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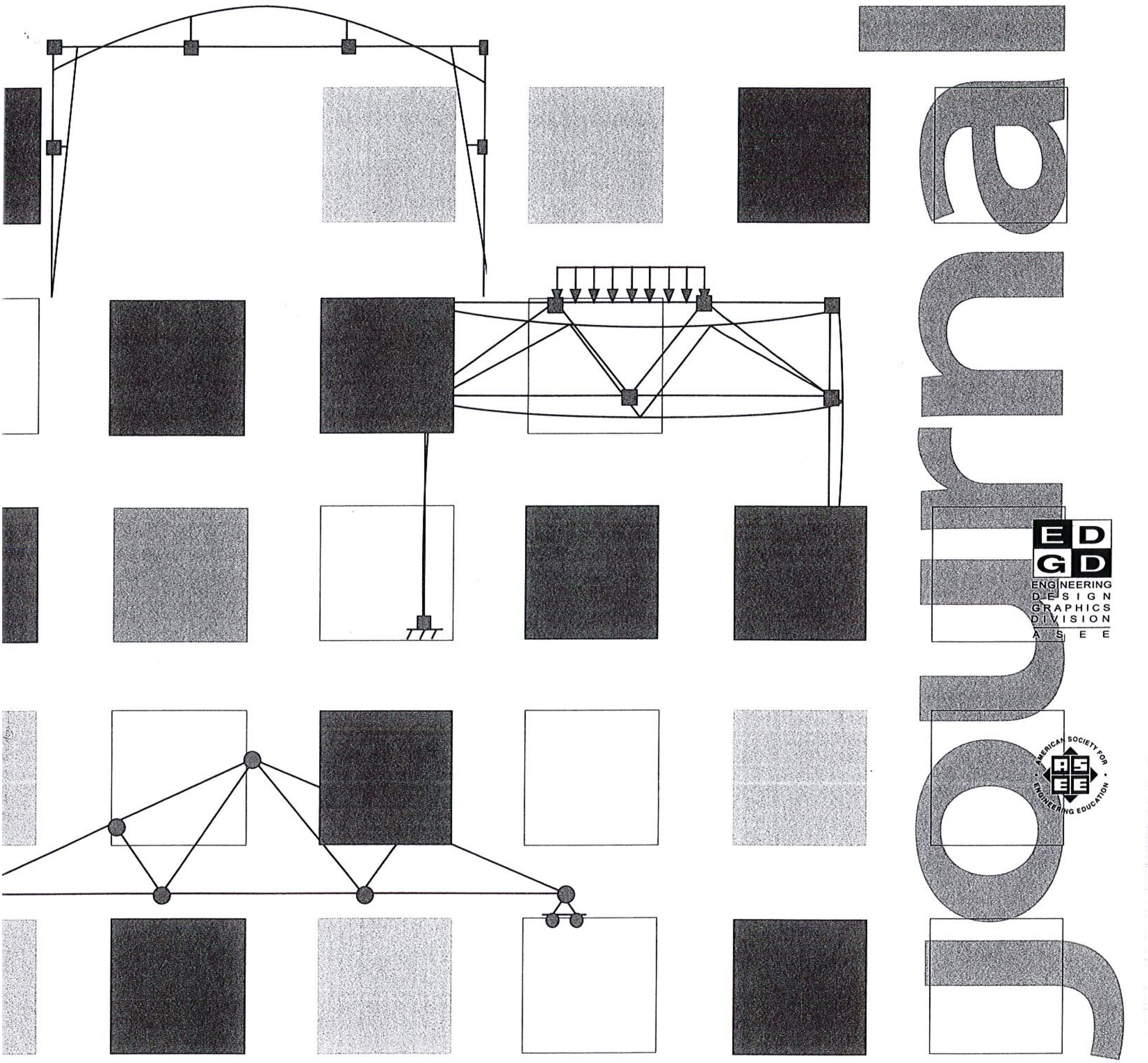
THE ENGINEERING DESIGN GRAPHICS Journal



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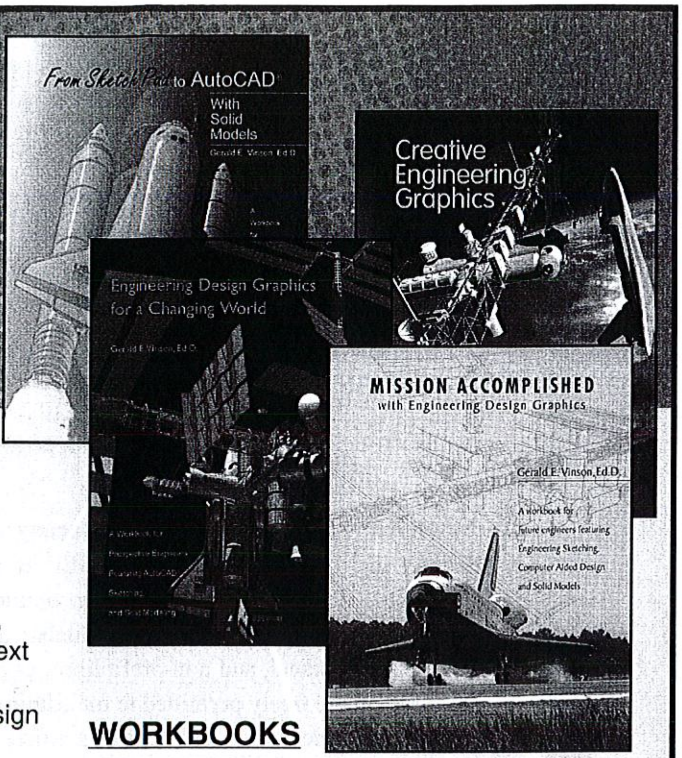

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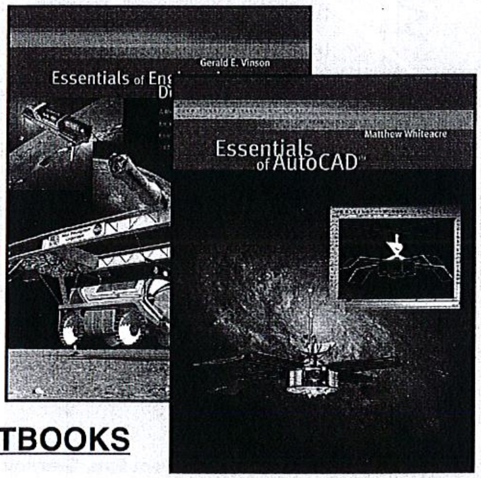

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The Engineering Design Graphics Journal is the official publication of the Engineering Design Graphics Division of ASEE. The scope of the Journal is devoted to the advancement of engineering design graphics, computer graphics, and subjects related to engineering design graphics in an effort to 1) encourage research, development, and refinement of theory and applications of engineering design graphics for understanding and practice, 2) encourage teachers of engineering design graphics to experiment with and test appropriate teaching techniques and topics to further improve the quality and modernization of instruction and courses, and 3) stimulate the preparation of articles and papers on topics of interest to the membership. Acceptance of submitted papers will depend upon the results of a review process and upon the judgement of the editors as to the importance of the papers to the membership. Papers must be written in a style appropriate for archival purposes.

Cover graphics from Sun, Gramoll paper.

ISSN 0046 - 2012

[From the Editor]

Dear Members:

Our current issue contains three articles that represent the breadth of the work being done by its membership. Through a real-life, industrial application, Morales shows how geometry, mathematics, and design all come together in a project. Just as important, it also points out the necessary skills our students need once they graduate from school. Sun and Gramoll's article demonstrates how structural analysis of trusses can be simulated over the Internet through a Web interface. This application allows engineering design activities to occur in classrooms that do not have the resources for stand-alone tools with this type of functionality. Barr, Krueger, and colleagues continue their work on defining a modern engineering design graphics curriculum. This paper demonstrates both the value of graphics in engineering education and the importance of quality assessment techniques. Finally, the Oppenheimer award winner, Dennis Lieu, provides a written version of what was an outstanding presentation at the Division's Mid-year meeting. His paper provides a counterpoint to Morales' article in demonstrating how animation can be used in more traditional mechanical engineering applications.

Congratulations goes out to one of our own, Ron Barr, who was recently elected President-elect of ASEE. The Engineering Design Graphics Division has a long history of being active in ASEE and providing leadership at the regional and national levels.

Finally, I'd like to encourage all of the membership to consider submitting articles to the Journal. The quality of the Journal is only as good as the articles submitted to it. If you don't have an manuscript right now, maybe you have a colleague who would be interested in submitting (we welcome non-members, too!). Whatever you can do to encourage submissions would be of benefit to the entire Division.

Eric N Wiebe

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Message from the Chair

Judith Birchman
Purdue University

After reading an article in *Prism* not long ago, I started thinking about the changes we have faced as educators since I first started attending EDGD meetings. When I first started teaching, we were just on the verge of using computers to teach graphics. When CADD became a part of our curriculum, the focus of papers presented at conferences began to change rapidly. Until then, we mostly debated the relevance of graphics topics, the sequence they should be covered and some helpful techniques —remember the glass cube? Since then, conference papers focused on new topics such as hardware and software issues, board versus CADD, ways to set up a computer lab and how CADD has changed teaching graphics. We then moved on to issues like 3-D modeling versus 2-D drawings. The point is, as educators, we have had to deal with many issues related to teaching beyond the core knowledge of our discipline.

Today, we face an additional challenge related to new modes of teaching. The *Prism* article I referred to—"Connecting the Dots" [December, 2003]—highlighted an online course which used shared resources from multiple authors at multiple universities. The big question today has to be —How is the web impacting the way we teach? We've already seen the move to provide course materials on the Web. Once again, we find ourselves exploring new software— software that can help us publish and maintain documents on the Web. There are new points for discussion — Should we post lectures on the Web? How does it effect class attendance? How do we handle security of our materials? How does it impact communication with our students?—that will become topics for discussions with our peers. Some faculty have already moved on to including chat rooms, question/answer queues, video lectures for distance learning and even gaming simulations for their courses. As division members share their experiences in papers, we will all benefit from the lessons they have learned as to what is effective and why. I'm excited to hear about how graphics educators are integrating these new technologies into their teaching as well as how they are coping with the changes.

The point is, as educators, we have to deal with many issues related to teaching beyond the core knowledge of our discipline.

Another article in the local paper started me thinking about our students and the world they are growing up in. The article was written by a woman in her late twenties and questioned why although practically anything can be done online these days we still can't vote online in elections. Her point was that in her world so much communication whether for business or pleasure is done conveniently using cell phones, text messaging, online accounts, chat rooms and any other number of communication options. She suggests that —"If voting were less of a cross between the SAT and going to the DMV and more like taking an online survey, it might be more appealing." [*Confronting T-shirt logic: 'Only old people vote'*, Catherine Getches for the Los Angeles Times] I have to admit I had mixed reactions to the article. Although I agree we should be striving for ways to make communication as efficient as possible I worry about the effect it is having on face-to-face communication skills. In addition to the learning curve that goes with all the new technology, we also need to consider how it is impacting the relationship between faculty and their students. Some additional questions we need to discuss and explore are—How is this technology affecting the interaction and communication with our students? How do we engage students in a world so dominated by the internet with its vast array of media – animation, multimedia, video, simulation, and games. I look forward to hearing how graphics educators are exploring these challenges and particularly how they are using new technologies to reach students in new ways without losing that face-to-face interaction which is why most of us got involved with teaching in the first place. I look forward to seeing many of you at the ASEE annual Conference in Salt Lake City and hearing your presentations about current graphics issues!

[Election Results]

2004

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Animation Production Pipeline for Matching Dissimilar Modeling, Animation, and Compositing Tools

Carlos R. Morales
Purdue University

Abstract

This paper provides a first-person account of a large-scale commercial project that required integration of dissimilar modeling, animation, and compositing tools. The author discusses the identification and solutions of production problems, as well as, the development of a custom production pipeline for the project. Specifically, a team of modelers, animators and compositors developed a production pathway based on the integration of organic NURBS and architectural polygonal models used to accurately depict the city of Chicago. The utilization of motion-capture data and the use of custom program scripts to repair NURBS defects are discussed.

Introduction

As educators we must prepare our students to perform in a marketplace that often requires them to assume a wider set of roles than in the past. It is not uncommon for graduates of engineering design programs to be asked to create technical and non-technical animations. This can be, in part, attributed to the fact that the underlying technology that drives most CAD packages is the same that drives 3D animation packages. For example, Electric Image's Universe is based on the ACIS kernel that many CAD packages such as AutoCAD are based upon. Thus, if a student knows how to visualize three-dimensional surfaces and is familiar with their manipulation in a CAD package, he/she will have the base requisite skills to be functional in an animation package.

A cursory look at the curricula offered at a sample of U.S. institutions of higher-education which address engineering design graphics, reveals that most offer animation either as a stand-alone course or as a portion of an existing course. Within the Computer Graphics Technology department at Purdue University, we offer multiple courses that address both animation and CAD. Thus, we can conclude that at least some engineering design programs have acknowledged the need to impart animation knowledge within their graduates.

To effectively prepare our students to undertake their wider roles, we must educate them on how to function in realistic environments that call on them to integrate dissimilar modeling and animation tools. It is common for companies to undertake projects that require these skills. Graduates must have the skills and experience to identify and solve integration problems, and the ability to develop customized production pipelines based on the project specifications, client's mandates, and specific software utilized.

This paper aims at presenting the type of knowledge that we must pass on to our students to be successful in such a scenario by providing a first-person account of a large-scale commercial project that required integration skills.

The Chicago Bulls Organization contracted High Voltage Software (HVS) to develop a 3D animated opening to be shown on the JumboTron at the United Center and on television before each home game. The client asked for the animation to include a series of 3D rendered bulls running from numerous places in the city toward the United Center. Along the way, the bulls would pass Chicago landmarks. Each landmark passed by the bulls was to "include enough detail so that the average Chicagoan could recognize it."

(Fiore, 1999). The total production time for the project was set at 46 days.

HVS assigned a total of six people to the project. Three would form the core production team responsible for generating all of the graphic elements that would actually comprise the final animation. The core production team was comprised of one character animator, responsible for creating all organic NURBS models; one architectural animator, responsible for creating all non-organic polygonal models; and one technical director/compositor, responsible for assembling the final renderings. The author served as the technical director. The remaining personnel formed the support staff comprised of one storyboard artist, one art director, and one project administrator.

Planning

The art director and storyboard artist concluded that the entire city should be built using 3D software. The look would be a hyper-realistic yellowish over-cast similar to what film makers call the golden hour. The bulls were to be fully textured using bitmap images. Buildings and street elements would be left untextured, and given definition though the use of creative lighting and basic color. The length of the animation was to be 32 seconds and take place over a series of 18 shots (Russell, 1999). A grayscale set of storyboards was prepared showing the sequence of the animation (Figure 1) and a set of three color still images to depict the look and feel of the animation (Figure 2). Combined these two documents would serve as an objective reference to which the production team could look to for guidance.

The client signed off on the contract based on the storyboards and color stills. The art storyboards functioned to give the client an idea of the look and feel envisioned by the production team and the sequential stills served to communicate the timing and locations for the events in the animation. The client could see the textured NURBS bull composited against the polygonal architecture of the city, helping sell the project.

Production

Figure 1. Sequential storyboards

Figure 2. Sequential still frames

While the art director and storyboard artist finalized the vision for the animation, the production staff worked on establishing a production pathway to meet the project needs. In the course of producing the sample scene, the production team would select software and hardware that could deliver the look established by the storyboards, test new techniques, and start to create the production models. In short, the production of the sample scene would serve to establish the milestone schedule, map out the production pipeline, and also secure the final approval from the client to start production.

To maximize production time while maintaining creative control, the production team decided to render all scenes in multiple passes. Individual elements would be created in the package of choice by the expert in his/her respective area and composited together by the technical director. This approach would allow all of the members of the team to use the software most appropriate for the task.

The character animator decided that only a high-end NURBS based animation package with support for expressions would be appropriate. SoftImage 3D Extreme™ was selected (Jeffrey, 1999). The architectural animator determined that a polygonal based package such as LightWave 3D would allow Chicago to be modeled, textured, and animated much faster than using SoftImage (Schutlz, 1999). The technical director decided that After Effects Production Bundle™ would be used for compositing. Organic models would be built and animated in SoftImage 3D, inorganic models in LightWave 3D, and everything put together in After Effects.

Once team members selected the tools they would be using for completing the sample scene, they focused their attention on making the necessary preparation to ensure a successful composite. To enable the production team to composite organic elements rendered in SoftImage with inorganic elements rendered in LightWave 3D, all of the objects in a scene would have to exist in both SoftImage and in LightWave at the same scale. Second, a texture that would receive and cast shadows, but not render would have to be developed. This would allow the bulls rendered in SoftImage to cast shadows on the streets and sidewalks rendered in LightWave. Finally, the movement of the camera and any lights would have to match exactly in both scenes.

Model Preparation

While the team exercised creative freedom in several aspects of production, they felt it was important to model the selected locations for the animation as accurately as possible. The team visited each of the selected locations, took photographs, and gathered architectural plans. All architectural features were built in LightWave using these documents as a guide. To create a sense of power and strength for the bull, its scale was changed to approximately four times the size of a real bull. The modeling of the bull proceeded rapidly using standard NURBS modeling techniques. The bull was modeled in SoftImage using primarily loft surfaces and proportional modeling. Construction history and the "select by U/V" made it possible to make small changes to the model effortlessly (Jeffrey, 1999). The character animator finished the basic model of the bull in three days.

To prepare the model of the bull for animation, an Inverse Kinematics (IK) skeleton was built and assigned to an automatic global envelope. The weights of the generated envelope were then edited manually and nulls added to the end effector of the IK chains. With the body of the bull set up for IK animation, it was time to prepare the head of the bull for shape or morph target based animation.

The head of the bull was replicated multiple times and modeled to reflect different facial expressions. Each instance of the bull's head was then assigned to a null object that would control how much of that instance would be reflected in the original head. SoftImage's expressions and channel drivers were used to connect the null to the influence of the individual shapes on the target bull head. This made it possible to animate the bull's face by just moving the null objects (Jeffrey, 1999). Finally, textures for the bull's skin were generated using Metacreations Detailer and Adobe Photoshop and applied as a UV map. Figure 3 shows the final bull model with textures applied. The entire process, including modeling, texturing, and enveloping the bull took approximately one week. When tessellated for rendering the bull weighed in at approximately two million polygons.

Figure 3 Bull Model

Models of the city streets were created using LightWave's standard polygonal tool set. Photographs gathered by the project administrator were used as a guide in modeling the street elements. The Bloom and Gaffer plug-ins were then used to give the buildings the look designated in the storyboards. It took approximately 1.5 days to set up the street scene (Schultz, 1999).

To allow for proper shadow interaction between the SoftImage and LightWave objects, a DXF model was made of a bull modeled in SoftImage. The bull was imported in LightWave and assigned the "unseen by camera" shader, which allows an object to cast a shadow onto the scene without appearing in the final render [4]. The net effect was that by placing the dummy DXF bull object in the same position to where the bull would be rendered in SoftImage, it was possible to properly cast a shadow onto the LightWave background plate without showing the dummy bull. The same was accomplished in SoftImage by importing a dummy DXF version of the street under the bull and assigning it a "shadow object" shader (SoftImage, 1998). This arrangement resulted in four unique layers rendered from the two packages (Table 1).

One of the most significant problems encountered by the team was that surfaces created in SoftImage would experience tears

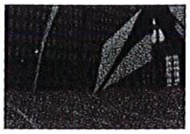
Layer	Software	Example	Layer	Software	Example
Foreground	LW3D		Bull Shadows	SI 3D	
Bulls	SI 3D		Background & Foreground	LW3D	

Table 1 Rendered layers

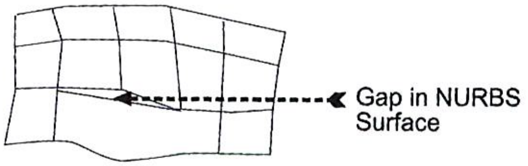


Figure 4 Geometric Tear

at places where there was a non-uniform subdivision of patches. Figure 4 shows a typical tear in SoftImage.

To correct this problem the author wrote a script, which repaired the gaps after the NURBS model had been tessellated, by taking the directional derivative at points on the mesh adjacent to the gap and adjusting them until the rate of change across the gaps was continuous.

$$D_u = \frac{\partial f}{\partial x} u_1 + \frac{\partial f}{\partial y} u_2 + \frac{\partial f}{\partial z} u_3$$

Another problem in the production pipeline was figuring out how to match camera movements in SoftImage to camera movements in LightWave. Commercial conversion utilities tried by the team transferred geometry, but not animation data (PolyTrans, 2003).

The team solved the problem by writing a program that converted LightWave's proprietary motion capture format to Biovision BVA, which could be imported by SoftImage. The LightWave motion data file differed from BVA in formatting and the orientation of the z-axis. Tables 2 and 3 show sample Lightwave and BVA motion capture files.

```
0.0225 0.12 -1.0837 0 0 0 1 1 1
0.0232557 0.117897 -1.0526 0 0  1 1 1
0.024022 0.115758 -1.02118 0 0 0 1 1 1
```

Table 2 Lightwave motion dump

Rendering

With the 3D elements matched, the production team was able to focus on rendering. SoftImage elements would be rendered using the Mental Ray renderer and LightWave elements using LightWave's internal renderer. The technical director decided to field render all elements for smoother motion at a resolution of 720 pixels by 486 pixel at D1 aspect ratio. Initial tests proved that while the field dominance could be set for SoftImage and LightWave, the method that both programs use to calculate field motion was incompatible. SoftImage rendered its fields to separate files and compressed the vertical size of the images to only constrain the information for that field (Softimage, 1998). This generated images that were half the height of the corresponding LightWave pictures. LightWave interlaced its fields into one file (Newtek, 2003). The technical director decided that it would be best to render the scene at 60 frames per second and then conform it to 29.97 frames per second with the appropriate field dominance during compositing.

After rendering the 3D elements of the test scene, the production team directed its attention to compositing. The 3D elements had been completed in four days, including building the scene elements, matching the camera, and rendering the scene. The produc-

```
Segment:  TEST
Frames:   3
Frame Time: 0.033333
XTRAN YTRAN ZTRAN XROT   YROT   ZROT   XSCALEYSCALEZSCALE
INCHES INCHES INCHES DEGREES        DEGREES        DEGREES

0.0225        0.12          01.0837       0      0      0      1      1      1
0.0232557     0.117897      01.0526       0      0      0      1      1      1
0.024022      0.115758      01.02118      0      0      0      1      1      1
0.0247978     0.113586      00.989462     0      0      0      1      1      1
```

Table 3 Biovision motion dump

tion team could use this figure as a guideline for how long the 3D portion of each scene would take to complete. Before benchmarks could be set for the entire process and the production pipeline could be finalized, the individual layers would have to be composited successfully.

Compositing and Editing

The integration of the discreet 3D rendered layers was accomplished by using Adobe After Effects Production Bundle. The process consisted of interlacing the frames, color correcting the layers, masking and keying out the shadow areas, and finally applying camera shake. The main premise of the compositing phase was to put everything together while keeping all image files uncompressed.

The first step was to conform the frames to 29.97 frames per second to adhere to the NTSC standard. This was accomplished via the After Effect interpret footage option (After Effects, 1998). With the footage properly interlaced, the technical director concentrated on color correcting the layers and adding effects. The materials rendered with Mental Ray had a different gamma than those rendered in LightWave. After Effects levels were used to match the color qualities of the renders. The bull's shadow layer was added by keying the non-shadow elements in the layer via a chroma-key and softened via a gaussian blur. The layer with the bulls was then given motion blur. The entire composition was nested into a second composition where camera motion could be added via the wiggler plug-in to simulate the weight of the bulls as they ran past the camera. The composition was output as an uncompressed QuickTime movie file at 720 pixels by 486 pixels at D1 aspect ratio lower field dominant. The composited animation was then output as MJPEG to BetaCam SP for delivery to the client. Figure 5 shows the composite of the layers shown in Table 1.

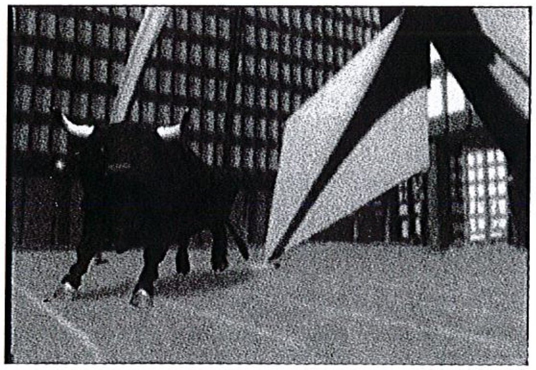


Figure 5 Composite Frame

The successful completion of the test scene finalized the production pathway for the rest of the project. Through the completion of the scene, the team had derived a production methodology which each team member could use a guiding reference for determining individual responsibilities. Not only had the team formed a procedural plan that dictated the order for the completion of the task by the team members, but they also generated a time schedule, that could be used to orchestrate the rest of the production (see Table 4). This made it possible for the team to use an assembly line approach in completing the project, and to accurately parcel out the time devoted to each task. Compensating for tasks that would not have to be replicated for each scene, such as writing the SIL application or building the bull model, the team estimated that it would take approximately five days to complete a single scene. The only unaccounted event was the final edit, because it could not be completed until all of the scenes had been composited.

Conclusion

By relying on multi-pass rendering, the HVS production team was able to exploit the best qualities offered by SoftImage and LightWave in the production of the Bulls animated opening. By concentrating on using the tools best for each task and then relying on compositing to integrate the results into a finished animation, the production team was able to bring the vision depicted on the storyboard to the screen.

The production model employed by the HVS production team identified two issues. First, the selection of the two 3D animation packages employed by the animators in this project had to be considered. The character animator selected SoftImage 3D Extreme. The architectural animator elected to use LightWave 3D. Choices were made not because of a limited budget or limited resources, but instead based on which software could best deliver organic form required of the character animator or inorganic elements needed by the architectural animator.

Second, the reliance on composting and the implications for the production pipeline employed by the team must be considered. Each scene contains elements completed by all members of the team. Each scene has bulls completed by the character animator, street elements by the architectural animator, and effects composited by the technical director. This level of interdependence of scene elements necessitated an exact production pipeline. The 3D animators had to exchange camera positions before they could animate their scenes. The character animator needed DXF versions of the street elements produced by the architectural animator before shadow layers could be rendered. The technical director could not composite anything until all of the layers had been properly rendered. It was imperative that all production members follow the production model developed while producing the test scene. If any of the steps in the pipeline model were skipped or not followed in order by any of the production members, the scenes would not composite correctly.

As educators, we must provide our students with the skills to be successful in scenarios like the one encountered in the realization of this project.

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Internet-based Simulation and Virtual World for Engineering Education

Qiuli Sun, Kurt Gramoll
The University of Oklahoma

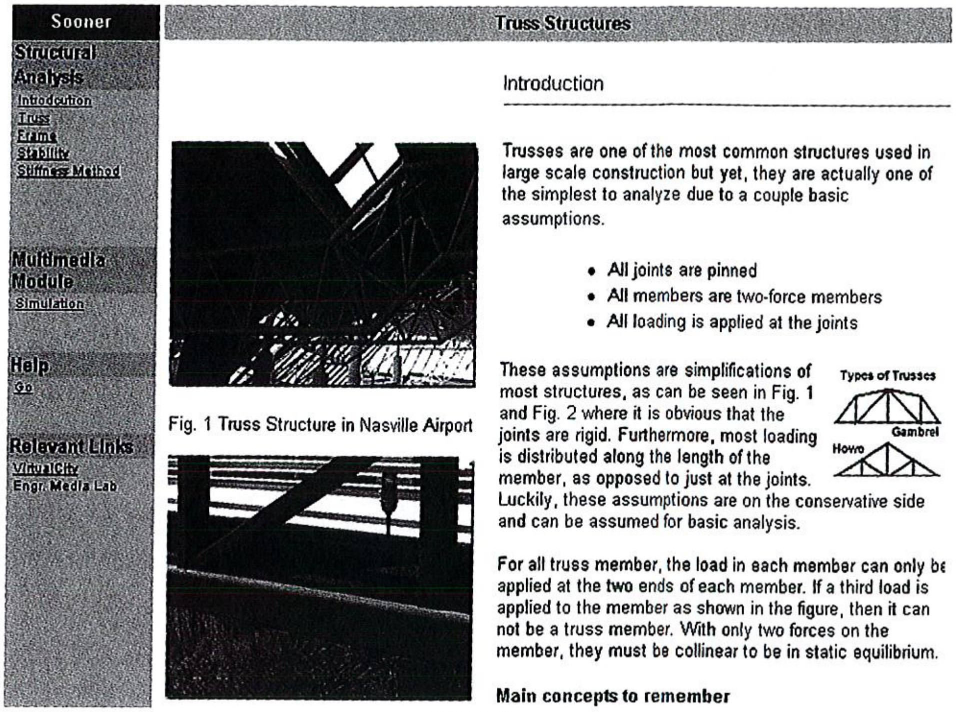
Abstract

In this paper the use of an Internet-based structural simulation and a 3D virtual world to view structures for engineering education was investigated. The generic truss and frame structural simulation allows the user to construct a truss or frame structure, apply boundary conditions, and place forces to any joint over the Internet. The computational results are also visually presented. For trusses, both the displacement and member loads are displayed. Different colors are used to demonstrate the load level in each member. For frame structures, moment, shear and axial diagrams are constructed in addition to deflection curves. Finite element method is used to compute all results. Vector-based graphics are used for structure development and results presentation to reduce file size and downloading times. In addition to any general trusses or frames, a special case study of bridge construction was included in the simulation. The user can draw the bridge, analyze it, and animate a typical moving vehicle over the bridge. The user can also deposit the bridge into an Internet-based 3D virtual world, which provides a 'big picture' of the bridge. Assessment was conducted to determine the effectiveness of the simulation. The results showed that the simulation was helpful in visualizing the computational results and reinforcing the understanding of the concepts of the truss and frame structures. To develop the simulation and the virtual world, Shockwave, VRML, ASP, SQL, and Perl were utilized together and programmed so that they communicate smoothly with each other. The simulation and 3D virtual world is open to the public at www.vcity.ou.edu. The structural analysis simulation is just one component at this virtual world design web-portal.

Introduction

As student populations increase, universities face the challenge of maintaining high standards and effective education (Lacy, 2000). This is particularly true in the resource-intensive engineering field. Also, in industry, as technological innovations are rapidly taking place, engineers and technicians must always continue to learn and master new technologies. Hence, efficient and inexpensive methods must be found to complement traditional education and training. One solution is to employ the Internet with its advantages of low cost, convenience and collaboration. With the help of the Internet, new approaches, such as Internet-based simulations and virtual worlds, can be adopted to help teach engineering concepts.

In order to make use of the Internet's unique features for education, a project called Sooner City was initiated at the University of Oklahoma in 1998 (Sun & Gramoll, 1999). A Virtual City framework was proposed to investigate the Internet-based environment for engineering education, design, and analysis (Sun & Gramoll, 2001). The framework adopts a three-tier architecture: an online database, a Web sever, and client browsers. The Virtual City is composed of five components: a 3D virtual world, multiple multimedia modules, an online database, a collaborative geometric modeling module, and a collaborative engineering analysis module. To illustrate the use of the Internet for education, this paper presents the structural analysis module and the 3D virtual world in detail. The structural analysis module and virtual world are examples that can serve as prototypes for Internet-based engineering education. There are also other modules at the web site, in addition to the structural analysis



Introduction

Trusses are one of the most common structures used in large scale construction but yet, they are actually one of the simplest to analyze due to a couple basic assumptions.

- All joints are pinned
- All members are two-force members
- All loading is applied at the joints

Fig. 1 Truss Structure in Nasville Airport

These assumptions are simplifications of most structures, as can be seen in Fig. 1 and Fig. 2 where it is obvious that the joints are rigid. Furthermore, most loading is distributed along the length of the member, as opposed to just at the joints. Luckily, these assumptions are on the conservative side and can be assumed for basic analysis.

For all truss member, the load in each member can only be applied at the two ends of each member. If a third load is applied to the member as shown in the figure, then it can not be a truss member. With only two forces on the member, they must be collinear to be in static equilibrium.

Main concepts to remember

Figure 1

module, that tie other aspects of undergraduate civil engineering courses together into the virtual world.

There are other examples of Internet-based simulations to assist engineering students in learning basic principals. Included is "Mallard" which was developed by Mike Swafford and Donna Brown at the University of Illinois at Urbana-Champaign (Graham & Trick, 1998). Two interactive Web-based applications called Virtual FlyLab and Virtual Earthquake were developed for learning science (Desharnais & Novak, 1998). An innovative use of Internet technologies for education is to employ Virtual Reality Modeling Language (VRML) to teach design over the Internet. Ranga and Gramoll successfully implemented two Internet-based design examples with the help of Practical Extraction and Reporting Language (Perl) (Ranga & Gramoll, 1999). Peterson utilized VRML and Java in teaching machine kinematics (Peterson, 1997). Shockwave is also a widely used Internet technology to design simulations. A number of Shockwave simulations have been developed to teach specific engineering topics (Sun & Grammol, 1999, 2000). Multiverse is another example providing a standard interface for various Internet-based simulations (Austin & Liddle, 1998; Thomas & Liddle, 1998) that facilitate the use of Internet-based simulation in education and training by employing Java and Web technologies.

Although educational activities over the Internet are diverse and Internet-based education is maturing, it is interesting to note that in the course of this project, no existing educational program was found to have implemented 3D visualization and generic simulations with flexible graphic input. Therefore, one of the goals of this project is to present an Internet-based prototype virtual world for 3D visualization. Because it is always difficult to provide the user with intuitive graphic input to simulations, the possibility of developing such a simulation was investigated in this project. Also, the concept of displaying 3D objects on the Internet and dynamically changing them for engineering education was demonstrated in this project.

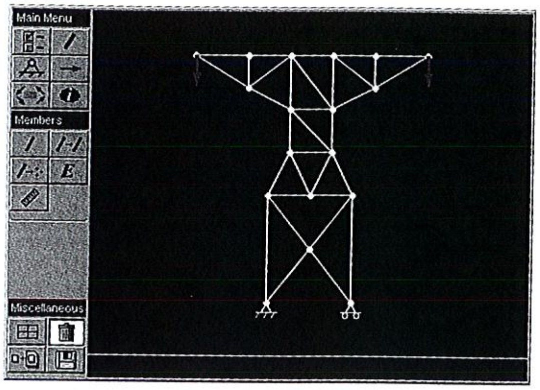
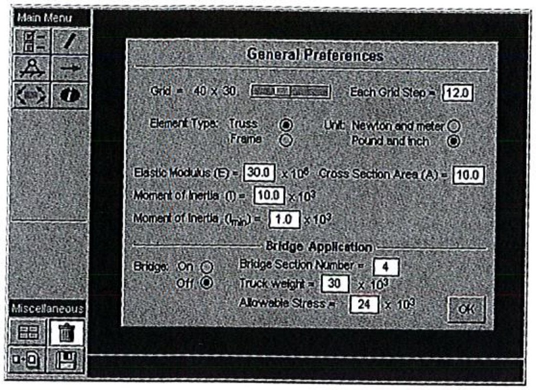


Figure 2



General Preferences

Grid = 40 X 30 Each Grid Step = 12.0

Element Type: Truss ● Frame ○

Unit: Newton and meter ○ Pound and inch ●

Elastic Modulus (E) = 30.0 x 10^6 Cross Section Area (A) = 10.0

Moment of Inertia (I) = 10.0 x 10^3

Moment of Inertia (I_{min}) = 1.0 x 10^3

Bridge Application

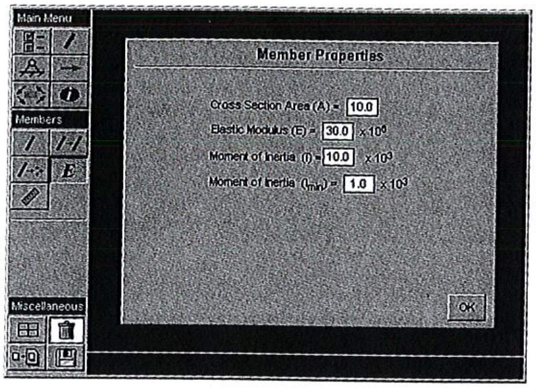
Bridge: On ○ Off ●

Bridge Section Number = 4

Truck weight = 30 x 10^3

Allowable Stress = 24 x 10^3

Figure 3a



Member Properties

Cross Section Area (A) = 10.0

Elastic Modulus (E) = 30.0 x 10^6

Moment of Inertia (I) = 10.0 x 10^3

Moment of Inertia (I_{min}) = 1.0 x 10^3

Figure 3b

Structural Analysis Module

In the Virtual City framework, there are nine multimedia modules developed for engineering education. In this paper, only the structural analysis module, designed for the Structural Analysis course at the University of Oklahoma, is presented. Its main purpose was to provide a generic solver for plane truss and frame problems. It is important for a structural designer to learn how to compute the forces and displacements of truss structures and how to compute the deflections, moments, shears and axial forces of frame structures. Although complex commercial finite element codes can be used, they are usually not readily available to students and have a steep learning curve. Thus it is particularly useful to provide a convenient solver that can be used to check the computational results of trusses and frames.

The online structural analysis module contains two sections: an information section (Fig. 1), and a simulation section (Fig. 2). The information section covers basic concepts for four topic areas that include trusses, frames, stability, and the stiffness method. This section is to give the student background information about trusses and frames.

The second section is the actual simulation that includes a help page. The simulation was programmed using Macromedia's Director that can be saved as an Internet-based Shockwave file. The actual scripting or programming language in Director that was used is called Lingo. The simulation is basically a finite element method (FEM) solver for trusses and frames. Although it is easy to obtain the code of the computational procedures of FEM, programming FEM in Lingo was challenging since it is actually a scripting language that is not suited for matrix operations.

In addition to the actual FEM solver, the other main challenge to programming the simulation was the graphical input and output. It was important to design the interface so that any engineering student could easily understand how to operate the program without the need of a reference manual or keeping track of node and element numbers. The purpose of the simulation was to help the student understand trusses and frames, and not FEM. Also, to minimize file size, all input and resulting graphics were based on vectors and not pixel-based graphics. Vector-based graphics can be completely controlled by Lingo, therefore it is particularly efficient to

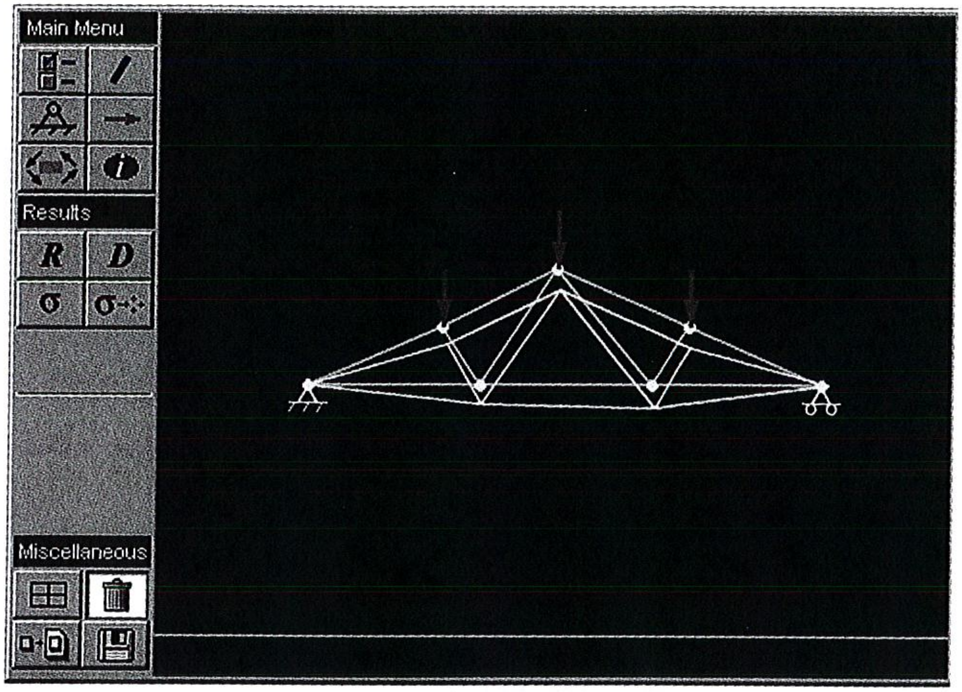


Figure 4

create, move, and delete the graphics dynamically. Using vector-based graphics minimizes the simulation's file size to about the size of a large graphic file.

Basically, two types of structures can be solved using the simulation of this module — truss structures and frame structures. For truss structures, the user can draw any kind of valid truss structure, apply boundary conditions such as pinned joints and roller joints, and specify the forces to any node of the truss. Because each truss member is considered internally as an element, the user can draw only one member at a time. Only point forces can be applied to the node. The maximum number of total members is 85. The maximum number of joints is 13 for each type of joint. The maximum number of forces is 20 for each type of force. The simulation therefore cannot be used to solve large truss problems.

There are two ways to specify detail input information: the preference window and the member property window. Figure 3a illustrates the preference window of the simulation. In the preference window, the user can specify appropriate grid step ratio of the grid system to map real-world dimensions. The lengths of the members are determined implicitly based on the grid system. Default values for material and member geometric properties are also set in the preference window. The user can also give material and geometric properties to individual members (Fig. 3b) by double clicking individual members.

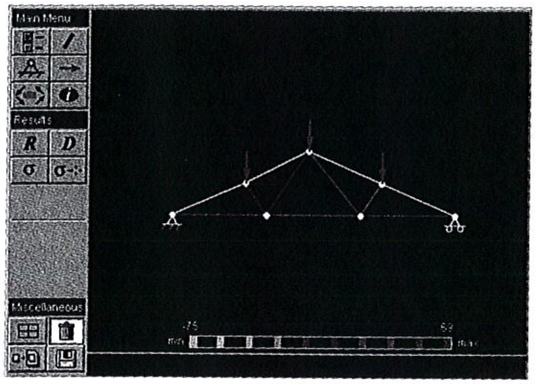


Figure 5

The results for truss structures are presented in four ways: summary of results, report of individual members, displacement visualization (Fig. 4), and load visualization (Fig. 5). In the summary of results, the values of

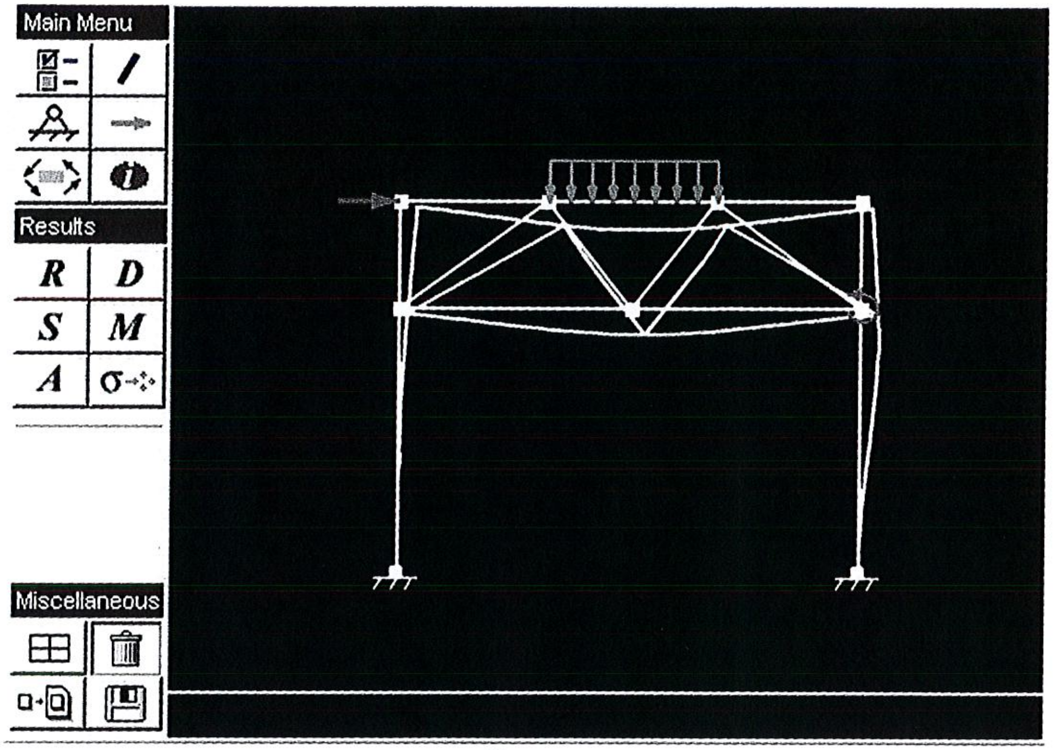


Figure 6

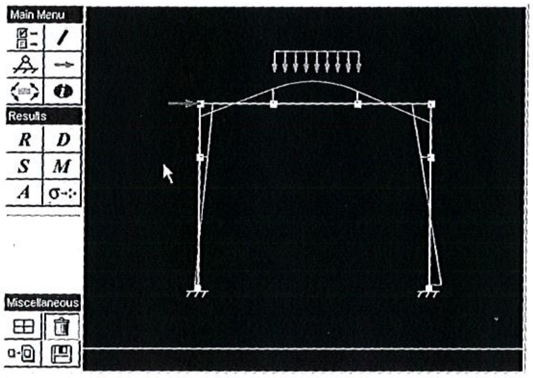
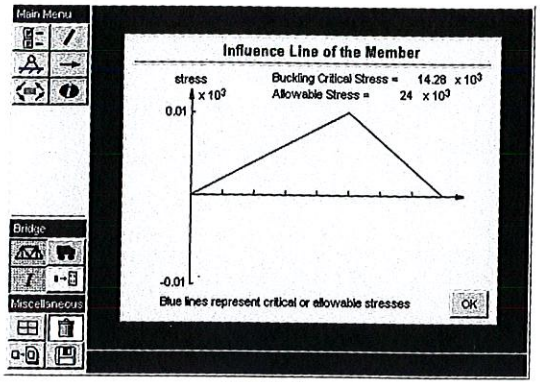


Figure 7

the maximum displacement and maximum stress are reported. If an individual member is double-clicked, its displacements and stress can be accessed. Also, the stability of each member is checked and reported based on the basic Euler equation. To demonstrate the relative difference of the displacement, a new truss structure with node movement based on the displacements is drawn. The color is utilized to show the loads in each member.

In addition to truss structures, the user can draw any type of frame structure. The number of members, joints, and forces are limited, similar to the truss structures. Point forces, moment, and distributed loads in x direction and y direction can be applied to the frame. By double-clicking the forces, the user can change their magnitudes. Similarly, the simulation reports a summary of the computational results, such as maximum displacement of nodes, maximum moment of nodes, and maximum axial force of members. Each member's deflection (Fig. 6), moment diagram (Fig. 7), shear diagram, axial force diagram can be visually presented.

The structural simulation is a generic application, and can be used to help develop various specific applications. One particular application, a bridge with a moving load, was a specific case that was programmed into the simulation due to its unique output needs. After the user chooses the bridge option, the number of the sections in the preference window can be specified. Then the user needs to add the actual truss members between the two end points of the bridge. A moving load, which simulates a vehicle, is applied to the



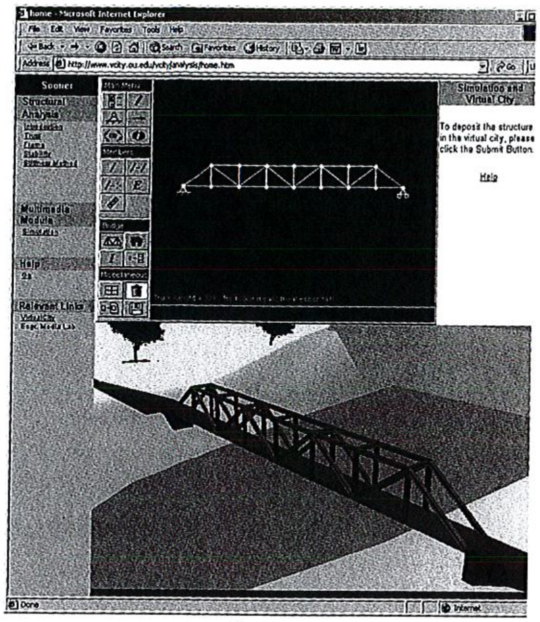
Blue lines represent critical or allowable stresses

Figure 8

bridge and the program calculates and records the member loads as the vehicle moves across the bridge. From this information, an influence line is drawn for any selected member (Fig. 8). In addition, an animation is developed to show the displacements of each node when the vehicle is moving.

A 3D virtual world, which is an Internet-based city built by the use of various multimedia modules, is used to provide a 'big picture' of the bridge (Fig. 9). The user can draw a 2D bridge in the simulation and then generate a 3D bridge by depositing it in the virtual world. More discussions about the virtual world can be found in the next section.

There are a number of attractive features for the web-based simulation. First, the simulation is completely Internet-based which allow easy access to any user. Second, the user can define the truss and frame structures by simply drawing individual members, which is an intuitive and convenient approach. Third, the computational results are visually demonstrated. For truss structures, the solved truss structures are drawn to display the displacement at each node. For frame structures, deflected frame structures are generated to represent the deflection of each member, which is usually difficult to draw by hand. Moment and shear diagrams for each member are also drawn for the frame structure, which are simple in concept but tedious to draw. Fourth, a complex bridge can be designed using this simulation and then deposited into the virtual world.



To deposit the structure in the virtual city, please click the Submit Button.

Figure 9

Fifth, the structure, as well as the forces and boundary conditions, can be saved on the server and retrieved later. Last, the simulation can help students design simple truss and frame structures with analytical results.

Virtual World

After a truss simulation is complete, it can be placed into a 3D virtual world or city and viewed on the Internet. This is demonstrated in Figure 9. The 3D virtual world provides an excellent way to tie various components from each simulation together. The truss/frame simulation program is only one of nine such simulations in the system and each simulation will help design a different component of the virtual city. The virtual world concept links together the online database, the multimedia modules, and collaborative engineering design modules, together into one system. The concept of using an online virtual world to visualize the simulation results is currently unique in engineering education and is one of the main reasons this project was started. By organizing multiple simulations together into a single world allows the user to better understand the overall design concepts of each component as it fits into the "big picture"

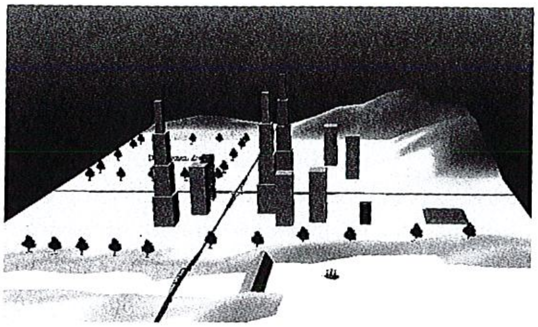


Figure 10

(Fig. 10). Also, since it is Internet-based, it can be accessed by any student from any location with real-time collaboration.

The 3D virtual world was designed using VRML with the help of Perl, Active Service Page (ASP), Structured Query Language (SQL), and an online database (Fig. 11). These Internet technologies work together to generate 3D visual structures on the web page in real time. The steps to generate 3D structures are as follows. First, a Shockwave simulation is used to help design and prepare the data for a particular design. For example, designing a bridge requires data that includes section numbers, node positions, and the layout of the bridge. Second, the data is transmitted from the simulation to the server. The server then starts a Perl program to take the data and generates a VRML format file of the structure. Since the simulation forces the virtual world to be updated simultaneously, the structure can be seen immediately. Third, the user can modify the structure by re-submitting new data. For instance, if the user dislikes the layout of the generated bridge they can modify the previous bridge by adding, deleting, or moving trusses and resubmitting it to the server.

In addition to using Perl to create individual structures, the entire virtual world is dynamically generated and managed by an ASP script with the help of SQL statements that access the online database. The virtual world is a customized world belonging to individual users. It is inefficient and inconvenient to save multiple copies of the virtual worlds. One solution is to save only the customized parts of the virtual worlds and utilize a creative strategy to manage them. This strategy employs an ASP script to accept the user's account data as input. Based on the input data,

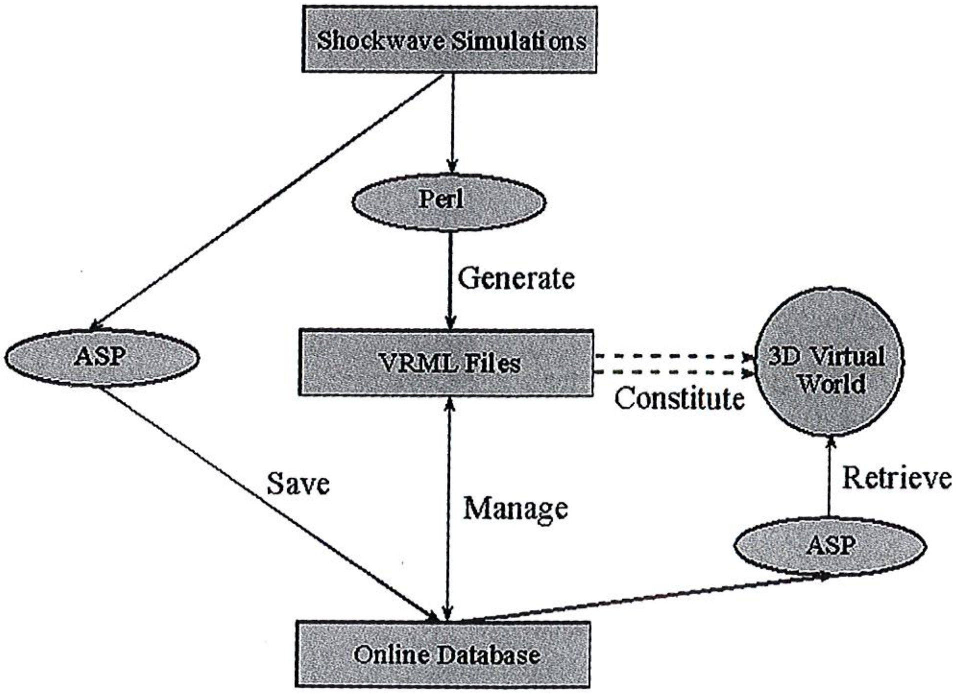


Figure 11

Questions and Results about Structural Analysis Module					
Questions	Useless	Not so good	Good	Excellent	No Opinion
1. How good is this module at helping you understand the concepts of frame or truss structures?	0	1	7	3	1
2. How good is this module at helping you better visualize the computational results of frames or trusses such as the moment diagram and deflection?	0	0	7	5	0
3. How good is the module at helping you check homework solutions?	1	2	5	3	1
4. How good is the module at encouraging you to design new truss or frame structures?	0	0	5	2	5
5. How good is the Virtual City at helping you visualize 3D models?	0	0	5	1	6

The total number of students that responded was 12.

Table 1

the ASP script then searches the database to retrieve virtual structures associated with that particular user and dynamically generates the virtual world. Also, it is easy to set different default viewpoints for different simulations. The strategy is efficient because it does not save redundant data and can be used to manage a large number of users.

Assessment

Since the structural analysis module was developed for engineering education, it is important to evaluate its effectiveness. An assessment was therefore conducted at the University of Oklahoma in the fall of 2000. The professor first demonstrated in class how the module could be used to solve frame problems, and two homework problems were then assigned. The students were offered five bonus points for using the structural analysis module to check their homework solutions.

The survey questions and their corresponding results are shown in the Table 1. Twelve students in all responded to the survey. Table 2 summarizes the means and standard deviation performed on the student responses to the questions about the module.

From the responses to questions one and two, it was concluded that the module was successful in helping students better visualize the computational results and understand the concepts of truss and frame structures. Based on the responses to question three, it was concluded that the students believed that the module was useful in checking homework solutions. The responses to questions four and five indicated that the module encouraged students to design new structures outside of the assigned homework and helped visualize 3D models. However, it is interesting to note that half of the respondents had no opinion in response to question five. This probably means that they did not try to design a bridge and deposit it into the 3D virtual world.

In addition to answering survey questions, these twelve students also provided useful comments about the structural analysis module. Examples of positive comments are, "If I would have learned to use this (module) earlier in this semester I think it would have helped me tremendously" and "The graphics and bending demonstrations and shear and moment diagram are great." Major complaints

Mean and Standard Deviation about the Responses on the Structural Analysis Module		
Questions	**Mean**	**Standard Deviation**
1	2.0*	0.85
2	1.58	0.51
3	2.41	1.31
4	2.23	0.75
5	2.41	0.66

* *The mean based on the following scale:*
1 = excellent, 2 = good, 3 = no opinion,
4 = not so good, 5 = useless.

Table 2

were that user interface was not user-friendly and that it was easy to forget to maintain consistency among all units.

Conclusion

In summary, the use of an Internet-based structural simulation and a 3D virtual world for engineering education was investigated in this paper. The user can employ the structural simulation to define the truss and frame problems intuitively and obtain visual results. The 3D virtual world provides the user a 'big picture' of the design components created by the use of different simulations. The assessment showed that the structural simulation helped the user to visualize the results and better understood the concepts of the truss and frame structures.

Acknowledgement

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Assessing Student Outcomes in an Engineering Design and Graphics Course

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Abstract

The Mechanical Engineering Department at the University of Texas at Austin has embarked on systemic educational reform throughout the curriculum. Called PROCEED, for Project-Centered Education, this curriculum reform is an attempt to bring real-world projects into the classroom that underscore the need to learn fundamental principles while adding excitement and relevance to the experience. The "Engineering Design and Graphics" course at the University of Texas is an integral part of PROCEED. This freshman course emphasizes the development of a 3-D geometric computer model and application of this digital database to all phases of the design process. The students make freehand sketches, build computer models, mate assemblies of parts, perform various analyses, create kinematics simulations, build rapid prototypes, and generate final design drawings. An assessment of student outcomes in the course was conducted in the Fall 2002 semester using a series of self-reported learning surveys. This paper depicts examples of class work that support these graphics learning activities and presents the results of these preliminary surveys, which universally showed a positive learning trend in the course.

Introduction

The freshman "Engineering Design and Graphics" course at the University of Texas at Austin continues to evolve from its inception many decades ago. In its early days, and up until about 1985, the course was primarily a drafting course that taught engineering students how to make manual board drawings and how to solve spatial geometry problems. The advent of affordable desktop computers ushered in a short-lived era of "electronic" drafting. In the 1990's, the Engineering Graphics program at the University of Texas at Austin received a series of NSF education grants (Barr & Juricic, 1990; Juricic & Barr, 1996; Juricic & Barr, 1997) to develop a new graphics curriculum based on 3-D solid modeling principles. It was in this era that the core element of the course changed from making an orthographic drawing to building a 3-D computer model. This recent era also slowly unveiled the important applications of the 3-D model to engineering analysis, manufacturing, and downstream documentation. Low-cost analysis, simulation, and rapid prototyping software and hardware systems are now becoming available for educational purposes, and the power of this latest design paradigm is now being realized by the engineering design and graphics education community(Wiebe, 1999; Ault, 1999; Cole, 1999; Tennyson & Krueger, 2001; Newcomber, McKell, Raudebaugh, & Kelley, 2001).

Project PROCEED

An engineering student project is an exercise that usually requires integrating several tasks to achieve a defined goal. It can be an individual project or a team project, or even some form of both. The Mechanical Engineering Department at the University of Texas at Austin has embarked on systemic educational reform throughout the ME curriculum. Called PROCEED, for Project-Centered Education, this curriculum reform is an attempt to bring real-world projects into the classroom that underscore the need to learn fundamental principles while adding excitement and relevance to the experience. One important aspect of PROCEED is garnering support from industrial partners who supply project ideas and personnel for

Engineering Design and Graphics Curriculum Modularization Scheme

Module	Activities and Learning Outcomes
1	**Computer Sketching I:** Set up the sketch plane units and grid parameters; demonstrate all 2-D sketching primitives; demonstrate all line editing features; make simple extrusions and revolutions to get 3-D geometry. Print hardcopies of 2-D sketches and simple parts for submission.
2	**Computer Sketching II:** Demonstrate the creation and editing of dimensions; set geometric constraints; make simple extrusions and revolutions to get 3-D geometry. Print hardcopies of 2-D sketches and simple parts for submission.
3	**Solid Modeling of Parts I:** Create 3-D extrusions and revolutions of individual parts; use some basic sweep operations; edit the geometry in 3-D; render the parts. Print color hardcopies for submission.
4	**Solid Modeling of Parts II:** Create 3-D parts; add feature-based, parametric design features; use advanced sweep operations; edit the geometry in 3-D; render the parts. Print color hardcopies for submission.
5	**Assembly Modeling and Mating:** Create individual 3-D parts; assemble parts as a mechanical assembly; mate features as appropriate; check for clearance and interference of parts; create color rendering of assembly. Print color hardcopy of the rendered assembly for submission.
6	**Analysis and Design Modification I:** Create individual 3-D parts; perform mass properties analysis; generate a mass properties report; modify the design and compare mass properties before and after modification. Create a design table spreadsheet; make multiple design configurations using the design table. Print color hardcopies of the various designs for submission.
7	**Analysis and Design Modification II:** Create individual 3-D parts; perform a Finite Element Analysis (FEA) study: set up applied forces, fix constraints, perform meshing, display color stress contours, visualize and interpret results. Propose design modifications. Print a color hardcopy of the FEA results for submission.
8	**Kinematics Simulation and Rapid Prototyping:** Create a mechanical assembly; mate the parts of the assembly; simulate motion of the assembly; generate an animation (.AVI) file; play the .AVI file externally on a suitable player. Print a rendered color hardcopy of the assembly and submit it along with the animation file. Create individual parts of a mechanical assembly; generate an .STL file of each part; send the .STL files to a prototyping machine; assemble the rapid prototype parts. Submit the rapid prototype assembly once finished.
9	**Section Views in 3-D and 2-D:** Create individual 3-D parts; make different 3-D section views of the parts; export acceptable color image files of the 3-D section views for presentation purposes. Project 2-D section views of a model; incorporate the 2-D section views into a technical drawing; submit printed hardcopies.
10	**Generating and Dimensioning Three-View Drawings:** Create a 3-D part and make a three-view orthographic projection of the part; use a suitable drawing sheet style; add centerlines where appropriate; dimension the drawing; add a title block and appropriate notes. Print a black and white hardcopy for submission.
PROCEED Project	**Team Design Project:** Assign teams; acquire, study, and reverse engineer a common mechanical assembly; sketch shape and sizes of individual components; build computer solid models of parts and assemblies; perform appropriate computer analyses; make rapid prototypes of parts; generate drawings and other design documentation; propose design improvements. Submit final team project report.

Table 1

the student projects. Two companies, Ford Motor Company and Applied Materials, have already joined the PROCEED effort at the University of Texas, and have supplied projects for the freshmen students (Barr, Krueger, & Aanstoos, 2002). In the "Engineering Design and Graphics" course, the PROCEED project consists of a team of four students who reverse engineer a mechanical assembly. They study the individual parts, make sketches and computer models, perform various analyses, and make rapid prototypes of their assembly. At the conclusion of this integrated graphics and design project, the team assembles a final written report.

Modularization and Assessment of Engineering Graphics

To facilitate this project-centered approach, the Engineering Graphics curriculum has been organized into a set of learning modules with specific educational outcomes. Table 1 lists the current modularization scheme and learning outcomes. It consists of ten units that serve as individual student projects, plus an integrated PROCEED project that is conducted at the conclusion of the course. With this modularization scheme, the ten individual units train students to develop computer skills and abilities that can be later used in the larger team project.

These modern course outcomes, as outlined in Table 1, were fully implemented in the Fall 2002 semester using some preliminary computer graphics laboratory notes written by our group (Barr, Krueger, Aanstoos, & Juricic, 2003). The initial modules stress individual learning activities, which build the student's confidence in going from 2-D to 3-D solid geometric modeling. Once their confidence in computer graphics modeling is established, the students explore the many design applications for the 3-D model database. In so doing, they experience the concurrent engineering paradigm that underscores the course. Several computer graphics exercises are available for each laboratory module, thus allowing the students some choice in the objects they model and analyze. All objects selected for the exercises are real parts taken from commercial catalogs, or actual parts from the shop.

With the pedagogy and learning objectives established, the next step was assessment of the learning activities in the course. Two types of preliminary assessment metrics were gathered. Short pre- and post-surveys were conducted about the specific learning activities for the modules in selected sections of the course. These short surveys were started during the fourth week of the course, once the students had become confident with the modeling software. A second, larger survey was conducted across all sections at the end of the course. This second survey dealt with ABET student outcomes, and focused on how the "Engineering Design and Graphics" course contributed to improvement in these important student skills and abilities, as defined by the new EC2000 accreditation process (Engineering Accreditation Commission, 2002).

Student Outcomes Study 1: 3-D Solid Modeling

The first student outcomes study focused on the feature-based 3-D solid modeling unit. The learning objectives for this module included: learning basic 3-D features like extrude and revolve; creating advanced 3-D features like shell and sweep; inserting reference geometry planes; mirroring 3-D features; creating linear and circular 3-D patterns; and editing features like fillets. Typical objects for these student exercises are shown in Figures 1 (air manifold) and 2 (hand wheel). Other choices for modeling were also available.

Figure 1 Air manifold

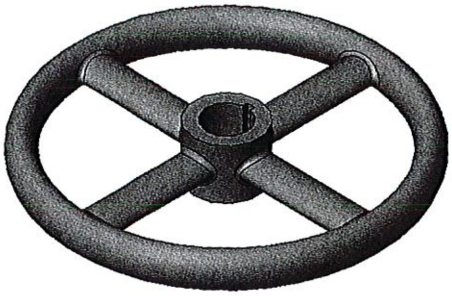


Figure 2 Hand wheel

Before the students started the module, a short survey form was completed and submitted. The survey asked the students to rank their level of understanding of the following three concepts:

1. Types of design features available in 3-D solid modeling,
2. Creating design features in 3-D modeling, and
3. Editing design features in 3-D modeling.

The response scale for the answers to the questions was: 5 (Exceptional), 4 (Good), 3 (Average), 2 (Below Average), 1 (None).

After the module exercises were completed,

Survey 1 Results (N = 76)

Question Number	Pre-Ranking	Post-Ranking	Difference (Post-Pre)
1	3.09	3.53	+0.44
2	3.08	3.45	+0.37
3	2.96	3.44	+0.48

Table 2

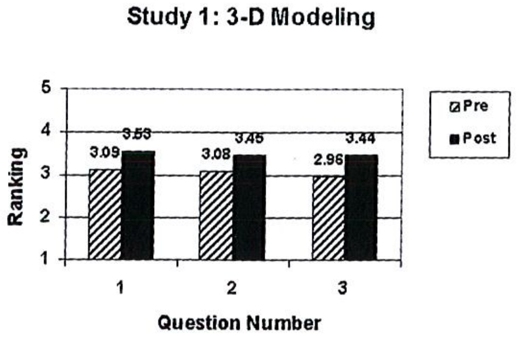


Figure 3 Results of Study 1

the same survey form was completed and submitted to the instructor. The students were also encouraged to list things they both liked and did not like about the exercise. Results of the two surveys were compared using the pre- and post- average rankings for these three questions across the participating sections (student sample size N = 76). The average rankings for all three questions increased in the post- survey, as indicated in Table 2 and in Figure 3.

The positive increases in the rankings, for all three questions, indicate that the student learning outcomes were achieved, at least as self-reported by the students. More importantly, the students listed several common themes about what they liked about the exercises:

- They were real-world examples, not abstract.
- The software was easy to use and many features were learned.
- The visualization controls were very useful.

In contrast, the students almost universally commented on the lack of clarity in the written notes, which were still in draft form.

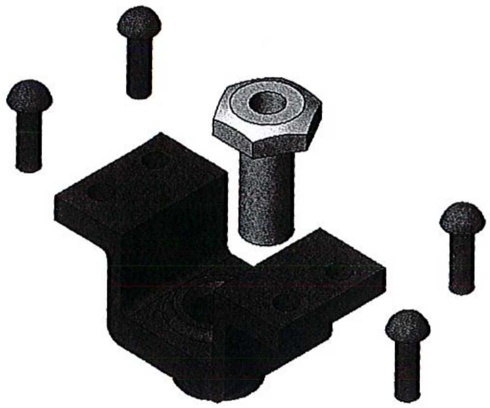


Figure 4 Terminal Support Assembly

Nonetheless, the general tone of the students written responses was quite positive for this first study.

Student Outcomes Study 2: Assembly Modeling and Mating

The next survey was conducted for the assembly modeling and mating module. The learning objectives for this laboratory were: building multiple 3-D parts that will fit together; starting a new assembly file; dragging and dropping parts into the assembly; moving and rotating components; and mating the parts with different mate types. A typical student exercise consists of building the terminal support assembly, shown in Figure 4 before mating.

For this assembly module, the students learn how to change the colors of the assembly components and how to apply several mate conditions: parallel, concentric, coincident, and distance. They also get a color hardcopy of the whole assembly once the exercise is completed.

As before, a pre- and post- survey was conducted for the student learning outcomes (level of understanding) posed by the following three questions:

1. Building multiple parts in 3-D solid modeling.
2. Building an assembly of parts in 3-D solid modeling.

Survey 2 Results (N = 76)

Question Number	Pre-Ranking	Post-Ranking	Difference (Post-Pre)
1	2.52	3.80	+1.28
2	2.23	3.68	+1.45
3	1.85	3.68	+1.83

Table 3

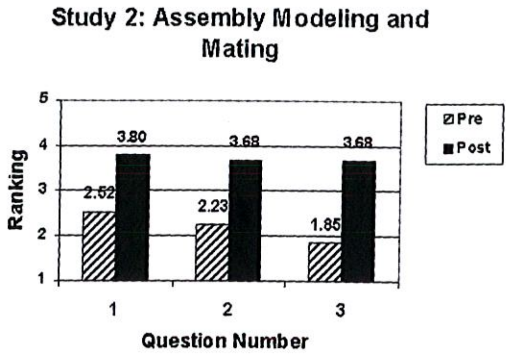


Figure 5 Results of Study 2

3. Mating parts in 3-D solid modeling.

The same ranking scale of 5 (Exceptional) to 1 (None) was used again. Results of the pre- and post ranking averages are shown in Table 3 and in Figure 5. Again the difference between pre- and post- average rankings indicates a positive trend for all three questions. In particular, the students commented that the exercise was real-life and that they liked mating the colored parts. The one difficulty was that some mating surfaces were hard to identify without using a rotate control function, which is not an intuitive skill for the students.

Student Outcomes Study 3: Mass Properties and Design Table

The third student outcomes study was concerned with analysis of solid models using the capability of the software. The specific analyses chosen here were mass properties and design tables. For the mass properties exercise, the students build two versions of an object (like the rocker arms shown in Figure 6) and then compare how the geometric functionality differs between the two by generating mass properties reports (see Figure 7 for an example).

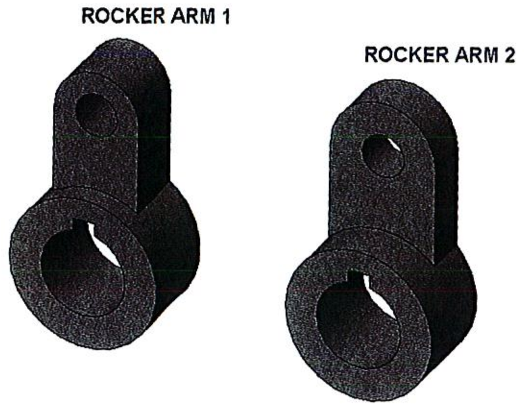


Figure 6 Two rocker arms

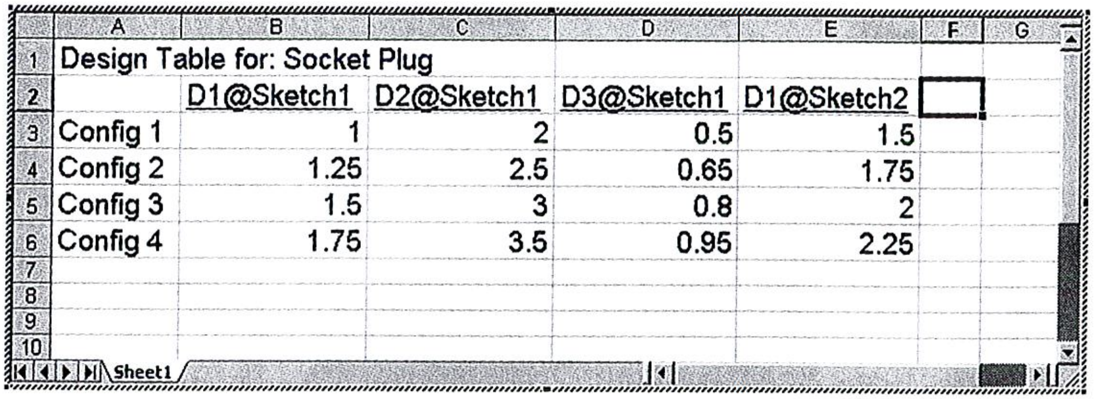
Density = 0.281 pounds per cubic inch
Mass = 1.264 pounds
Volume = 4.499 cubic inches
Surface area = 49.272 square inches
Center of mass: (inches)
X = 0.000
Y = 0.542
Z = -0.001
Principal axes of inertia and principal moments of inertia (pounds * square inches)
Ix = (0.000, 0.001, 1.000) Px = 0.894
Iy = (1.000, 0.000, 0.000) Py = 1.018
Iz = (0.000, 1.000, -0.001 Pz = 1.442
Moments of inertia: (pounds * square inches) taken at the center of mass and aligned with the coordinate system
Lxx = 1.018 Lxy = 0.000 Lxz = 0.000
Lyx = 0.000 Lyy = 1.442 Lyz = -0.001
Lzx = 0.000 Lzy = -0.001 Lzz = 0.894

Figure 7 A Mass properties report

A design table uses a spreadsheet approach to design a family of parts. The parent solid model is created, and key dimensions of this parent model are parameterized (e.g. D1@Sketch1). Then the spreadsheet cells are filled-in with the various values for the different design configurations, as shown in Figure 8. Once the design table is completed, the students execute the command that produces the different configurations of the model, for example, as shown in Figure 9.

The pre- and post- surveys posed the following three questions concerning the students' level of understanding about:

1. General engineering analysis of a 3-D solid model.
2. Mass properties analysis of a 3-D solid model.



	A	B	C	D	E	F	G
1	Design Table for: Socket Plug						
2		D1@Sketch1	D2@Sketch1	D3@Sketch1	D1@Sketch2		
3	Config 1	1	2	0.5	1.5		
4	Config 2	1.25	2.5	0.65	1.75		
5	Config 3	1.5	3	0.8	2		
6	Config 4	1.75	3.5	0.95	2.25		
7							
8							
9							
10							

Figure 8 A design table spreadsheet

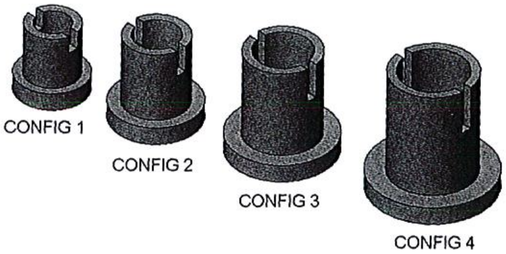


Figure 9 Design table configurations

Survey 3 Results (N = 76)			
Question Number	Pre-Ranking	Post-Ranking	Difference (Post-Pre)
1	2.32	3.58	+1.26
2	2.00	3.65	+1.65
3	1.97	3.71	+1.74

Table 4

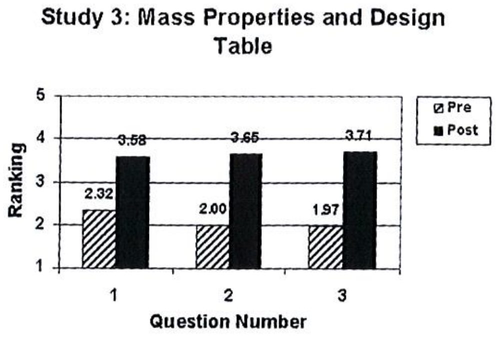


Figure 10 Results of Study 3

3. Creating design tables for a 3-D solid model.

Results of the pre- and post ranking averages are shown in Table 4 and in the bar chart of Figure 10. Again, the differences between the pre- and post- average rankings are pronounced, and it indicates a positive increase in learning of the material.

In the post- survey form, the students offered the following general comments for study 3:

- The mass properties analysis was easy to follow.
- Liked changing the material densities to get different properties.
- Liked designing several parts with one table.

The main negative comment was that little explanation was given about the meaning of the different types of mass properties (e.g. moment of inertia) and about their units. In general, this exercise was very gratifying to the majority of the students and provided good insight about the real potential of solid modeling.

Student Outcomes Study 4: Finite Element Analysis

The fourth outcomes study dealt with finite element analysis (FEA). An example exercise used a pillow block and shaft assembly to illustrate the usefulness of FEA to analyze and improve upon a design. The students first build and assembled the solid parts. They next declare an FEA study. They assign dif-

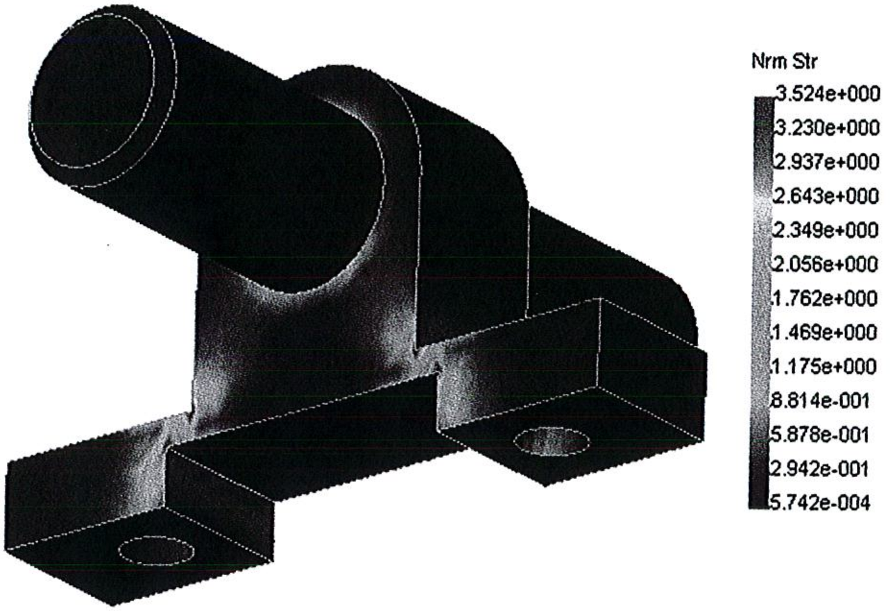


Figure 12 Stress concentrations

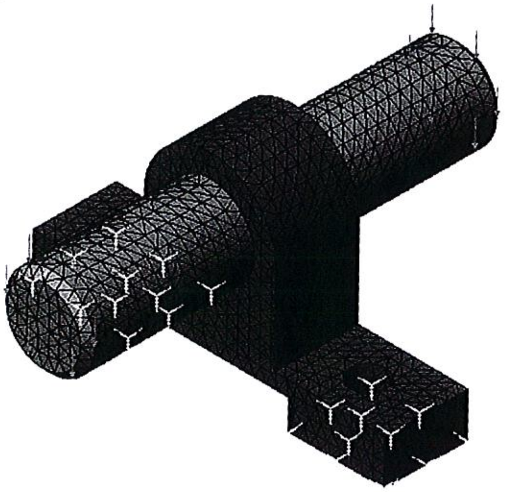


Figure 11 Applying a mesh

ferent material properties to the two parts, and then apply constraints and forces in appropriate places. A mesh is next applied, as shown in Figure 11. They now run a static FEA study, which results in a display of the von Mises stresses, as shown in Figure 12.

The color gradient of the plot is particularly valuable in showing the stress concentrations, which are areas that need improvement in the pillow block design. The students then complete the exercise by modifying the design. In this case, they add fillets in key places to thicken the material where the stresses had concentrated. This final step provides a vivid illustration of the advantage of the FEA method, particularly if they run a new FEA study on the improved design. This was not required, but many students ran the study anyway.

The pre- and post- surveys posed the following three questions concerning the students' level of understanding about:

1. Finite element analysis (FEA) of a 3-D solid model.
2. Applying constraints, loads and meshes to a 3-D solid model.
3. Visualizing results of an FEA study of a 3-D solid model.

Results of the pre- and post-ranking averages are shown in Table 5 and in Figure 13. Again, the differences between the pre- and post- average rankings indicate a positive increase in the general learning of finite element analysis of a solid model (at least in the context of this freshman exercise as self-reported by the students).

Survey 4 Results (N = 69)			
Question Number	Pre-Ranking	Post-Ranking	Difference (Post-Pre)
1	1.74	3.52	+1.78
2	1.78	3.60	+1.82
3	1.99	3.64	+1.65

Table 5

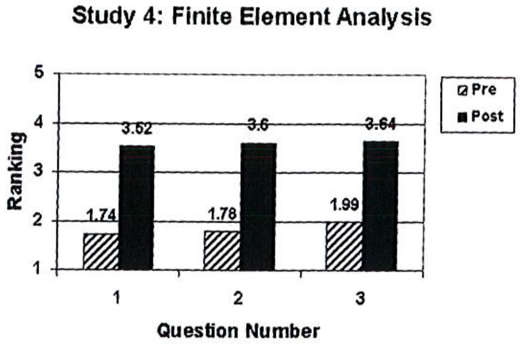


Figure 13 Results of study 4

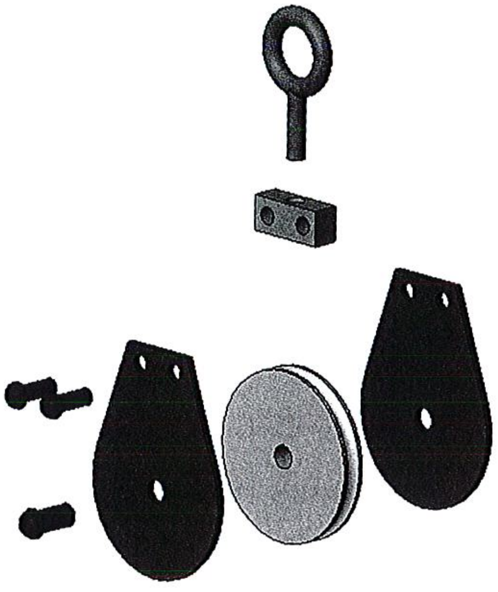


Figure 14 Exploded Assembly

For this FEA study, the students offered the following favorable comments:

- The visualization of the results was great.
- Seeing the forces and stresses was helpful to understand the study.
- Very real-like engineering design example.

The main negative comment seemed to be universal amongst the students: the mathematics behind the finite element method remained elusive to them after the exercise was over, even though they saw the great potential for its application. One student commented while leaving the room: "This was a great exercise, but I still don't know what I did." This aspect of the FEA module needs to be improved as these types of advanced topics are introduced at the freshman level.

Student Outcomes Study 5: Kinematics Animation

The fifth student outcomes study was concerned with kinematics animation. For this module, the students either build a new assembly of solid model parts or use a previously built assembly (i.e. see study 2). While the software offers elaborate tools for creating motion pathways for animating 3-D models, a simple approach was taken in this exercise. Once the parts are properly mated into an assembly, the students use an "Explode Assembly" command available in the software. The parts are then exploded along nominal pathways as shown in Figure 14. Next they can use an "Edit Path" command for each part to create a new animation schedule. Finally they play the animation on an external viewer and then save it in a universal .AVI file format.

The pre- and post- surveys posed the following three questions concerning the students' level of understanding about:

1. Exploding a 3-D assembly of solid model parts.
2. Creating a kinematics animation of a solid model assembly.
3. Creating an .AVI animation file that can be played on an external viewer.

Results of the pre- and post- ranking averages are shown in Table 6 and in Figure 15.

Survey 5 Results (N = 67)			
Question Number	Pre-Ranking	Post-Ranking	Difference (Post-Pre)
1	1.88	3.79	+1.91
2	1.77	3.72	+1.95
3	1.88	3.70	+1.82

Table 6

Once again, the differences between the pre- and post- average rankings indicate a positive increase in the general learning activities, averaging almost +2.00 point increases for all three questions.

The students exit comments for this animation study were all very positive. A common comment was that it was a "cool" exercise. They liked creating an animation and saving it as an .AVI file that could be played externally. This was particularly gratifying since none of them had ever made an .AVI file before. The instructions were easy to follow, due mainly to the "Animation Wizard" and accompanying tools that were available in the software.

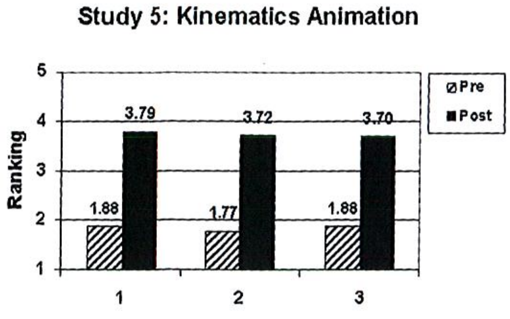


Figure 15 Results of Study 5

Student Outcomes Study 6: Rapid Prototyping

The sixth study was conducted during the rapid prototyping lab exercise. The learning activities for this module included: building a solid part; creating a stereolithography (.STL) file from the solid model data; transferring the .STL file to a rapid prototyping machine; and completing the rapid prototype. Some example parts used as student exercises for this module are shown in Figure 16. This

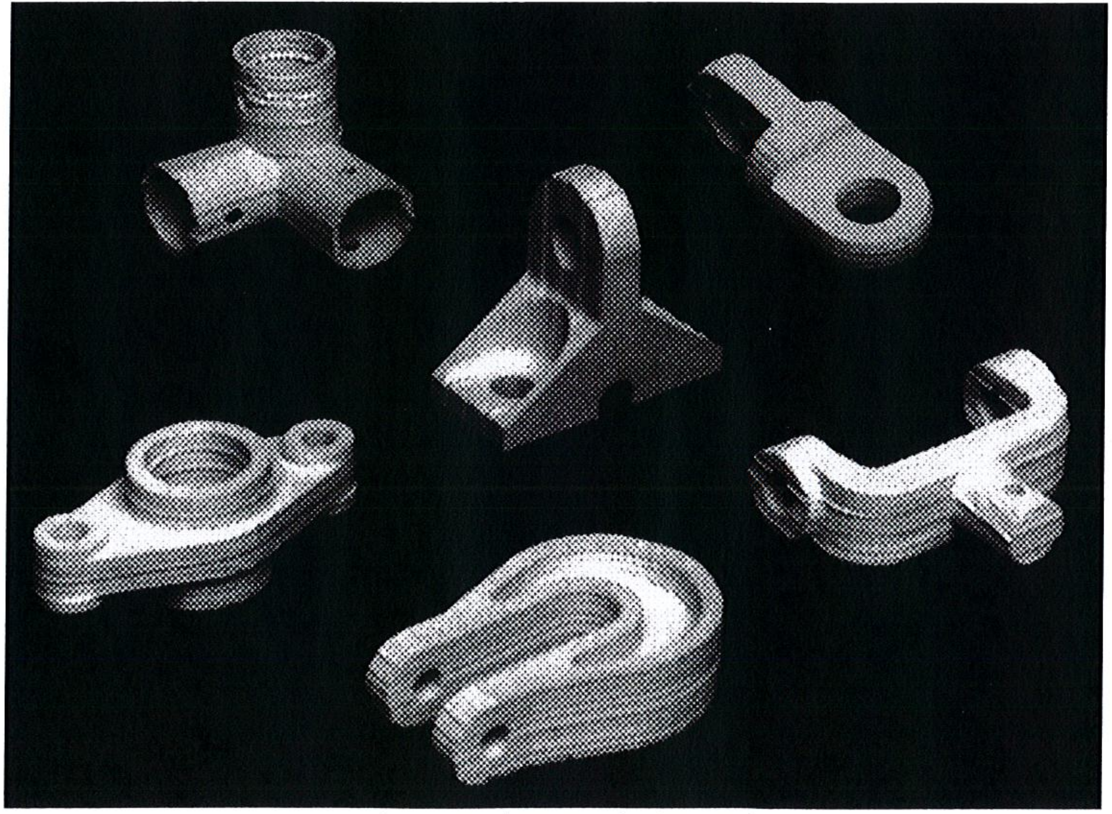


Figure 16 Rapid prototype of student parts

Survey 6 Results (N = 45)

Question Number	Pre-Ranking	Post-Ranking	Difference (Post-Pre)
1	1.80	3.85	+2.05
2	1.78	3.99	+2.21
3	2.01	3.86	+1.85

Table 7

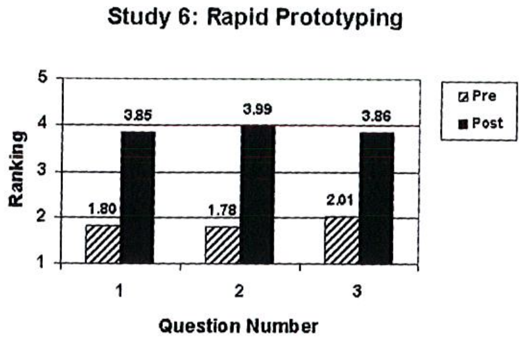


Figure 17 Results of Study 6

particular approach here uses the paper slicing and layer adhesion system.

The pre- and post- surveys posed the following three questions concerning the students' level of understanding about:

1. Generating an .STL file from a 3-D solid model.
2. Building a rapid prototype of a 3-D solid model.
3. The role of rapid prototyping in the design process.

Results of the pre- and post- ranking averages are shown in Table 7 and in Figure 17. Once again, the differences between the pre- and post- average rankings indicate a positive increase in the general learning activities, averaging around +2.00 point increases for all three questions.

In general, the students enjoyed this module even though it was time-consuming due to the manual assembly requirements of the rapid prototyping system. They clearly enjoyed building a real part from a computer model. As one student stated simply, "seeing the computer sketches go to an actual model was very impressive."

Student Outcomes Study 7: Section Views in 3-D and 2-D

The seventh study focused on the traditional topic of section views, focusing on both 3-D and 2-D techniques. The educational objectives for this module included: viewing 3-D section views of solid models; projecting orthographic views onto a drawing sheet; setting hatch pattern options; creating the cutting plane line; making a 2-D section view; printing a section view drawing. An example of a 3-D section view student exercise is shown in Figure 18, and a 2-D section view student example is shown in Figure 19.

The pre- and post- surveys posed the following three questions concerning the students' level of understanding about:

1. Making a 3-D section view of a 3-D solid model.
2. Making a 2-D section view from a 3-D solid model.
3. Detailing a 2-D section view drawing.

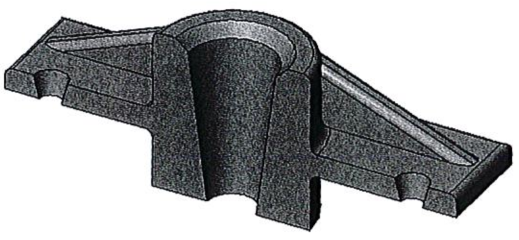


Figure 18 3-D Section view

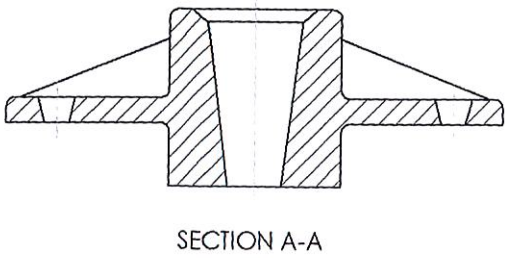


Figure 19 2-D Section view

Survey 7 Results (N = 66)			
Question Number	Pre-Ranking	Post-Ranking	Difference (Post-Pre)
1	2.13	3.84	+1.71
2	2.25	3.80	+1.55
3	2.11	3.64	+1.53

Table 8

Results of the pre- and post- ranking averages are shown in Table 8 and in Figure 20. Again, the differences between the pre- and post- average rankings indicate a positive increase in the general learning activities, although maybe not quite as large a differential as in studies 5 and 6.

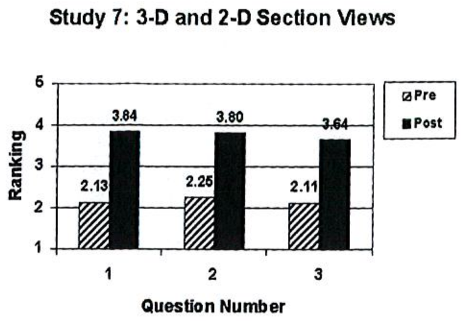


Figure 20 Results of Study 7 (N = 66)

Student Outcomes Study 8: Generating and Dimensioning Three-View Drawings

The final study focused on the traditional need to generate an engineering drawing for final design documentation. The learning activities and objectives for this module included: 1) inserting a drawing sheet onto the screen; 2) setting the drawing sheet options; 3) projecting three orthographic views of a solid model onto a drawing sheet; 4) adding centerlines; 5) dimensioning the drawing; 6) adding title block and annotations; 7) printing the drawing. A typical student computer modeling exercise is shown in Figure 21, and its projected and dimensioned engineering drawing is shown in Figure 22.

The pre- and post- surveys for Study 8 posed the following three questions concerning the students' level of understanding about:

1. Generating a three-view drawing from a 3-D solid model.
2. Arranging the three-view layout on a drawing sheet.
3. Dimensioning a three-view drawing.

Results of the pre- and post- ranking averages are shown in Table 9 and in Figure 23. Again, the differences between the pre- and

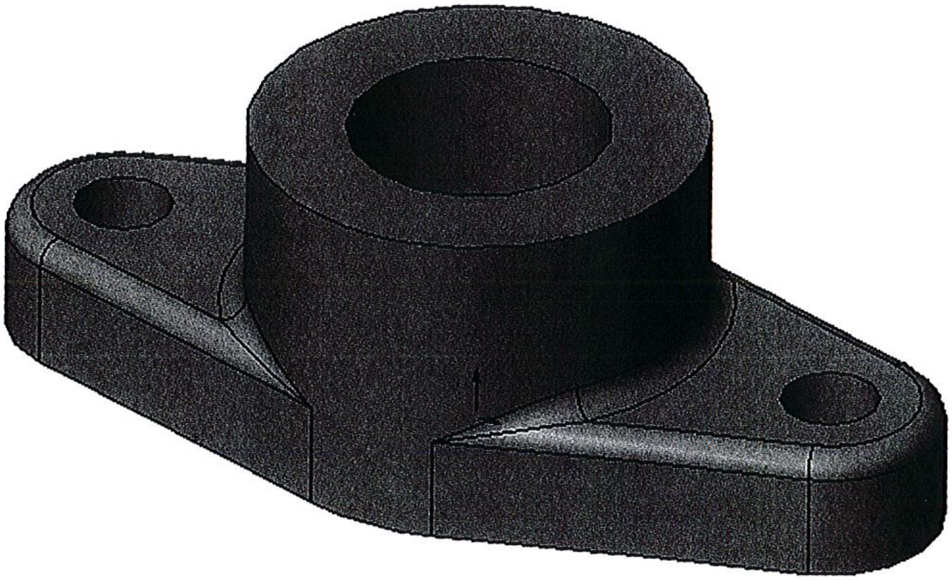


Figure 21 A 3-D computer model

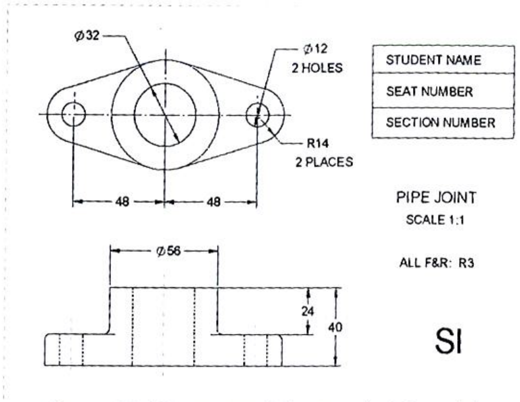


Figure 22 A Dimensioned drawing of a 3-D model

post- average rankings indicate a positive increase in the general learning activities, although maybe not quite as large a differential as in previous studies.

The students were generally receptive to this final learning activity, even though they realized that making an engineering drawing is relegated to a secondary role in the modern concurrent engineering paradigm. They frequently commented on the "ease" of creating three-views from a solid model with the current software. They also felt that the last two modules reinforced the basic concept of deriving design documentation from a solid model, rather than creating the documentation from scratch. The one consistent negative comment was the degree of difficulty in applying details to the final engineering drawing, particularly in placing centerlines and in deciding which dimensions to select.

Comparison of Eight Student Learning Outcomes Surveys

All eight student learning outcomes surveys showed a positive trend in learning, based on self-reported pre- and post- exercise surveys. This is to be expected, since the students gained some additional knowledge and skills doing each exercise, and appropriately reported that in the surveys. Table 10 lists the average pre- to post- increases, in descending order of average gain. It can be noted that study 6 (rapid prototyping) had the largest gain in self-reported learning, with an average increase of 2.04 ranking points, and study 5 (kinematics animation) was second with an average increase of 1.89. Conversely, study 1 (3-D solid modeling) had the lowest net gain of just 0.43 ranking points. That is not surprising since the students already had received three weeks of exposure to the modeling software before the surveys were initiated. A comparison of all the studies indicates that the advanced topics (prototyping, kinematics, FEA) were the most novel to the students and hence showed a bigger gain in the pre- to post- level of understanding of the topic. This underscores the students' enthusiastic reception of these modern, technology-based topics in their freshman engineering design and graphics coursework.

Survey 8 Results (N = 57)

Question Number	Pre-Ranking	Post-Ranking	Difference (Post-Pre)
1	2.72	3.93	+1.21
2	2.77	3.93	+1.16
3	2.40	4.02	+1.62

Table 9

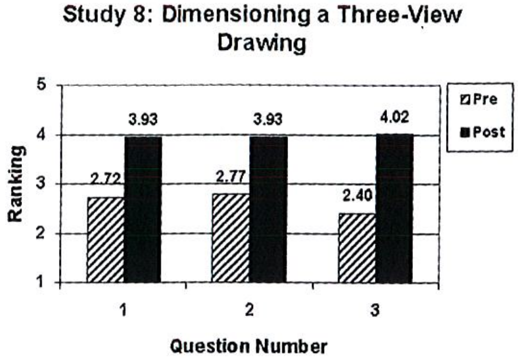


Figure 23 Results of Study 8

Average Pre- to Post- Increases (Descending Order)

Study	Average Increase
Study 6: Rapid Prototyping	2.04
Study 5: Kinematics Animation	1.89
Study 4: Finite Element Analysis	1.75
Study 7: Section Views in 3-D and 2-D	1.60
Study 3: Mass Properties and Design Table	1.55
Study 2: Assembly Modeling and Mating	1.51
Study 8: Dimensioning a 3-D Drawing	1.33
Study 1: 3-D Solid Modeling	0.43

Table 10

ME Program Outcomes

1. Knowledge of and ability to apply engineering and science fundamentals to real problems. (a)*
2. Ability to formulate and solve open-ended problems. (e)
3. Ability to design mechanical components, systems, and processes. (c)
4. Ability to set up and conduct experiments, and to present the results in a professional manner. (b)
5. Ability to use modern computer tools in mechanical engineering. (k)
6. Ability to communicate in written, oral and graphical forms. (g)
7. Ability to work in teams and apply interpersonal skills in engineering contexts. (d)
8. Ability and desire to lay a foundation for continued learning beyond the baccalaureate degree. (i)
9. Awareness of professional issues in engineering practice, including ethical responsibility, safety, the creative enterprise, and loyalty and commitment to the profession. (f)
10. Awareness of contemporary issues in engineering practice, including economic, social, political, and environmental issues and global impact. (h,j)

* Mapping of ME program outcomes to the ABET prescribed a through k outcomes (Engineering Accreditation Commision, 2002).

Table 11

EC2000 Student Program Outcomes Study

A final survey of EC2000 student program outcomes was conducted across all ten sections of the "Engineering Design and Graphics" course in the Fall 2002. Program outcomes are defined to be the knowledge, skills, abilities, and attitudes engineering graduates should be able to demonstrate at the time of graduation. Table 11 lists the ten program outcomes for the Mechanical Engineering Department at the University of Texas at Austin. Included in the table is the mapping to the ABET prescribed a through k outcomes.

A survey was conducted to determine the level of improvement in these ME program outcomes from the beginning (pre-) of the class to the end (post-) of the class. The same pre-/post- survey form was used and it asked the students to "describe their skills and abilities supporting each outcome at the beginning (or end) of the course" using the following 5-point scale:

5 - Very significant skill/ability
4 - Significant skill/ability
3 - Some skill/ability
2 - A little skill/ability
1 - No skill/ability

Results of this survey for all the responding students (N = 163) are shown in Table 12 and in the bar chart of Figure 24. It can be noted that all ten ME program outcomes improved from the pre- to post- condition, ranging in percent improvement from 11.3 to 67.0%. This is quite gratifying since the students felt that the graphics course was contributing to the overall departmental goals.

It is interesting to study which of the ten outcomes showed the greatest improvement, as self-reported by the students. Figure 25 shows a bar chart of the level of improvement from the pre- to post- condition. It can be noted that Outcome 3 (ability to design mechanical components, systems, and processes) and Outcome 5 (ability to use modern computer tools in mechanical engineering) received the two highest values of 67.0% and 58.8%, respectively. This is a very pleasing result, since the underlying objective of the course is to teach the modern design process using an integrated series of computer graphics exercises under the unifying theme of concurrent engineering.

No single course could realistically contribute significant improvement to all ten ME program outcomes. So there is some "halo effect" in these student ratings. For example, there was little course content on contemporary issues and global impact (outcome 10), even though the students rated it at a 30.7% improvement. Nonetheless, this survey raised an awareness in the students' minds concerning all the intellectual issues

Results of ME Program Outcomes Survey (N = 163)

ME Outcome	Pre-Score	Post-Score	Change (Post-Pre)	Percent Improve-ment
1	2.74	3.38	+0.64	+23.4%
2	3.06	3.59	+0.53	+17.3%
3	2.24	3.74	+1.50	+67.0%
4	2.62	3.3.6	+0.74	+28.2%
5	2.60	4.13	+1.53	+58.8%
6	3.13	3.91	+0.78	+24.9%
7	3.25	4.20	+0.95	+29.2%
8	3.45	3.84	+0.39	+11.3%
9	2.64	3.22	+0.58	+22.0%
10	2.41	3.15	+0.74	+30.7%

Table 12

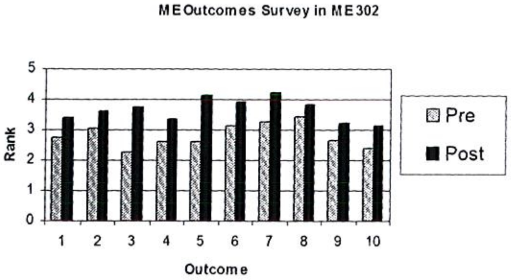


Figure 24 Results of ME Program Outcomes Survey (N = 163).

that ME faculty deem important during the students' undergraduate engineering studies. That awareness is certainly of benefit to the ME freshmen.

Discussion and Conclusions

The freshman "Engineering Design and Graphics" curriculum has evolved to a new era in which 3-D geometric computer models, and the design applications of the digital database, are the center of instruction. Table 1 lists a sequence of engineering graphics learning modules that systematically introduce the students to this new engineering design and graphics paradigm. This modular sequence was fully implemented in the Fall 2002 semester in all sections of the engineering graphics course at the University of Texas at Austin.

This paper presents the results of an initial, systematic assessment of the learning outcomes of this new approach to "Engineering Design and Graphics." Two types of assessment were conducted. Specific learning activities for eight graphics modules were identified and formulated into a set of surveys. The surveys were conducted in three selected sections of the graphics course using self-reported pre- and post-study rankings. The results of these rankings are presented in Tables 2 through 9 in this paper. In all cases, the difference between the post- and pre- ranking score, deemed improvement in learning, showed a positive trend. This indicates that all the graphics activities resulted in a positive learning experience on the part of the students.

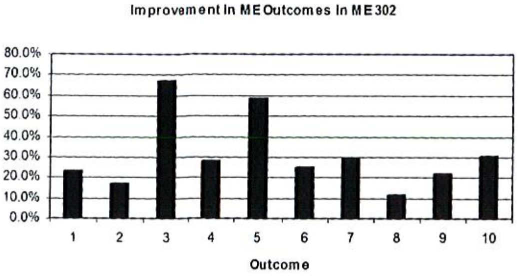


Figure 25 Improvement in Ten ME Outcomes for Fall 2002.

The second survey was conducted over all students in the course and measured the improvement in the ten ME departmental program outcomes during the course. These ten ME outcomes are listed in Table 11 and are the same ones used for the ABET EC2000 accreditation process. Results of this second study for all students in the course are listed in Table 12. A positive improvement was noted in all ten outcomes as depicted in Figure 25. While it is not surprising that engineering students would report that they learned something in a course, the overwhelming positive trend of all surveys conducted in this preliminary assessment suggests that, as a minimum, the course is well-received by the students and is on the right track. As a result of the learning activities achieved in this freshman course, it can be said that the students are prepared to meet the challenges of the ME program outcomes in subsequent courses.

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Techniques for Creating Animations for Technical Presentation

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University of California, Berkeley

Abstract

In the past, animation was used mainly as a medium for entertainment. However, animation has recently evolved into a highly desirable means for the presentation of technical information, especially if the audience members have non-technical backgrounds. In this sense, animation can be used as a bridge for information flow between the technical community, its management, the political community, or even directly to the consumer. The availability of software tools to easily create animations from solids or surface models gives engineers a unique media for the presentation of ideas, as well as a means for expression of creativity. Also, allowing engineers to create their own animations ensures their technical accuracy. This paper will review some techniques that can be used to improve animations for technical presentation.

Introduction

Animation is the sequential presentation of individual graphic images at a rate sufficient to convey an impression of real motion within those images. If the individual images have sufficient detail, and if the rate is sufficiently high, an illusion of real objects in motion can be projected. In some cases, the viewer can control the motion, as with the dynamic image rotation feature found in most solids modeling software programs. This feature allows a pictorial image of a solid object to be rotated and viewed from different angles in real time, giving the viewer accurate visualization of the part. In other cases, the animation sequences are pre-recorded, and particular sequences are replayed upon command, such as by using control buttons. Sometimes sound is added for enriching the presentation.

In the past, animation was used extensively for entertainment. The reason was this use was animation's ability to create characters, objects, places and events that did not exist in reality. But the great skill, time, and expense required to create animations made their casual use prohibitive. However, solids modeling and animation software has recently made it possible to create animations with much less effort than in the past. The use of animation has thus evolved into a highly desirable means for the presentation of technical information for the following reasons:

1 It offers unparalleled clarity in the explanation of assembly and operation of devices.
2. It offers an excellent means of presentation of technical information to non-technical audiences.
3. If engineers, instead of artists or technicians, are permitted to create the animations, errors in proper depiction of parts, processes, and operations will be reduced.

It can be used, for example to demonstrate not only the 3-dimensional geometry of engineered parts, but also the way in which these parts can be assembled to make a structure or mechanism. Further, it can be used to demonstrate the operation of a mechanical device. Some clever tricks can be used to demonstrate gas flow or even heat flow. In education, having students graphically create the assembly and operation of mechanical devices is an excellent means for students to learn about these devices. In this sense, a course in technical animation is not only an excellent stand-alone course, but also an ideal complement to a mechanical dissection course.

Basic Tools

Traditionally, animations were created frame-by-frame. If an animation was presented at a rate of 30 frames/second, thirty separate images, or cells, were needed to produce one second of animation. This was a lot of work. Usually, a master animator would make the outline of the artwork, and apprentice animators would add the color. This required skilled labor and was expensive. Fortunately, computers and software have greatly reduced the time and effort required to produce the necessary images.

With the advent of software such as 3D Studio™, only the keyframe images needed creation. Keyframes are "perfect" frames that specify the precise location of objects at several important times in the animation. The intermediate frames, between the keyframes, would then be created automatically by the software. The software also allows for objects to be created within the software, or imported from other software. The ability to create or import three-dimensional objects within the software and manipulate location and rotation of these objects were important features that greatly reduced the effort required in making an animation. Most animation software have provisions for the following features:

1. Materials and material mapping of colors and images onto objects.
2. Lighting control.
3. Camera control.
4. Control of entry and exit rates for object translation and rotation to/from keyframes.
5. Kinematic control of time, and object position, and rotation.
6. Rudimentary dynamics, considering the mass of an object and the forces applied to it.
7. Linking and constraints to motion of objects relative to one another.
8. Exporting of solids or surface files to external software.
9. Export of final results to commonly used formats.

For engineered devices, however, the object creation facilities in most animation software is difficult to use. Fortunately, most solids modeling software, such as Solidworks, have facilities for exporting model information, such as in stereo-lithography format (STL), which can be used by animation software. Using a solids modeler is a very efficient creation method for engineered objects. Most solids modeling software now include some rudimentary animation capability that is very easy to use and is capable of demonstrating basic assembly and operation. For a great percentage of presentations, this internal capability is more than adequate.

For Technical Adeptness...

Once an animation is completed and its distribution has begun, the original pre-rendered files will likely see little further use. The final, rendered production will probably be the version that will see wide distribution, and thus any additional effort to improve this version will be well worth the effort. For rendering of the final work, the following advice is forwarded for technical adeptness:

Use AVI or MOV. The final file format should be in Windows Media™ or QuickTime™ formats. These are the most popular formats for video on computers today, and result in the widest distribution and maximum utility. Other formats can, if necessary can be extracted from Windows Media or QuickTime.

Keep the resolution high. Although it is sometimes tempting to reduce the resolution in an attempt to save rendering time and space, in general this is not a good idea. As long as the rendering times and file sizes are tolerable, higher resolution is better. If rendering time is a real problem, other means such as eliminating the calculation of unnecessary shadows or reflections can be employed. Low-resolution versions can be extracted from high-resolution versions in the future, if needed, but not vice versa. For presentation on a computer a minimum resolution of 640x480 pixels is recommended

Use at least 15 frames/second. The frame rate should be at least 15 frames/second for presentation on a computer. This rate is the minimum before significant image "jumping" between frames is noticed. For more professional productions, the frame rate should be 30 frames/second, which is the NTSC standard.

Use video compression, but only once. With most animations, the use of a video compressor will reduce the file sizes by a factor of 10 – 20 times, with little loss in resolution. An animation that is over 700 Mb in size can be unwieldy. It takes a long time to load, and doesn't fit on a single CD. A good file size would be less than 100 Mb. The Cinepak and Sorenson video compression algorithms (CODEC's) are the classics, work rather well, and come standard with Windows Media and Quicktime. Indeo seems to be a bit better for animation, but the later versions need to be purchased. Use compression as the final step before production of the final version. Repeated compressions result is severe loss of resolution.

Use at least 24-bit color. The deeper the color resolution, the better everything will look. 8-bit color is generally insufficient to present realistic colors and textures. A color resolution of at least 24-bits is recommended. Beyond 36-bits, there is very little to be gained for the added computation time or file size.

Improving the Presentation

Presentations can be further enhanced by careful attention to details and also by using techniques to make the animation more interesting, engaging, and even entertaining. A basic assembly animation shows a device being assembled and working. If the camera shows only a single angle, and the parts assemble only in a linear fashion, the presentation is still useful, but also boring. The following recommendations are forwarded for improving the presentation of the basic information contained in a technical animation:

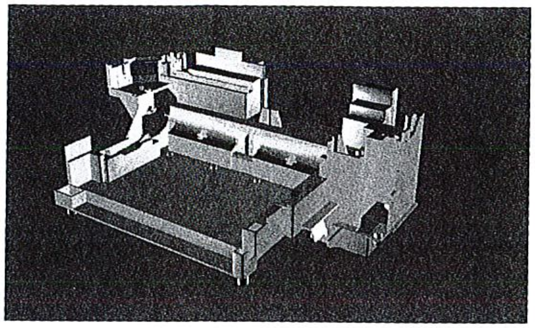

Figure 1 Solids modeling makes it easy to create accurate detailed parts

Add sound. The addition of sound dramatically enriches the presentation. Use good quality sound. Sound at 16 bit, 22 kHz bandwidth should be fine. Stereo is usually unnecessary for computer presentations, and will double the size of your audio file. Instrumentals usually work better than vocals, although either or both are acceptable. Try to cater to the tastes of the target audience, and try to avoid stuff that is too new or controversial. Remember that in the field, a technical, engineering presentation will likely be to a fairly conservative audience.

Make accurate models. Are all the parts there? Are all the features of each part there? Sometime in the future, the animation may be examined by someone, frame-by-frame, for completeness and accuracy. If this happens, you'll be glad you took the time to be accurate. With solids modelers, the creation of accurate parts should be easy, as shown in Figure 1.

Make the materials accurate. Metal should look like metal, and not like plastic. Rubber should look like rubber, not metal. Many stock material maps are available as part of the solids modeling or animation programs. Many devices being modeled will have PC boards, and it is usually a simple procedure to scan the boards to get an image map that can be applied to a surface. Adding 3-dimensional components to a PC board also serves to improve realism. But be sure

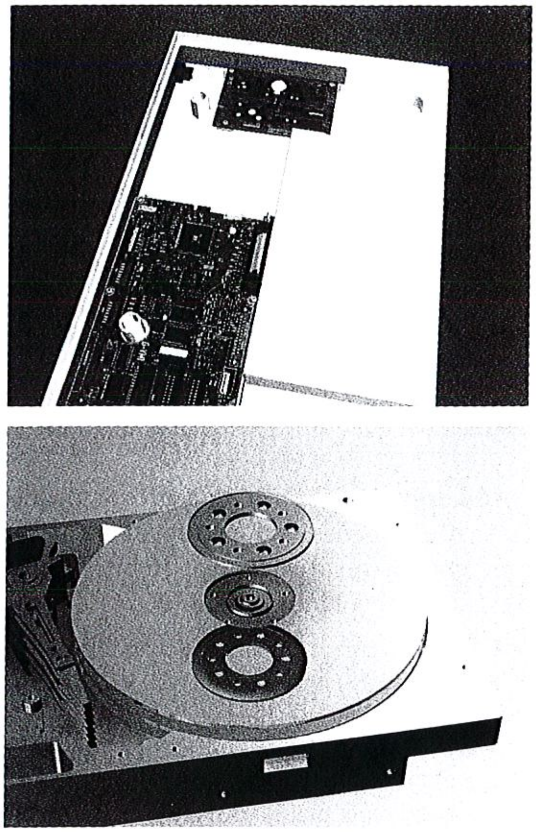

Figure 2 Accurate materials modeling. Artwork on a PC boards (above), relection from a polished surface (below).

to scan with enough resolution to match the quality of the other parts. Low-resolution PC boards look out-of-place if the rest of the materials have good resolution. If a surface is highly reflective, this property should be demonstrated. Examples of surface mapping and reflection are shown in Figure 2.

Make the motion interesting. By moving and rotating the objects and camera, not only is the motion more interesting, but it also allows for more details of the objects and assemblies to be revealed. This adds to the sense that the objects are indeed real and 3-dimensional. Some animation software allows for objects to be deformed or morphed. If object deformation is a part of the assembly process, it should be shown.

Use visibility. Having parts appear and disappear at strategic times is a very dramatic presentation method that will make the animation more interesting.

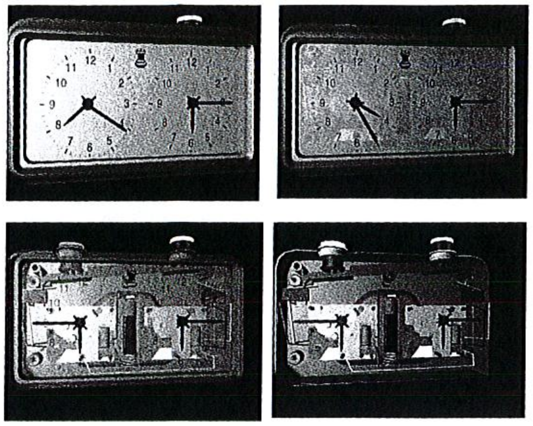

Figure 3 Dynamic transparency can be used to reveal interior detail

Use transparency. Once a device is assembled, or even during partial assembly, it may be difficult to see what's happening. Turning the covering parts transparent or partially transparent at strategic times can solve this problem. An example of a dynamic transparency sequence is shown in Figure 3.

Use a slow steady pace for your assembly. If the animation is too fast, not only is it confusing, it is not doing its job of demonstrating assembly. Do not try to hide something by going so fast that the viewer can't see it. It will be seen when it is examined frame-by-frame. If the animation is done in segments, make sure that the pace is somewhat the same for each segment. Of course this does not mean you should only go at a single pace. A very successful presentation technique is to adjusted the pace of the animation to match the pace and beat of the music used. Motion can be synched to the beat of music.

Be sure the assembly sequence is correct. Make sure you are assembling your parts in the correct order, as shown in Figure 4. If the project is supposed to be a demonstration of assembly and operation, and assembly is done in the wrong order or incorrectly, the animation will fail its intended purpose. If you are uncertain of the proper assembly process for your project, it would be a good idea to find out.

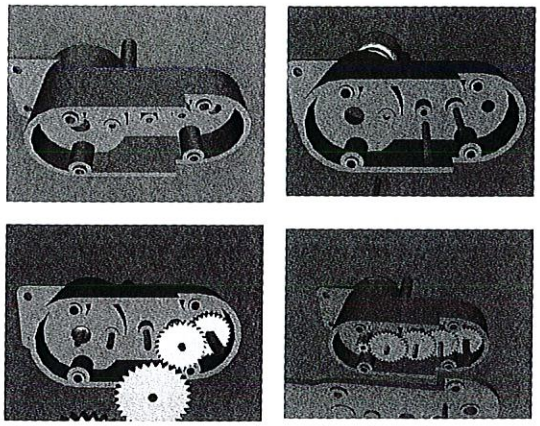

Figure 4 Animation can be used to show the proper assembly sequence of parts.

Make the surrounding environment interesting. Place the device in its intended operating environment, for example as shown in Figure 5. It is easy to download 3-dimensional models of things like tables chairs, lamps, even entire rooms or houses form the Internet, or from commercial software library files. However, do not make these items the main focus of the animation. For more commercial applications, it is advisable to add leaders and trailers that contain the title and credits for the work.

Discontinuities in the animation are bad. This is a particular problem with projects that are done as a group effort. One common method of dividing the workload for a group project is to have each person contribute a different part of the animation. If this is done, be sure that the individual sections come together to make a single seamless animation for the final project. Too often it is very easy to tell when one person is finished and another person begins. In the worse cases, the animation abruptly ends with the parts, and sometimes the music, disappearing, and a new set of parts suddenly appearing. Easy solutions to the segment patching problem include having the camera pan to a blank screen and then onto the new parts, and moving or fading the parts out of the scene and then moving or fading the new parts onto the same scene. If this is done, keep in mind that when the camera pans off a certain set of parts, the viewer is left in his or her head with a certain expectation for camera speed, direction of motion, and zoom. The new parts should enter the scene with about the same settings, otherwise it is confusing for the viewer.

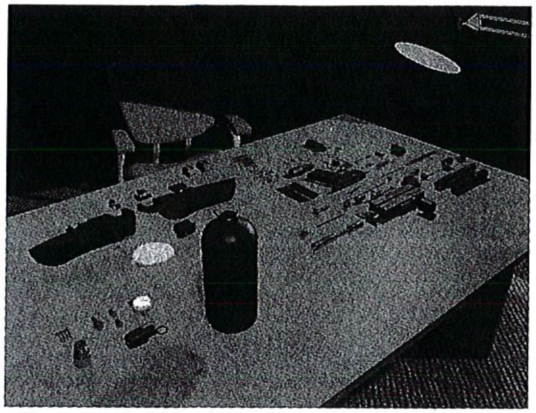

Figure 5 Showing objects in their intended environment gives a sense of realism and utility to the device.

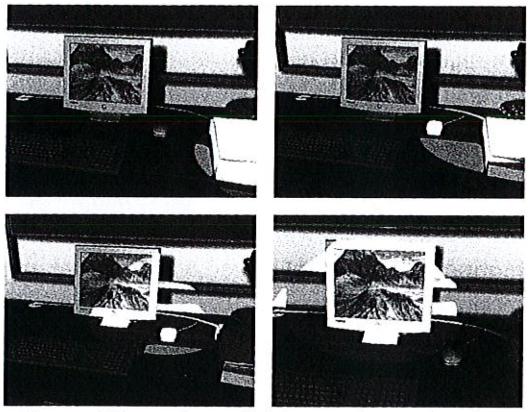

Figure 6 Dynamic spotlighting can be used to draw attention to areas of interest.

Don't go overboard with the camera motion. If fact, don't go overboard with any motion. Once it is discovered how to control motion, it is often tempting to use a lot of it. Some variation in the motion makes the production more interesting, but too much, such as continuously circling an assembly at a fast rate, makes the viewer dizzy.

Use variation in lighting. Spotlights, variation in light intensity and color, and moving lights can be used to emphasize or call attention to certain features that need emphasis. An example of a moving spotlight is shown in the sequence in Figure 6, where attention is to be drawn from one area to another.

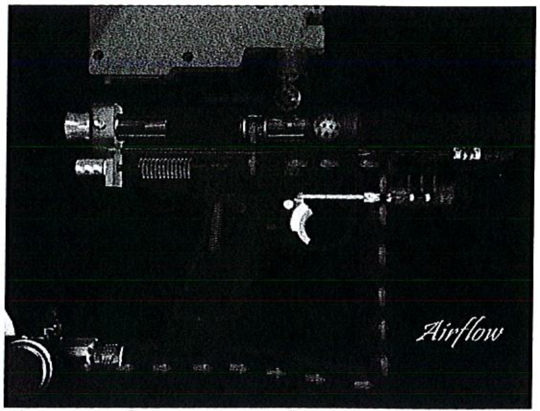

Figure 7 Airflow can be simulated with moving arrows

Show things you can't normally see. Animation can be used to help visualize things that can't normally be seen. For example, thermal gradients in a part can be shown by changing its color and color distribution. Airflow can be simulated with moving arrows, as shown in Figure 7. Very small motions can be emphasized with lighting and motion arrows.

Concluding Remarks

Unfortunately, some animation software do not have segment patching facilities. This means that if you are trying to patch together a series of smaller animations to create a singe large animation, you need to another software package. Two software packages can be recommended. The first is QuickTime Pro™. QuickTime is an Apple product. The player is a free download from the Apple website, but all it does is allow you to play an animation. To do any sort of editing, patching, sound addition, etc., you need QuickTime Pro, which is a modest cost upgrade. QuickTime is very easy to learn. The second package recommend is Adobe Premier™. It does everything but is expensive, and has a rather steep learning curve. Fortunately, on most new computers, including HP™'s and Sony™'s, video-editing software of various flavors is included. Also, there is apparently a lot of shareware available from the Internet for this purpose. In general, you are pretty much free to use anything that works.

Resolution

Frank M. Croft, Jr.
2003 Mid-year Meeting Resolutions Chair

Whereas the 58^{th} Annual Engineering Design Graphics Division Mid-Year Meeting has occurred at the Holiday Inn Sun Spree Resort and Conference Center in sunny Scottsdale, Arizona, where our host, Arizona State University-East, has provided us with a suitable forum for the exchange of ideas, concepts, methodologies, and conviviality;

And, whereas, we were extended a warm and gracious welcome from Dr. Albert McHenry, Dean of the College of Technology & Applied Science at Arizona State Univesity and enlightened by a thought provoking keynote address delivered by Dr. Theodore Kraver, President of Global eLearning Industry Association;

And, whereas Professors Jon M. Duff of Arizona State University-East as General Conference Chair and Mary A. Sadowski of Purdue University as Conference Program Chair have attracted scholars from across the United States who presented excellent and thought provoking papers;

And, whereas conference sponsors, AutoDesk, Outcomes Assessment Solutions, Journey Ed.com, The CAD Store, Thomas Learning, Schroff Development Corporation, and SolidWorks provided the support to ensure that a quality conference was held;

And, whereas, the breaks and social gatherings were hosted by Schroff Development Corporation and SolidWorks;

And, whereas, the Division had a wonderful evening at the Rawhide Western Town, where the conference chair was duly arrested, charged, and hanged for crimes too heinous to mention; however, he miraculously recovered to continue his duties at the conference;

And whereas, we were blessed with the presence of Frank Oppenhiemer, who presented the Oppenhiemer Award for the best presentation at the Conference;

And, whereas the spouses and families of our division members have enjoyed special tours, family events, and ambiance of Scottsdale and the Phoenix area;

Now therefore it is resolved that the Engineering Design Graphics Division of the American Society for Engineering Education extends its thanks and appreciation to the aforementioned organizations and individuals.

Copies of this resolution shall be transmitted to these individuals and shall be spread on the records of the division.

59th annual midyear meeting

November 21-23, 2004
Woodlands Conference Center
Williamsburg, Virginia

"Graphics - Past, Present, & Future?"

call for papers

Authors are invited to submit full-length manuscripts for presentation at the conference and inclusion in the conference proceedings. Papers addressing the conference theme "Graphics - Past, Present, & Future?" and possible session topics listed below will have first priority.

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Visualization
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Send a 250-300 word abstract in standard word processing format by August 2, 2004. Submit final paper for inclusion in the conference proceedings by Monday, October 22, 2004.

Robert A. Chin, Professor
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[Standards Corner]

Patrick J. McCuistion
Ohio University

Two significant new standards were released this fall. The Y14.41 Digital Product Definition Data Practices standard has been needed by many companies for a long time. Companies who deal primarily with a 3D data base now have a standard to guide them in applying geometric dimensions to their pictorial drawings. All EDGD members should be aware of its contents because it sets the guidelines for what is required from a digital model. As such, it should make an impact on CAD software developers. It also introduces a new circle U symbol to be used with profile tolerances to indicate the direction of the tolerance zone (this symbol should be included the next Y14.5 release). As a point of interest, the only CAD company that consistently contributed was SDRC.

The other standard is Y14.43 Dimensioning and Tolerancing Principles for Gages and Fixtures. This standard has had a 10 year, sometimes turbulent, development period. It incorporates some of the information from the discontinued B4.4 gaging standard (the toolmakers tolerance table is not included). This is the first time a standard provides design information for fixtures. Also for the first time three different methods are described for gage tolerance allocation (Absolute, Tolerant, and Optimistic). Most of the figures show isometric views of functional gages for parts that are shown in the Y14.5 Dimensioning and Tolerancing standard. I'm fortunate to say that I was allowed to draw all the drawings in the standard.

The Y14.2 Line Conventions and Lettering standard finished the latest revision at the Fall meeting in Kansas City. As I am the chair, as soon as I receive the updated figures, I'll send the text and figures to ASME so the review process can begin. The document is first sent to the Y14.2 sub committee and the Y14 Main committee for a three month review. After passing this hurdle, it is sent out for a public and Department of Defense three month review. If all goes well, it will be available about this time next year.

The big debate in the Y14.5 Dimensioning and Tolerancing standard is how to treat non-size features as size features particularly when they are used as secondary and tertiary datums. The hard part is forming the right words that encompass all the possibilities. There are a few partial solutions that work for some examples but not all. One of the problems is with the phrase, "virtual condition" – it is too confining. The concept and terms for maximum and least material condition boundaries was discussed at length during the fall meeting. The same concepts have been discussed for several years by members the Section 4 Datums Working Group (I am a member of this small group). ASME thinks we need to bring the discussion to a timely close because they need the revenue generated by a new Y14.5 standard. It is their largest selling standard.

In an effort to finish somewhat close to the 2004 deadline, there are three Y14.5 meetings scheduled for 2004. The first meeting was February 2-5 at the Hyatt Hotel in Sarasota, FL. The second meeting was from May 2-7 at the Sheraton Hotel in St. Louis. The third meeting is tentatively scheduled for the week of October 4 in Denver. They are public meetings held from 8:00 am-5:00 pm with an hour for lunch. You are all invited.

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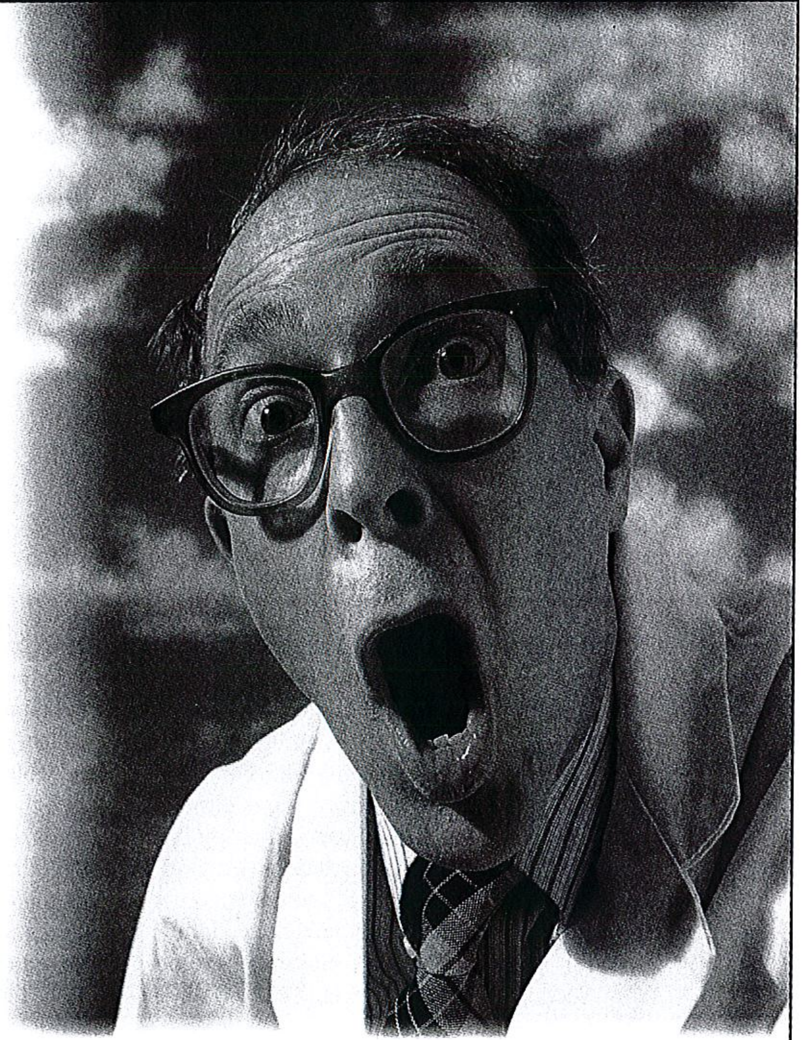

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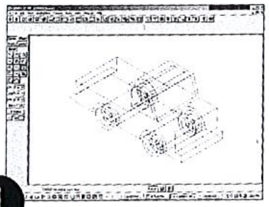

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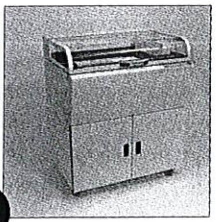

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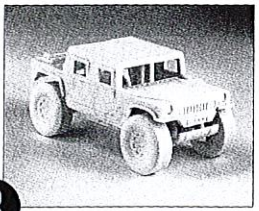

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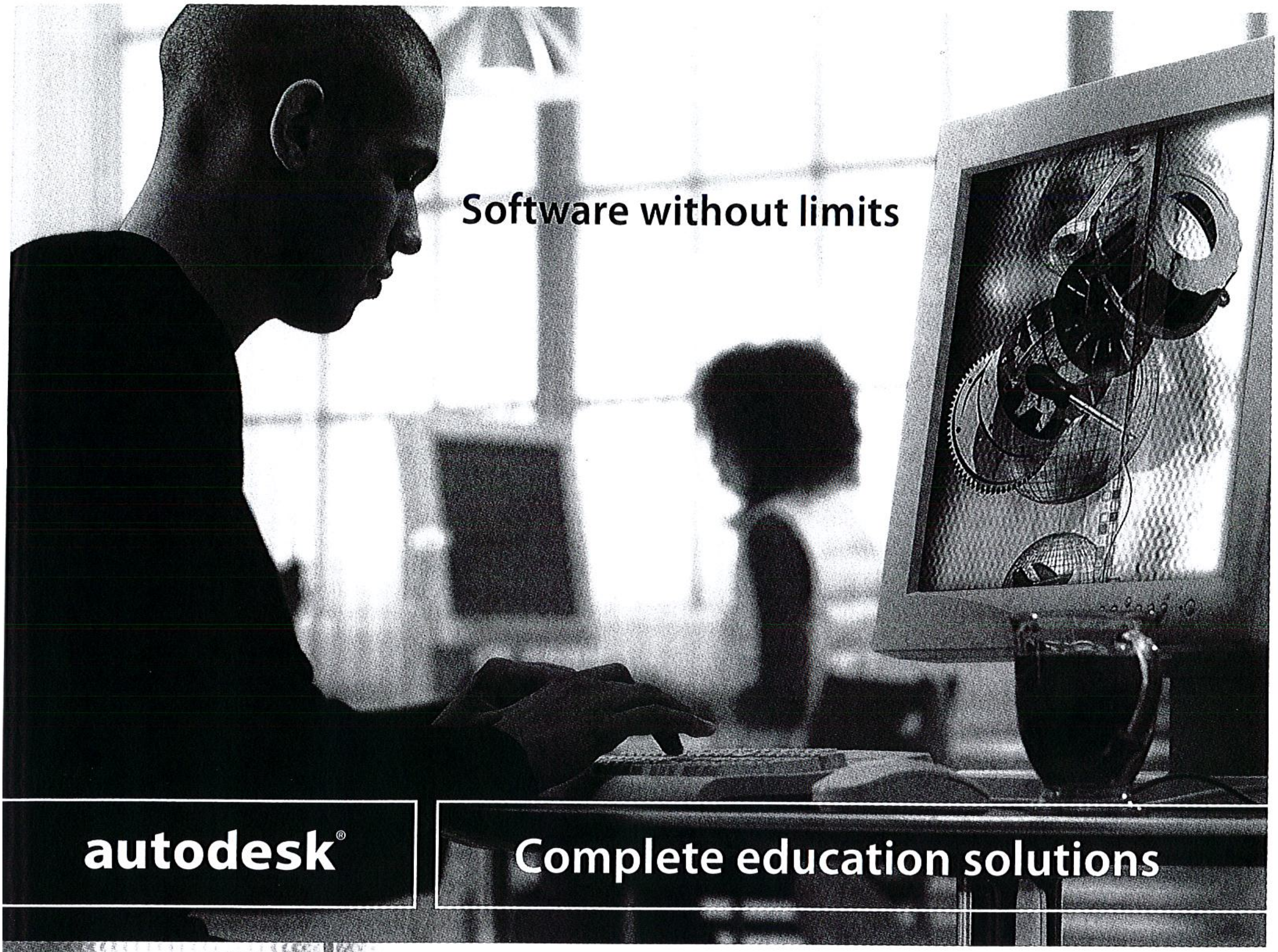

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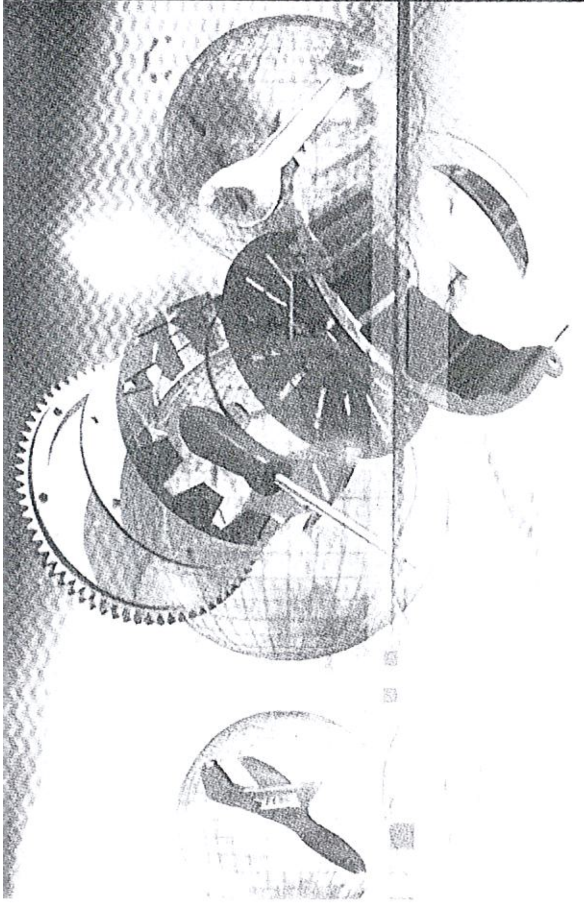

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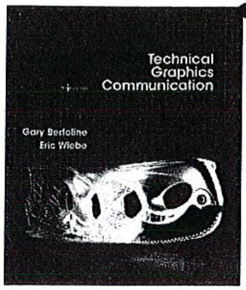

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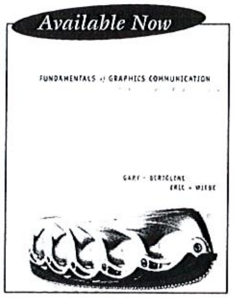

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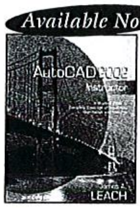

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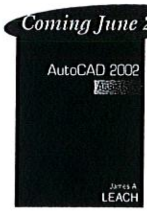

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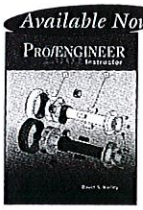

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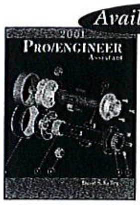

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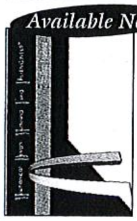

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