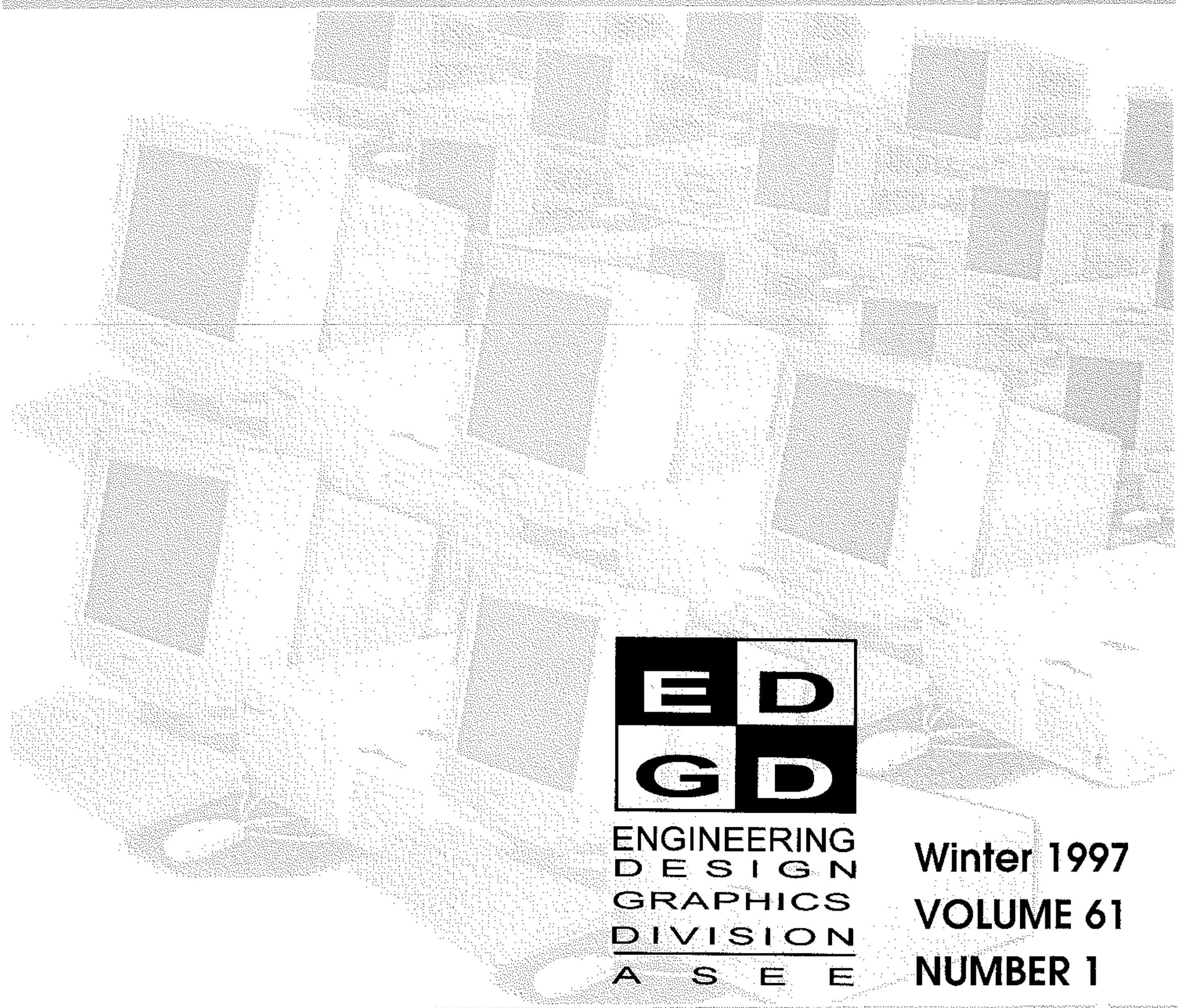
THE ENGINEERING DESIGN GRAPHICS JOURNAL



ENGINEERING DESIGN GRAPHICS DIVISION ASEE

Winter 1997
VOLUME 61
NUMBER 1

ENGINEERING DESIGN GRAPHICS DIVISION
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

ENGINEERING DESIGN GRAPHICS WORKBOOK

A Concurrent Engineering Approach

Barr, Juricic, Krueger, Wood and Miller
University of Texas-Austin

This workbook allows you to incorporate engineering design, analysis and manufacturing into your engineering graphics course. It takes an integrated approach to engineering design by utilizing sketching, CAD, FEA and building of a design model with a rapid prototyping system.

TABLE OF CONTENTS

Each module consists of the following sections:

1. Introduction
2. Text material
3. Manual sketching sheets
4. Computer lab exercise

Software and manufacturing tools used by this book: AutoCAD Release 12, AutoFEA, and JP System 5.

Available: June, 1997 Net price $39.95 482 pages.

The version of this text using AutoCAD Release 13 will be available Fall, 1997.
Information on JP System 5 and an extended Table of Contents for this book are available on our web site.

Please contact Stephen Schroff for a complimentary examination copy. We will be showing JP System 5 and this text at the ASEE Annual Conference, June 15-18, 1997.

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EDGD ENGINEERING DESIGN GRAPHICS DIVISION ASEE

THE ENGINEERING DESIGN GRAPHICS JOURNAL

Volumn 61 Number 1 Winter 1997

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.

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. . . from the EDGE

Dear Members:

It used to be that as the software was upgraded to a new version, we were faced with the dilemma that the textbooks were constantly one version behind where we wanted them to be. Now the problem seems to be just the opposite. There are several illustration and page set-up packages that we use in our freshman and sophomore level classes. We are quite happy with them, since our beginning students don't begin to push the software to the limits. Our curriculum group met last week and decided as a group to save some money and some of the hassle and not upgrade for another year. This seemed like a good decision for several reasons. Our Department Head is pleased because we save the cost of the upgrade. The instructors don't have to learn the ins and outs of a new interface, and the course supervisors don't have to coordinate the text with the new version of the software. The students will find it easier to work in other university labs, because the university isn't planning to upgrade these versions of software either.

What seemed like a good solution has become the cause of a new dilemma. It seems that we can no longer order books that coordinate with the version of software that we are currently using. Publishers can now produce books as fast as software companies can design new versions of their software. I am sure that authors love this, as Jon Duff has told me many times, authors get nothing from the sale of used books. Since the books become obsolete as the software changes, the publisher prints new versions of the books which correspond to the new software. The texts for the older version are no longer printed. If we stick with the old version of the software, the information in the books that the students purchase will not coordinate with what they see on the screen. If we upgrade to the new versions, the students will face problems working in university computer labs which continue to have the old version of software.

There is no simple solution to this dilemma. It has occurred to me that those who teach english and history don't have these problems. These disciplines are not faced with constant changes in technology. *(Although our Communication classes are designing Web pages.)* I sometimes feel like I have been in a race during the past several years. No sooner do I become comfortable and confident doing something when something new opens up and it is off to the races again. I have added new software to my repertoire every year and don't see a slow down or pause in the race. Now, don't get me wrong, in most cases I enjoy the challenge and feel good about the accomplishments. Sometimes, however, I do look at those teaching in other disciplines and think that it would be nice to pull out last year's stuff and be ready to go.

Mary A. Sadowski

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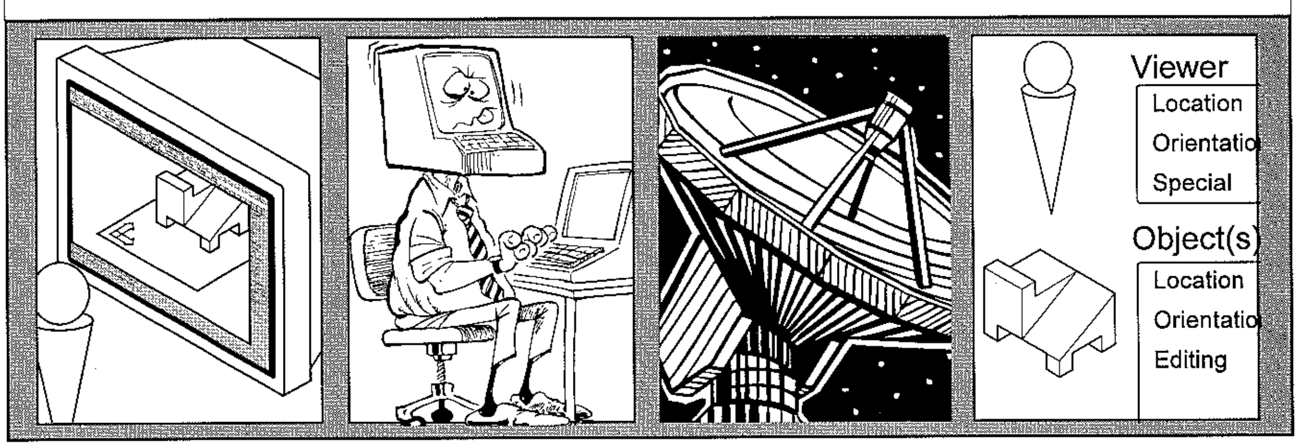
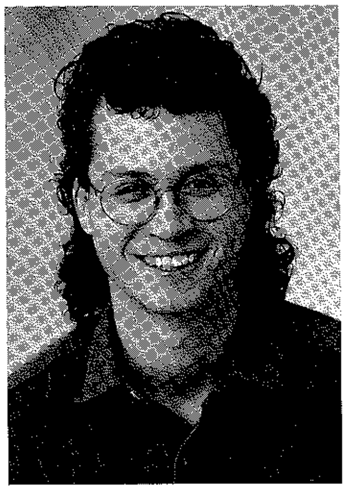


An Instructional Method for the AutoCAD™ Modeling Environment

Oppenheimer Award Recipient



Presented at the 51st Annual
Engineering Design Graphics
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Raleigh, North Carolina
November 1997

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Abstract

This article presents a command organizer for AutoCAD to aid new users in operating within the 3D modeling environment. While teaching solid modeling as the basis for engineering design, as well as a using the modeling database as a focal point for the generation of other types of technical and engineering graphics, it was found that new users frequently encountered the same problems and asked the same questions when presented with the 3D environment. The organizer presented in this article is designed to help engineering students become acquainted with the AutoCAD modeling environment and the commands that control the environment; it has met with limited success in both visually organizing the command structure and decreasing new user questions. Although it is specifically designed for the AutoCAD environment, it must be noted that the underlying environmental controls and the operation of the environment is consistent and applicable to many other software packages and graphical applications.

Introduction

The use of three-dimensional environments in engineering education has drastically changed the way engineering graphics concepts can be presented and taught. Three-dimensional modeling enables engineers and designers to work in a realm that on paper can so easily evade them. As educators continue to increase the implementation and use of computer modeling tools, they continually request more and more features in their desktop CAD software. In doing so, the interface and other aspects of the software become more complicated for new users.

As engineering educators, we ourselves have no doubt gradually migrated to the modeling package of our choice. Often this migration occurs in small, incremental steps over several years of our professional career. Unfortunately, for students, the introduction to 3D tools is foreshortened. Students must become accustomed to the software tools much more quickly for success in the limited amount of time they have in the computer laboratory. Many times students struggle to not only learn a new software, but also to adapt to the three-dimensional environment and the graphics concepts being taught.

As modeling continues to become a larger part of engineering education, often it is difficult to separate theory instruction from tool instruction. Much classroom time is spent teaching tool specific techniques rather than more global, conceptual matters. Techniques and procedures in model manipulation are a daily occurrence because tool instruction is important in the day-to-day nature of the tasks and projects the student must execute. But the optimum is to be more than teachers of a software tool. To empower students, engineering educators must help students overcome the learning curve of new software and the modeling environment so they may conscientiously attend to learning concepts.

Enabling students to move beyond the software should be a goal; allowing them to focus on visualization and spatially-focused analytical skills.

In software such as AutoCAD, new users are often intimidated by the wealth of commands, not to mention the three-dimensional working environment. Many of these 3D modeling packages have evolved significantly from version to version, with very few features being removed. The evolutionary nature of the software presents the student with several complex paths to get from A to B; some being more efficient than others. This nonlinear characteristic makes the CAD software an inhibiting and unstructured environment for new or casual users.

In addition, educators continue to involve students with the modeling paradigm earlier in their education. Several sources state that early introduction to modeling increases visualization skills. Likewise, many have departed from traditional board-based descriptive geometry to modeling environments to teach visualization (Bertoline 1991, Devon, et. al. 1994, Sexton 1992).

The focus of this paper is not to debate these issues, but rather to acknowledge that early introduction to computer modeling and the 3D environment compounds the number of cognitive skills being concurrently developed, particularly if computer skills are waning. Engineering educators must analyze the possible attributes that make the 3D environment difficult for students to use, as well as the various teaching aids that can assist the student in understanding and becoming efficient in the operational 3D modeling environment. By endeavoring to decrease the software learning curve through the use of mnemonic devices, organizers, multimedia and visual descriptive aids, students can more easily focus on the process instead of the tool or environment. Enabling students to move beyond the software should be a goal; allowing them to focus on visualization and spatially-focused analytical skills. In reality, anything engineering educators can do to help the user cognitively arrange and understand the 3D environment and software commands lowers the learning curve and empowers the student.

Analyzing the Problem

To begin creating efficient and effective tools or aids for instruction the problems associated with learning a 3D tool must be analyzed. A review of literature points out that there are many factors that can contribute to the difficulty new users have with a 3D environment. Let's face it, students who can now interact and build almost anything within the virtual universe contained within the desktop computer are not used to being able to draw or operate within a virtual 3D environment. Previous drawing experiences of most students are almost certainly limited to drawing in two-dimensions. Experiential conditioning to be *flatlanders* has prepared most students to think in a two-dimensional manner, always striving to find a way to draw in three-dimensions when they only have two with which to work. Three-dimensional environments contradict the traditional drawing and sketching paradigm that students have been presented and for which they have been conditioned. This alone presents students with a learning curve that is quite pronounced when it comes to 3D environments. Not only must they deal with the environment but they must also learn to control it. Yet there are also other factors that contribute to the difficulties of today's 3D modeling environments.

Visualization Skills

In addition to the tremendous shift in paradigms, another problem is that many students have little visualization ability. To present students, whose visualization skills are waning, with a 3D environment can be disastrous because they often do not have spatial visualization or spatial orientation abilities. Yet, one does not have to subject a student to a 3D environment to see this weakness exhibited. In most instances, visualization ability can be revealed through the use of imaginative sketching exercises as well as specially designed tests which reveal the level of spatial proficiency within the student. Engaging a student, weak in visualization, with a 3D modeling environment only magnifies the studentís visualization weakness.

The study of visualization ability and its affect on the student has a long history in many professional societies. As described by Miller (1996), visualization has long been a part of the information disseminated throughout *The Engineering Design Graphics Journal*. One of the most intriguing factors, at least to this author, is the role that imagination plays in visualization ability. Many of the sources discussed by Miller, including prominent historical individuals in the field such as Orth (1941), Blade (1949), and Kliphart (1957) state that imagination is primary to visualization ability. It would seem natural (and is pointed out by these sources) that the ability to imagine familiar objects such as a chair, table or other item is a precursor to being able to visualize an object based on orthographic multiviews. It would also stand to reason that imaginative ability would be a precursor to operating within a 3D environment which requires spatial visualization and orientation abilities.

Within our own decade, the impact of imagination can be seen through suggestions for curricula and media tools to aid in teaching visualization. Wiley (1990), Wiebe (1993), and Ross & Aukstakalnis (1993) suggest that the use of real models, animations, and virtual environments can aid in teaching or enhancing visualization ability.

It seems that as technology continues to increase in its ability to entertain students, imagination is used less and less by students. Students become used to being entertained rather than imaginatively entertaining themselves. Therefore, the imaginative skill is undeveloped. Does a decreased use of imagination decrease potential visualization ability? Although research is needed to validate this point, it is intriguing to consider that a loss (or decrease) of a historically noted precursor to visualization — imagination — could be one of the reasons a greater number of students have difficulty with visualization, and consequently, operation within a 3D environment. It will be interesting to see the impact that computer technology such as the World Wide Web, Virtual Reality Modeling Language (VRML), and the 3D human-computer software interface has on the visualization skills of the next generation of engineering students. If 3D technologies infiltrate the younger generation, visualization skills may be more refined within entering freshman — if not as a result of imagination, then as a result of experience.

Nonlinear Tools

Another possible contributor to the problems that students have with the AutoCAD modeling environment is the way in which they have access to the commands that control the 3D world, as well as the way in which those commands are presented in the educational setting. Much of this is related to the ability to perform any number of operations within the 3D environment at any given time — the software's nonlinear attribute. For example, at any time, an object can be rotated or moved. At any time the view of the database can be rotated or moved. The coordinate plane can also be positioned anywhere at anytime. This scenario presents the student with a unstructured or independent mode of operation. Most often students become disoriented as a result of unstructured control — too many variables.

Note that even the most primary introductions or exercises to the 3D environment tend to be unstructured. Often creating simple primitives, an *easy* exercise, requires more than simply defining two corners of a box or defining an origin and radius for a sphere. Attributes such as the current view, coordinate plane, and the 3D position of objects all enter into this seemingly simple exercise; making the 3D environment more difficult to learn for most individuals. It is the ability to change the view, object position or orientation, and coordinate plane at any time that causes problems because students do not understand the interrelationship between these attributes.

...when students are presented with a nonlinearly structured tool, such as a 3D modeling environment, they often become disoriented and find it difficult to learn.

It is no surprise that most students learn best in a structured environment. Most educators understand that structured learning environments are a vital method of receiving instruction. Time has proven that this is an effective method of instruction in many different fields. Yet when students are presented with a nonlinearly structured tool, such as a 3D modeling environment, they often become disoriented and find it difficult to learn. Humans by nature are linear creatures and often become disoriented in nonlinear environments.

From experiences in early childhood, the brain is conformed to acquiring information in an organized and progressive fashion. Yet the brain, in many individuals, can be more responsive to nonlinear and nonsequential environments. Looking at the various learning styles of a range of individuals reveals that while some thrive on structured learning or information reception, others have significant difficulty decoding and encoding the information in this atmosphere.

It is no surprise then that when presented with a nonlinear tool, such as AutoCAD, that most students need an organized schema of analyzing and controlling the 3D world. When presented with even a simple task, such as creating a series of primitives, the are many variables that enter into the creation of those primitives beyond simply defining a box, cone or sphere. Location of the coordinate plane, viewing position, and the points chosen for defining the primitives all must be dealt with in this simple exercise. With so many variables, students need a structure for learning how to control a 3D environment.

A Static View of a Dynamic World

In the literature surrounding 3D environments, much research has been performed to determine the effectiveness of dynamic environments and dynamic graphics. A student's perception of concepts, interrelationships, and spatial relationships is affected by the use of animations and virtual environments. Much of human depth perception and stereoscopic vision is based upon a dynamic, rather than a static view of the world.

With 3D tools, often the student does not understand the relationship between the attributes of the actual modeling environment and what is seen on the display screen. Questions often arise concerning why something on the display has gone awry when the view has been changed or when the model has been moved. The static display could be one of the contributors to this misconception.

Fundamentally, students are used to dealing with dynamic environments and they are used to being able to move about their environment to better understand it. To better understand a tangible object, the student can move himself or turn the object to better view it, but given a 3D environment, most students become confused about how to do either of these operations when presented with a static display of the environment.

Indeed, some of the newer modeling environments such as 3D Studio Max as well as tools such as VRML focus on the need for a dynamic environment. The developers of these tools are aware that the perception of the 3D environment is much more accurate and efficient when the environment is dynamic. For example, real-time display of rotation operations along any given axis, as well as constant redrawing of the coordinate plane make the modeling environment of 3D Studio Max more understandable by those who are weak in visualization skills. A dynamic display environment is advantageous in a 3D modeling environment. Without it, the student must understand the attributes of the 3D environment as well as the interrelationship between the view and objects and their six degrees of freedom.

The AutoCAD Organizer

While teaching an introductory CAD course at Purdue University, it was noted that a simple organizer for AutoCAD commands reduced much of the confusion concerning the introduction to the three-dimensional environment. An organizer is a cognitive organization scheme that allows the learner to mentally comprehend, arrange, and synthesize information. Organizers create a global picture that can be seen among and between the individual pieces of information in the arrangement, while also providing a means for deductive reasoning and analysis. Organizers are best used when there is relationship among and between the information pieces, as is the case with the AutoCAD solid modeling environment.

Over a period of two semesters, a trend began appearing within Technical Graphics 200 Introduction to CAD, the first modeling course, as well as the first CAD course for most of the students. During the early months of the course and throughout all sections, many students seemed to have difficulty operating in the three-dimensional environment. Most of the difficulties seemed to arise out of an apparent misconception of the three-dimensional environment and the commands that control it. Many students would change the view point and believe that the model had somehow changed location or orientation. Subsequent movement of the model further complicated the situation because the student assumed other variables had somehow changed. The ability to not only move the viewer and the object(s), but also the coordinate system, seemed to present the user with too many opportunities for error.

Through observation and student questions, it seemed that the students did not understand the global concepts of the three-dimensional environment. Primarily, students were not making the mental connection between the commands and how they affected and controlled the three-dimensional environment. Later in the semester the students did make the cognitive connections — between the commands and the environment — without intervention, but it seemed that it should occur much earlier in the course to be optimally effective. Through these in-class observations it was noted that to become productive in the 3D AutoCAD environment the student must (a) understand the attributes of the 3D environment, and (b) develop a mental hierarchy of the commands used to control the environment. The organizer for AutoCAD is based on these two assumptions. The organizer must be preceded by an explanation of the attributes of the environment; what makes up the environment. All the AutoCAD commands can then be divided by the attribute they affect.

Environment Attributes

Most three-dimensional CAD courses begin by introducing students to the three-dimensional environment; requiring them to create a series of the modeler's primitive objects (assuming the use of a CSG modeler) or some other base exercise. Creation of the basic primitives allows the students to "get their feet wet" in the three-dimensional, digital world. However there are underlying attributes, beyond the objects, with which they must contend. For example, the particular view that is used in the creation process directly affects what appears on the studentís display. The coordinate system also affects this exercise by limiting the way the primitive is defined. These underlying factors, view and coordinate system, create a

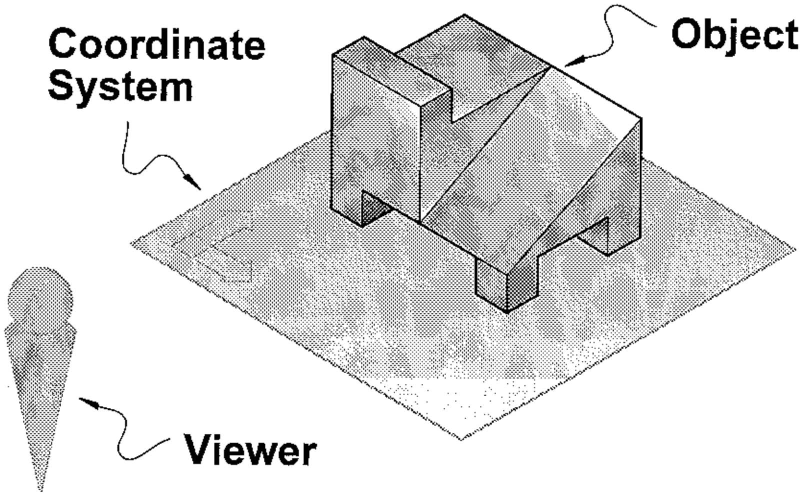

Figure 1 The three primary attributes of the 3D modeling database: viewer, object(s), and coordinate system.

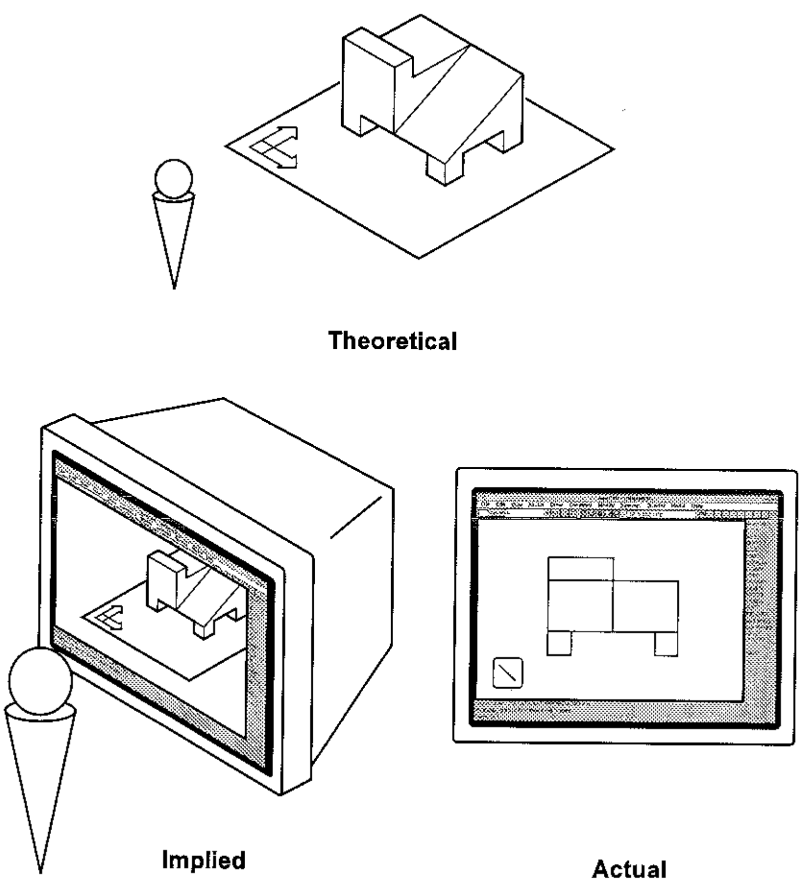

Figure 2 The theoretical, implied, and actual display of a 3D environment.

mild barrier in this exercise because the student is actually dealing with three separate attributes at one time. Many times students do not recognize that all three attributes, viewer, object(s), and coordinate system, exist, interrelate, and affect the database simultaneously. Because they do not recognize the three attributes, students become confused with the commands that control the viewer, object(s), and coordinate system. Hence, the thought that changing the view has moved the object. As a result of this logic, this simple exercise lead to the development of the AutoCAD organizer which is based on the three primary contributors to the three-dimensional environment shown in Figure 1. These primary contributors include the viewer, the object(s), and the coordinate system. Once students understand and recognize both the existence and relationship of these three elements they can more easily operate in the three-dimensional environment.

To support the organizer command structure, students must be taught that there are three major elements or attributes found in the three-dimensional database. In Technical Graphics 200, the modeling environment was described in the following way.

The first attribute or element of the modeling environment is the objects. They are the main focus of the modeler; they are what is being created. The objects exist in theoretical space without ends. Each object has both a location and an orientation, and can be moved, rotated, or edited anywhere in the theoretical space.

The second element is the viewer. The viewer is the studentís vantage point of the three-dimensional world. Unfortunately, the theoretical space (in which the model exists) goes on without end; therefore, students can only see through a small window on the monitor (Figure 2). However, the student's view can be changed, allowing them to see adjacent parts of the three-dimensional world. Knowing this, the viewer, like the object, has a specific location and orientation.

The third element, the coordinate system, is the orienting plane. During the introduction to the environment, the students were encouraged to use a grid to help visualize the location and orientation of the coordinate plane. In AutoCAD, the student must realize that the height of all primitives rises out along the Z-axis; therefore, the coordinate plane affects how primitives are created (Figure 3). The coordinate plane, or User Coordinate System, is moveable and it has a location and orientation. If the plane did not move, all primitives would have to be created in one location, then rotated and moved to the "final" position. A moveable construction plane allows primitives to be created "on-site."

Once students understand these elements, the environment can be summarized by the following:

1. The viewer, objects, and coordinate system (UCS) exist in conceptual space that is unlimited in scope and defined by an absolute, fixed coordinate system called the World Coordinate System (WCS).
2 The viewer, objects, and coordinate system (UCS) can be oriented and/or moved anywhere in the coordinate space.
3. The relationship between the viewer location and orientation and the object location and orientation determines what is seen on the computer screen.
4. The coordinate plane determines how a primitive is created in the drawing space.

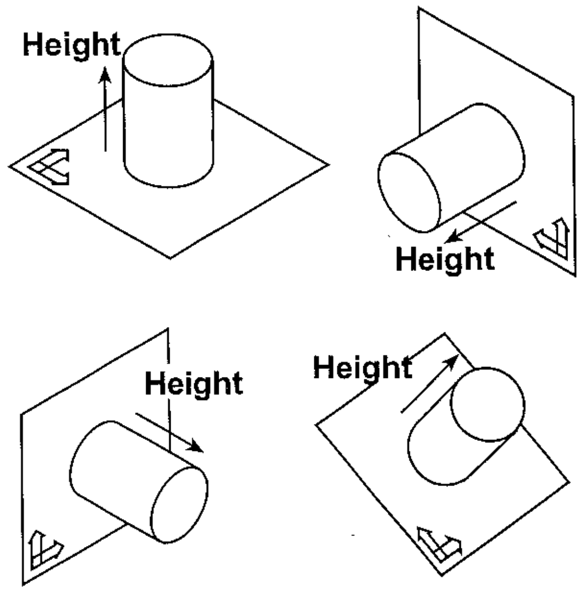

Figure 3 In AutoCAD, the height of all primitives rises parallel to the Z-axis.

Controlling the Environment

Once the students understood the environment attributes, the commands were then described using the organizer. In Technical Graphics 200, all the commands were divided into one of four areas: object, user, coordinate system, or utility (see Figure 4). By dividing them in this way, students could analyze what they wanted to do and find the division to which it belonged. They could then reference the divisionís commands and decide upon the scheme that allowed them to analyze what they were doing in real time. For example, students might want to change the current view. Looking at the organizer and understanding that the viewer location and orientation defines the view, they find the viewer division in the organizer and execute the appropriate command. If they want to affect either of the other two attributes, simply referencing the organizer structure will indicate the appropriate command.

In addition to hierarchy, the organizer also provided a means for students to understand that changes can only occur within one of the areas at a time. For example, many beginning students change the location of the viewpoint and mistakenly believe that the object has somehow changed location or orientation. Using the organizer and understanding that changes can occur only within a single division gives students a means of checking their logic versus the organizer and to the possibilities within the three-dimensional AutoCAD database.

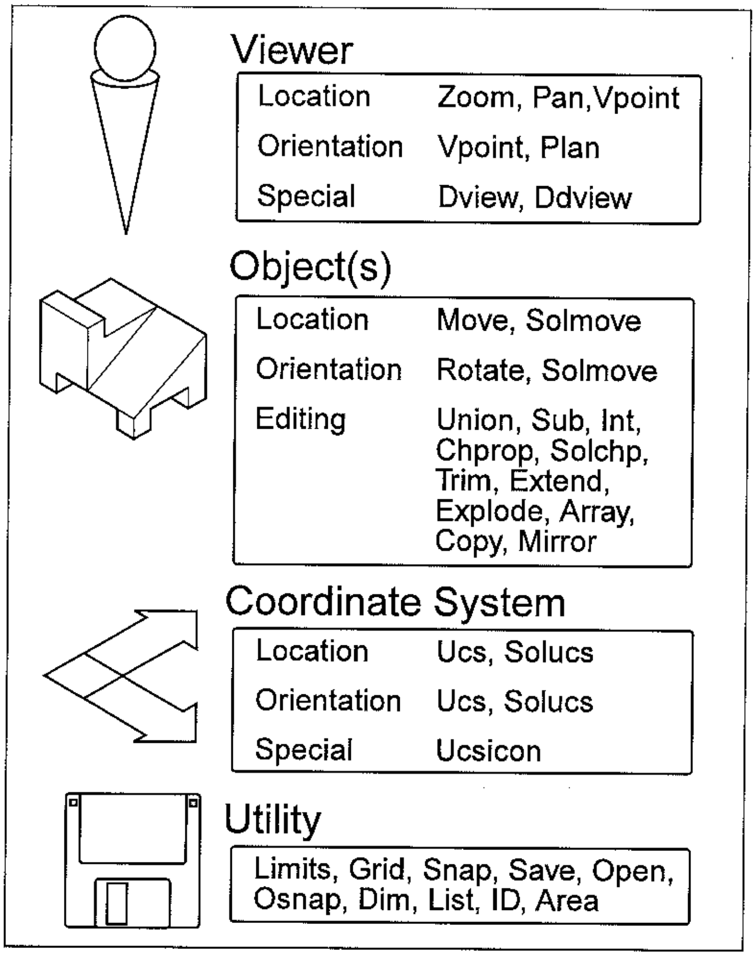

Figure 4 The AutoCAD command organizer.

Why Does the Organizer Work?

One of the pervading questions that persists concerning the command organizer is why does it work? Review of the literature concerning spatial visualization leads this author to believe that the organizer works because it describes and cognitively separates the two main spatial skills that compose visualization ability. These two skills are required for efficient and effective use of the 3D environment: spatial visualization and spatial orientation.

Sexton (1992) describes the effect of using 3D CAD technology to introduce basic engineering graphics concepts. In this article he notes that there is much disagreement about the nature of visualization ability even though it is agreed that it is an important component of intellectual ability. There is also agreement in the field concerning two basic components that comprise visualization ability: spatial visualization and spatial orientation. Quoting McGee (1979), Sexton's article described spatial visualization as *the ability to mentally rotate, manipulate and twist two- and three-dimensional stimulus objects*. Again, quoting McGee, spatial orientation is *the comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude to remain unconfused by the changing orientations* of those patterns.

This author believes the organizer works because it aids the student in understanding how to manipulate and control the objects in the 3D environment (through the organizer structure) which satisfies the spatial visualization component of visualization ability. The understanding of the environment attributes (object, viewer, coordinate system) enables the student to *comprehend the arrangement of the elements within a visual stimulus pattern* (paraphrase McGee, 1979) by understanding what is in the environment. This satisfies the spatial orientation component.

At the time of the presentation of this paper, the biggest question for this author was, why does the organizer work? Respectively comparing the organizer method (environment attributes and command structure) to the components of visualization ability (spatial orientation and spatial visualization) may reveal the answer.

Although the significance of the organizerís impact on use of the three-dimensional environment needs further analysis, preliminary in-class results indicated that students were able to more quickly understand how the environment works. In addition, the number of questions concerning manipulation of the viewer, objects, and coordinate system decreased. Undoubtedly, the most significant reason the organizer helped the student is because it is a visual command hierarchy. Having a reference sheet designed in this way helped reduce questions concerning the AutoCAD commands.

Other instructors have also questioned how all the remaining commands could be grouped into the general *utility* division. It must be noted that the main purpose of the organizer is to provide a logical structure for understanding how to manipulate the three main elements: viewer, object(s), and coordinate system. With the wealth of commands available in AutoCAD, undoubtedly more divisions could be added to the organizer. Further development of the organizer command structure, subdividing the remaining commands in AutoCAD, could increase its significance, importance, and application.

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Viewing 2D Vector CAD Drawings Over the Internet Using the New .DWF File Format

James A. Leach, Michael Anderson, Douglas Clark
University of Louisville

Abstract

The World Wide Web has presented new opportunities for exchange of drawing data among colleagues and clients in many industries; however, the proliferation of raster-based images does not provide the capabilities needed by the engineering, design, and construction industries. A new standard file format for CAD drawings has recently been established to provide individuals a method for viewing drawings in real-time over the Internet. The .DWF (Drawing Web Format) file is a compressed vector-based file. Using the WHIP!™ Plug-In (for Web browsers), engineering and design professionals can use zoom and pan tools to maneuver through complex, detailed drawings.

Two WHIP! (Windows High Performance) components are required to create and view .DWF images. The WHIP!™ Plug-In is needed to view the .DWF images from within Netscape Navigator™ 2.01 (or later) or from Microsoft Internet Explorer™. The .DWF files can be created from AutoCAD™ Release 13 Version C4 drawings (.DWG files) by first installing another WHIP!™ driver for AutoCAD. Both WHIP!™ drivers are free and downloadable from the Autodesk (makers of AutoCAD) web site. The .DWF is an open standard; therefore, other CAD software makers will develop tools for creating the publicly viewable .DWF files from their proprietary CAD drawing formats.

This paper discusses the details of downloading and installing the necessary components, as well as creating and viewing .DWF files. Other topics include publishing .DWF files on your home page, additional features and limitations of the .DWF standard, and potential opportunities and benefits to the engineering, design, and construction industries.

Introduction

A new standard file format for 2D CAD drawings has recently been established to provide individuals a method to view drawings over the Internet and within intranets. The DWF (Drawing Web Format) file is a compact vector-based file. Using the *WHIP!*™™ Plug-In for Netscape Navigator™™ and Microsoft Internet Explorer™, engineering and design professionals can use zoom and pan tools to maneuver through complex, detailed drawings. The DWF file format and *WHIP!*™ (Windows High Performance) drivers provide new opportunities for project teams, clients, and customers to collaborate over the Internet or within an intranet using only basic web-browsing tools.

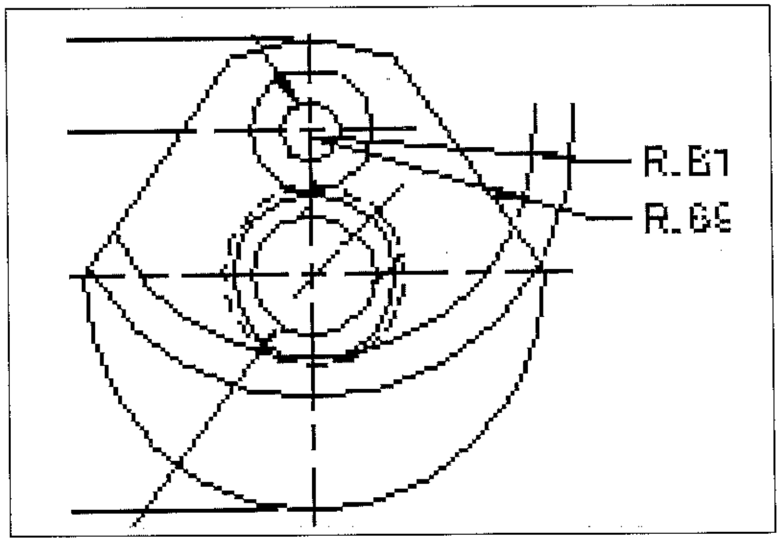

Figure 1 Enlargement of a Raster Image

Raster Files

The Current WWW Standard

The current World Wide Web graphic standard uses a raster image format such as GIF or JPG. These files can be highly compressed, making the information displayed in the images quickly transportable over data transmission lines and devices used for the Internet. However, because raster images are pixel-based, or composed of tiny *dots,* viewing detail is not possible–zooming in only enlarges the *dots*. Figure 1 displays a raster image having been enlarged.

Raster images, such as a *screen grab* for example, are defined in the data file as a map of pixels–rows and columns of picture elements either in black and white or in colors. Raster images are sometimes referred to as *bitmaps,* since the file retains the map of each dot (placement within the rows and columns) with its color information. Examples of raster image file formats (file name extensions) are given in Table 1.

BMP	Windows / OS/2	PBM	Portable Bitmap
CLP	Windows Clipboard	PCX	PC Paintbrush
DIB	Windows BMP	PSD	Photoshop
GIF	CompuServe	RAS	Sun Raster
ICO	Windows Icon	SGI	Silicon Graphics RGB
IFF	Amiga ILBM	TGA	Truevision
JPG	JPEG	TIF	TIFF
MAC	MacPaint	XBM	X-Windows Bitmap
MSP	Microsoft Paint	XPM	X-Windows Pixel Map
NIF	Navy Image File	XWD	X-Windows Dump

Table 1. Example Raster File Formats

CDR	CorelDRAW	**IGS**	IGES
CGM	Computer Graphics Metafile	**MCS**	MathCAD
CMX	Corel Metafile Exchange	**P10**	Tektronix Plot 10
DGN	MicroStation	**PCL**	HP Laser Jet II
DRSW	Micrografx Draw	**PGL**	HP 7475A Plotter
DWG	AutoCAD	**PIC**	Lotus
DXF	AutoCAD	**PRT**	CADKEY
GEM	GEM Metafile	**WRL**	VRML

Table 2 Example of Vector File Formats

Vector Files

The CAD Data Standard

Raster images are of little use to professionals who require drawings with detailed information. Instead, the engineering, architecture, design, and construction industries use vector images to retain data with great precision and detail. CAD programs, which are the primary graphics creation and storage media for these industries, generate vector data. Figures 2 and 3 illustrate the same vector image (a CAD drawing) in a *zoomed out* and *zoomed in* display.

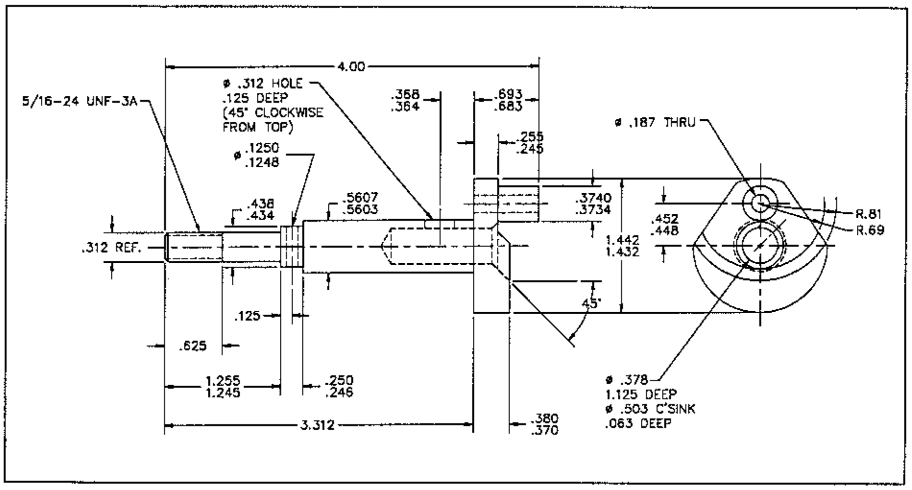

Figure 2 Example Vector Image

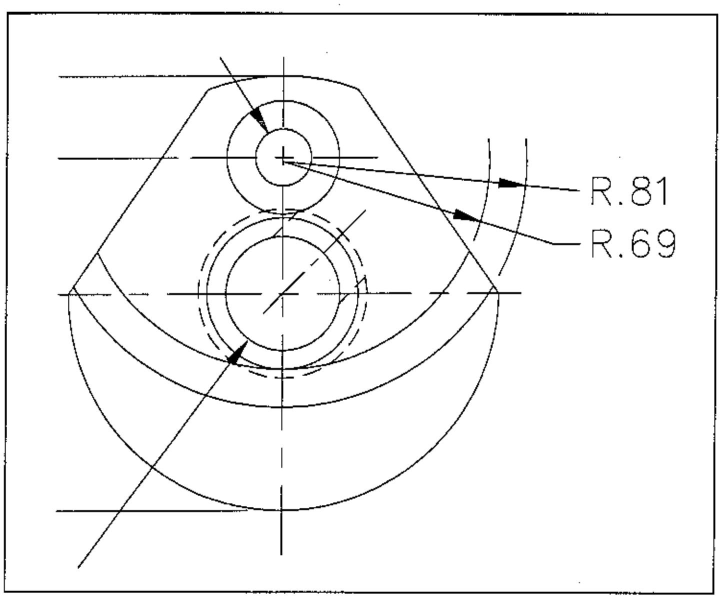

Figure 3 "Zoomed" Vector Image

Because a vector file defines a line, for example, as a vector between two endpoints, only one dimension is retained–length. *Zooming in* does not create a second dimension (thickness or width) for the line. The thickness of the displayed line on a computer monitor is always one pixel, the size of which is determined by the display device. Table 2 lists some examples of vector file formats. Before the new DWF standard was introduced, the World Wide Web provided inadequate usefulness for the engineering, architecture, design, and construction industries. Raster files are unable to retain the necessary detailed information, while the data-rich vector files generated by CAD programs are too large to be *viewable* over the web. A CAD file's size is partially due to the non-graphic information contained in the file, such as layers and other named dependent objects, procedures used in creating the files, drawing and editing preferences, symbol definitions, and so on. Although CAD files can be compressed and transmitted via e-mail from one location to another and then uncompressed and loaded into the associated CAD program, they cannot practically be *viewed* over the web from a remote location.

The DWF File Format

The DWF file format developed by Autodesk provides a medium for storing only the necessary display information of a CAD-generated drawing file. The DWF file format is a 32-bit, vector format for 2D graphics. The main advantage of this file format is size, usually about 5%-20% of the parent CAD file. This compact vector file facilitates faster transport of images over the web, thus making it possible to view a vector image stored on a web server, with zoom and pan capabilities, from a remote location such as your computer at home or from a laptop on the construction site.

Only basic web-browsing tools plus the *WHIP!*™ Plug-In are needed to view the images–not the original CAD software. Because the DWF files cannot be edited, drawing security and integrity are maintained. The complete data-rich CAD file can be attached to the DWF for transport via e-mail if desired.

The *WHIP!*™ Plug-In provides real-time zoom and pan capabilities. From within Netscape Navigator™ or Microsoft Internet Explorer™, right-clicking (on the mouse) invokes a menu displaying zoom, pan, and other options. Figure 4 illustrates a web page displaying a DWF image (full view) with the menu open.

Real-time pan and zoom are accomplished by holding down the left mouse button while moving the mouse up (for zoom in) or down (for zoom out), or moving the mouse any direction for panning. In this way genuine detail can be viewed, similar to capabilities in the original CAD program with the associated CAD drawing. Figure 5 displays detail within the same DWF image.

With the new DWF file format, drawings can be made accessible over the World Wide Web or within an intranet for a variety of applications. For example, an engineering architectural, construction, or design firm could post DWF images on its web page, providing immediate viewing accessibility to associates or clients in the field. The images could be construction plans for viewing from laptops on the construction site or requests-for-bid drawings displayed for all interested clients.

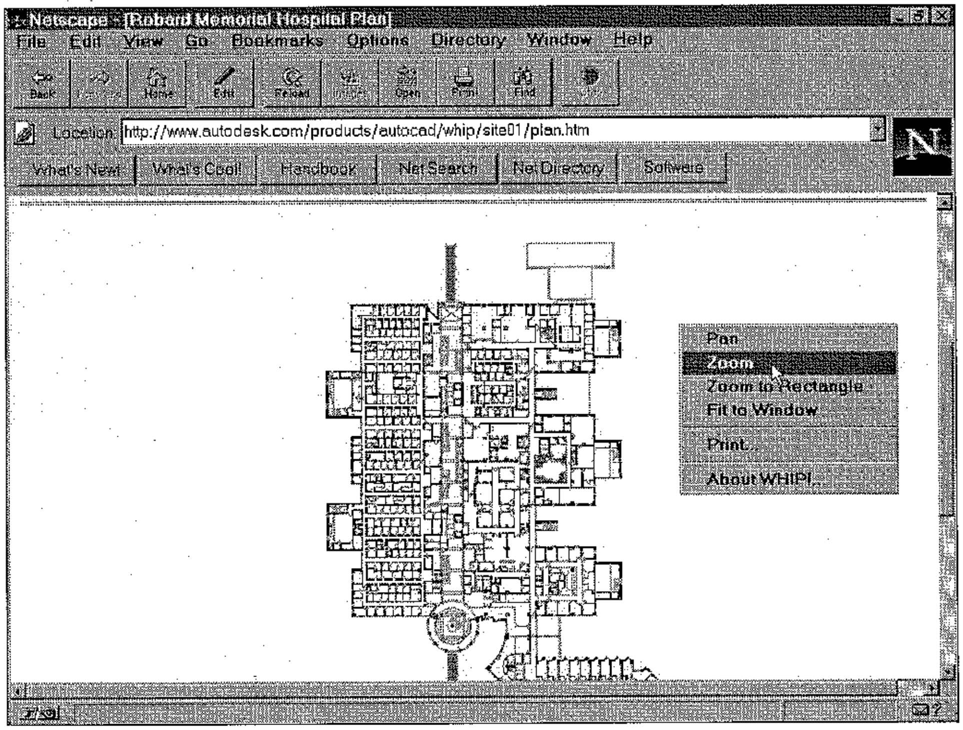

Figure 4. Netscape™ Displaying DWF Image and *WHIP!*™ Plug-In Menu

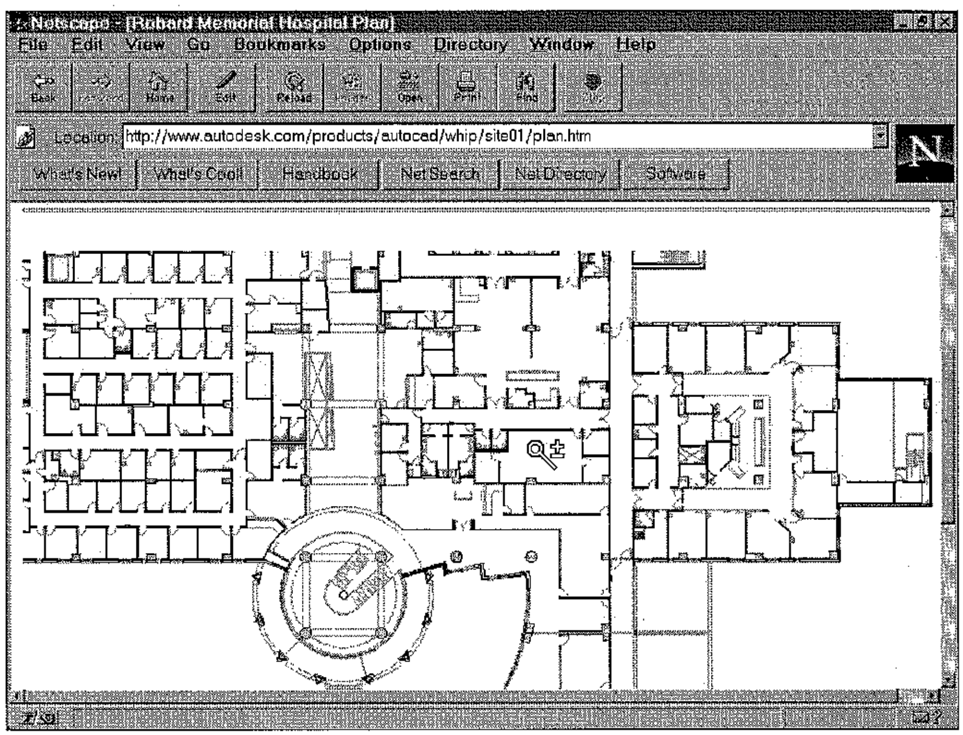

Figure 5. Example DWF Image After Zooming

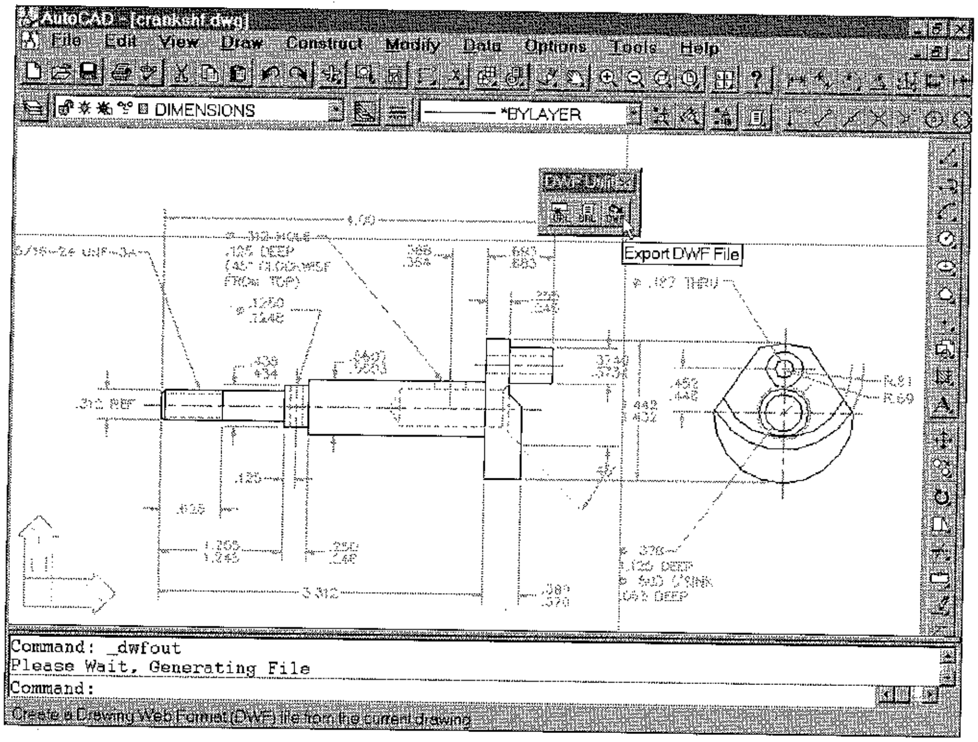

Figure 6. Creating a DWF File from an AutoCAD™ Drawing

Mechanical parts drawings or instructional assembly information could be available on the manufacturer's pages for viewing by consumers or clients. Parts catalogs or consumer goods catalogs with detailed graphical information could be available to the general public or available only to subscribers using password protection. Architectural or design projects in process can be posted for collaboration between team members in remote locations. Maps, public building layouts, directional information, and other diagrams can be made viewable to the public.

DWFOUT	Saves the open DWG drawing file in DWF format.
URLATTACH	Enables you to select one or more objects in a drawing file and associate them with a URL (Uniform Resource Locator) or other image. When a user views the DWF file across the Internet and selects the URL, the user is hotlinked to that web site.
URLLIST	Enables you to select one or more objects in a drawing file and list the URLs associated with them.

Table 3 Commands available with the *WHIP!*™ display driver for AutoCAD™

Creating DWF Files

Although the DWF is an open standard, only AutoCAD drawings (DWG files) are currently convertible to the DWF format. Producers of CAD programs other than Autodesk should soon follow suit to enable their proprietary CAD drawing files to be convertible and viewable as DWF drawings. It is likely that the DWF format will emerge as the standard for web-viewable drawings, based on AutoCAD's large user base and the existence of the DWG and DXF as industry-wide CAD drawing standard formats.

A new *WHIP!*™ display driver for AutoCAD Release 13 Version C4 for Windows 95 or NT is required to create DWF files from within AutoCAD (DWG) drawings. After configuring AutoCAD to utilize this driver, a new set of commands is available. As shown in Figure 6, the DWFOUT command creates a (separate) DWF file from the current open drawing. The DWF file is generally approximately 5%-20% the size of the original parent CAD drawing (DWG) file, depending on the ratio of the number of objects in the display to the amount of other non-graphic data in the CAD file.

Commands (including icon buttons for activating commands) available with the *WHIP!*™ display driver for AutoCAD are shown in Table 3.

The URLATTACH feature offers particularly creative possibilities. With this feature, a DWF image can *contain* additional graphical or textual information. When viewing a DWF image, passing the mouse pointer over a URL-linked object displays a small hand image. Clicking on the linked object automatically links to the new URL, which could be another DWF image or textual data. For example, clicking on a door, window, or fixture in an architectural layout could in turn display a table of text information listing price, manufacturer, specifications, etc. Or, clicking on one component of a mechanical assembly could in turn display a detail drawing of the selected part. It would also be possible to view a map, select a building, and be shown written information about the business or be linked to the web site of the business.

Publishing DWF Files on Your Web Page (Using HTML to Place a DWF)

Once the DWF files have been generated, they can be included in a web page using HTML codes. HTML (Hypertext Markup Language) is the platform-generic open standard set of codes used for formatting text and images to be displayed within web pages. To display a DWF image (for example, one named *plan.dwf*) on your web site (named *yourwebsite)*, use the code given in Table 3.

It is possible to add both references to the same HTML file. The Netscape Navigator™ ignores the Microsoft Internet Explorer™ reference and vice versa. Instructions for displaying DWF files in a web page using HTML are also available from the Autodesk web site.

The web server machine containing your web page must also be made to recognize DWF files so that it causes the *WHIP!*™ Plug-In to be invoked. You must add a new MIME type to your server using your Internet server software. *Register* the type *drawing/x-dwf* with the extension as *dwf*.

In Netscape you would add:

```
<embed src= "plan.dwf" width=300 height=300>
```

For the Microsoft Internet Explorer you would add:

```
<object
CLASSID ="lsid:B2BE75F3-9197-11CF-ABF4-08000996E931"
WIDTH=300
HEIGHT=300>
param name="Filename"
value="http:/www.yourwebsite/plan.dwf">
</object>
```

Table 4. HTML Code for Displaying a DWF Image

Obtaining the Two *WHIP!™* Drivers

Two *WHIP!™* components are required to create and view DWF images. Both *WHIP!™* drivers in beta form are free and downloadable (at the time of this writing) from the Autodesk (makers of AutoCAD™) web site at www.autodesk.com. Both drivers are compressed and self-extracting.

The *WHIP!™* Plug-In (file name WHIP05.EXE) is needed to view the DWF images from within Netscape Navigator™ 2.01 (or later). The *WHIP!™* Plug-In for Netscape Navigator™ is automatically installed during the self-extraction process.

The *WHIP!™* display driver (file name WHIPAR05.EXE) for AutoCAD™ Release 13 Version C4 (or higher) for Windows 95 or NT is needed to generate DWF file images from within AutoCAD™ drawings. After downloading and extracting the file, AutoCAD™ must be configured to use this new display driver by using the CONFIG command at the AutoCAD™ command prompt and selecting from the list of available drivers the following option:

```
2. 'WHIP/DWF Beta 1' - HEIDI(TM)
Display Driver w/DWF Internet sup-
port Version: I 2.30
```

Alternately, the AutoCAD™ Release 13 Internet Publishing kit can be purchased (available October 1996) for $99 or for $49 for existing AutoCAD™ customers. The kit includes Netscape Gold™ 3.0, *WHIP!™* Plug-In Version 1.0 (for Netscape), AutoCAD™ Release 13 Internet Utilities (*WHIP!™* Driver for AutoCAD™), and Quickstart Webpages.

Conclusion

Use of the Internet and intranets will greatly increase for the design, engineering, architecture, and construction industries with the advent of the new DWF vector file format introduced by Autodesk. Previous World Wide Web formats offered little usefulness for the extensive detailed graphics requirements of these industries. Now that existing AutoCAD™ drawings can be converted for use on the WWW, many new opportunities have arisen for these industries as well as for the general public.

Although many possibilities exist for the current DWF format, there are also limitations. Because only the display portion of the file is used, much information is stripped from the data-rich CAD files when the drawing is converted to DWF format in order to limit file size. The next challenge for the producers of CAD software and services for the Internet is to expand the DWF standard to include more information and controls that can currently be found in the robust CAD files, while maintaining a practical file size. Features such as layers and controls, access to coordinate data, support for attribute (text) data attached to graphical objects, or redlining capabilities would make the DWF standard more useful and likely to be used for a wider variety of applications. In addition, producers of the popular web browsers should include the *WHIP!™* Plug-In or other drivers with their software so viewers do not have to download and install them.

Even though limitations exist for the DWF format, it seems likely that this new vector file format will flourish on the World Wide Web and on intranets, particularly within certain industries.

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Hijaak PRO User's Guide, (1993). Inset Systems, Inc.

ENVELOPE PRINCIPLE

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As this is the first article I've written for the "Standards Corner," I thought it appropriate to explain one of the most basic and most important concepts of dimensioning, the Envelope Principle. It is the cornerstone for all the other dimensioning concepts described in the Dimensioning and Tolerancing standard ASME Y14.5M - 1994. By definition, "the Envelope Principle is the concept that there is a space between the least material condition (LMC) and maximum material condition (MMC) of a size feature where all the surface elements must lie." For my students that statement usually requires much explanation.

The Envelope Principle used to be known as the Taylor Principle. The concept was named for the English gage maker, William Taylor. In 1905 Taylor received a patent for a "Full Form Gage." Today we would call it a GO gage. It is a device used to check the form of a part size feature when produced at MMC (largest shaft, smallest hole). Any point to point size measurements are made separately.

The Envelope Principle is actually composed of three different but inseparable parts. The first is, "The actual size of the feature, at any cross section, must be within the stated limits of size. " This requires diametrically opposed surface to surface contact measurement made at a sufficient number of locations along the feature.

The second part is, "The feature may not exceed the perfect form boundary at maximum material condition." When a shaft is produced to its largest size possibility or a hole to its smallest size possibility, there can be no variation in form. Unlike ISO standards, the basic premise in the United States is, a size dimension is a specification of form as well as size.

The third part is, "A variation in form is allowed between the least material condition and the maximum material condition." The closer a feature is produced to least material condition, the more form variation it may have.

Figure 1 shows the MMC and LMC cylinders drawn with phantom lines around the shaft. All the feature elements must fit in the space between these "envelopes." The difference between the least and maximum material conditions is the tolerance.

The reason the Envelope Principle is used is as important as the principle itself. In a sentence, "It allows the calculation of an allowance." The allowance is the difference between the MMC of two mating parts. If part form was allowed to vary outside a perfect form boundary at MMC, an interference fit may result when a clearance fit was desired.

Figure 2 illustrates the reason for a uniform boundary at MMC. The MMC and LMC are shown in phantom drawn around the shaft and the hole.

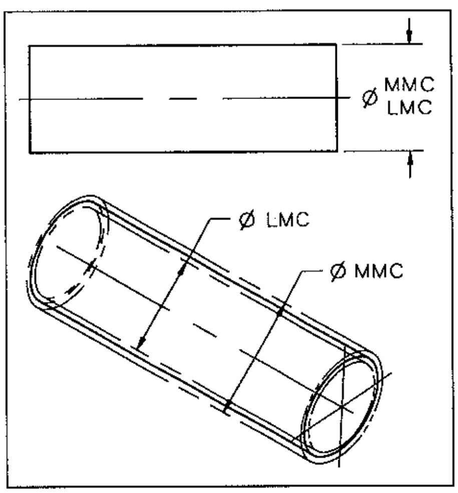

Figure 1 Envelope Principle

As long as both mating parts are made within their respective envelopes the amount of clearance or interference may be calculated. The difference between the least material conditions is the maximum clearance.

An example of when knowledge of the allowance is important is in determining the viscosity of lubricants for mating parts. Another example may be to aid in determining what type of sealing element would be required between mating parts.

If at any time perfect form at MMC is not required, a note is added to the drawing indicating that fact. ISO practices allow the addition of an "E" in a circle (same as a MMC modifier in a feature control frame) next to any dimensions that are required to meet the envelope principle.

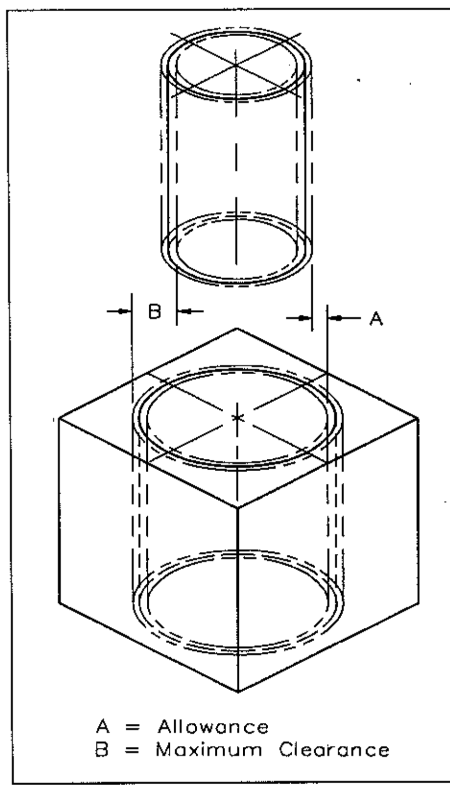

Figure 2. Envelope Principle Usage

50 Plus 50 In Jeopardy

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Raleigh, NC

Abstract

The Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE) celebrated its 50th Midyear Meeting in Ames, Iowa. The 51st meeting in Raleigh, North Carolina, seems an appropriate venue to reflect on the first 50 years and evaluate EDGD today. The EDGD has seen its membership decline and engineering design graphics courses cut back or eliminated in most engineering programs around the nation. This decline must not continue or the there may not be another 50 years, and the 100th Midyear Meeting may never materialize. This paper attempts to give insight into the decline of engineering design graphics and possible solutions to reverse the decline.

Introduction

It is timely to look back at the Engineering Design Graphics Division's (EDGD) history during this 51st Midyear meeting. Timely because we move from the first fifty Midyear meetings to our second fifty with this conference at North Carolina State University. Timely because the Division membership is static after years of decline. Timely because it was on a train to Chapel Hill, NC that the idea for a Drawing Division in ASEE developed. In 1928, the Society for the Promotion of Engineering Education (SPEE), later named the American Society for Engineering Education (ASEE), approved its first division. The Engineering Drawing Division, later named the Engineering Design Graphics Division (EDGD), was formed through the efforts of Thomas French, Randolph Hoelscher, Clair Mann, Frederick Higbee, Harry McCully, William Smith, Harvey Jordan, and others (Rogers, Spring, 1993).

The original founders of the organization recognized a need to bring together graphics instructors who shared a similar interest: improve the teaching methodology in graphics for engineering students. For years, EDGD had summer schools to promote, educate, and develop a curriculum that was very much the same throughout the nation. Today, the descendants of that organization share the same vision by continuing the midyear meetings. However, the graphics needs necessary to educate an engineer are very different. Since the late 1950's, the number of courses and credit hours in engineering graphics required for an engineer have continually declined. Major disciplines and some university programs do not require even a single graphics course. These are the same institutions that previously devoted entire departments to the teaching of engineering graphics.

A Name Change

During this decline in engineering graphics, the division changed its name to the present form: Engineering Design Graphics Division. However, it takes more than a change in name to affect curriculum. Courses must also change to reflect the intent of the name change. To some, design graphics means teaching the graphics science which can be used to support many activities including the design process. To others, it means teaching the design process using graphics. Although the differences may seem subtle, in reality, they are extremely important. The former implies that graphics is an important area of study worthy of our time, research, study, and dedication as professionals. The later implies that graphics is merely a tool used in a more important process. The emphasis is on design and not graphics. That misplaced emphasis is one of the major causes for the decline of engineering graphics in engineering education.

The Role of Engineering Design Graphics in Engineering Education

What is the role of graphics in engineering education? That question must be asked when preparing to teach engineering design graphics to engineering students. Not too long ago the answer to the question was simple. Engineers needed to know how to create multiview, dimensioned drawings used in the manufacturing process. As engineering education became more mathematically and scientifically based, the need for engineering graphics became less important in the education of engineers. Design/drafters produced most of the engineering drawings, and engineers became checkers. Engineers made design sketches and managed the production of working drawings. Ullman found that 92% of the design process is based on graphics including sketching, drawing, and visualization (Ullman, 1989). This process continued even as CAD became the tool of choice in industry to produce engineering drawings.

Many times this author has been asked by colleagues faced with cutbacks in their graphics courses: *What do I say?* or How can I defend the value and need for engineering design graphics in engineering education? What would you say to defend your courses? Some will answer that design graphics is the most effective way of communicating design information. Others emphasize visualization, sketching, standards, problem solving, or 3D modeling. But what is really important about what we teach? The answer to that question defends the existence and expansion of graphics in engineering education.

As CAD tools become more powerful and easier to use, what role does the engineer play in the modeling and documentation of a design?

With the development of powerful 3D modeling CAD systems and parametric-based modeling software, this trend of engineers managing the process may be changing. It is now possible for engineers to make simple, easily produced sketches which are used as a basis for creating constraint-based 3D models. Once created, the models can be analyzed using powerful analytic tools. After the final design is approved, multiview drawings are automatically extracted from the 3D model.

As CAD tools become more powerful and easier to use, what role does the engineer play in the modeling and documentation of a design? Some companies advocate engineers to facilitate the modeling and documenting using CAD. Other companies utilize their engineers to manage the production of 3D models and engineering drawings. The mixed environment we find in industry makes it difficult to determine the role of graphics in engineering education if courses are based on technology and processes.

Engineering Design Graphics Body of Knowledge

Courses developed around technologies or systems are in a constant state of change because technologies and systems are constantly improved, modified, and changed. To liberate engineering design graphics from the constant changes taking place with the tools used to produce graphics, a fundamental body of knowledge must develop. This body of knowledge must be based on fundamental concepts and principles that do not significantly change with the technology or processes.

Visualization, geometry, and imaging are fundamental to all graphics courses (Bertoline, 1993). Visualization is a cognitive process which views, interprets, stores, changes, and retrieves the geometry that surrounds all humans. Geometry is the basis for all physical things. Imaging is the process of analyzing, producing, and reproducing geometry.

A discipline can be defined as that which is unique, a way of knowing that represents a portion of a domain of knowledge. Visualization, geometry, and imaging are the basis for the discipline called graphics science. Graphics science is the answer to those who question the need for engineering design graphics in engineering education.

Of course, instructors of engineering design graphics do not live and work in a vacuum. Higher education and engineering, in particular, are researched-based programs. Outside funding is the lifeblood of many engineering programs in the nation. Professors are primarily promoted and tenured based on the research funding received and the advancement of new knowledge. To survive, faculty teaching engineering design graphics must also engage in research. However, most research conducted by engineering design graphics faculty is in areas outside of graphics. Although that research assists the professor in surviving the promotion and tenure process, it certainly does not promote and improve the graphics as a discipline.

No wonder it is so easy to cut back and eliminate engineering design graphics from the engineering curriculum. With no one willing to stake their professional careers and no recognized structure to the discipline, it is easy to view design graphics as expendable. The 100th meeting of the EDGD is certainly in jeopardy.

Possible Solutions

Design graphics needs dedicated professionals to promote and improve the discipline — dedicated professionals like those involved in the EDGD. This group can be the catalyst for the emergence of a stronger discipline. Possible activities leading to a solution to the discipline's and Division's problems might include:

- Mentoring/Adopting other engineering design graphics programs in your region.
- Aggressively recruiting graphics instructors in engineering technology programs.
- Creating a model curriculum based on knowledge and not technology.
- Disseminating this model curriculum to every graphics instructor, Dean of Engineering and Engineering Technology.
- Creating an accreditation program for graphics programs/courses and graphics instructors.
- Developing a graduate program to teach a new core of dedicated graphics professionals.
- Using technology to leverage the development of the solutions.

Employing funding sources, such as NSF and industry partners, to leverage the process.

Resurrecting the EDGD summer schools to educate and re-educate graphics faculty.

Surveying practicing engineers to determine the importance of graphics in engineering design.

These activities may not be the ultimate solution. Other activities will have to be developed as work progresses. However, after having completed most of the proposed solutions, the Division should approach ABET for recognition.

Conclusions

In many ways the solutions to our problems can be found in the history of this Division. The problems facing the Division and its members today are not very different from those problems of 50 years ago. The founders of the EDGD struggled with what to teach and how to teach it; we still struggle with those problems today.

If we are to perpetuate another 50 years of midyear meetings, EDGD and its members must face the challenges in a professional, disciplined, and organized manner. A tremendous synergy results when like-minded people confront problems together. The EDGD and its members must make a professional commitment to effect the changes necessary to ensure the next 50 years of meetings. More importantly, if there is to be a 100th meeting of the Engineering Design Graphics Division, it will be the result of the hard work and dedication of today's membership to develop a discipline that will survive and thrive well into the future.

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Note

This paper can also be found on the web at: http://www.tech.purdue.edu/tg/faculty/bertoline/bertoline.html

The North Carolina State University Orthogonal Medal

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Abstract

A historical description of the North Carolina State University Orthogonal Medal given by the Graphic Communications Program to selected persons who have made outstanding contributions on a national and international level in the field of Graphic Communications is presented. Included are the inceptual purposes and design philosophy of the medal as well as the historical experience of the medal presentations and the awards program that has grown out of the initial effort. A description of the recipient selection process, the distinguished lecture and banquet arrangements and the resources required are included. Previous awardees and distinguished lecturers are listed and briefly described. An evaluation of the initial goals and accrued ancillary benefits to the Graphic Communications Program at North Carolina State University during the past twelve years is given.

Introduction

The North Carolina State University Graphic Communications Orthogonal Medal was created by the Graphic Communications Program faculty to honor nationally and internationally known graphicians and to further the recognition and advancement of Graphic Communications at North Carolina State University and in the State of North Carolina. This paper presents a brief discussion of:

1. the historical background and inceptual purposes of the medal and
2. the resulting accrued ancillary benefits to the Graphic Communications Program.

Historical Background and Inceptual Purposes

The Graphic Communications Program at North Carolina State University had its origin in the initial founding of the institution as a land-grant college in 1887. At that time all engineering students were required to study four years of Mechanical Drawing. This was later reduced to two courses entitled Engineering Graphics and eventually to only one required course for certain fields of engineering. From the beginning, Graphics was regarded strictly as a service course to other fields of study and not encouraged to develop as a major discipline of study in and of itself.

In 1979, the Engineering Graphics Faculty and their teaching responsibilities were transferred by administrative fiat from the College of Engineering to the College of Education and Psychology. This afforded the Graphics Faculty an opportunity to expand their course offerings, to include computer integration, and to consider a more encompassing name change for the program. As such, the Graphic Communications Program in the Department of Mathematics, Science, and Technology Education is now currently seeking authorization from the academic administration to obtain undergraduate degree-offering status in a technology-based curriculum.

During the early 1980s, the Graphic Communications Faculty—in an effort to further the recognition and development of Graphic Communications at North Carolina State University and in the State of North Carolina—gave consideration to the creation of an annual distinguished lecture and awards banquet that would culminate in the awarding of a medal to selected nationally and/or internationally known graphicians. The first Graphic Communications Distinguished Lecture and Banquet, and consequent awarding of the Orthogonal Medal, was held during the Spring of 1985.

A brief description of the design philosophy of the medal, the recipient selection process, the banquet program and facilities, a listing of the previous recipients, and an evaluation of the initial goals of the Distinguished Lecture and Banquet Series during the past twelve years is presented here.

Figure 1 The North Carolina State University Orthogonal Medal

Design Philosophy of the Orthogonal Medal

The Orthogonal Medal was originated in 1985 by the Graphic Communications Faculty at North Carolina State University to honor those persons who have made outstanding contributions to the advancement of Graphic Communications. The name of the Medal was derived from the right-angular relationship of three mutually perpendicular planes that intersect to create four quadrants used in developing the theory of orthographic projection for recording the shape and size of three-dimensional objects. Within each quadrant depicted on the medal is the likeness of a notable person whose accomplishment contributed significantly to the development of Graphic Communications as a field of study.

Euclid (third century B. C.). His famous book *The Elements* was a treatise on geometry and the theory of numbers and for well over two thousand years served as a model of logical reasoning starting with a few simple assumptions and building a theory based on them.

DaVinci (1452-1519). Concerned with what the eye could see, Leonard da Vinci was a great painter and sculptor, and analyzed human anatomy, dimensions and proportions. As an engineer, Leonardo developed many creative machine designs and drew plans for hundreds of inventions using graphical methods to explain their constructions.

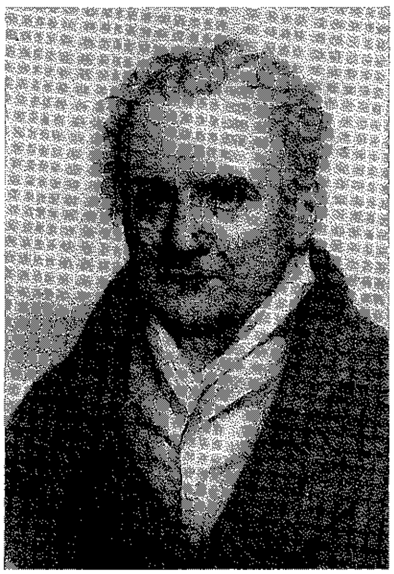


Figure 2 Gaspard Mongé

Mongé (1746-1818). Considered the father of descriptive geometry, Gaspard Mongé developed a graphical method for solving mathematical problems by projecting three-dimensional figures onto a two-dimensional plane of paper in such a manner as to allow geometric manipulations to determine lengths, angles, shapes, and other descriptive information concerning the figures.

Jefferson (1743-1826). Not only was Thomas Jefferson a diplomat, political thinker, author, scholar, philosopher, and the third President of the United States (1801-1809), he was also an inventor, scientific farmer, and one of America's foremost architects to employ three-dimensional graphical methods.

The precise, yet infinite nature of the orthogonal image planes provides an appropriate symbolism for the North Carolina State University Graphic Communications program and its dedication to the recognition and continuing advancement of knowledge in the graphical language of technology.

Recipient Selection Process

Recipients of the Orthogonal Medal are selected by unanimous vote of the Graphic Communications Program Faculty. At the beginning of the fall semester, candidates to be considered for selection are solicited from each faculty member. Each candidate's qualifications are later discussed during special called meetings for this purpose. The distinguished lecturer recipient is chosen first by a series of open voting among the faculty and then additional recipients, if any, for that year are discussed and confirmed. Only one distinguished lecturer recipient is chosen each year and he or she must be of national and/or international stature in the field of Graphic Communications. In the selection of additional recipients (limited to two each year), special consideration is given to colleagues and/or other persons who have made outstanding contributions in the field of Graphic Communications to the people of the State of North Carolina. By late fall, all recipients are notified of their selection and a date for the Distinguished Lecture and Banquet is chosen for the following spring semester.

The distinguished lecturer recipient is always introduced as the featured speaker of the evening. Any additional recipient(s) are formally introduced at an appropriate time during the program with an audio-visual presentation that exemplifies his or her unique contributions and/or accomplishments in Graphic Communications.

An examination of the listing of previous Orthogonal Medal recipients selected during the past twelve years will reveal the extent of their diversity and broadness of scope in special interests and contributions made to the field of Graphic Communications. They include noted textbook authors, a graphic artist, university teachers, computer programming entrepreneurs, a wildlife painter, a drawing instruments manufacturer, an editorial cartoonist, and a technology historian.

Banquet Program and Facilities

Historically, the choice for a lecture topic has been left to the distinguished lecturer. This policy has resulted in a wide variety of themes, but most have dealt with the history and development of graphics and *tools of the trade*, effective use of graphics in teaching and communication, or current and future projections of trends affecting the field. The presence of each distinguished lecturer and frequent references to persons influential in determining major changes in the field have given insight and inspiration to our faculty and other attendees.

The continuing source of the core financial support for this series is the result of the decision by the Graphic Communications faculty to channel the proceeds from the sale of jointly-authored course workbooks into the Graphic Communications Trust Fund instead of into royalties for individual faculty members. Other resources include gifts from interested individuals and from corporate sponsors. It has been the custom to provide an honorarium to the distinguished lecturer, and expenses for the lecturer and spouse.

The ambiance of the banquet setting has consistently been somewhat spacious and informal. This has been enhanced by integrating less somber portions of the program with the more serious aspects of the major purpose which is honoring the achievements of those being recognized. Those honored have included the distinguished lecturers and other recipients of the Orthogonal Medal, students completing the Graphic Communications Minor Program, retiring Graphic Communications Faculty, and administrators who have been instrumental in promoting and advancing the purposes of the program. A recent addition has been the development of the Robert H. Hammond Award consisting of recognition, a certificate, and a monetary sum to a graduating senior who has demonstrated outstanding achievement in Graphic Communications. The less somber portions of the program have been used for a variety of purposes ranging from roasting retiring faculty to promoting fictitious products to support the overall effort. Ever-popular has been the drawings for door prizes (usually enough for at least one-third of the attendees to win) and the table favors.

Listing of Previous Orthogonal Medal Recipients

An engraved plaque containing the Orthogonal Medal and the names of all the recipients, with distinguished lecturers identified, is displayed in the Graphic Communications office suite. The listing of previous Orthogonal Medal recipients (as seen on page 30) gives the year of each award and the names and respective titles of each awardee as they appear on the banquet program each year

Evaluation of Initial Goals

The success of the Distinguished Lecture Banquet and awarding of the Orthogonal Medal can be determined, in large part, by the extent to which the initial goals of furthering the recognition and development of the field of Graphic Communications have been achieved at North Carolina State University and in the State of North Carolina.

Clearly, the most immediate and apparent result has been the high degree of visibility attained by the Graphic Communications Program on the North Carolina State University campus. This has been achieved by promoting the Distinguished Lecture and Banquet and by inviting and involving key academic administrative officials as honored guests. College deans, department heads, and selected faculty and students from varied disciplines of study across the campus, having either direct or indirect interest in the expertise of a particular lecturer, continue to be included as guests and are often solicited as participants in the introduction of the lecturer. In addition, an administrative official from the Office of the Provost always assists in the awarding ceremony of the Orthogonal Medal(s). This combination of events and activities has created a heightened awareness of the academic mission, goals, and

Orthogonal Medal Recipients

1985	**Warren J. Luzadder**	*Distinguished Lecturer* Professor Emeritus, Purdue University
	Robert H. Hammond	*Professor Emeritus* North Carolina State University
	Robert T. Troxler	*Assistant Professor Emeritus* North Carolina State University
1986	**James H. Earle**	*Distinguished Lecturer, Professor* Texas A & M University
	Jerry W. Miller	*Nationally-acclaimed Graphic Artist*
	E. Hoyle Stinson	*Professor Emeritus* North Carolina State University
1987	**Steve M. Slaby**	*Distinguished Lecturer, Professor* Princeton University
	Duane Raver, Jr.	*Nationally-acclaimed Wildlife Painter*
1988	**Carl Machover**	*Distinguished Lecturer* *President, Machover Associates Corporation* White Plains, New York
1989	**William B. Rogers**	*Distinguished Lecturer, Professor Emeritus* Virginia Polytechnic Institute and State University
1990	**Frank Oppenheimer**	*Distinguished Lecturer* Founder, Gramercy Guild Group, Inc. Innovator of High-Quality Drawing Instruments
	Benjamin D. Webb	*Lecturer Emeritus* North Carolina State University
1991	**Joel N. Orr**	*Distinguished Lecturer* President, Orr Associates, Inc., Virginia Beach, Virginia
1992	**Gary R. Bertoline**	*Distinguished Lecturer, Associate Professor* Purdue University
	John L. Crow	*Assistant Professor Emeritus* NCSU Alumni Distinguished Professor for Undergraduate Teaching North Carolina State University
1993	**Douglas N. Marlette**	*Distinguished Lecturer* Pulitzer Prize Winning Editorial Cartoonist for New York Newsday
1994	**Eugene S. Ferguson**	Distinguished Technology Historian *Distinguished Lecturer, Professor Emeritus, Lecturer Emeritus* University of Delaware
	Garland K. Hilliard	*Graphic Communications Program Coordinator* North Carolina State University
1995	**Vera Anand**	*Distinguished Lecturer, Associate Professor* Clemson University
1996	**Henry Petroski**	*Distinguished Lecturer, Professor* Duke University

course offerings of the Graphic Communications Program within the academic community at North Carolina State University.

The Distinguished Lecture and Banquet has continued to provide an educational platform for the promotion of the Graphic Communications Minor Program and student achievements. The enrollment in the Minor Program has continued to increase with students in such varied curricula as engineering, business and management, pre-medicine, communications, life sciences, forest resources, design, liberal arts and multidisciplinary studies. These students elect to take an additional fifteen semester hours in Graphic Communications beyond the total number of hours required for graduation in their chosen field of study. Additionally, the faculty have been encouraged to develop and offer advanced courses in Graphic Communications as well as courses of special problems and topics of interest having a research component.

The influence of the Distinguished Lecture Banquet and Orthogonal Medal concerning achievement of the initial goals of furthering the recognition and development of the field of Graphic Communications in the State of North Carolina is more difficult to assess; however, there are certain indicators that are useful. First, there is the obvious publicity given to the field of Graphic Communications due to the press releases published in the recipients' hometown newspapers. Secondly, the invitation, attendance, and support of administrators and/or faculty members from other selected universities and community colleges in the State offering similar or related Graphic Communications Programs, have been very encouraging and beneficial in establishing on-going lines of academic communication. Thirdly, the invitation and attendance of selected high school vocational education drafting teachers have resulted in an improved understanding of the differences and similarities in educational foci between graphics at the secondary-education level and at the university level.

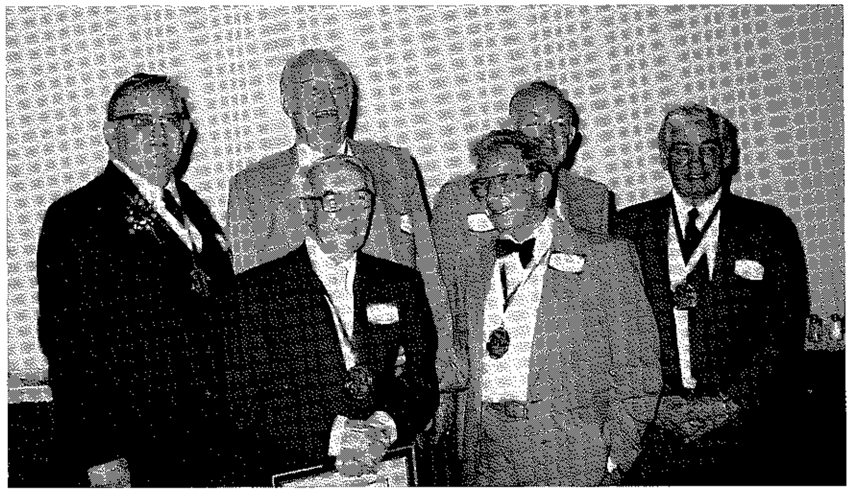


Figure 3 Front Row, left to right: 1990 Orthogonal Medal Recipient Frank Oppenheimer with Robert T. Troxler(1985).
Back Row, left to right: Benjamin D. Webb (1990), Robert H. Hammond (1985), William B. Rogers (1989) and Jerry W. Miller (1986).

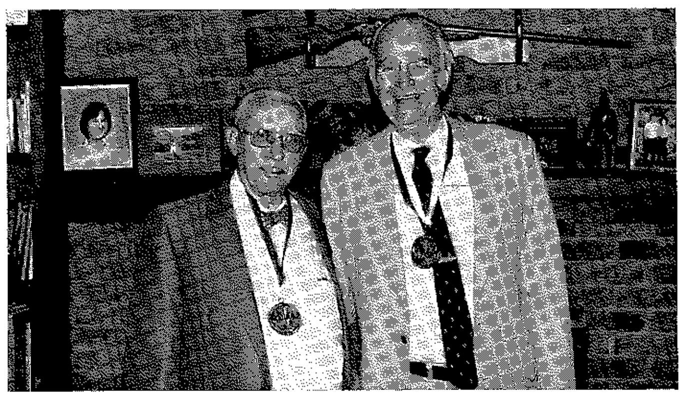


Figure 4 1985 Orthogonal Medal Recipients, Warren J. Luzadder and Robert H. Hammond

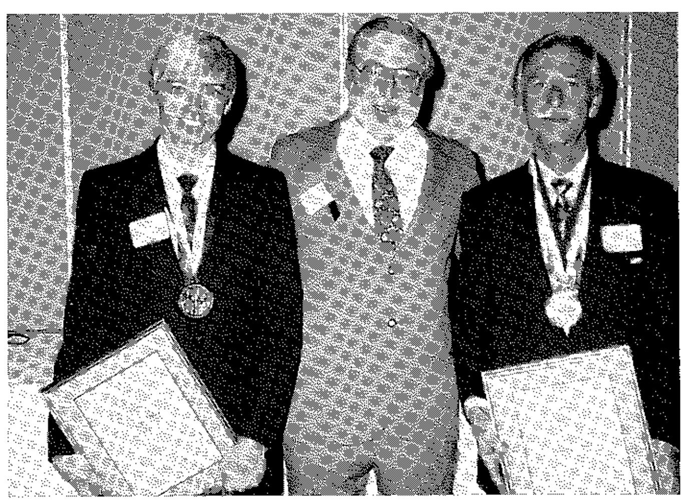


Figure 5 1992 Orthogonal Medal Recipients, Gary R. Bertoline (left) and John L. Crow(right) with Garland K. Hilliard (center), NCSU Graphic Communication Coordinator

In addition, there has been some interchange of information between these two levels with respect to consultation and curriculum materials.

It can therefore be surmised that during the past twelve years since its inception, the Distinguished Lecture Banquet and the awarding of the Orthogonal Medal have been very effective in initiating improved recognition and development of the status of Graphic Communications at North Carolina State University and, to a more limited degree, in the State of North Carolina.

Accrued Ancillary Benefits

Beyond the more obvious high-visibility public relations aspects of the Orthogonal Medal, are the unplanned for, yet accrued, ancillary benefits to the Graphic Communications Program that have manifested themselves as follows:

1. It would be appropriate to say that the success of the Distinguished Lecture Banquet and the Orthogonal Medal has created a greater sense of unity and program identity among the Graphic Communications faculty. Increased recognition and status of the Graphic Communications Program have resulted in the faculty becoming more introspective and focused concerning unique program objectives and course offerings. At the same time, the faculty have broadened their scope of identity by becoming more cognizant of the shared heritage and basic commonality of purpose evident in many other Graphic Communications programs nationwide. The result has been an increased opportunity for dialogue and the development of working relationships among the Graphic Communications Program faculty at North Carolina State University and other similar programs.
2. An increased interest in working relationships has been observed between the Graphic Communications faculty and faculty from other academic departments and college curriculum committees at North Carolina State University who were previously unaware of the value of graphics being included as part of their students' education. There is now a more plausible possibility of initiating interfacing activities with the North Carolina State University Undergraduate Studies Program and the First Year College Program administration for the purpose of giving consideration to including a beginning Graphic Communications course in their respective curricula.

The Distinguished Lecture and Banquet has evolved to serve as a vehicle of overt recognition honoring, on occasion, persons in academia and industry as well as in public and private enterprise who have been supportive and appreciative of the Graphic Communications Program. It has also served to highlight the value and the unique contributions that Graphic Communications makes toward a student's preparation for occupational success in a technological society.

Conclusion

In conclusion, the North Carolina State University Graphic Communications Distinguished Lecture Awards Banquet and the Orthogonal Medal concurrently reflect the best of the Graphic Communications Program. The historical background of the Graphic Communications Program was influential in the initial shaping of the Orthogonal Medal. The Orthogonal Medal has been, in turn, influential in shaping future directions of the Graphic Communications Program.

Tenure-Track Position in Graphic Communications Department of Mathematics, Science and Technology Education

College of Education and Psychology
North Carolina State University

Graphic Communications Program:
Graphic communications program currently provides thirteen service and/or elective courses in engineering graphics, technical graphics, descriptive geometry, visual thinking, scientific visualization, and computer graphics (CADD) courses. It prides itself in maintaining a leading edge in technical graphics instruction including both 2-D and advanced 3-D computer graphics. The program offers a fifteen credit-hour Minor in Graphic Communications. Approximately 450 students are served each semester, most of whom are majoring in engineering. The Graphic Communications Program currently consists of six full-time and two to five part-time faculty. The program is administered throughout the College of Education and Psychology which has an enrollment of approximately 1600 students and is served by 100 full-time equivalent faculty.

Position Description:

- Develop/revise courses and curricula in Graphic Communications
- Teach courses in engineering/technical graphics, computer graphics, and CADD
- Participate in program area and departmental activities
- Provide technical assistance and service to relevant educational, industrial and business agencies

Application Procedure:
Applicants must submit a letter of application, a current resume, transcripts of graduate work, and three current references to:

John R. Freeman, Chair of Search Committee
Department of Mathematics, Science, andTechnology Education
North Carolina State University
Box 7801
Raleigh, NC 27695-7801

North Carolina State University is an equal opportunity/affirmative action employer
Women and minorities are encouraged to apply.

Faculty Position Computer Aided Design and Drafting Indiana University Purdue University Indianapolis (IUPUI)

Applications and nominations are invited for a tenure track faculty position in the Department of Manufacturing Technology of the Purdue School of Engineering and Technology at IUPUI beginning August 1997.

The Department of Manufacturing Technology has 250 students and offers ABET-accredited programs in Computer Integrated Manufacturing Technology (A.S. and B.S.), Mechanical Engineering Technology (A.S. and B.S.), and Mechanical Design and Drafting Technology (A.S.). The School of Engineering and Technology with 2,000 students is one of the largest of 18 academic units at IUPUI. For more information about the School, visit our home page at http://www.engr.iupui,edu/. IUPUI is a comprehensive urban campus that enrolls more than 27,000 students and offers 174 academic programs.

Primary responsibilities for this position include teaching and developing undergraduate courses in Computer Aided Design and Drafting, scholarly activities, student advising, and participating in committee activities. The School has recently made a major investment to upgrade both hardware and software used in the related courses. Current Computer Aided Design related software used in present courses includes AutoCAD and Pro Engineer. Planned expenditures this year will include the purchase of a rapid prototyping system and multimedia related hardware and software.

Applicants must have a minimum of a master's degree in Engineering Technology or Engineering and at least three years of industrial experience in a closely related field. Prior teaching experience is desirable.

Applicant must submit a resume, a statement of academic accomplishments and objectives, and names of five references. Materials must be submitted by March 31, 1997 to:

Professor Tim Price
Chair, CADD Search Committee
Indiana University Purdue University Indianapolis
723 W. Michigan Street
Indianapolis, IN 46202
Email: tprice@indyunix.iupui.edu

Women and minority candidates from industry, engineering, and engineering technology programs are encouraged to apply. IUPUI is an Equal Opportunity/Affirmative Action Employer.

Division News and Notes

Chair's Message
Gary R. Bertoline

The trouble with the rat race is that even if you win, you're still a rat.

Lily Tomlin
Great Quotes from Great Women

In the last issue, I wrote about the need to make significant changes to what we teach in engineering design graphics. I also suggested that we, as a professional organization, are charged with the task of defending, upholding, and improving engineering design graphics instruction for engineers. I challenged the profession to create a model curriculum to better prepare the engineers of the future.

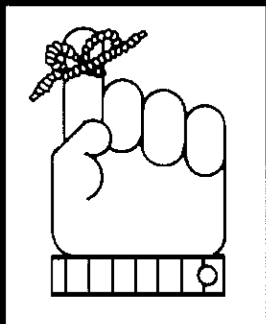
However, there is one major problem that must solved if we are to take on the task of developing a model curriculum. That problem is time. Where do busy professionals find the time to work on something that it out-of-sight, out-of-mind except for one or two times are year? I am referring to the oft disregarded third leg of the modern higher education stool; teaching, research, and service. Service to our professional organization seems be something we do when we have time, which is not very often. Time spent working on service will not reap the rewards of equal amounts of time spent in teaching and research. Faculty are promoted, tenured, and given merit raises based on their performance in the teaching and research arenas. We all try to give service when asked and as time permits, but that does not seem to be enough for EDGD.

We must make a greater effort to serve EDGD in the coming years. There are many challenges facing the organization which, when combined, are no less than the very survival of our professional group. When I became Vice Chair and was introduced at the Midyear Meeting in Iowa, I asked everyone to stand and repeat a pledge to spend 30 minutes every week working for EDGD. I have to admit, at first I did not follow my own oath. However, in the last few months I have implemented a technique that prioritizes and schedules my time during the work week. It is a technique devised by Steve Covey in the book, *The Seven Habits of Highly Effective People.* Before adopting his techniques, I could be better characterized as utilizing *The Seven Habits* of *Highly Defective People!* Using Steve Covey's techniques, I simply made EDGD one of my high priority items and scheduled time every week.

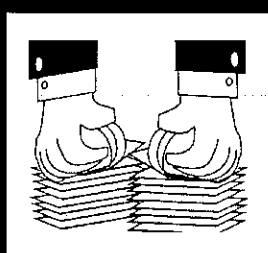
I am not suggesting that this technique will work for everyone. I am only suggesting that we all consider renewing our efforts at service for EDGD. This is especially important for the Executive Committee and members of all our committees. We have some very active and caring individuals in EDGD, but quite frankly, we need more. The general membership should refer to page 55 in Volume 60, Number 3 of the *Journal* and take time to see which committees would be of interest to them. Then, contact the committee chair or me. An organization is only as vibrant as its membership. We must make a better effort to serve rather than be served. It is my experience that there is no greater joy than that received when giving. We need your help to move our organization forward so we may guarantee the future of EDGD as a vibrant division of ASEE.

Gary R. Bertoline

Call for Papers



EDGD
ENGINEERING DESIGN GRAPHICS DIVISION
ASEE



52nd EDGD MidYear Conference
University of Wisconsin - Madison
October 24 - October 26, 1997

The Engineering Graphics Division is currently developing its program for the 1997 MidYear Conference. Abtracts related, but not limited to the suggested topics listed below are being sought.

Suggested topics:

- ✔ Uses of VRML in engineering graphics education.
- ✔ Engineering graphics instruction and the World Wide Web.
- ✔ Successes and failures of the 3D solids based graphics curriculum.
- ✔ How much "geometric modeling" is enough for today's students?
- ✔ The role of CAD/CAM in an undergraduate curriculum..
- ✔ Identifying the relevence of geometric modeling throughout the engineering curriculum.
- ✔ The current role of descriptive geometry in graphics and geometric modeling.
- ✔ Innovations in visualization technique instruction.
- ✔ What is the current role of theoretical graphics?
- ✔ Should all engineers receive graphics instruction?
- ✔ The role of engineering graphics in a unified engineering curriculum (first year).
- ✔ Promoting the evolution of graphics as a science.

Conference Coordinator
Kim Manner
Department of Mechanical Engineering
1513 University Ave.
University of Wisconsin-Madison
Madison, WI 53706
kmanner@engr.wisc.edu
(608) 262-4825

Submit Abstracts by:
June 1, 1997

Submit Abstracts to:
Sheryl Sorby
Michigan Technological University
1400 Townsend Dr.
Houghton, MI 49931
E-mail: sheryl@mtu.edu
Fax: (906) 487-2943

Calendar

The address for the EDGD web page is

http://www.tech.purdue.edu/tg/edgd_division/index.html

52nd Annual 1997 EDGD
Mid-Year Conference

See page 35, this issue
Oct. 24-26, 1997
Theme (tentative): ***This Year's Model***
Program Chair: Sheryl Sorby
Michigan Tech

General Chair: Kim Manner
Department of Mechanical Engineering
1513 University Ave.
University of Wisconsin-Madison
Madison, WI 53706
kmanner@engr.wisc.edu
(608) 262-4825

53rd Annual 1998 EDGD
Mid-Year Conference

If you are interested in hosting, contact Gary Bertoline, Purdue Universtiy

54th Annual 1999 EDGD
Mid-Year Conference
Ohio State University, Columbus, OH

1997 Annual ASEE Conference
Milwaukee, WI, June 15-18, 1997
Topics: ***What's Happening in Graphics?***
Theme: What are you doing and how does it relate to the rest of the profession.
Program Chair: Frank Croft,
The Ohio State University
2070 Neil Ave.
Columbus, OH 43210
Phone: 614-292-6230
Email: croft.3@osu.edu
FAX: 614-292-3780

1998 Annual ASEE Conference
Seattle, Washington

1999 Annual ASEE Conference
Charlotte, South Carolina

2000 Annual ASEE Conference
St. Louis Missouri

2001 Annual ASEE Conference
Albuquerque, New Mexico

ICCE 97
INTERNATIONAL CONFERENCE ON COMPUTERS IN EDUCATION
December 2 - 6, 1997
Kuching, Sarawak, Malaysia
Submission date: Apr 30, 1997
Program Chairs:
Thomas Ottmann
Universitaet Freiburg, Germany
Zahran Halim
Universiti Malaysia, Sarawak
Inquiries to:
ICCE97 Secretariat
Faculty of Information Technology
Universiti Malaysia Sarawak
94300 Kota Samarahan, Sarawak, Malaysia
Email icce97@fit.unimas.my
Tel + (6082) 671000 x370
or + (6082) 672279
Fax + (6082) 672301
Web Site: http://www.icce97.unimas.my

1997 Frontiers in Education Conference (FIE)
November 5-8, 1997
Teaching and Learning in an Era of Change
Pittsburgh Hilton &Towers
Pittsburgh, PA
Abstracts Due: January 15, 1997
For further information:
www.engrng.edu/~fie97 or e-mailfie97@engrng.pitt.edu
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Chairs:
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Larry J. Shuman: shuman+@pitt.edu
Alisha A. Waller: waller@macalester.edu
S. B. Seidman: seidman@cs.colostate.edu

50th Anniversary Symposium
Hosted by Oregon Institute of Technology
Klamath Falls, OR
April 23-27, 1997
Theme: ***High Tech Education for the Third Millennium***
Keynote speaker: Senator Mark Hatfield
Abstract Due : December 15, 1997
Marilyn A. Dyrud
Communications Department
Oregon Institute of Technology
3201 Campus Drive
Klamath Falls, OR 97601
Phone: (541) 885-1504
Fax: (541) 885-1687
E-mail: dyrudm@mail.oit.osshe.edu

Ed Media & Ed Telecom '97 World Conference on Educational Multimedia, Hypermedia, & Telecommunications
June 14-19, 1997
Calgary, CANADA
For further information, see
http://www.aace.org/conf/edmedia
Hosted by University of Calgary
Organized by AACE Association for the Advancement of Computing in Education (AACE).
ED-MEDIA 97/AACE
P.O. Box 2966
Charlottesville, VA 22902 USA
E-mail: AACE@virginia.edu;
http://aace.virginia.edu/aace
Voice: 804-973-3987; Fax: 804-978-7449

EDUGRAPHICS '97 - Third International Conference on GraphicsEducation
Graphics Education and the World Wide Web & **COMPUGRAPHICS '97** - Sixth International Conference on Computational Graphics and Visualization Techniques
December 15 -18, 1997
Vilamoura, Algarve, PORTUGAL
Organized and sponsored by GRASP - Graphic Science Promotions & Publications
General Organizer and Chair
Chair of the Program Committees
Harold P. Santo
GRASP - EDU+COMPUGRAPHICS '97
P. O. Box 4076
Massama 2745
Queluz PORTUGAL
Tel. + AM + Fax : +351-1-439-2571
grasp@ip.pt
http://www.geocities.com/ResearchTriangle/2217)

8th ICECGDG Conference International Conference on Engineering Computer Graphics and Descriptive Geometry
July 31-August 3, 1998
Austin, TX, USA
Sponsored by: International Society for Geometry and Graphci
Co-sponsored by: Engineering Design Graphics Division of ASEE
& Japan Sociey for Graphic Science
Abstract (400 to 500 words): Sept. 30, 1997
Inquiries:
Continuing Engineering Studies
University of Texas, P.O. Box H
Austin, TX 78713-8908
Phone: +1-512-471-3396
Fax: +1-512-232-1972
Steve D. Slaby, *Honorary Conference Chair*, Princeton University
Davor Juricic, *Conference Chair:*
The University of Texas at Austin
E-mail: juricic@mail.utexas.edu
Conference Vice-Chairs:
Ronald E. Barr, *Programs*
The University of Texas at Austin
Gary R. Bertoline, *Liaisons*
Purdue University, Indiana
Dennis R. Short, *Communications*
Purdue University, Indiana

FACILITATING THE DRAWING OF AUXILIARIES by Pat Kelso

I use a software-operation type manual in my classes rather than a standard graphics texts because there is at least some graphics theory presented with the operational steps that I can expand upon whereas I have found little software operational description in standard texts. On the other hand the software operational literature seems not to deal well with auxiliary views. Second and third auxiliaries are rarely, if ever, even addressed. Usually the literature relies heavily upon the students' intuition in determining and transferring the proper distances from, and to, the proper views, and is customarily accomplished in awkward CAD steps. Below is a method of projecting these distances rather than some how transferring measurements to an auxiliary. The projection method uses an angle bisector to bypass the view shared orthodirectionally by two views. In other words, the angle bisector projectively connects the "previous, previous views."

Figure 1 is the object to be drawn. Figures 2 and 3 are general views of the glass box model, including the auxiliary planes of projection. The glass box also contains the object; here the object is in contact with the frontal plane. The front and top planes of projection are partially opened for clarity. (Note that the third auxiliary is needed to show the true shape of the dove tail angle and is later treated as a removed section.) Figure 4 shows the front, top, right side, and the three auxiliary planes unfolded into a planar surface and with the angle bisectors added. The angle bisector between the top and right side view is recognized as a standard miter line. The remaining figures show the projection lines connecting the "previous, previous views." as the projection lines travel parallel to the edge views of the skipped plane of projection on both sides of the angle bisectors.

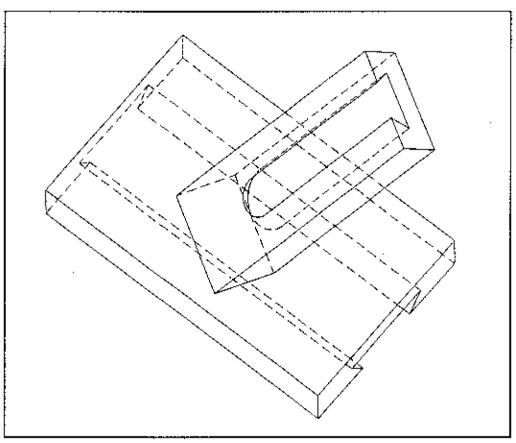

Figure 1 Object to be drawn

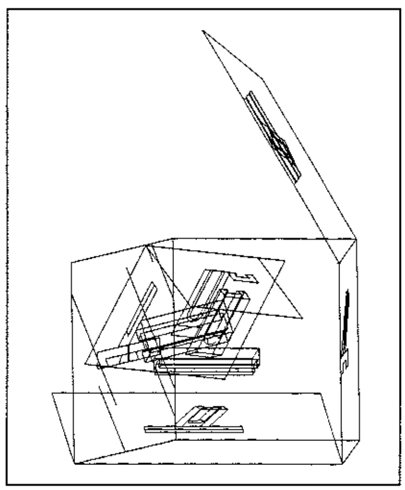

Figure 2 Glass box model

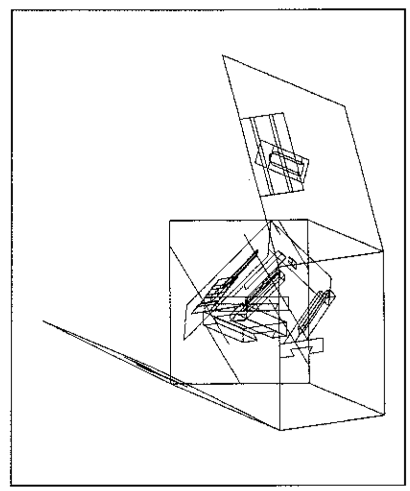

Figure 3 Glass box model

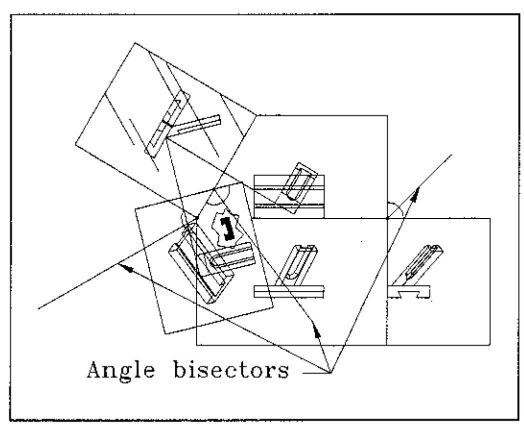

Figure 4 Auxiliary planes with angle bisector added

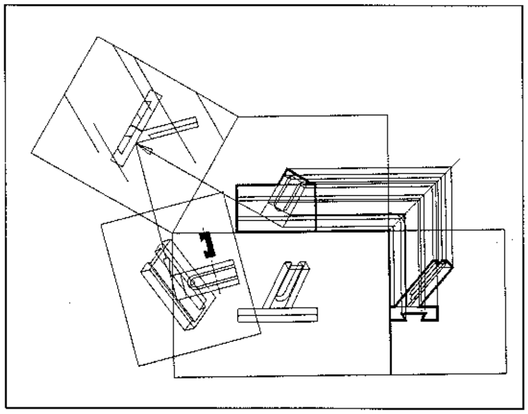

Figure 5 Angle Jig within the "glass box"

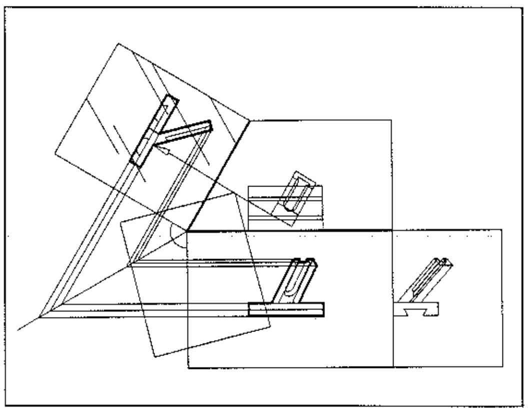

Figure 6 The glass box unfolded with angle bisectors added

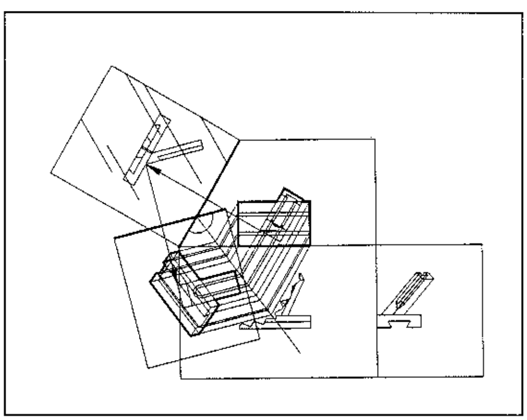

Figure 7 The glass box unfolded with angle bisectors added

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