \leq k_s \leq 1$)
- I_{p*} = intensity of point source of light for $*$
- n = measure of "shininess" of the surface, very shiny = large n (> 150)
- d = distance to the point source or distributed source of light

There are many other models that could be considered, for example, GOUR71[10], WARN83[11], VERB84[12], and NISH85[13].

Figure 3



Section 4: The Spline's the Thing

When trying to represent an object mathematically, quite often it is impossible to construct an appropriate model using only simple geometric shapes. If this is the case, then arbitrary curves need to be created to model the object. The curves of choice are splines and other parametric curves. These curves are used in animation to generate in-between frames, or to create curves when only a few datapoints describing the curve are known. Yet another application of these curves is the generation of arbitrary surfaces. Each of these applications has essentially the same premise: from a few data points, generate a smooth curve based on this data. This curve should be simple to compute and easy to modify if a change in data is necessary.

Parametric equations are used to represent curves that are not easily represented or are impossible to represent by a function. Examples of this would be curves that have loops or places of infinite slopes. In this case we use a parameter, say t, and describe each variable x and y as functions of t, x = x(t) and y = y(t), over some range of t. If we are working in three dimensions then each of x, y, and z would be parameterized. The slopes of tangential lines for parametric curves are simple to compute. For example, dy/dx = (dy/dt)(dt/dx) = (dy/dt)/(dx/dt), i.e. the chain rule of differentiation becomes simply a quotient.

Splines are piece-wise defined polynomial functions of, usually, low degree. If you have data points $(x_0, y_0), \ldots (x_n, y_n)$, x_is distinct, then the Natural Cubic Spline, S(x), will interpolate this data (i.e., $S(x_i) = y_i$) and is given by cubic polynomials defined on each of the intervals $[x_i, x_{i+1}]$, i = 0,..., n-1. To determine the coefficients of this spline, one must solve an (n-1)x(n-1) tridiagonal linear system of equations. This spline, though historically significant, is not very useful in computer graphics. A unique spline does not exist if there is a repeated x value and if a data point needs to be changed then the entire spline will need to be recomputed.

To overcome these problems, splines that do not necessarily interpolate the given data are used. The most often used splines are the Bézier[14,15] and uniform B-splines.[16] Splines can be defined for any degree, though the cubic splines are usually sufficiently robust to handle the smoothness requirements in graphics.

The uniform cubic B-spline, b, stretches over five data points, called knots. The distances between the knots are all taken as 1 and the point 0 is put in the middle of these five knots to achieve symmetry. Formally this is given by:

$b(u) = 0$	if $u \leq -2$
$b(u) = (2 + u)^3 / 6$	if $-2 \leq u \leq -1$
$b(u) = (2 + u)^3 / 6 - (2 + u)^3 / 3$	if $-1 \leq u \leq 0$
$b(u) = 2(1 - u)^3 / 3 - (2 - u)^3 / 6$	if $0 \leq u \leq 1$
$b(u) = (2 - u)^3 / 6$	if $1 \leq u \leq 2$
$b(u) = 0$	if $2 \leq u$

If we need to draw a curve based on knots $P_0 = (x_0, y_0, z_0)$, ... $P_n = (x_n, y_n, z_n)$, then one way to construct the approximating curve is to form the linear combination:

$$C(u) = \sum_{i=0}^{n} p_i b_i(u)$$

where p_i stands for x_i, y_i, or z_i. The most convenient way to draw the B-spline curve is to use a matrix product. This product expresses the value of C in any subinterval $[u_i, u_{i+1}]$ with i not 0 nor n-1 and is given as Exhibit 6 on the Conference Abstracts and Applications CD-ROM.

As the parameter u changes from 0 to 1 the formula generates the curve from P_i to P_{i+1}.

The other most commonly used cubic spline is the Bézier spline. The main difference between the two is that the Bézier curve is globally, not locally, controlled by the points P_i. Changing one of the control points affects the entire Bézier curve, but its strongest affect is in the neighborhood of the point. The matrix formulation of the Bézier curve is given on the Conference Abstracts and Applications CD-ROM as Exhibit 7.

To generate spline surfaces, one simply takes the Cartesian product of two splines. For example, we define a B-spline surface b(u,v) = b(u)b(v). The matrix formulation of this surface is given by $S(u,v) = 1/36 UMPM^T V^T$ where $U = (u^3, u^2, u, 1)$, $V = (v^3, v^2, v, 1)$ and

$$M = \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 0 & 3 & 0 \\ 1 & 4 & 1 & 0 \end{bmatrix} \quad \text{and } P = \begin{bmatrix} p_{i-1,j-1} & p_{i-1,j} & p_{i-1,j+1} & p_{i-1,j+2} \\ p_{i,j-1} & p_{i,j} & p_{i,j+1} & p_{i,j+2} \\ p_{i+1,j-1} & p_{i+1,j} & p_{i+1,j+1} & p_{i+1,j+2} \\ p_{i+2,j-1} & p_{i+2,j} & p_{i+2,j+1} & p_{i+2,j+2} \end{bmatrix}$$

A similar formulation for Bézier surfaces exists.

There are, of course, other splines and generalizations that can be used to model curves or surfaces, e.g., Hermite, non-uniform B-splines, and Beta splines.[17]

Section 5: Other Neat Stuff

We have only begun to scratch the surface of the different types of mathematics used in computer graphics, and we have omitted many of the details of the concepts presented in this paper. For example, most of the calculus concepts involved in the illumination section were omitted. However, it should be fairly obvious that geometry, linear algebra, and calculus play fundamental roles in the representation and manipulation of images. Other aspects of computer graphics often utilize more complicated mathematics. For example, antialiasing uses digital signal processing and hence Fourier transforms, and physically based modeling requires the solution of partial differential equations. To truly understand fractals, complex arithmetic and a little analysis will go a long way. In order to fully appreciate and understand the finer aspects of computer graphics one must at least appreciate, if not understand, the finer aspects of mathematics, as you would not have one without the other.

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Math and Computer-Generated Effects: Tools of the Trade

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Classroom

Many types of math (geometry, algebra, and calculus, among others) are crucial "tools of the trade" for people who create computer-generated effects. For example, animating people and creatures calls on methods from geometry and trigonometry. Rendering actual images requires algebra and arithmetic, among other things. And simulating physical phenomena like cloth and water uses knowledge from calculus. This presentation shows some examples from film and commercial effects that illustrate the use of these mathematical tools.

Tools

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Minotaur: A Tactile Archaeology Game for Kids

This tactile educational game on Greek mythology for children aged 6-8 is designed for presentation in a museum setting. The intent of the project is to combine the tactile nature of museum interaction design with the computer's ability to create a stimulating audio-visual environment.

Unlike a traditional classroom setting where the course of learning is pre-structured and linear, an interactive environment allows students to choose their own paths, creating unique experiences. In essence, they become active participants in the learning process, not unlike archaeologists who unravel ancient mysteries with their brushes and spades. In the same spirit of exploration, the users of this game learn about ancient Greece and its myths through sight, sound, and touch.

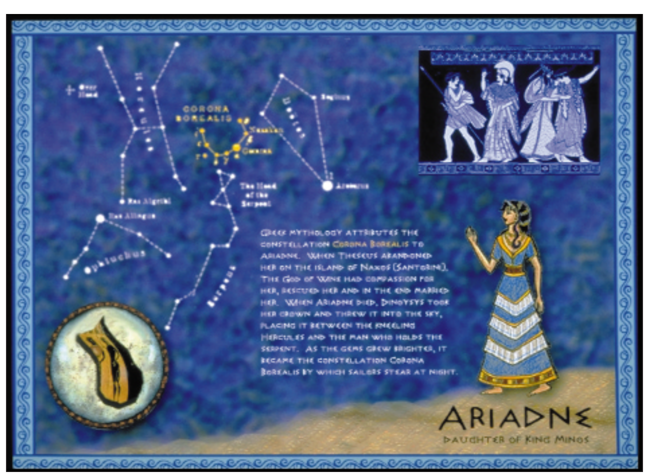
The story of Theseus and the Minotaur was chosen for the game because it has all the ingredients of an adventure: a monster, a hero, romance, conflict, and the triumph of good over evil. This myth is unique in that it introduces users to Theseus, the greatest hero of Athens; Minos, the greatest ruler of Crete; and their respective cultures.

In Minotaur, users participate in an archaeological dig for treasures of ancient Greece. Their task is to find the six missing pieces of an amphora at the site and re-construct it. Each piece of the fragment represents a character of the myth depicted on the amphora. When a fragment is found and put in the right place, a mythical character, such as Ariadne, appears in the video projection, unveiling history, art, or myth-related information about the ancient world. When all six pieces are found, a short 2D animation of the myth is unfolded to the user as a reward.

Tactile interaction is made possible by embedding magnets in the fragments and magnetic switches in the amphora. An ADBIO box then relays the information to the computer, directing it to project short animated sequences onto the screen.

Reconstruction of the amphora mimics an archaeological dig; the users learn through physical interaction with the object, and segments of history are unveiled. By direct manipulation of the game (amphora fragments) rather than the mechanics (for example, the computer mouse), cognitive distance between intent and execution is minimized. Combining the tactile nature of museum design with the computer, Minotaur blurs the line between the digital and physical world, creating a more layered and fuller user experience.

This game is a graduate thesis project produced in partial fulfillment of the requirements for a M.F.A. degree from Pratt Institute.



Museums and Computer Games

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Classroom
Playground

Panelists
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Elisabeth Cameron
Los Angeles County Museum of Art

Carla Roth
Think Jacobson & Roth

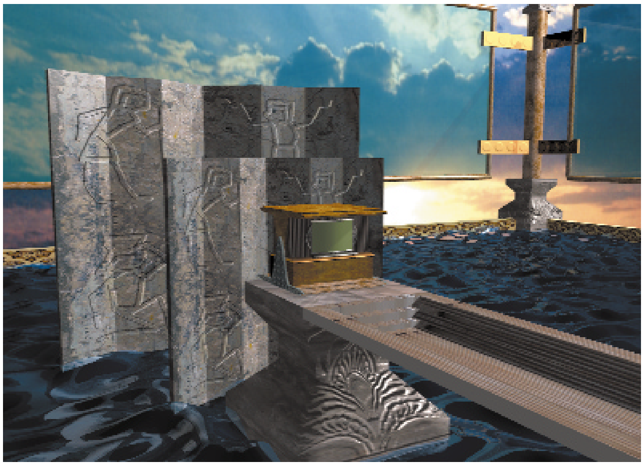
Bill Zullo
Z-Digital

Museums are discovering that well-designed computer games that require active decision-making capture and keep children's attention. This panel looks at how curators, writers, interactive designers, producers, and educators, each with different agendas, work together to create an entertaining learning environment for young museum visitors.

The panel focuses on multimedia productions created specifically for a museum environment using game design methods often reserved for entertainment titles. By combining the entertainment value of new media with specific educational goals, museum multimedia games are powerful learning tools in an exhibition environment.

The production "Secrets of the Ancestors" is discussed by the curator, educator, interactive designer, and producer. This engaging computer game helps children decipher meaning in objects from around the world. The production, part of the Los Angeles County Museum of Art exhibition "Ancestors: Art and the Afterlife," is played at two kiosks and in a new interactive theater for school groups in the museum's experimental education gallery.

From multiple and sometimes conflicting points of view, the panel reviews the challenges and pitfalls of developing interactive game-based media for a museum environment.



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Classroom

Organizing Summer Computer Graphics Camps

This presentation explains how the annual Computer Graphics Summer Camp at Purdue University is organized and operated. The discussion includes how students are identified for inclusion in the program, funding issues, computer project sessions, student participation, software and hardware uses, tours, and entertainment. While this camp was previously operated as a regional resource, it is now open to students from all U.S. states and territories. The camp's success has led the sponsoring department to extend the program to include professional educators in computer graphics, math, and science in their own camp to increase their technological literacy.

Camps

People in the Past:
The Ancient Puebloan Farmers of Southwest Colorado

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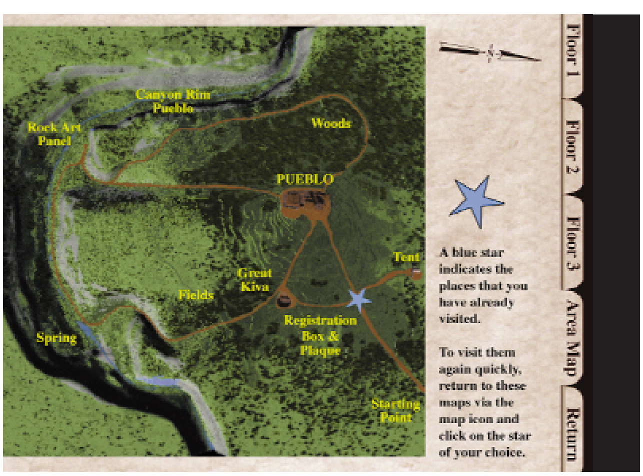
Playground

People in the Past: The Ancient Puebloan Farmers of Southwest Colorado is currently installed as an exhibit at the Anasazi Heritage Center in Dolores, Colorado, and was exhibited at the Houston Museum of Natural Science during the summer of 1998. It also won both first and second place in the 1998 National Association of Interpretation Awards (first place for the CD-ROM and second place for its companion teachers guide, "Classroom Activities"). This program is available as a CD-ROM for both Windows and Mac. The "Classroom Activities" guide for grades 4-12 is a 160-page book with lesson plans related to the program contents for language arts, math, social studies, science, and art. The CD-ROM is included with the book.

The program explores Lowry Pueblo, a prehistoric Anasazi village in southwest Colorado, during the last days of an archaeological excavation. The Pueblo and the entire site have been recreated in 3D. As assistants to the lead archaeologist, users explore the area, the Pueblo, and the archaeologist's tent, helping out with such tasks as piecing ceramics together, taking photographs, and excavating artifacts. In QuickTime videos, several archaeologists speak to the assistants as they explore. Hopi and Tewa people, descendants of the Anasazi who are the Puebloan people of today, speak throughout the program about their ancestors who lived in the village. They provide insights into their daily lives and culture.

In many areas of the program, the assistants are able to go back in time, to AD 1125, and see life as it might have been lived through narrated 3D re-enactments and animations. Special features of the program include an animated corn grinding scene, recreations of rooms in the Pueblo, recreations of both the plaza and the fields throughout a full year's seasons, and a nature walk through the canyons where participants can find the ancient Puebloan's water source, a rock art panel, and native plants. The archaeologist's tent is filled with books, maps, a microscope, a computer, a CD player, and a VCR, all of which the assistant can explore to uncover the methodology of contemporary archaeologists.

"People in the Past" was created for the Anasazi Heritage Center with grants from the Colorado Historical Society. It was produced by Paradox Productions and Living Earth Studios, Inc.



The Area Map of the Entire Site

Entering the Archeologist's Tent

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Proposal Writing 101: Ensuring Your Submission is Understood

Few things are as frustrating as submitting a proposal to a conference and being turned down because of the ways in which your ideas were presented. Often times, the ideas or projects themselves aren't the problem. It's the way the proposals are written that frequently disqualifies a submission. I know the feeling. When I've had projects rejected, I wonder, "Why didn't the reviewers realize how perfectly my work fit with their conference?" or "Gosh, was my idea that bad?"

After serving on numerous selection committees for major conferences, and playing a role in the SIGGRAPH conference selection process for the past three years, I have some suggestions that will help submitters increase the chance their proposals will be accepted to a conference. Drawing upon many of the concepts I teach in rhetoric courses, this essay describes some practical ways to ensure that your proposal will be considered on the merit of its content for inclusion in a conference such as SIGGRAPH.

There are two major sections to this paper. First, I'll describe how you can use the Call for Participation to tailor a proposal to be a "perfect fit" for both the conference and program. Secondly, I'll highlight some basic writing techniques that will help reviewers quickly grasp your main ideas.

Using the Call for Participation

This may sound silly to some, but a key way to make sure your proposal will "fit" within a conference program is to create a checklist of what needs to be included. At SIGGRAPH, the program chairs already create that checklist for you: the Call for Participation (the Call).

The Call is created to invite proposals and to describe the content the program chair is seeking for the conference. The Call is designed to help streamline the process of reviewing submissions. Contrary to being an arbitrary set of rules that you can ignore, the Call is important because it asks for exactly the information the program chair needs in order to make a decision. Contributors to a conference such as SIGGRAPH are asked to adhere to a set of specific guidelines; the Call is the first of these requirements. Your proposal is the first indication of how well you will pay attention to details later in preparation for the conference. Submitting a proposal that is difficult to understand, poorly written, or that fails to include all requested information decreases your chances of being accepted regardless of how good your idea is.

When writing a conference proposal, perhaps the most important consideration is making sure you complete the requirements put forth in the Call. It's surprising how many rejected proposals are simply due to a failure to pay attention to the Call. Don't fight or ignore the Call. Instead, use it to your advantage!

Perhaps the best way to use the Call to your advantage is to make sure you fulfill all of its requirements. I suggest treating the Call as a strict set to guidelines. Always keep it in front of your eyes, and even commit parts of it to memory.

Step One: Obtain the Call for Participation

Make a copy of the Call. Use it as a draft to help you prepare your proposal. Different conferences may ask you to submit your proposal online or to mail a paper copy.

How can you use the Call to help you prepare? It's simple: write all over it! Grab a highlighter before you ever start writing, and highlight all of the requirements put forth in the Call. If you'd like, you can even create a checklist and cross each item off the list once you've completed it. When I'm writing, I tend to highlight the requirements on a copy of the Call, and make notes to myself about what I think that means.

Write

Step Two: Identify the Requirements

Distinguish between the types of requirements. Generally, the requirements for the SIGGRAPH conference fall into two categories: technical requirements and content requirements.

Meeting Technical Requirements
The technical requirements have little to do with your ideas, and much more to do with the format in which they are presented. To determine what the technical requirements are for the program to which you are submitting, start by looking at the actual checklist within the Call. These tell you what is required in order for you to have a complete submission. Without a complete submission, it's highly unlikely that your proposal will be accepted.

First, and perhaps a bit too obvious, make sure that you provide the complete contact information for yourself and everyone who will participate in your presentation. You'd be surprised how many submissions include incorrect or incomplete information. The more ways you provide for the program chair to contact you, the more interested you seem in having your submission included in the program.

Second, be sure to include a signed copy of the Submission and Authorization form. Also known as the permission-to-use form (PTU), it gives SIGGRAPH permission to print the information in your proposal in the conference publications. In order for a submission to be included in the program, it must have a signed PTU on file.

Next, most programs require at least two abstracts, a long and a short version. Be sure that your abstract provides a brief yet complete summary of what you'd like to cover in the presentation. Also (very important), make sure that your abstracts fit within the required word (or page) limits. It's very difficult for reviewers to sort through abstracts that are too sketchy (they don't provide enough information to tell what will be talked about) or too detailed (remember that reviewers may be evaluating many proposals so even the long abstract should be clear and concise). The assigned limits should be adhered to pretty strictly. That way you are consistent with what is requested in the Call.

Fourth, if the program to which you are applying requests supplemental materials, be sure to follow the guidelines within the Call for those materials. If you deviate from the acceptable formats, or don't provide enough copies, it is likely that your wonderful supplements won't even reach the reviewers. Also, since the timeline for reviewing is often very tight, if you would like to have your "extras" included in the review process, you should make sure that they arrive at the address in the Call on or before the due date. Otherwise, once again, it is likely that the reviewers won't see those materials.

Meeting Content Requirements
Meeting the technical requirements is only one part of using the Call to your advantage. Once you are sure that you've made a checklist for what is required, now it's important to make a list of how things are required: the content requirements.

What I mean by content requirements is this: program chairs have certain things they are looking for in a proposal. Generally, this information can be found within the part of the Call that describes the program itself. Often, the types of content are directly stated when the program is described. For example, the 1999 Electronic Schoolhouse Call asks potential contributors to "share how you teach computer graphics and/or use computer graphics to teach at all levels and across all disciplines." This tells us directly that in this program, proposals must at least deal with computer graphics and their relation to education. Make a note to include a discussion of that relationship. While it sounds obvious, a number of submissions to the Electronic Schoolhouse did not include a reference to one (computer graphics) or the other (education).

Beyond making note of the obvious clues within the Call, you can also look for particular words within the description of the program that seem to stick out when you read them. For example, you might notice that the authors use words like "innovative" or "cutting-edge." These words give you clues as to what types of submissions will be chosen. Add these words to your list of things to include in your proposal. We'll come back to them later when we begin the actual writing of the proposal.

Step Three: Post your Lists

Before you begin writing, I suggest completing one more task. Take the lists you've made of technical and content requirements and put them somewhere so you can see them while you're writing. I actually put the Call (or list) on the wall over my desk so that every time I look up from my computer, I see the requirements. That serves as an effective reminder that I have to work within the guidelines that are constantly in front of my face.

Step Four: Write the Proposal

At this point, all the necessary leg-work to write is complete. We've completed lists for both technical and content requirements for the program, so we know what types of information we should include, some key words or phrases to use, and how much space (or how many words) we have to work with while writing the proposal. Now let's work on style.

Develop a Clear Thesis
One of the most common complaints I've heard from reviewers over the past several years is: "From this proposal, I can't tell what this person wants to do." In spite of telling submitters what they wanted to hear in the Call, reviewers and program chairs still don't receive the types of proposals they need in order to make decisions. I believe this complaint is due to the writing style of the submitters, perhaps even more than the specific content. This final section suggests some stylistic approaches to proposal writing that will immediately answer the "what does this person want to do" question.

The most important part of your entire proposal is a short statement (the thesis statement) that summarizes what you would like to present. The shorter and clearer you can make this statement, the more effective its impact will be. Often times, the "I can't tell what this person is saying" proposals either lack a thesis statement, or state it in a very complex or convoluted manner. Developing one short, clear statement that tells the reader what to expect avoids any confusion. Generally, I will spend up to an hour working on a thesis statement that will work for the given essay. Time spent developing a clear thesis will always pay off.

Write Deductively
Related to developing a clear and concise thesis, the order in which you present your ideas is also very important. Since proposals are usually read very quickly, it's really important that they be written deductively, and not inductively. This means that you place the main point of each paragraph in the first sentence. Writing deductively allows the reader to quickly glance at your paper and still "get the gist" of what you're trying to say even if she or he does not have much time to devote to your proposal. After the main point of the paragraph there should be an explanation of why that point is important: expand the statement you made in the first sentence. Next, provide support or examples that "prove" to the reader why what you've said is true. Finally, after the examples, re-state the main point and link it to the next point you'd like to make. As a general rule, here's the formula for deductive writing: Make a statement. Explain what it means. Support it with examples. Summarize and move to the next statement.

Use the Appropriate Vocabulary
Another frequent problem in proposal writing is that an author tries to write using a particular type of jargon. Of course there is nothing wrong with using technical words in a proposal, and a conference like SIGGRAPH needs to include certain jargon. But it is important to realize that the more technical your word choices, the more likely a reviewer may not understand your topic. So if you decide that you need to use technical words, be sure to explain what a given word means immediately following the first time you use it. Only then can you be sure that your audience will understand your words.

The most important thing to focus on when making specific word choices is clarity. Can someone understand what you "want to do?" If the words you choose to use don't help make your proposal clearer, then you're using the incorrect vocabulary.

Step Five: Using Your Checklist

After you've completed your writing, making sure that you have a clear thesis, you've written deductively, and you've chosen an appropriate vocabulary, it's time to revisit the checklist you created when you first read the Call for Participation. Double check to make sure that you've included each point on the list. If you haven't, you need to re-work your proposal so that the missing item is included. Once an item has been accounted for, cross it off your list. You know that the proposal is completed when you have no more un-crossed items. The advantage of this system is that you can constantly see where you are in the process of developing your project.

Once you've completed these steps, the proposal will be complete, and hopefully easily read. At the very least, by following these guidelines you can be confident that your submission contains all the necessary content and technical elements, and that the reviewers will at least take your proposal seriously enough to read it. Then you know that you have given the proposal your best effort. By following a systematic approach to proposal writing, the chances of reviewers being able to quickly and easily understand your proposal dramatically increase. Now your proposal can be measured on the strength of your ideas. Hopefully that means I'll see you at SIGGRAPH 2000!

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Classroom

The Round Earth Project: Collaborative VR for Elementary School Kids

This paper discusses deployment of a collaborative VR environment in an elementary school to help teach children that the Earth is spherical.

The concept of a spherical Earth and the implications of that fact are well-represented in the AAAS Project 2061 Science for all Americans report, and the difficulty of teaching it has been documented by Nussbaum, Vosniadou and Brewer[3,4]. It is not a simple concept for children to acquire. Their everyday experience reinforces their deeply held notion that the Earth is flat. More precisely, their mental model of the world separates "sky" and "earth" into two parallel layers, one "above" the other; the two directions "up" and "down" are absolute. Telling young children that the Earth is round does not cause their intuitive model to be replaced by a spherical conception of the Earth. Instead, children assimilate the new information into their prior knowledge and often conclude that the earth is flat and circular.

The spherical Earth is a simple example of a deep idea, a fundamental concept that lies underneath our extensive system of domain knowledge and influences how experience and discourse are conceptualized. Revising these deep ideas, these core concepts, is difficult because new knowledge is assimilated in terms of existing knowledge. When the new knowledge is both different from and more fundamental than the existing knowledge, the typical outcome is distortion.

The Round Earth Project is a collaboration among researchers in computer science, education, and psychology investigating two alternative pedagogical strategies for teaching children that the Earth is spherical, and the implications of that fact. The transformationalist strategy attempts to effect conceptual change by evidencing a breakdown in the children's prior models. The alternative displacement strategy attempts to effect learning in an alternative setting free of pre-existing biases, and to relate that learning back to the target domain: the Earth. In the transformationalist approach, VR simulates the launching of a spacecraft from the Earth's (apparently flat) surface and subsequent exploration within a fixed-height orbit. In the displacement approach, VR simulates a small-diameter asteroid where the learner walks on a curved horizon, sees objects appear from below the horizon, takes a long walk around the globe and comes back to the departure point.

The virtual worlds are collaborative. One child experiences the surface of the world as an astronaut, and the other, acting as mission control, sees the avatar of the first child on the spherical world. The kids are given a task that requires the astronaut to move around the spherical body. This way, the astronaut is often "upside down" on the sphere but "rightside up" on the surface. The task fosters positive interdependence because neither child can perform the task alone. They need to cooperate and communicate, and through this communication the children must reconcile their different views.

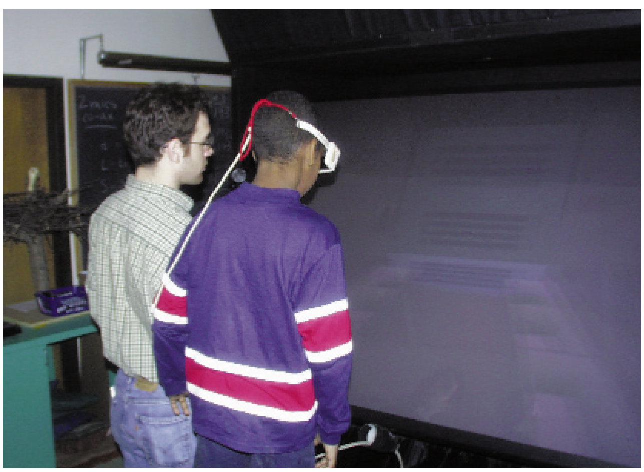
The children are first given a five-minute orientation to each view, which shows them how to use the controls and points out features of the environment that are important to the learning goal (the ability to circumnavigate the globe, seeing the tops of objects over the horizon first, not feeling "upside down" when you are at the South Pole). Each of the children then experiences each role for 10 minutes.

Collaborative

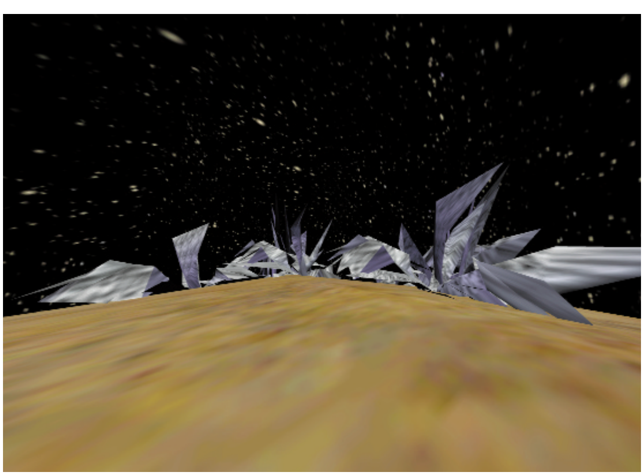
The displacement strategy requires a second step. This new knowledge, established at the alternative cognitive starting point, must be brought into contact with the child's prior knowledge. The point is not just to know what it would be like to walk on a spherical planetary body, but to understand that the Earth is such a body. We call this second step bridging activities. It involves talking to the children about their VR experiences for 10 minutes using a physical model of the Earth and the asteroid.

We have previously described our pilot studies, which were conducted by bringing children to VR equipment in the laboratory [1,2]. For these actual studies, we worked in close cooperation with the teachers and administration of a local elementary school. An ImmersaDesk driven by a Silicon Graphics desk-side Onyx and a stereo-capable monitor driven by a Silicon Graphics Octane were brought into a classroom in the school for two weeks, and studies on the displacement strategy were conducted onsite. The ImmersaDesk was used for the astronaut view, giving the user a wide field of view on the surface, while the stereo monitor was used for mission control.

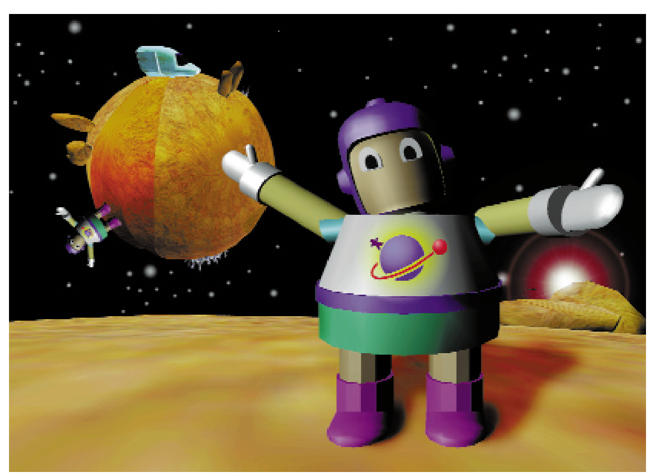
A guide introduces a student to his role as the astronaut at the ImmersaDesk.



A guide introduces a student to her role as Mission Control at the stereo monitor



The astronaut approaches one of the crystal forests on the asteroid.



The happy astronaut.

There are 84 second graders in four classrooms at this school. Seventy-six permission slips were returned (a pretty high return ratio), and all of these children took the 20-minute pre-test. The pre-test consisted of 18 questions spread over five topic areas: the sphericality and support of the Earth, the relativity of up, circumnavigation, occlusion, and egocentric vs. exocentric perspectives. These questions were asked three ways: verbally, with 2D paper drawings, and using 3D PlayDoh models. This was done to minimize representational bias. We developed a simple scoring system and divided the children into three groups: the high group answered 14 or more correctly, the intermediate group answered 11-13 correctly, and the low group answered 10 or fewer correctly.

The 29 children in the low group were chosen as the treatment group for the VR experience. From our previous experiments with third-grade children at another school, we expected to have a larger subject population. Because we only had 14 pairs of children, we had them all experience the displacement-based asteroid world. One week later, randomly chosen pairs of these children went through the 30-minute VR experience and the 10-minute bridging activities. They were given the post-test on the next day.

During development, we were concerned about whether we would be able to create a compelling alternate reality. This did not seem to be a problem, as several of the children reported being scared when they first stepped onto the asteroid in front of the ImmersaDesk, thinking that they would fall off the nearby horizon. One of the children was unable to continue as the astronaut. Another child reported being dizzy at mission control, but wanted to continue. Overall the children had little difficulty using the apparatus, but the adult guides who handled the orientation session stayed with the children during the VR experience to provide guidance.

As with our previous studies, the children became very focused on completing their task before their time ran out. Because of this, we waited until after the orientation phase to give them their mission. In the case of the asteroid, the two children are told that their spaceship has crashed on this asteroid, and they need to recover fuel cells scattered about the surface to allow their spaceship to leave. Once they had their mission, the children's dialogue tended to focus on getting to the next fuel cell. Mission Control would frequently tell the astronaut to "go up" or "go down" with reference to the sphere, which then initiated a conversation as the astronaut tried to map this direction into moving forward, turning left, or turning right on the surface.

The 22 children in the intermediate group became the quasi-control group. These children were given the post-test without having the intervening VR experience. To be fair, once these post-tests were performed, the children in the intermediate and high groups were given a chance to experience the VR worlds.

The score for the treatment group increased from a mean of 7.3 correct out of 18 to 12.9 out of 18, and this change was statistically significant. The questions on the post-test were identical to those on the pre-test, so there is the possibility that the test itself contributed to learning. The quasi-control group, who didn't have the VR experience, saw their scores increase from a mean of 12.2 on the pre-test to 14.0 on the post-test, and this change was also statistically significant, but the magnitude was considerably smaller. Additionally, the difference between the treatment group and the quasi-control group was statistically significant on the pre-test, but there was no significant difference between the two groups on the post-test. This suggests that the combination of the VR experience and bridging activities brought the treatment group up to the level of their classmates in the quasi-control group.

Compared to our previous studies in the laboratory, this study in the classroom went much faster and required fewer personnel. Our previous experience with taking ImmersaDesks to conferences made the deployment to the school quite straightforward, and the 15-year relationship one of the investigators had with this school provided an environment of trust that was invaluable.

This study also showed that the children learned more than in our pilot studies, which we believe is a direct result of the changes made during those pilot studies. For this study, we were able to use the adult guides more effectively at the beginning of the experience to point out features of the environment that were important to the learning goal. We believe that this orientation helped the students bridge the gap between the two representations of the astronaut on the asteroid, making it easier for them to relate the two heterogeneous perspectives. We also modified our tests to ask the same question three different ways to avoid the biases that the media introduced into the questions and get a better idea of the child's model.

The children seemed very excited by the experience, and as word spread through the school many children and teachers from other grades came by to see what we was going on. We were concerned that the children might be jaded by their familiarity with video games, but several children favorably compared our setup to a Sony Playstation. There was great interest among the children, teachers, and staff in having us return to the school for future work, and we plan to return in the late spring to continue this investigation. This will include giving a delayed post-test for the children who participated in this experiment, comparing the transformationalist to the displacement approach used here, and investigating the relative influence of the VR experience and the bridging activities.

Acknowledgements

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The ImmersaDesk is a trademark of the Board of Trustees of the University of Illinois.

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Playground

The SIGGRAFFITI Wall: Multi-Input Painting

The SIGGRAFFITI Wall is a 3D virtual canvas that allows simultaneous input by multiple artists through various input devices. Some input devices are 2D, while others are 3D. The 3D input devices are used to create a virtual sculpture, while the 2D input devices are used to create texture maps on transparent polygonal virtual walls surrounding the sculpture.

One input device is a large wall space allowing artists of all ages to make their "marks" by throwing beanbags at the wall. As each beanbag hits the wall, a paint-splat primitive with time-varying characteristics appears on the transparent, 2D texture-map. Meanwhile, an artist using a glove input device is creating the 3D sculpture in the center of the virtual creation space, which onlookers view through the paint-splat wall. Other users may be finger-painting on the 2D texture maps from touch-screens, or drawing with lasers. The works of art can be saved and printed out by the hour or the day.

This is an ongoing creative process, created live at SIGGRAPH 99, just for the fun of it!

Painting

SP3D and the Lighthouse: Explorations in 3D Internet Learning

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Classroom
Playground

Introduction

In most classrooms, subjects such as Shakespeare and philosophy are associated with the words "boring," "haughty," and even "incomprehensible." Using the Internet and 3D graphic technology, students can now be transported to a 3D interactive world where these subjects become "real."

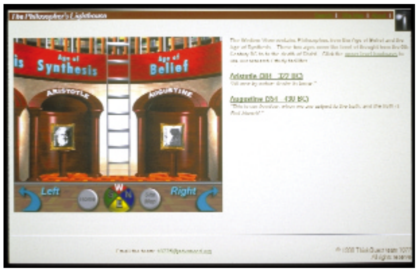
Shakey's Place 3D (library.advanced.org/10502/index.htm) and The Lighthouse (library.advanced.org/18775/index.htm) are Web sites designed to breathe life into Shakespeare, philosophy, and the students who study them. The sites' use of 3D graphics creates striking environments meant to peak interest and increase the educational value of the interactive devices they contain.

Background

In 1996, three students decided to attempt to free students from "painful" lectures and readings about Shakespeare by creating a 3D world that any student could visit and, more importantly, learn from. As part of the ThinkQuest Project, William Shakespeare's Globe Theatre was rebuilt in 3D and placed online. Students and teachers alike could visit and understand that Shakespeare, although a stereotypically boring subject, could be interesting. The result: Shakey's Place 3D.

SP3D was a success, not only in the ThinkQuest Project, but also in its intent. It received second place in the ThinkQuest competition, earning $48,000 dollars in scholarships and grants. More than three million visits have been logged since its release in August 1997. Teachers, students, academics, and enthusiasts have walked through the theater, and its influence is still growing.

With the success of SP3D, the idea was expanded to philosophy, as a new entry in the ThinkQuest contest: The Philosophers' Lighthouse. Here, the graphics were improved, and, once again, a topic was revitalized with 3D technology and Web design. The Lighthouse has prompted a great amount of discussion and response since its release in August 1998 and has been selected as an Honorable Mention in the 1998 ThinkQuest contest.



In-Depth

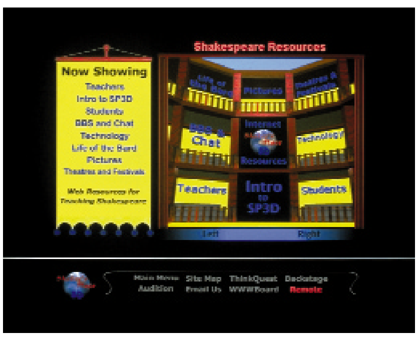
The success of these Web sites has prompted a new method of teaching students, where field trips can be an inexpensive treat, where new ideas are bolstered and encouraged, even where collaborative study moves beyond the boundary of the classroom and on to a global realm. As Shakey's Place decrees in its introduction: "It's not what you need to learn... it's what you are inspired to learn." The worlds created in these sites draw the user in beyond the boundary of stereotypical "forced" education. Users are enticed further into the site, to explore. They can then use the tools without pressure or boundaries, thereby strengthening the educational value of the interactive devices. A few of these devices include:

- Madlibs (SP3D), where users are prompted to type random words, then the Web site replaces keywords in, for instance, a soliloquy by Hamlet with the random words provided. This shows the importance of iambic pentameter, poetic meter, and especially how words "paint" emotions. It is a perfect example of "effortless retention." Students are much more likely to remember if they have a "fun" example to remember, rather than just their notes.

- Online Auditions (SP3D), where users choose a "face" from a gallery of graphics, then decide which part they would like in which play. This creates not only a one-on-one relationship with the student, but also provides teachers and researchers statistics on which characters certain age groups associate with. Thus, not only does the Web site create a personal link with visitors, but it also gives teachers that opportunity as well.

- Voting Booths (Lighthouse), where visitors can vote on which philosophy or philosopher makes the most sense to them. This gives value to visitors' opinions and causes them to think, compare, and contrast, then vote.

- Bulletin Board Systems (both Web sites), where visitors are encouraged to collaborate on topics and formulate opinions. These bulletin boards broaden the horizons of the sites, perhaps even bringing to light topics that were not approached on the sites before.

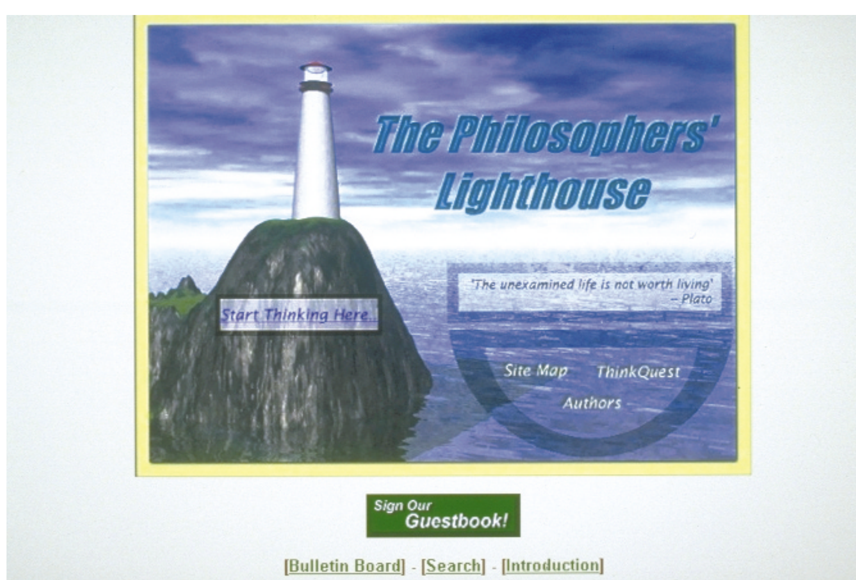


These tools would be useless, however, without a strong hook to interest the user. The 3D environments draw the user in by making navigation easy, minimizing unnecessary reading, and simulating a field trip. Teachers can lead their students into a computer lab or classroom and walk them through an exciting world, teaching them and entertaining them at the same time. Enthusiasts of all ages can research or discuss their topics without being slowed by continual searching or reading. SP3D and The Lighthouse also use technology to encourage users to respond in a way that other sites and media cannot offer. These sites do not tell users what to think. SP3D and The Lighthouse bring a whole new meaning to the word "interactive."

Plans

Using the same concept, these principles of design and education are being applied to another site. In this trio of sites, each site will be unique in its subject matter, but they will share the same ideal: using 3D graphics as an interface to bring difficult or unpopular subjects to light. The new site is displayed alongside SP3D and The Lighthouse as a case study, to show how these sites come into existence.

The software, hardware, and World Wide Web issues involved are explored in an effort to encourage similar efforts and use of the Web in education. Perhaps someday trips to ancient Rome, colonial America, or even mystical Atlantis will be possible from a classroom, and learning will be inspired, not required.



Supporting Online Collaborative Communities

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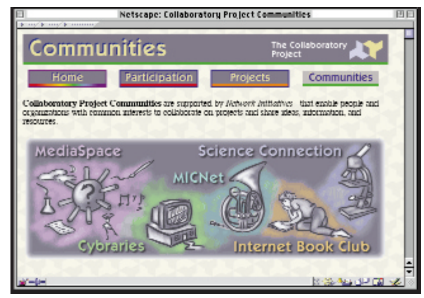
Playground
Workshop

This workshop demonstrates the Northwestern University Collaboratory Project's MediaSpace and other collaborative environments, and provides participants with the chance to develop a multimedia "hub" in MediaSpace.

The Collaboratory Project (collaboratory.nunet.net/) is a Northwestern University initiative funded by a grant from the Ameritech Foundation. Its staff provides consulting, training, technical support, and information services to education, cultural, and nonprofit organizations interested in using network technologies to advance education. The Project's goal is to establish an easy-to-use, network-based collaborative environment that enables organizations in the greater Chicago region to work together to share information, resources, and expertise.

As part of the University's Information Technology organization, the Collaboratory Project draws on the experience and technical expertise of the entire organization to support its mission. It works with individual educators, school project teams, and multi-school collaborations in the Chicago Public Schools system and surrounding school districts. In addition, the Collaboratory Project works with museums, libraries, and cultural institutions to develop innovative Web-based educational resources.



Within the project's collaborative environment, various collaborative communities enable people and organizations with common interests to share projects, ideas, information, and resources. The communities are Web-based activities that participants can join as part of established curricular activities. They enable educators and students to share projects through dynamically created Web pages and discuss their ideas using Web-based discussion and chat resources. They also provide gateways to Internet resources and facilitate access to experts in the region.

An educator can join a collaborative community from the Collaboratory Project Web site and use it to meet specific curricular needs. Students can participate with anything from a single computer and a modem to a fully networked computer lab or school. Through a network connection, they submit text, graphics, sound, and video files from a standard Web browser to a database on a Collaboratory Project server. Educators can manage the content their students submit through other Web pages that provide password-protected access to the database. Web pages are created dynamically from the database.

Collaborative communities available on the Collaboratory Project Web site include:

Cybraries
A Cybrary (Cyber Library) enables educators and librarians to identify, organize, and share Internet resources that support curricular activities. Teachers, librarians, and students can review and contribute useful URLs to a shared virtual library or create a new one to meet their own needs. The Collaboratory Project provides training on how to locate Internet resources, create online references, and prepare materials for network access and distribution as a Cybrary.

Internet Book Club
Designed for the K-12 curriculum, the Internet Book Club has four project areas where students and teachers can share language arts activities. Students can post book reviews, stories, essays, and original compositions and poems. Teachers can share project ideas and curricular materials in the Teachers Lounge. In particular, they can search participant databases to find other teachers who are using the same books and plan threaded discussions and online chat sessions for their students.

The Science Connection
The Science Connection brings together science activities and resources. Northwestern University scientists and engineers, who answer questions from teachers developing classroom science activities, support "Ask a Scientist." Observation, data collection, and reporting projects that support scientific inquiry are being developed with Chicago museums. Teacher resources for science fair projects, reference materials, and more, are also available.

Music Internet Connections (MICNet)
MICNet is an Internet music collaboration project that supports school music teachers interested in exploring music composition activities with their students. Students can exchange music compositions in MIDI files and play and discuss those compositions from networked computers. Professional composers provide feedback to student composers.

MediaSpace
Media Space is a collaborative environment designed to encourage sharing of multimedia information, projects, and activities. Participants create "electronic multimedia postcards" using text, graphics, sound, and/or video files they have created. They can contribute a project to an existing theme or start a new theme and invite others to participate. MediaSpace supports a number of projects, for example:

- Community-based research projects for schools along Interstate 57 in Illinois.
- Fairy tales written and illustrated by students around the world.
- Student explorations of their musical heritage.
- Reports on places students have visited.
- Documentation and discussion of a teacher's visit to Swaziland, via a live link to an Internet café in Swaziland.
- Creating and "documenting" imaginary cultures.

Educators can join an existing activity or start new MediaSpace projects from the Collaboratory Project Web site and use it to meet their particular needs, such as science reports, multimedia essays, history reports, personal journals, etc. MediaSpace emphasizes the use of images and sound in preference to text.

Within the Collaboratory Project's shared environments, responsibility for content is distributed to educators and other interested parties while the server manages page layout, graphic design, and navigation using templates created by project staff. Each of the environments provides an easily extended and replicated model for networked collaboration. Because collaborative communities are participant-driven and used in projects that are closely tied to the curriculum, they provide fertile environments for developing innovative, collaborative projects and activities.

The Teacher's Mid-Life Crisis: Moore's Stairmaster of the Fittest

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Classroom

In his article "As We May Think," Vannevar Bush proposed a device called the MEMEX as a solution to the problem of information overload. Today, those teaching computer graphic design, animation, non-linear video production, multimedia and Web page design, sound editing and composition, or interactive art face a related problem of the information age: ongoing obsolescence of knowledge, skills, expertise, even aesthetics, and the imperative to continually upgrade and acquire new skills and knowledge to keep pace with the march of technological innovation and cultural fashion. In institutions of higher learning, Moore's Stairmaster favors the young, the fit, and the tireless. The World Wide Web may be a partial realization of Bush's vision for managing the explosive growth of information. For the educator, there appears to be no relief from the perpetual scramble to match teaching and research to the demands of a client-centered model of higher education.

Many credit Bush with the invention of hypermedia technology, which later inspired Tim Berners-Lee's proposal for the World Wide Web. Motivated by concern for the loss of scientific information, Berners-Lee explains, "...the dream behind the Web is of a common information space in which we communicate by sharing information." Yet this vision of the Web as a solution to the problem of information overload, management, and retrieval offers little relief for the educator suffering a mid-life crisis.

Moore's Law is unforgiving. As the power and complexity of silicon chips doubles every 18 months, each previous generation of computers and the software applications designed for them are rendered obsolete. The marketplace drives the proliferation of new features in upgrades and proclaims: upgrade or die! Software development resembles an autocatalytic chemical process, which increases in speed according to the volume of products it has created. With each hardware and software upgrade, there can be a concomitant obsolescence of skills. Educational institutions are hard-pressed to find the funds to cover costs of the next cycle of upgrades. Administrators are often reluctant to pay to retrain faculty and find it more expedient to hire recent graduates or expatriates from industry who are already expert users.

High-end software packages from Softimage, Discreet Logic, and Alias|Wavefront have steep learning curves that demand a tremendous time commitment. For a mid-career educator with full teaching, administrative, and personal responsibilities, this time is hard to find. Specialization is nearly unavoidable. If one chooses to maintain skills in Web site development using HTML, JavaScript, Lingo, Shockwave, Flash, VRML, CGI, and Java, there may not be time to tackle Softimage. A few years ago, it may still have been possible to maintain up-to-date working knowledge of a number of commonly used packages. Today there are Adobe Photoshop experts who may have never heard of VRML. Like increasing the resistance on the Stairmaster, the need to simultaneously maintain and reinforce existing skills and acquire new ones is an uphill struggle.

Mid-Life

The client-centered model of education tends toward training on demand. Especially with complex software, the desire to learn how to do something often upstages questions about what to do and why. From the viewpoint of protocol analysis, much end-user software expertise is essentially scripted or procedural knowledge. Almost all tutorials follow this step-by-step cookbook recipe approach. This "training" approach lends itself to distance-learning strategies, which may have the secondary effect of reducing a teacher to the role of a technical troubleshooter. For some administrators, this diminished role is a cost-cutting opportunity.

Stairmaster

The Teacher's Mid-Life Crisis: Moore's Stairmaster of the Fittest

Theory is compressed into practice. Critical thinking is often shunted aside because students know what they like. The cultural paradigms that drive young imaginations are increasingly drawn from popular culture. There is a clear feedback loop from industry to the schools. The window on popular culture is a shifting frame of reference that increases the gap between the educator and the student regarding what is "kewl" to do. Like Dawkins' selfish-gene, new aesthetic memes are rapidly eclipsing the cultural icons of earlier generations. Influences can be traced from games and films like *Mortal Kombat*, Japanese anime culture, or the continued predominance of DJ club culture. Interest in these stylistic approaches shows no sign of abating and, in fact, continues to spread among the youth cultures of the world. Rather than hoping to be a Rembrandt or Beethoven, today's students are more likely to emulate a graffiti artist or a DJ. Increasingly, educators must acknowledge that this represents a legitimate cultural shift that offers opportunities for critical consideration and a rich resource for artistic creation.

I, among others, have argued elsewhere that learning by doing is by far one of the most effective methods for teaching the use of computer technology in fine art and design. The way to learn to draw with a piece of charcoal is to do it. Likewise, you learn how to create and edit NURBS through the experience of doing it. There is a tendency to confuse art made with computer with a kind of objectivity that belongs to science and engineering. In order to make art with a computer, you must conform to the dictates of the interface, which requires a deliberate and planned step-by-step approach. This is a rational process that yields to scripting and recipes. Yet this objective knowledge is no substitute for the subjective know-how and understanding that only comes from repeatedly using the menu-driven tools to achieve different aesthetic ends. In order to get over the hurdle of learning the interface, there must be the desire and infatuation with both the technology and its aesthetic outcomes. The "kewl" factor as a motivator is not to be underestimated.

New programs, curriculum development, and the needed implementations brought about by the demands of clients, both students and industry, affect hiring practices and conditions of employment for mid-career and entry-level educators. Could a revolving door between institutions of higher education and industry benefit the educational process and enrich the industry as well?

Teaching and Creating Animatics

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Workshop

This hands-on workshop guides educators and students through the process of setting up an animatic and teaches them how to create a short story using traditional and computer-aided methods. The presentation includes:

- Story – how to structure around a given theme or music.
- Storyboarding – written as well as drawn visualization.
- Key framing – posing out the characters and scenes.
- Timing – guessing at what it should be (theory vs actual).
- Premeire – using the software to marry the visuals with sound; putting "theory vs actual" to work.
- Scheduling – how do you estimate the time it takes to do the work?
- Budgeting – if this were a real job what would it cost?
- The business – how students should think about marketing themselves.

The workshop also teaches the teachers what they need to set up a similar situation for their own teaching purposes. It includes samples of completed works and works in progress, to illustrate the process more completely.

Animatics

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Classroom
Playground

ThinkQuest: Students and Teachers Exploring a Global Web-Based Education Project

ThinkQuest is an educational initiative committed to advancing learning through the use of computer and networking technology. ThinkQuest challenges teachers and students of all ages to use the Internet in innovative and exciting ways as a collaborative, interactive teaching and learning tool.

Because of the Internet, groups of people from diverse locations, backgrounds, experiences, and nationalities are able to work and communicate in meaningful ways. ThinkQuest capitalizes on this new form of communication by inviting learners to explore topics they choose, collaborate to achieve a goal, and add meaningful content to the Internet.

An exemplary model of student-directed, project-based learning, ThinkQuest promotes an "Internet style of learning" – an interactive, participatory method that encourages students to learn by doing and take advantage of the Internet as a constantly growing source of information.

ThinkQuest teams have created a broad and valuable collection of Web-based educational resources for use by others around the world. In this way, ThinkQuest allows students to move from passive information consumers to active knowledge producers whose work is used and valued by millions. The initiative is comprised of several programs.

ThinkQuest Internet Challenge

The ThinkQuest Internet Challenge is an international program for students age 12-19 that encourages them to use the Internet to create Web-based educational tools and materials. Students form teams with colleagues from around the block or around the world and are mentored by teachers or other adult coaches. Competing for scholarships and awards totaling more than $1 million, student participants learn collaboration, project management, leadership, and critical thinking skills that help raise their level of academic and technological prowess. Teams submit their entries in one of five categories: Arts & Literature, Science & Mathematics, Social Sciences, Sports & Health and Interdisciplinary. Finalist team members and coaches from each category are invited to the ThinkQuest Awards Weekend. Participation has grown at more than 40 percent per year, with over 10,000 students and coaches from 64 countries participating in 1999.

ThinkQuest Junior

ThinkQuest Junior is a classroom-based competition that encourages girls and boys in grades 4-6 to take a meaningful interest in computers and technology. ThinkQuest Junior teams create educational Web sites on a variety of subjects that make learning fun and contagious for other students of the same age. More than $250,000 in cash, computers, and networking resources are awarded to winning students, teachers, and their schools. Participation in ThinkQuest Junior has more than doubled in its second year, with more than 1,000 teams participating from across the United States.

ThinkQuest Educational Technology Conference

This three-day conference for teachers and educational leaders is being held in Los Angeles, 10-13 November 1999, in conjunction with the ThinkQuest Awards Weekend. At the conference, noted technology and educational leaders share their visions and knowledge of technology and its implications for learning in the next century. Through presentations, panels, and small group discussions with conference attendees, issues critical to teachers and educational leaders, such as the future of the Internet, integrating technology into the classroom, and emerging Internet applications for education are explored in depth. For more information, check the ThinkQuest Web site: www.thinkquest.org

Virtual Harlem

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Classroom
Playground

The University of Missouri-Columbia's Advanced Technology Center presents Virtual Harlem, an innovative use of virtual reality in an American literature setting. This virtual world allows students to visualize the setting and context of fictional texts in a computer-generated environment. Students are able to navigate streets, interact with historical characters, and participate in the virtual world's design. Approximately 10 square blocks of 1920s Harlem (the Harlem Renaissance) have been reconstructed to give students an unprecedented view of the cultural wealth and history of this area. It took over six months to gather material, maps, photos, and films to begin "building" Virtual Harlem. The environment was constructed to specifications detailing the exact lengths and widths of streets and placement of buildings. Currently, students are expanding this base and adding extra dimensions to the project.

According to Thomas Nagel (1974), research in cognitive science has demonstrated that experiential elements offered by various environments enhance acquisition of knowledge. Expanding environmental effects on learning, William Winn (1993) proposed that a different type of learning occurs in a virtual environment, called "constructivism," (which was actually an expansion of earlier constructivist theory proposed in the early 1980s by R.M. Gagne et. al.), in which students actively engage in the learning process. Rather than passively receiving knowledge, students must navigate and make decisions based upon various options presented to them. This active decision-making gives students the feeling of not only participating in a real-world environment, but also turns learning into exploration. Because they feel a sense of agency, students are more likely to engage in learning. The cognitive research of Bartlett, Neisser, and others has shown that, because of the experiential effect of VR and the interaction that users have with other users and objects within the environment, meaning within a virtual environment is very closely tied to that gained from the real world.

When students read novels, they are experiencing, second-hand, the experiences of the author. Although this second-hand account of an author's knowledge of a place or event may lead to a good understanding of what the author is trying to express, VR affords the student an opportunity to experience the same environment first-hand. Students may discover entirely new or additional meanings after "seeing" the scene themselves. In this way, VR becomes an intertextual engagement, allowing students to engage in a simulated environment, filled with music, photos, and dialogue. This intertextuality allows students to have a sense of engaging with the characters or author of a text rather than simply receiving information second hand. Students can then compare their experiences to those of the author, shaping their own reading of the environment or text, as well as better understanding the basis for the author's interpretations. VR promises not only to open the text to new possibilities, but also to revolutionize the notion of what it means to "read" or experience a text. Because of recent currents in literary criticism focusing on intertextuality, pastiche, and reader response, this aspect of VR should be vital to the future of literary criticism.

One of the primary reasons for using virtual reality in this course is to engage students on a technological and critical level. By entering a realistic rendition of the environment that inspired a story, a work of fiction can be better understood and more critically evaluated. Opening a novel spatially in this fashion helps students renegotiate their understanding of how fiction should be read. In Virtual Harlem's virtual world of sights and sounds, period photos were used for the reconstruction, as well as narrative and music from the 1920s. Participating in the creation of this literary environment encourages students to become more engaged in the class as a whole. Quantitative and qualitative assessments support this claim.

We have developed an advisory committee comprised of scholars from various disciplines, such as history, sociology, art, music, and psychology, all of whom see a relationship between Virtual Harlem and units they teach within their areas of specialization. The cross-disciplinary incorporation of VR technology in the humanities encourages students to explore relationships among art, history, economics, music, literature, and other fields that are usually taught separately.

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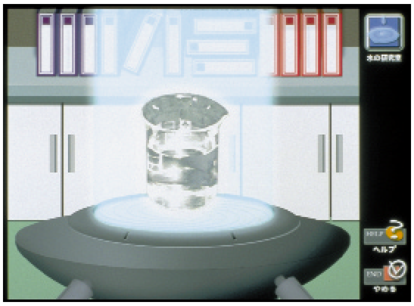
Playground

Virtual Science Laboratory

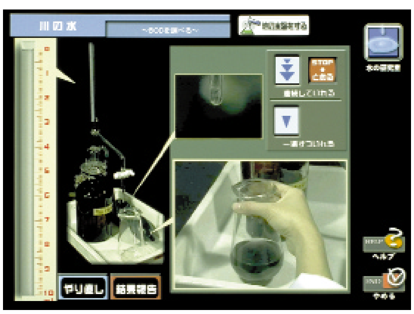
Virtual Science Laboratory is an interactive kiosk program with 2D character animation, 3D computer graphics, and actual tools and samples, imaginatively combined for the purpose of letting ordinary people, especially junior high and high school pupils, experience how scientists analyze environmental pollution, the hygienic condition of various food products, and other matters related to public health. Users are presented with a variety of actual samples or their mock-ups (for example, a piece of food, river water in a flask, etc.) and asked to analyze one of them in a scientifically appropriate manner. When they pick up the sample or mock-up and place it in front of our computer set-up, they are taken into the interior of the virtual (3D CGI) laboratory and greeted by a delightful pair of 2D animated characters: a seasoned scientist named Dr. Hygiene and a little girl, Ms. Ecolo. The participants' samples are represented in 3D CGI, and Dr. Hygiene shows them how to work on their samples in an interactive fashion. Dr. Hygiene is a bit absent-minded, and his instructions might sound a little confusing now and then, but when that happens Ms. Ecolo comes in to help the visitors.



A research sample is just forwarded into our Virtual Laboratory from the transport platform.

In order to analyze their samples, visitors must interact with a variety of experimental tools in multimedia representations. They can see live-action video footage of their operation in a first-person point of view if they handle the equipment correctly. The result of the analysis differs depending on how visitors conduct it, so they feel as if they are real research scientists.

For difficult technical terms and measures, visitors refer to the Terminology Dictionary that is linked in the computer network and further linked to a variety of Internet sites related to the laboratory's subject-matter, so that visitors have access to more detailed information. Sometimes, a quiz is presented to visitors so they can confirm the results.



An analysis procedure: titration with a burette.

This program was originally developed for the Gunma Prefectural Institute of Public Health and Environmental Science in Japan, where scientists are actually involved in analyzing air, water, food products, and pathogenic microbes. In an exhibit hall at the Institute, this kiosk informs the general public about the institute's activities and purposes. The program is intended to make those visitors, especially junior high and older pupils, more conscious of the environment and hygienic conditions in their communities and help them to lead a healthier life.

Dr. Hygiene and Ms. Ecolo in the Laboratory; the animated characters who guide our visitors.

Visual Effects through Adaptive Technologies

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Workshop

Classroom of the Future

This Workshop covers computer animation for the artist with disabilities who has a desire to enter the computer animation effects field. As new technologies emerge for the disabled computer user, the animation software being utilized by some of the major animation companies becomes more accessible for wheelchair-bound animators. The workshop stresses customization of the computer interface to the user, techniques for creating visual effects for various media, and computer animation as a viable career opportunity for the differently abled computer user.

Topics include:

- Unique computer interfaces, such as voice command, and alternative input devices.
- Pen-based interfaces that allow for more intuitive programs.
- Animation basics within popular animation systems and interfaces appropriate to creating animation within a production environment.

With the advent of Web-based informational content, many of the techniques and instructional resources for visual effects can be accessed through Web interaction and research. The workshop also summarizes these online resources, system integration, and research techniques.

Visual

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Classroom

Walking the Tightrope: Balancing Digital and Traditional Skills in Undergraduate Education

Panelists
Jeremy Butler

Kate Francek
Kathy Griswold
Jeffrey Lerer
John McIntosh
School of Visual Arts

Joel Sevilla

Ground-zero: there is a collision between the visual arts and emerging digital technologies:

It's not "On The Road." It's "In The Studio" where streams of consciousness are running wild. Small animation teams hidden away in sprawling lofts. Clandestine jungles of endless cables, technology, and meteoric talent. Here, coffee is considered a vitamin supplement.

OR

Independent developers, outside providers of content sitting in nearly hermetic isolation. Quietly, they shuttle between home and studio. Much of their content transmitted via modem, they may never meet their clients face to face. Defying the 24-hour day, they have usually surpassed the 40-hour week by Wednesday morning.

OR

Game developers? We won't even talk about THEM. Forget about it!
Lunatics!

OR

Feature film production work. Four-year target strategies, two-year projects. Hundreds of artists pushing the stone and today only a few full-time contracts in the whole house.

OR

Independence! Experimental artists pursuing the festival circuit and grants. Perpetually plagued with no money, driven by an internal vision, sneaking around the periphery of a multi-billion dollar industry.

These are a few examples of how digital technologies are redefining art and the role of the artist. A hyper-evolution of tools and concepts is underway, and academia must evolve to meet the challenge and adjust to the needs of emerging digital artists.

The concepts of art training have been evolving for millennia. There is a continuity. Traditions handed down from one generation are broken by the next generation, and then juggled and revived by subsequent generations. Styles change, materials change, but the academic foundations that are most helpful to artists, in their formative years, remain unscathed. Identifying the critical foundations and insuring their survival in the digital environment are vital and essential.

With the advent of digital technology, most visual artists found the digital medium too expensive, too hard to maintain, too complex, too slow, too visually limiting. Computers were anything but inspiring to most visual artists. Complicating the matter was the limited amount of training that was available, and most of it was geared toward basic computer competency and navigating software interfaces.

As the computer has evolved into an affordable, user-friendly, outrageously powerful artist's tool, the focus on software operation in the early years of computer education has endured today, at the cost of our students' potential and the medium as a whole.

Digital

Traditional

First, Art; Second, Computer Art; Third, Industry Needs

In the ever-increasing volume of academic programs based in digital media, a closer connection with the tradition of art school training needs to be rediscovered and re-established. It is not sufficient for a school to provide a software training site or even a level of proficiency for students to enter any of the commercial industries mentioned earlier. Our mission is to expose students to the values and concepts of art in addition to the mechanical mastery of computers and software.

Have educators lost sight of their mission by focusing on vocational training in a response to the false challenge of an entertainment industry (promising to hire thousands of computer animators) to train artists as fodder for their now often empty production cubicles?

New curricula in the digital arts will only be vital if all the major concentrations of a thorough art education are included and stressed. Certainly, a higher degree of critical rigor must be imposed on digital work. In recent years, the function of effective art criticism has been scaled down to make allowances for the fact that it was digitally generated, the aesthetic standard fuzzy, and lowered for the mostly non-artists driving the medium.

Traditionally, one of the most valuable aspects of art school is the exposure to working artists. Students begin to understand first hand what a career in art means and what an artist's identity implies by their contact with the faculty. Today, too many instructors are in fact actually not practicing artists, and they do not have the expertise necessary to be training in an academically rigorous environment. Talented, experienced digital artists are in great demand. Most schools do not have the ability, flexible schedules, or funds to attract the most experienced artists, even as adjunct faculty.

These, and more, are the challenges facing technology-driven programs in undergraduate education. But these are only the philosophical or administrative concerns that will haunt the educational process for years. In the meantime, we still are trying to provide the best education possible to our students. We point, where we can, to the skills that will serve our students best and over the longest time.

One truly visual skill that artists share is their ability to translate or interpret what they observe into a work of art. In animation, observation is paramount. The first phase of the translation from the world to the computer most often lies in a drawing or a sketch. Capturing texture, tone, gesture, expression on paper to be used at first to remember or explore, then as a character sketch to reference while building a 3D model and animating it on a computer.

The creative process of moving from observation to drawing to computer animation can take as many unique turns as there are artists who attempt it. Depending on the skills of the artist, any single element of this process can be critical. Imagination vs. observation, quick sketch vs. detailed drawing, the decisions and the style of a mature artist are the important discoveries for a talented student. It is the student's perspective we wish to explore in this panel. It is their process of discovery and knowledge that is our concern and our reward. Here are some comments from two graduating seniors from the School of the Visual Arts.

Observation in Computer Animation
Jeremy Butler

"The importance of observing a motion, or performance, for animation purposes is essential for capturing true life in motion. Almost all animation, whether cartoon or realistic, relates to real-world physics and the laws of motion. The process of computer animation is not as simple as making a 3D character move. The true art and goal of animation is to bring the character to life. The animator wants the viewer to know, without question, that the character on the screen is moving on its own with its own motivation and purpose. Part of that believability comes from observation.

"Observing from life gives clues to the subject's manner, it's habits, and most importantly the distinctive motion that defines it. These clues are vital to the believability of the character no matter how stylized the final output is. Observing from life is ideal, since it's easier to see how the form relates to itself in three dimensions. Video reference is valuable because the actions can be repeated infinitely for longer studies.

"The notes from my studies are generally a mix of words and sketches, with the notes being similar to captions for the drawings. Besides the notes and sketches, the process I go through is aided by acting the motions out myself in a mirror. Acting out the motion is probably the best way to 'feel' it. This brings me to a better understanding of the motion, and from there I form the basis of my animation."

Animation through Observation
Joel Sevilla

"Because we all move, the ability to animate should be relatively easy. If you can get yourself into a position or pose, then putting your character into the same position is a piece of cake, right? Wrong! It is the understanding of how you got into that creation position that makes animation fluid and believable. Weight shifting, hierarchy of movement, and bone structure are important elements of animation.

"The best way to implement these elements and to understand them starts with drawing from life. Being able to put your ideas for an animation down on paper before ever touching the computer is infinitely important. It not only helps in understanding what poses and actions your character must perform, but it also allows for the building of personality for the character. Would the character be able to do backflips, or is the character someone who likes to spend hours in front of the tube with a bag of chips? These are questions that are answered in the development stage through writing and drawing.

"Observing emotions and feelings is also very important in the animation process. Showing a character go through a cycle of emotion will make that character believable. What does it look like when someone is worried, happy, or mad? These feelings are not only conveyed in one's face but in their body language as well. This coincides with the performance that the character must give. The animator becomes an actor who is giving a performance through the character. Like an actor, the animator takes his or her observations, feelings, and experiences in life and uses them in the performance."

The Panel

This panel features aspiring animators Joel Sevilla and Jeremy Butler, independent animator and faculty member Jeffrey Lerer, and the chair of the Computer Art Department of the School of the Visual Arts, John McIntosh. The panel presents a no-holds-barred conversation and debate on the experience and challenges of balancing digital techniques in a fine art curricula. Illustrations from the faculty and students demonstrate the creative advantages of applying traditional skills in developing the most elaborate computer animations.

Web Pages, Interactive Interfaces, and Worm Holes: The Next Generation of User Interface Designers

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Classroom

Presenters
Carol Bahruth
MaryEllen Coleman
IBM Corporation

IBM wanted to work with elementary school students to see how the next generation of computer users viewed state-of-the-art technology, Internet communications, and software user interface design. We hoped that this insight would help us improve our products for these future customers. As information developers, we are using the Web more frequently to deliver technical information to our customers. We also work on teams in order to complete all our projects. We decided we could learn how children view the Web by teaching them how to put together a Web site of their own.

Through previous contacts, the IBM team leaders approached the principals at Regina Coeli and North Park Elementary Schools and asked them if they would be interested in working on this collaborative project. They accepted the offer and selected students and faculty advisors to join the project. Each school team consisted of eight accelerated students, boys and girls in the fifth and sixth grades, school librarians, and technology teachers.

IBM kicked off the project by meeting with all 16 students and advisors at Regina Coeli. We talked about the project – what we expected to create and what we hoped to learn along the way. After letting the students gather ideas, members of the IBM team met with them and their advisors at their schools. The students called out their ideas while the IBMers wrote them down on the board in a tree-diagram. Through this lesson, the students learned how to organize their ideas into a hierarchy of topics that can be navigated on the Web. They also learned how to critically evaluate an idea without shooting down the person who suggested it and how to build on others' suggestions. After the meeting, the students met on their own (with their advisors) to gather pictures and text to put on their Web sites. They involved their schoolmates who were not assigned to the project by asking them to write essays about their school, their classes, their projects, and their special days.

When the students had their content ready to assemble into a Web site, they came to IBM for two all-day work sessions. At IBM, they got their hands on the same equipment that the human-factors team uses to evaluate interface usability; that the graphic-design team uses to draw, scan, and enhance images; and that the multimedia team uses to record and manipulate sound, create animation, and code HTML. The IBM team helped guide the students in all aspects of the project, including group dynamics, Web page design, and the technology and tools used for creating Web pages. Most of all, we stressed teamwork. The students had 12 hours of lab time at IBM, but they also spent many lunch hours and free periods at their schools working on their Web sites.

The students also learned leadership and presentation skills when they selected two of their teammates to present their Web sites at IBM's "Interact'98 Ease of Use" conference in Yorktown Heights, New York, an annual gathering of usability ease-of-use professionals from IBM sites worldwide. Attendees were fascinated with the students' accomplishments and their enthusiasm for working with IBM on user interface design issues. Here, the students admitted some of the challenges they faced while working in a team and described how easy it was to assemble a Web site once they organized their content and learned how to use the tools.

Throughout the entire project, we videotaped our meetings and lab sessions so that we would have a record of our thoughts and experiences along the way. In the tape, one can watch the students move from being shy individuals to valuable contributors to the team effort. At IBM, projects are rarely completed by individuals. We were happy to give students the opportunity, time, and space to work on a truly group project, while also giving them a glimpse into what human-factors specialists, graphic designers, and multimedia programmers do.

IBM continues to work with these students and is looking for additional opportunities to work with other schools and communities to develop collaborative projects like this one. We hope that our experience of a successful collaborative effort between industry and academia will inspire educators and industry to work together to learn from each other.

Designers

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Classroom
Playground
Workshop

When Children Draw in 3D

In this student animation project, children tell stories, draw, and work with modeling compound to create characters and scenery, then produce their stories on the computer.

Children

Why is the Mona Lisa Smiling?
(library.advanced.org/13681/data/davin2.shtml)

Steve Feld
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Classroom
Playground
Workshop

My experience as a ThinkQuest coach has been extraordinary. I am a teacher at John F. Kennedy High School in Bronx, New York. In December 1996, I was asked by Gino Silvestri, the principal of the school, to attend a classroom session by Dr. Sheila Gersh at City College to learn about the ThinkQuest Project. ThinkQuest is an annual international contest that brings together distant schools to partner on Internet projects. At the time, I had little Internet experience, but a great desire to get my students involved in the international collaborative project. Because our computer classroom had rudimentary equipment, I knew we would face compelling challenges to succeed in this process.

Seven years earlier, my students competed in the Learning Technologies Fair in Albany, New York. They won the competition with Da Vinci's Visions, a student-created computer research project, which included a video component and a 24-screen computer game. At the fair, we met Dr. Lillian Schwartz, who was in the audience. She introduced herself and explained that she had researched Leonardo da Vinci and had made some remarkable discoveries. It is her theory that da Vinci painted himself as Mona Lisa. Although Dr. Schwartz's book, *The Computer Artist's Handbook*, was out of print, my students selected the theme *Why Is the Mona Lisa Smiling?* as their project for the ThinkQuest contest to revitalize her theory.

Mona Lisa

We needed to collaborate with another school, and first we used the ThinkQuest Team Finder (where participants can post a message on the ThinkQuest server) to seek partners for our project. Although we located a Canadian student to help us with team formation, she dropped out of the project just as the deadline approached. We ultimately found partners from Borlange, Sweden, using a Canadian listserve called INCLASS. We knew we had to work quickly because the deadline was only three months away.

The key component was to make the Web site accessible to all. Through their research, my students discovered that da Vinci wrote music. They found the music and digitized the score to make it Internet compatible. We also wanted to include an online interactive quiz, but we wanted it to be viewable with any browser. That meant that we needed to learn how to incorporate Java Applets and CGI scripts into our project. We secured permission to use copyrighted images in our project. My students coded the project using text processors, while our Swedish collaborators researched the Web to find the best da Vinci resources available. We communicated with each other through email.

Because we wanted our project to be accessible to schoolchildren, we included elements that would be fun to use. We added random research and digital postcard elements. We also included a guest book and site survey to encourage feedback from our visitors. We responded to those who provided contributions from the field.

Why is the Mona Lisa Smiling?
(library.advanced.org/13681/data/davin2.shtml)

The response to our project has been phenomenal. On August 23, 1997, a visitor from Mongolia signed our guest book. Since then, our guest book has been signed each day for over eight months, a continuous chain of support from educators, art historians, and schoolchildren from more than 48 states and nearly 60 countries. On September 2, 1998, our site became a USA Today "hot site." On the same day, it was selected as a "cool site." As a result, our site received 2,000 visitors in one day! Our growth has been exponential. In October, Gloria Edwards used our site in a classroom integration session at Purdue University. In November, the newsletter Classroom Connect selected our project for inclusion in its Web guide resource.

In December, we presented our site at City College, and we were featured on the front page of two local newspapers. As a result, we met art historian and author Rina De Firenze who wrote *The Mystery of the Mona Lisa*. We collaborated with her on the subject of the painting and have added scientific inquiry to our project by comparing her theory with that of Dr. Schwartz.

In January 1999, our site was featured on Radio Net's "The Human Factor," a live broadcast that is also Web-based, and *Seeker Magazine* gave our site their "site of the month" distinction. The Getty Museum has recently placed our site in their new Digital Experience. We were also featured as a "hot site" for The School Page UK, and we formed a partnership with *MidLink Magazine*.

In March, we presented the project at the Make It Work Conference, sponsored by AT&T and the New York City Board of Education. We were also entered in Teachers' Choice at The Well Connected Educator, and the encyclopedia Microsoft Encarta included our lesson as part of their collection.

In April, we were invited to present our project at the School Tech Expo at the New York Hilton. As part of the Web publishing workshop by Caroline McCullen, editor of *MidLink Magazine*, we shared our project with school administrators and teachers. At the School Tech Expo workshop by Robert Sibley, the educational director of ThinkQuest, we expanded the interest in our project to potential ThinkQuest participants. My students also presented their project as part of the Virtual Classroom Experience at the expo.

As our project evolves, we continue to expand our partnerships and outreach. We were the *Computer Currents Magazine* featured link of the Week on May 11, 1998 and are now part of the permanent review section on their site. We were also a featured "site of the month" on Prodigy. We anticipate an article in the fall edition of *Technology and Learning*.

As the ThinkQuest head coach, it was my responsibility to keep the ambitious project on schedule and to assist with promotion of the site. The experience has brought exposure to our school, and we will be getting four new computer labs and a T1 line at John F. Kennedy in the fall.

The students who worked on the project experienced the power of the Internet for collecting links that are pertinent to a given problem construct. As our guest book grew, the students noted how the use of that Internet-supported vehicle could serve as a multigenerational, multisector, collaborative forum. They weighed conflicting evidence, perspectives, and issues evoked by the comments in the guest book and reflected on the differing theories showcased in the project.

The students also learned how a Web site not only can be a forum for problem construct inquiry and evaluation, but also can serve as a vehicle for project dissemination. The students' responsibility to code their site so that it would be accessible to all led to their familiarity with and fluency in HTML, Java Applets, and CGI scripting. As researchers, investigators, and Web builders, they also learned the importance of scheduling, staying on track, and daily monitoring of site functions. The students became sensitive and responsive to the evolution of the project in response to the feedback from our participants through our site survey.

Steve Feld

Steve Feld is a veteran fine arts instructor who has been infusing computer graphics into the curriculum for over 25 years. He has received numerous awards, including: an Impact II Developer Grant, a Computer Learning Foundation Grand Prize, and the New York State Learning Technologies Championship for his student-created project *Da Vinci's Visions*. He has helped the International ThinkQuest team create the award-winning Web site *Learning About Leonardo* (library.advanced.org/13681). His projects have also been funded by the William T. Grant Foundation and the Bronx Superintendency. He is the author of *Computers in the Art Classroom* published by the New York City Board of Education.