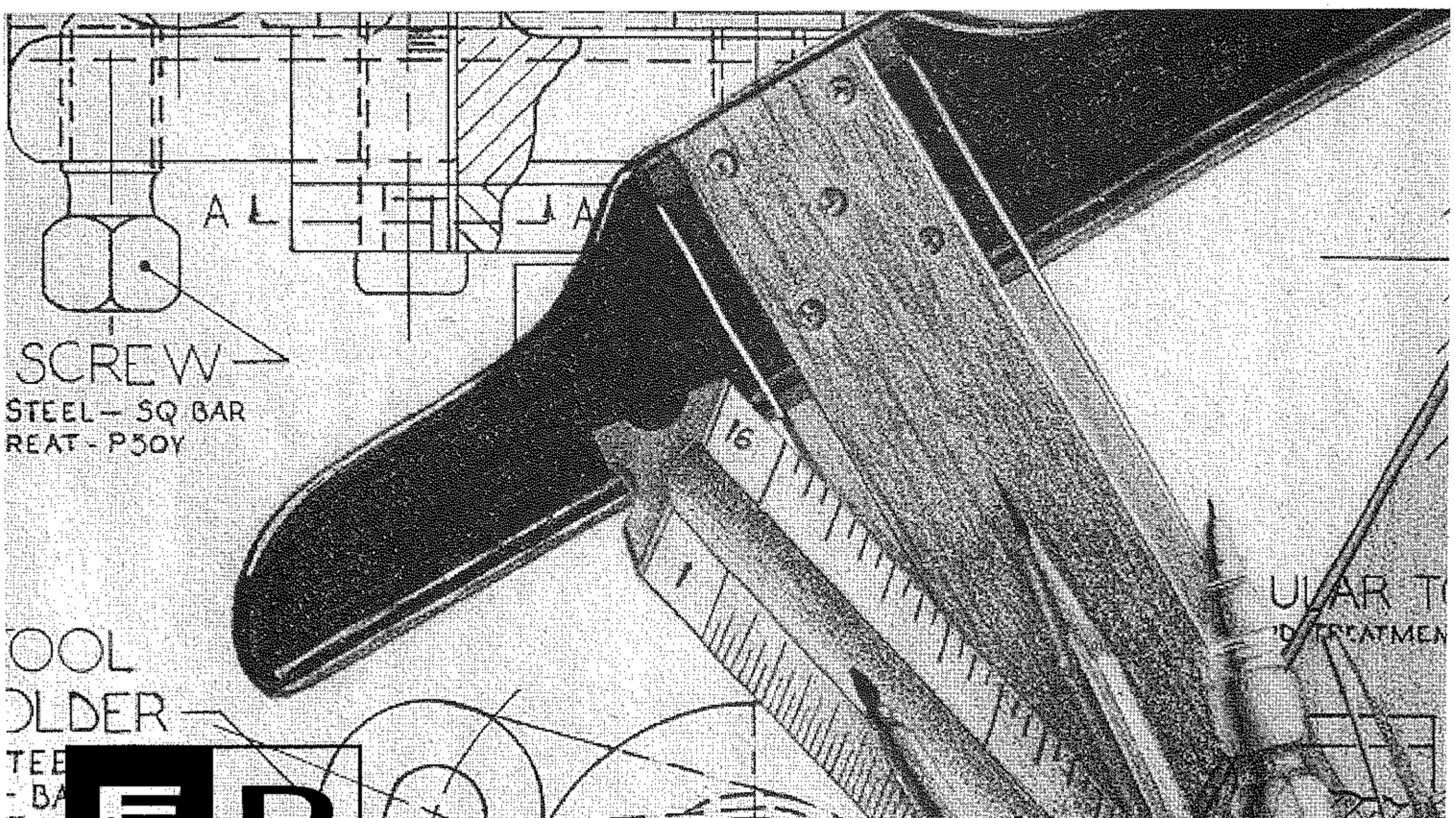
THE ENGINEERING DESIGN GRAPHICS JOURNAL



ENGINEERING DESIGN GRAPHICS DIVISION
A S E E

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ENGINEERING DESIGN GRAPHICS DIVISION
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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ENGINEERING DESIGN GRAPHICS DIVISION
A S E E

THE ENGINEERING DESIGN GRAPHICS JOURNAL

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

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. . . from the EDGE

Engineering • Design • Graphics • Editor

Dear Members:

In this issue you will find an article by Craig Miller who has looked all of the *Journal of Engineering Drawing* and *Engineering Design Graphics Journals* to find references and articles on visualization. This historical review allows all of us to get a better idea of the roots of the EDG division as well as a good insight into who some of the contributors have been in this area.

I found other information that interested me as well. I was able to could get a feeling about the times, the make up of the division, and how time have changed in some areas by looking at some of the citations used in Miller's paper.

Back in 1938 Grant and Heacock wrote about the students using the all inclusive terms *HE*, and *HIM* in every case. Well, I guess back in 1938 he and him were pretty inclusive, because there probably weren't very many female students.

In the 40's Orth, Gerardi, Warner, Wellman were still using phrases like *his* drawing instructor, *his* interest, and *his* ultimate success. Well, these were the war years and things hadn't started to change yet.

In 1957 Kliphart was asking us if a student can count the number drawer handles on *his* desk, or sketch things from *his* mental image. Now by this time Mary Blade had become an important force in the division, but I guess she was only one women. Apparently there weren't any female engineering students yet.

A late as 1977 Jasper was still referring to the student *himself.* It is not until 1979 that the first reference to a female is found in this literature. In writing about engineers, Newlin mentions that *he* or *she* must be able to visualize a problem. It is good to note that with the 80's and beyond, most references have not totally excluded the possibility of females as engineers. I know that there is still a major controversy about women in the military, but the idea of women in engineering should be accepted and encouraged by everyone. As the number of students available to enter our programs diminishes we must seek out and encourage qualified women and minorities to enter our programs.

We must consider (if we haven't already) making our materials and our classrooms conducive to all. Maybe some of the examples and problems that we have been using for the past 5, 10, or 20 years need to be updated to be more inclusive.

In the December 1995 *ASEE Prism*, Cheryl Sorby (an EDG member) explained that some engineering students, particularly women, may fare poorly in design graphics courses because they lack strong 3-D spatial visualization skills. Does this mean that we will naturally lose these students as engineers or does it mean that we should find out how to help them become better visualizers? My hope is that all of us will become more aware of non-traditional students and make our classrooms and programs better places for everyone.

F. A. Mosillo from the University of Illinois at Chicago set me a fax and pointed out that in the Spring '96 issue I placed Frank Oppenheimer's first MidWinter meeting at the University of Chicago, Navy Pier whereas it should have been the University of Illinois in Chicago, Navy Pier. Sorry for the error. I guess people really do read the editorials.

Mary A. Sadowski

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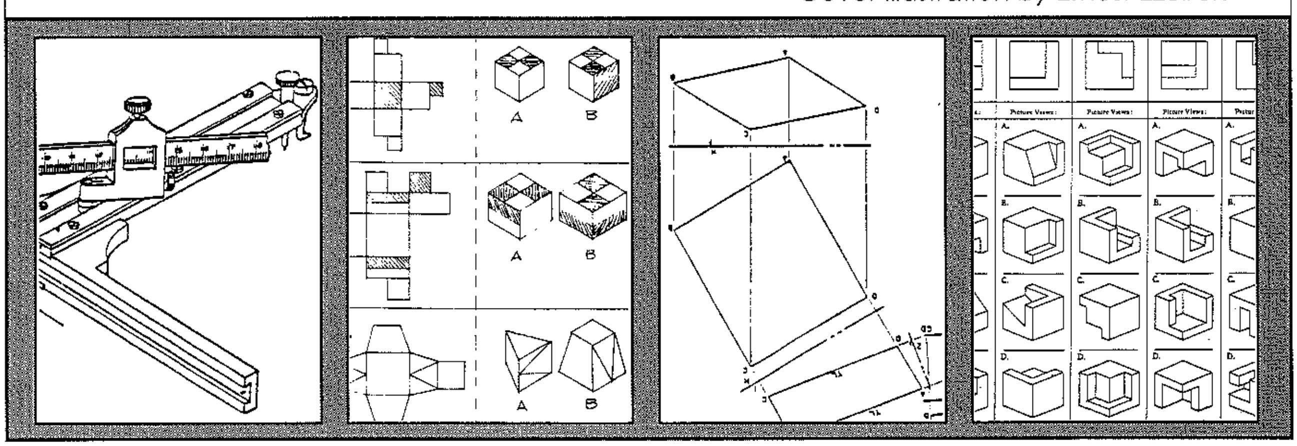

Curve and Surface Modeling Yesterday, Today and Tomorrow

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Abstract

This paper examines our methods as engineering graphics educators over the past fifty years given the tools of the times. The paper specifically addresses how our methods have changed in presenting techniques and procedures for drawing or displaying the curved entities or surface models used in engineering design. It begins with an examination of texts and manuals from fifty to one hundred years ago, their content with respect to drawing instruments, and their approach to geometric constructions and problem solution techniques in the representation of curves and surfaces. The paper then addresses the changes that have taken place in the way we teach these techniques; changes brought about through changes in graphics tools involving computer technology. Finally the paper will examine current technology and teaching methods used in surface modeling and design and what we can expect in the future.

Introduction

A thorough examination of the evolution of teaching methodology for specific instruction in the modeling of curves and surfaces could occupy volumes, but the events of the last fifty years and the milestone fiftieth anniversary conference of the Engineering Design Graphics Division of the American Society for Engineering Education present a unique opportunity for examining one of the most fundamental of modeling tools: curves and surfaces.

Curves and surfaces in engineering design have presented challenges for the engineer and the engineering educator since the days of Gaspard Mongé. Peter Jeffrey Booker summarized Mongé's work in four rationalized drawing procedures as follows:

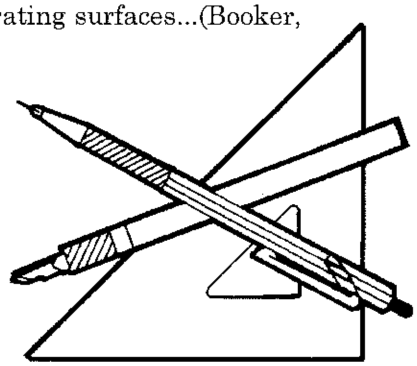
> bodies bounded by straight edges may be defined and recorded by giving their projections on to two reference planes at right angles to one another...

shapes and angles may be ascertained by revolving any line or face until it is parallel to one reference plane...

curved surfaces may be represented by showing their method of generation...

and

one may define through projections the curves of intersection of penetrating surfaces...(Booker, 1979)



The mathematical roots of geometric design extend back even further to Euclid, Descartes, etc. Until computer technology evolved into a user-friendly and cost-efficient venue the representation of curved entities was dependent upon freehand techniques or devices such as the center-wheel compass and other instruments for drawing curves which were made of paper or wood. Curves as functions of radii have been drawn using compasses since the middle of the eighteenth century. Compasses, before they were adapted to hold pencil leads or ruling pens with ink, were originally dividers. The dividers were used to scratch impressions on vellum or paper and these scratches were inked using quill pens. Irregular planar curves have been drawn using a variety of instruments including French curves, splines and curve-rulers. The representation of three dimensional surfaces was best accomplished through the use of section views. Elliptical and parabolic curves of wood or hard rubber have been available in sets since the latter part of the nineteenth century.(Anand, 1993), (Booker, 1979)

Computer aided geometric design of curves and surfaces had its practical beginning with automated machinery to compute, draft and manufacture objects with freeform surfaces brought about by the critical needs of the aircraft and shipbuilding industry during World War II. This need stimulated many new devices and methods to enhance and accelerate design and manufacturing (Rockwook, 1995).

One of the most important developments in computer graphics technology came from Ivan Sutherland, working at M. I. T. in 1963. His *SKETCHPAD* computer graphics software contained only two primitives: lines and text. The line primitive was used to create circles. Many computer graphics software packages today contain similar representation schemes for circles and other classifications of curves (Juinnies, 1996).

The same scientific and technological advances necessitated by World War II changed design and manufacturing practices forever and these changes, in turn, changed forever the way engineers were educated. Significant technological advances of the World War II era include the electronic computer, missile, transistor, microwave and Polaroid camera.[5] Engineering education, often primarily concerned with design, is generally defined as creatively applying scientific principles to develop new products and systems, but the training received in science, mathematics and industrial processes has changed from tedious manual methods to electronically mediated methods.

Of special interest is the presentation of material in engineering graphics texts over the last fifty years, particularly those sections devoted to curves and surfaces. The following sections present excerpts from texts from each decade of the last fifty years.

Fifty Years Ago

Fifty years ago engineering students needed drawing boards and a conglomeration of tools and equipment to facilitate the construction of their drawings. They spent many hours in the classroom laboring over the theory and execution of orthographic projections and descriptive geometry and they relied on drawing instruments and tedious, painstaking procedures to assure the accuracy of their drawings. The graduate engineer of the 1940's had the training and the tools to be his own professional drafter but according to H. L. Thayer's Industrial Drawing, (1942),

> It will seldom happen that the student or the draftsman will possess complete equipment. Often he will be compelled to improvise an instrument or perhaps change some work to conform to what he has...he will sometimes find, especially in the larger drafting rooms, ...labor-saving devices.

Included in Professor Thayer's list of standard equipment along with his text are some thirty other different items. Parts of the list are presented in Figure 1.

Sections of the text are devoted to drawing curved lines with pencil, drawing curved lines with ink, drawing irregular natural curves, and irregular artificial curves. There are no less than five different manual methods for drawing an ellipse: the trammel method, parallelogram method, conjugate diameters, concentric circle method, and the locus method.

There is no mention of methods for designing or constructing freeform surfaces.

How Things Changed in 50 Years

In 1953, the eighth edition of one of the classics in engineering graphics texts was published, *Engineering Drawing*, by Thomas E. French and Charles J. Vierck. In their chapters devoted to the selection and use of instruments a list of twenty-seven items is given. This list is shown in Figure 2 and contains many of the same tools required by Thayer (French & Vierck, 1953).

Much of the chapter entitled "Applied Geometry" contains instruction for the drawing of parallel curves, tangent arcs, ogee curves, reverse curves, the conic sections, epicycloids, the spiral of Archimedes and others. An illustration of double curved

Instruments and Supplies

One ruling pen
Plain dividers
Bow dividers
One compass for pencil work
One pen for the preceding
One bow pencil compass
One bow ink compass
One drawing board
One T-square
One triangle, angles 45° 45° and 90°
One triangle, angles 30°, 60° and 90°
One irregular curve
One architect's 12" triangular scale
One protractor
12 thumb tacks
One 4H pencil
One 2H pencil
One pencil sharpener
One erasing shield
One bottle of India ink
One set of lettering pens
One penholder
One penwiper
One packet of paper containing:
- 15 sheets 9 x 12 detail paper
- 5 sheets 9 x 12 vellum (tracing paper)
- 2 sheets 9 x 12 pencil cloth
- 60 sheets $8^{1}/_{2}$ x 11 cross-section paper with light blue squares $^{1}/_{10}$" to $^{1}/_{4}$" apart both ways

Figure 1 Partial listing of instruments and supplies recommended for engineering graphics students in H. L. Thayers's *Industrial Drawing*, 1942.

Check List of Instruments and Materials

1. Set of drawing instruments, including at least: 6-in. compass with fixed needle-point leg, removable pencil and pen legs, and lengthening bar; 6-in. hair-spring dividers; 3 1/2-in. bow pencil, bow pen, and bow dividers; two ruling pens; box of leads; or large bow set containing: 6 1/2-in. bow compass, 4 1/2-in. bow compass, 6 1/2-in. friction divider, pen attachment for compass; 5 1/2-in. ruling pen, beam compass with extension beam; box for extra leads and points.
2. Drawing board
3. T-square
4. 4° and 30°-60° triangles
5. Three mechanical engineer's scales, flat pattern or equivalent triangular
6. Lettering instrument or triangle
7. French curve
8. Drawing pencils, 6H, 4H, 2H, H and F
9. Pocketknife or pencil sharpener
10. Pencil pointer (file or sandpaper)
11. Pencil eraser (Ruby)
12. Artgum or cleaning rubber
13. Penholder, pens for lettering, and penwiper
14. Bottle of drawing ink and bottleholder
15. Scotch drafting tape or thumbtacks
16. Drawing paper to suit
17. Tracing paper or cloth
18. Dusting cloth or brush

To these may be added:

19. Civil Engineer's scale
20. Protractor
21. Erasing shield
22. Slide Rule
23. Six-foot steel tape
24. Clipboard or sketchbook
25. Hard Arkansas stone
26. Piece of soapstone
27. Cleaning powder or pad.

Figure 2 Recommended instruments and supplies from French and Vierck, *Engineering Drawing,* 1953.

surfaces and warped surfaces is shown in this chapter. The same exhaustive methods for ellipse construction as those in the Thayer text are included with some additions, e.g., the pin and string method. One of the more interesting tools illustrated in this edition is the ellipsograph described as one of the..."several instruments for drawing ellipses... a very satisfactory one." This text includes illustrations of drafting machines, diagram curves and splines with ducks all of which were used in the construction of curved entities. The ellipsograph, spline with ducks and diagram curve are shown in Figures 3 and 4.

Surfaces are defined and illustrated using the principles of orthographic projections. They are classified in the traditional manner and there is, of course, a lengthy discussion of methods of finding intersections of surfaces in subsequent chapters. Figure 5 shows some of the standard geometric shapes students were expected to recognize and be able to construct.

The 1966 seventh edition of French and Svensen's *Mechanical Drawing* introduces templates for drawing curves and circular arcs. The templates are praised as being an important time-saving part of the equipment needed by engineers and professional draftsmen (French and Svensen, 1966).

Although this text contained no methods for the modeling of freeform surfaces, one of the pioneers of freeform surface modeling, Ferguson (1963), at Boeing was developing one of the first patch systems by which a set of individual curvilinear patches are joined smoothly to create a surface "quilt".

Coons (1964) developed the general scheme which became the basis of an early surface modeler made by Ford (Rockwood, 1995).

Other classics in the annals of engineering graphics texts are those written and published by James Earle. Some of the early references to computer usage in engineering design and analysis are found in his 1977, third edition, of Engineering Design Graphics. The author recognizes the computer's importance in solving increasingly more of the engineer's problems and cites examples of the development of three-dimensional models, viewing transformations and even animation. The traditional manual methods of geometric construction of curves are included and some of the significant innovations in surface design of the times are shown: the geodesic dome, Ionosphere, NASA's launch escape vehicle and others. All of these involved the modeling of standard surfaces of spheres, cones etc. (Earl, 1977). There is still no mention of freeform surface modeling.

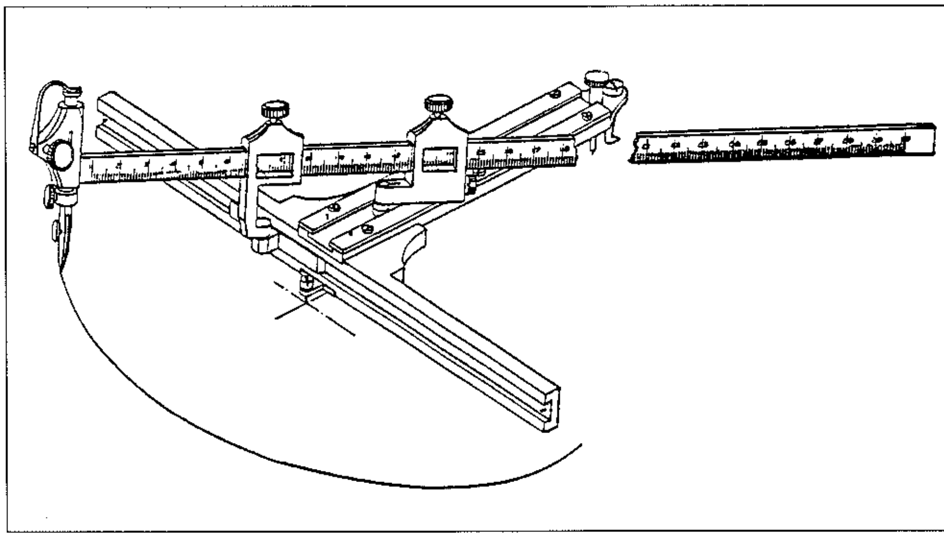


Figure 3 Ellipsograph for drawing ellipses - illustrated in *Engineering Drawing* by French & Vierck, 1953.

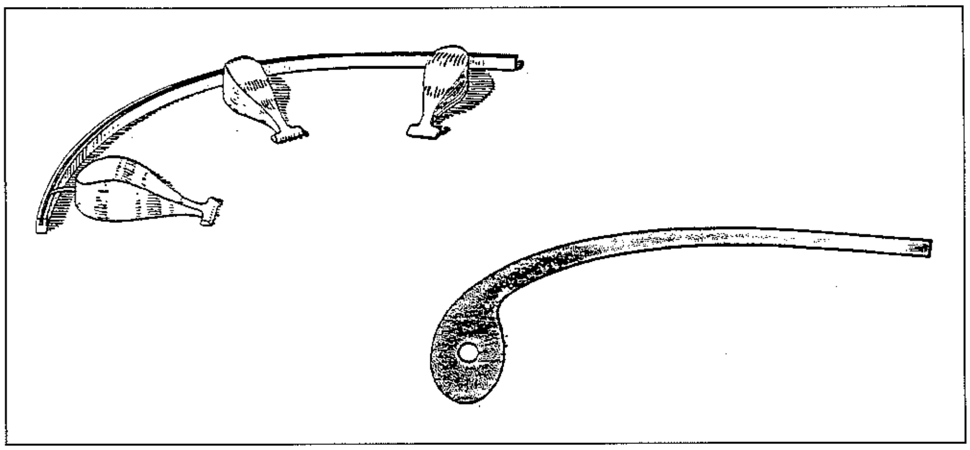


Figure 4 Spline with Ducks and Diagram Curve from *Engineering Drawing* by French & Vierck, 1953

In the 1970's, as in the 1960's, surface modeling techniques utilizing computer technology were emerging from industry; primarily the automobile, aircraft and shipbuilding industries. Bezier in 1971 reformulated Ferguson's ideas so that a draftsman without any extensive mathematical background could design a smooth surface as a way to drive NC machinery. Gordon and Riesenfeld working with General Motors in 1974 utilized the properties of B-spline curves and surfaces for design (Anand, 1993), (Rockwood, 1995).

By the beginning of the 1980's the power and versatility of computer aided design was recognized by anyone who had a freeform geometric surface application. Corporations able to afford them were beginning to use commercial modelers.

By 1987, the Earle texts contained generic and software specific chapters or sections on computer graphics. The fifth edition of Engineering Design Graphics contained a brief treatise on fitting a curve to a polyline and it is interesting to note that AutoCAD (Version 2.15 supported this technology. Other curve and surface modeling primitives

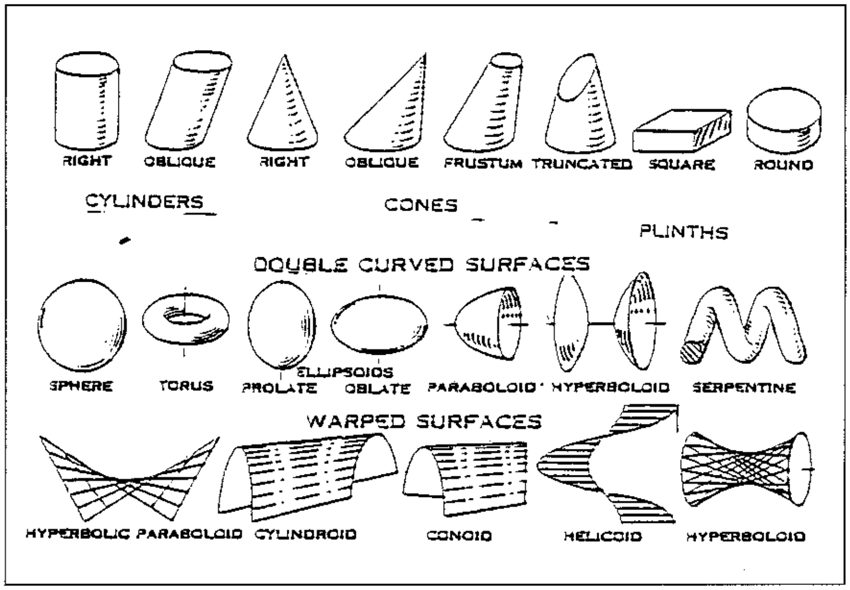


Figure 5 Curves and Surfaces illustrated by French and Vierck, 1953

contained in that early version were arcs, circles, tangent arcs, ellipses, fillets and others. A 3D option was part of the root menu enabling the user to display extruded entities (Earle, 1987).

The Challenges and Accomplishments of the 1990's

Looking back over the past fifty years of curve and surface modeling and the teaching techniques to accomplish them, it is obvious that the tried and true is still useful and used. The instruments of manual construction are still with us, even though they are not as widely used. The computer has had an enormous impact on teaching techniques, perhaps first having had impact on the design process, manufacturing and design implementation. New engineering graphics texts have been published with fresh approaches to traditional problems and could even be considered classics of this decade. Bertoline, Rodriguez, Anand, Leach, Stewart and others have recently published engineering graphics texts, some of which include sections on traditional methods of curve and surface modeling as well as computer based curve and surface modeling. Gary Bertoline's 1995 Engineering Graphic Communication includes both the traditional approach to two dimensional and three dimensional surfaces as well as a clearly explained and illustrated section on computer modeling of freeform surfaces (Bertoline et.al., 1993). Vera Anand's 1993 Computer Graphics and Geometric Modeling for Engineers contains an entire chapter on conic sections and freeform curves and surfaces. Mathematical formulations for curve representation ranging from simple splines to non-uniform rational B-splines are given (Anand, 1993). Interpolation and approximation techniques are defined and compared in both texts and both cover parametric and other formulations. The Anand text includes a number of subroutines for generating curves and surfaces as appendices to the chapters.

Summary

The geometric entities used to create graphical models have not changed in fifty years. The major changes are in the methods of representation. Circles, arc, ellipses, the conic sections, the standard surfaces are still needed and used in model development; manual methods are still used to create these entities and these methods are still

appearing in the engineering graphics texts of the 1990's. Computer tools have cleared the way for more efficient, accurate and creative curve and surface models and the most significant difference in engineering graphics texts of this and the last two or three decades is the presence of computer based solution methods used in curve and surface modeling. On the horizon are virtual reality languages and software which will enable the engineering graphics educator to use immersive environments for instruction, visualization, design validation etc. These already exist for use in the instruction of mathematics, languages and the arts. Physically based modeling is emerging as an important new approach to computer animation and computer graphics modeling by using ordinary differential equations to represent anything from rigid bodies to deformable objects (Witkin, 1995).

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A Historical Review of Applied and Theoretical Spatial Visualization Publications in Engineering Graphics

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Abstract

Spatial visualization, for years a central part of the engineering graphics curriculum, is receiving renewed attention in journals and at conferences. As the engineering curriculum in general in the United States is undergoing critical evaluation and review, a renewed interest in spatial abilities has occurred. Engineering educators again are realizing that a successful engineer must have strong spatial abilities and be able to specifically visualize solutions to design problems. To provide a reference for future research, this article reviews previous research by the engineering graphics educators in spatial abilities as reported in the Engineering Design Graphics Journal. The intent is to give future researchers a basis on which to review, compare, and add research in the area of spatial abilities in the context of engineering graphics.

Figure 1 Frederick G. Higbee First editor of the *Journal*, 1938

The Early Years

During the early years of the Division of Engineering Drawing of the Society for the Promotion of Engineering Education (**SPEE**) some of the most formal important research in spatial abilities occurred. During the late 1920's through 1940, the division was very active in this area. Of all the research conducted in this era, one individual was of central importance—Clair V. Mann. It should be noted that Mann was active in this area over a long period of time, and his works were instrumental in the development of visualization tests that were used by the United States Army Air Corps during World War II. The amount and the thoroughness of the spatial ability research that occurred during this period has only been recently repeated.

The Division of Engineering Drawing of the Society for the Promotion of Engineering Education (**SPEE**) was formed in June 1928 with the appointment of four working committees:

> 1. Objectives and scope of courses in engineering drawing,
> 2. Objectives and scope of courses in descriptive geometry,
> 3. Methods of simulating research and projects for research in engineering drawing and allied subjects, and
> 4. Summer school for teachers of engineering drawing and allied subjects. (Jordan, 1938)

Although the third objective clearly noted the need for research in engineering drawing and related subjects, published research in visualization did not appear until May 1937 in the first volume of the *Journal of Engineering Drawing*. One of the *Journal's* projects was a Committee on Visualization. Clair V. Mann chaired the committee which was established to determine the relative accuracy and reliability of existing tests in predicting achievement in engineering, as predicted on the capacity to visualize. To date, there is nothing more definite or specific than personal opinion of several existing tests is the more accurately reliable in predicting engineering achievement. This committee has been assigned the program of applying concurrently several of the most commonly accepted tests, each in a different school, to several groups of engineering freshmen. By correlating their test records with their scholastic achievement during the ensuing four years, and with their professional development for as long as the committee functions, irrefutable information pertinent to student personnel analysis will be available to those who need it. (p. 21)

From the first *Journal of Engineering Drawing*, a keenly interested engineering graphics profession has noted the importance of the visualization abilities of engineering students. This committee further reported in the January 1938 issue:

> Purdue, Iowa State College, and Texas Technological College among other schools have sent him (Mann) data on completed tests. These are now being correlated. Five tests are being used.
>
> 1. Wright's Drawing Test,
> 2. Mann's Drawing Aptitude Test,
> 3. Mann's Dynamicube Test,
> 4. Mann's Staticube Test, and
> 5. Mann's Mutilated Cube Test.
>
> These are being applied concurrently or individually, depending on the wishes of the department under whose administration they are being administered. Professor Mann asks that more institutions participate in the program he has organized (p. 26).

The committee's work was detailed in the May 1938 *Journal of Engineering Drawing*, in *Progress Report of the Committee on Visualization A Project for Measurement of Power to Visualize.* This article stated that the committee's work has been based on a 1930 questionnaire, The *Value to the Engineer of Power to Visualize,* funded by the Engineering Foundation and sent to approximately 200 eminent United States design engineers. Composite answers, reported Mann, indicated the ability to visualize is indispensable in the work of engineering design and administration. The report further stated that visualization can be measured and is possessed in high degree by most designing engineers. Of all college subjects taken by engineering students, the report showed that only descriptive geometry both develops and utilizes visualization ability. A comprehensive literature review of visualization in engineering accompanied the questionnaire. The combined project resulted in the development of several tests measuring visualization ability (Mann, 1938).

Mann reported that work on this project was continued by the Selection and Guidance of Engineering Students Committee, a division of the Engineering Committee of Professional Development (**ECPD**) and the Committee on Tests and Comprehensive Examinations of **SPEE**. The project next was turned over to the Engineering Drawing Division with two stated objectives:

> 1. To establish national norms for visualization tests and
> 2. To test desirability as measures of the quality and the extent of validity in predicting success in engineering study and practice, and most importantly their relationship to success in descriptive geometry, and technical engineering studies.

Tests actually implemented in this study were: Mann's Mutilated Cubes Test, Mann's

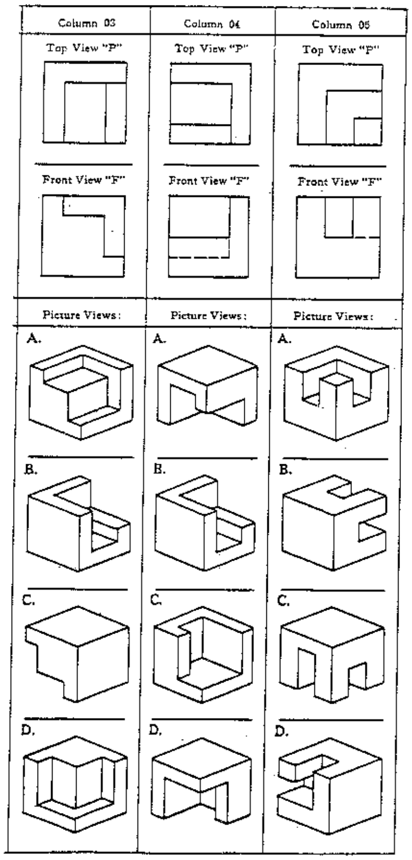

Figure 2 Sample Problems from Mann's Mutilated Cubes Tests

Drawing Aptitude Test, Mann's Dynamicube Test, Mann's Staticube Test, and McCauley's Tetrahedron Test.

Participating institutions were: Purdue University, University of Dayton, University of Iowa, Iowa State College, New Mexico State College, University of Tennessee, Lehigh University, The Citadel, Virginia Polytechnic Institute, University of Washington, Antioch College, University of New Hampshire, Columbia University, State University of North Dakota, St. Lawrence University, Missouri School of Mines, Columbia University, Yale University, University of Arizona, Swarthmore College, Ohio State University, Texas College of Technology. The Proctor and Gamble Company also participated. More than 2,000 scores were obtained on each test (Mann, 1938).

The project results were to be presented to the Engineering Drawing Division of **SPEE** at the June 1938 Annual Meeting. In addition, Mann (1938) stated, "It is the purpose of the committee to continue with the project until a five-year study has been made, and thereafter until students to whom the several tests have been given have graduated and placed themselves in industry. In this way the prognostic value of the several tests, and other new ones that may from time to time come to the attention of the Committee, may be determined" (p. 22).

A progress report by the Committee on Visualization in the May 1938 *Journal of Engineering Drawing* - the last published report by the committee - listed its members but did not detail any research findings or other accomplishments. No results were reported in later issues of either the *Journal of Engineering Drawing* or the *Journal of Engineering Education.*

In *Direct Descript* C. E. Row (1938) described the essentials of the direct method as: first, the direct attitude of the mind; second, visualization; third, analysis; and fourth, practical drawing board constructions in accord with the above conception. Row further stated,

> the visualization of planes is most satisfactorily accomplished by the use of strike and dip as employed practically by geologists and mining engineers. This method is very simple compared with the visualization of planes by inspection of their traces which are shown in such a great variety of arrangements (p. 2).

Row concluded,

> The instructor's job is to teach them to visualize and to think. Of all the courses in the engineering curriculum, descriptive geometry offers the best opportunity to accomplish these objectives (p. 3.)

In *Use of Mirrors in Orthographic Projection* H. E. Grant (1938) wrote that students are asked to visualize the various orthographic views by projecting them upon a plane. Grant concluded, "...there is more visualization thrust upon the student at this initial stage than at any other corresponding length of time in either mechanical drawing or descriptive geometry. In other words, his first visualization is the critical period in his course" (p. 22). He added:

> It is difficult for the average or below average student entering the entirely new subject to place himself out of the realm of perspective and into the orthographic. He is not fully aware of the obliquity of the visual rays to the picture plane of projection. It is this initial state that is so vital to this large group of students. It is most difficult especially for the weaker student to make this visualization when he looks from one position of the eye perpendicular to surfaces parallel to the plane of projection that the surfaces are actually perpendicular to the plane of projection are not visible as surfaces, as he actually sees them, but are according to orthographic projection only lines. It is like looking down a hallway. He sees the two walls, ceiling, and floor, yet the plane of projection is perpendicular to all. (p. 22)

Frank Heacock (1938) wrote in *Visualization Tests for Beginners*:

> An important objective in the teaching of engineering drawing is to develop the ability to read drawings; that is, to visualize three-dimensional form from orthographic views. Progress in learning to visualize varies greatly with individual students. Some minds adapt themselves readily to this kind of constructive thinking, while others need a great deal of explanation and guidance. Frequent brief tests are found to be valuable aids in teaching students to visualize drawings.
>
> The value of these tests is twofold. In the first place, they measure a student's ability to visualize an orthographic drawing and provide a reliable check on the progress of his training. Secondly, a test of this type gives each student a powerful incentive to concentrate on the problem before him, so that he will exert his visualization powers to the utmost. (p.18)

In cooperation with the Committee on Visualization, Maurice Grancy of Purdue University conducted a study to determine the relationship between the ability to visualize, as measured by certain tests, and success in the engineering education curriculum. The study aimed to select tests to accompany or replace Wright's Drawing Test, then used to determine freshman placement in advanced drawing courses. The use of coefficients of correlation indicated no selected test correlated with success in the introductory engineering drawing course. Drawing skill, comprising one third of the course grade, might have been a factor keeping correlation coefficients low. Grancy (1938) recommended more research, noting it highly probable that a valid visualization test might predict success in advanced engineering drawing courses.

V. D. Hales in *Development and Use of Attitude and Training Tests in Engineering Drawing* noted that aptitude tests were available for some subjects such as mathematics and English but not for engineering drawing. He described the development of two tests - an aptitude test and a training test. The aptitude test was to help determine a student's ability to visualize objects and changes of position, to understand verbal descriptions, to follow directions, to be critical, to apply mathematics, and in general to use common sense.

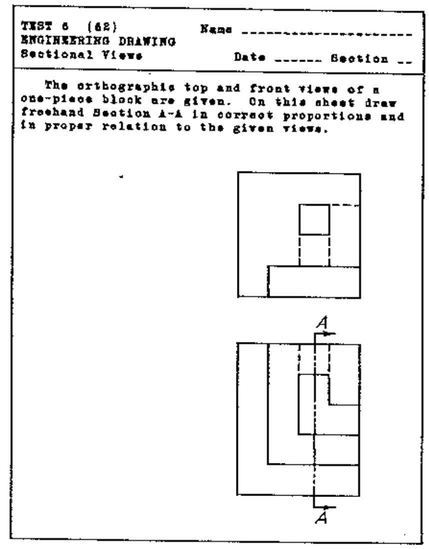

Figure 3
Sample Problem from Heacock's Visualization Tests

The training test was to test the student's general knowledge of engineering drawing, use of tools and instruments, and visualization; ability to letter and criticize; familiarity with applied geometry; and understanding of orthographic projection (p. 7).

The World War II Years

During this time period a significant shift had occurred in research in spatial abilities by engineering graphics educators. A majority of the focus on spatial abilities up to this point had been on the development of visualization instruments which had been developed, evaluated, and implemented by graphics educators. During the 1940's focus was shifting from a research base to a curriculum development base which focused on spatial visualization. Most of the emphasis during this time was on the development, promotion, and defense of descriptive geometry in the engineering curriculum. Thus, the initial research base in the investigation and importance of spatial abilities for the engineering curriculum was not emphasized. With Clair V. Mann changing his focus to a broader realm that was mostly outside of engineering graphics, engineering graphics educators were essentially without leadership in this area. Except for research reported by Mann it wasn't until the late 1940's that true research in spatial abilities was undertaken or reported by an engineering graphics educator. The significance of this research by

Mary Blade was that it was based on psychological research in spatial abilities rather than justification of descriptive geopmetry as the main visualization tool.

In *Progress in the Teaching of Descriptive Geometry* (1940) C. E. Row quoted a 1913 descriptive geometry book by Miller and Maclin.

> In preparing the following text in descriptive geometry, the authors have endeavored
>
> 1 to make the subject easier for the student,
>
> 2 to help the student to visualize magnitudes in space, and
>
> 3 to present the subject more nearly in accord with commercial practice (p. 13).

Row continued by saying that certain instruction practices in descriptive geometry allowed the students to visualize rather than measure an object . He concluded:

> The course in descriptive geometry deals with problems that require instruction in the determination of visibility, in visualization, and in orientation. Orientation is the mental process by which the draftsman or the reader of a drawing relates himself to any view of an object in such a manner that the view appears to him as the actual object would appear for that particular direction of sight. Auxiliary views and oblique views require orientation before they can be visualized completely. (p. 14)

Harold Howe (1940) noted that descriptive geometry problems develop the power to visualize and plan solutions. He added:

> Undoubtedly one of the chief values in studying and applying descriptive geometry lies in its adaptability to the development of visualization. Visualization does not confine itself to the realm of scientific endeavor. Although we with technical attributes may realize our need of it, obviously it is most essential to all the concepts of mankind. It is evident that some have more, let us say, natural power than others, and many have surprisingly little. But, if by any means we can arouse that which is dormant or encourage that which already has its boots on, we should make the effort. Certainly the successful individual is the one who, by looking ahead, may visualize the danger or the opportunity and prepare for it. (p. 2)

Howe observed that means other than a practical descriptive geometry course should be used for visualization ability and should be implemented early in the curriculum. He contended:

> In conclusion, with due consideration to the practical usefulness of descriptive geometry, I wish to stress the fact that we are fortunate in finding this subject the opportunity for arousing and strengthening the mental concepts called visualization. This, it must be acknowledged, is a most important asset in forming and directing our future attentions. (p. 3)

Writing about the importance of descriptive geometry, Jasper Gerardi (1940) noted, "a person will also find it difficult to make, understand, or read a complicated drawing because he has not had the proper training in visualization, a training which descriptive geometry is preeminently capable of giving. Visualization can best be taught at a time when the mind is flexible" (p. 10). He further adds, "Visualization is like a catalytic agent in the brain. It stimulates the power to think logically" (p. 10).

In the article *Establishing and Maintaining Standards of Excellence in Drawing,* H. D. Orth (1941) discussed five standards for engineering drawing. These were:

> 1. lettering,
> 2. freehand sketching,
> 3. pencil mechanical drawings,
> 4. tracing in ink, and
> 5. visualization.

He defined visualization as "the ability to form clear mental pictures of objects which do not exist or for which we have only orthographic views" (p. 9).

Orth also made suggestion for developing visualization standards.

> Because of the fact that these pictures exist only in the mind, the problem of setting up standards and determining when we have approached them is by far the most intangible of those we are

> considering. Several attempts have been made to devise tests which will measure this important ability, none of which seem to have been universally adopted.
>
> From the teaching standpoint, it seems to me that the most logical approach to a solution of a problem is to begin with simple rectangular prismatic forms and progress to the forms having inclined surfaces, cylindrical and conical surfaces. A course in solid geometry might well be considered a prerequisite for a course in drawing as a foundation for visualization.
>
> I am convinced that the student makes little if any progress in visualization by merely copying orthographic views. If he is given models or pictorial views, his mental picture is formed from these aids without effort and little gain is made toward reading an original orthographic drawing. If he is given the orthographic views alone the effort necessary to visualize is greater and he gains in proportion to the effort put forth.
>
> Perhaps some aid may be necessary to give the student the idea of what is wanted and to boost his mental processes over the threshold of visualization. This may be accomplished by using a model for demonstration purposes which will illustrate the principles under consideration. The student should be required to draw a different form involving the same principles.
>
> When a problem is presented to the student his natural inclination is to try to visualize the object as a whole at the outset. For the beginner this is difficult if not impossible and he may sit and stare at the problem without making progress. The instructor can help him over this difficulty by suggesting that he center his attention on one detail until he has it clearly in mind and then proceed to another. In this manner he will gradually build up a mental picture of the object as a whole.
>
> One of the most successful methods of promoting visualization involves numbering the corners in each view so that surfaces and edges may be pointed out in one view and the student asked to indicate the same surfaces and edges in other views by giving the corresponding numbers in those views. This device has the virtue of centering the attention of the student on details one at a time. His answers reflect the vividness of his mental picture. By increasing the difficulty of the problems as the course progresses the standard of visualization can be raised to a satisfactory level (p. 9-10).

Orth (1941) listed survey comments:

> - Should be imaginative.
> - Should have the ability to visualize problems and carry out their solution.
> - Should be able to visualize.
> - Ability to assemble parts by visualization.
> - Does not try to visualize what he is drawing; that is, he tries to draw by
> - "rule of thumb" rather than picture the part in his mind. Lots of them
> - cannot recognize the part in the shop after they have drawn it. (p. 10)

Drawing is a language, the oldest language and the one universal language. It should be recognized as a language and should be taught as a language.

Carl Svensen, 1948

Frank Heacock (1941) in *Graphic Aids to Three-Dimensional Thinking* contended that an engineering drawing course should train students to produce working drawings, develop skill in producing and reading freehand drawing, and to think constructively in three dimensions. He added that the practical draftsman learns these traits from actual experience while students are taught from the beginning to visualize in three dimensions. Heacock observed:

> We may ask what it is, how it is done, and how the process may be aided and made easier for the student. We may expect the freshman to form and grasp a correct mental picture of every object represented in his drawings. For the beginner this is often difficult, because his naive mind does not always take kindly to this kind of thinking. It is necessary to arouse the interest and point out a convenient and

> satisfactory approach that appeals to the student. Without going into the psychology of the process, the teacher of engineering drawing can do a great deal to stimulate and develop a student's power of visualization (p.10).

Clair V. Mann in *A Partial Suggestive Analysis of Graphic Talent* suggested several topics of investigation for graphic talent. Visualization was one of the main areas to be investigated. He contended that graphics tests of visualization offer highly interesting data for further philosophical study, such as using blind subjects to explore how they visualize through the "mind's eye." Mann advocated that engineering drawing educators should want to experiment and test visualization abilities. He concluded that graphic talent tests would be developed through persistent efforts or a master's or doctoral student seeking research topics (p. 19).

In 1945, B. M. Aldrich wrote in *An Isometric Approach to Descriptive Geometry*, that students developed habits of static thinking and lack kinetic thinking ability as evidenced by their difficulty in relative motion assignments. He categorized descriptive geometry students as:

> 1. those who grasp the subject with comparative ease,
> 2. those who grasp the subject with considerable difficulty, and
> 3. those who cannot grasp the subject. Students must be trained to make the transition from three-dimensional to two- dimensional, he said, adding that descriptive geometry supplies this training.

H. H. Katz (1945) noted that a designer must develop a three-dimensional picture of the design and then sketch it freehand. In blueprints the planer views must be visualized into actual objects and sketching may allow the mental picture to occur. Engineers also can use sketches to analyze and discuss problems and to visualize suggestions to the draftsperson.

Katz noted in the article, *Visualization of Motion by Pivoted Cutouts,* that cutouts help designers visualize motion. He noted that many mechanisms require visualization of motion, and many nongraphical methods may be used to help visualization. He concluded that motion must be visualized, and that cutouts may help accomplish this type of visualization.

Carl Svensen (1948) in *Drawing in Engineering Education* noted its importance as a curriculum component. He said that engineering drawing develops constructive imagination from the power of visualization, accuracy of thought, and the ability to analyze. He added:

> Drawing is a language, the oldest language and the one universal language. It should be recognized as a language and should be taught as a language. Engineering education should be taught as a language. Engineering education should include the development of ability to think in this language - in the engineering world the engineer must be able to think in the engineering language - must be able to visualize. (p. 20)

Svensen (1948) also noted that both physical and non-physical things can be visualized. He said, "With the increase in accuracy of representation and visualization has come the life and growth of civilized man. Thus I repeat that the accuracy of visualization is the yardstick of education. The power of visualization has been and must continue to be developed as an essential factor in education." (p. 20)

He contended that thought development was divided into literary, mathematical, and graphical. The most important factor of the graphical language is visualization and its related problems of translation. He discussed the development of a classification system forming the factor of visualization and concluded, "Without visualization there could be no engineering education - no truly professional engineering." (p. 20)

In *Integration of Engineering Drawing and Descriptive Geometry,* James Rising (1948) contended that engineering drawing and descriptive geometry would supplement development of visualization abilities and help integrate graphics as a whole. In developing courses, he noted two main objectives:

> 1. development of the student's ability to read and write the language of the engineer and
> 2. maximum emphasis on the qualities of space visualization in the solution of engineering problems.

He concluded that engineering drawing and descriptive geometry can assist in the development of visualization skills in engineering students and an integrated engineering drawing and descriptive course will continually stress visualization.

B. Leighton Wellman (1948) in *The Logic of Visualization* described how most engineering graphics students are typically good students but they cannot visualize. He contended that these students visualization abilities can be improved through logical examination of multiview drawings and the simplification of them into familiar geometric solids and two-dimensional surfaces. He notes that most experienced drafters and instructors use a logical process to visualize multiview drawings. Wellman contended that students can improve their visualization abilities if instructors make the effort to use logical processes to present visual clues to their students.

In, *Development of Students Ability to Think and Analyze in Space*, F. M Warner (1949) suggested that visualization skills might be developed in an engineering drawing course. He elaborated on the need to develop visualization abilities of engineering students:

> One of the most important assets of a professional engineer is his ability to think and analyze in three dimensions. Some students who are just beginning their engineering education have a natural ability along this line and others have very little. A definite effort must be made to develop this ability for all students if we are to give them the best preparation possible for an engineering career. The responsibility for teaching visualization falls squarely on the shoulders of drawing instructors because our subject deals entirely with three-dimensional objects. Since the student's first college contact with engineering is usually made through his drawing instructor, the degree of success we attain in teaching visualization may be a determining factor in arousing his interest and assuring his ultimate success. (p. 31)

Mary Blade (1949) in *Experiment in Visualization* presented one of the first in-depth visualization articles based on psychological research. She reviewed the topic historically and gave several definitions of visualization. She noted that engineers must be able to visualize and to solve problems as well as be able to communicate the visualized solutions and understand other graphic communications. She added:

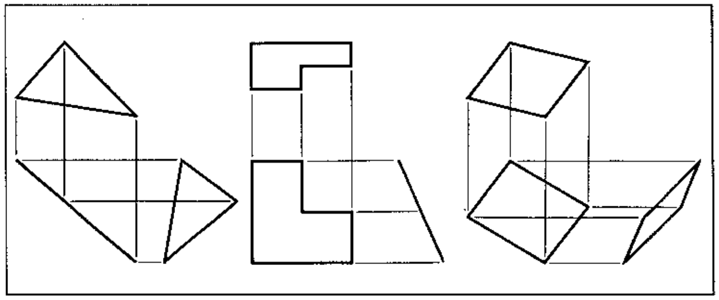

Figure 4 Examples of Wellman's Visualization Problems.

> Thus, engineers must visualize, (must form mental pictures) must draw pictures of objects in space according to a conventional system they learn, and must be able to understand the pictures of other engineers in the conventional language. Our purpose, as teachers, is first of all to teach the engineering student how to solve problems by creative analysis, and as a necessary part of this, to assist him in the visualizing which is so important to solve problems, as I have pointed out. (p. 20)

Blade presented both developmental and environmental theories of spatial visualization and introduced nine clues to perceive space relations. The making, manipulating, and interpreting of abstract symbols must be included in any engineering student's visualization development," a process developed through descriptive geometry exercises.

Blade advocated the measurement of spatial ability to determine any correlation between students and their success as engineers. She noted the differences between males and females in spatial ability and questioned if these measures are a result of experience or potential ability. Encouraging further research, she concluded by noting that motivating a student's interest is the most effective means to develop spatial visualization ability.

Figure 5
Mary Plumb Blade

A Changing World and a Changing Engineering Curricula

As the 1950s began, interest in visualization concepts was strong but dropped sharply by the end of the decade. This was of critical importance because the engineering curriculum was going under major revisions that directly effected the acceptance and importance of engineering graphics in the engineering curriculum. While the ASEE (American Society for Engineering Education) Committee on *Evaluation of Engineering Education* was calling for engineering programs to emphasize spatial visualization ability, engineering graphics educators were spending less research and curriculum development time in these areas. Thus a critical time period in which engineering graphics could have taken the lead in a vital component of the engineering curriculum was lost. The consequences of this oversight were disastrous to engineering graphics departments and programs. Over the next twenty to thirty years almost all engineering graphics programs were reduced in stature and size or completely eliminated.

In *Appreciation of Engineering Drawing as a Basic Academic Study*, Stanley Radford (1950) called for instructors to instill an appreciation of engineering drawing with their students through improved presentation, visual aids, sketching, and practical engineering problems and projects. These and other practices develop better engineers and various qualities of the mind such as imagination and the power to visualize.

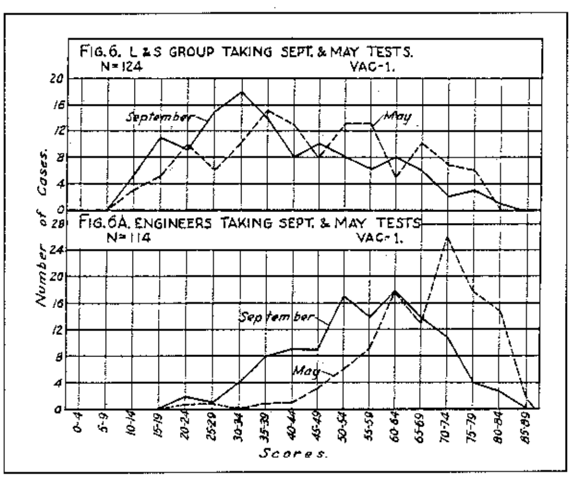

Figure 6 Worsencroft's frequency distribution charts

The 1953 report of the ASEE Committee on *Evaluation of Engineering Education* renewed interest in the Engineering Drawing Division. R. P. Hoelscher in *A Reappraisal of Engineering Drawing*, noted:

> Graphical representation is both a form of communication and a tool for analysis. Its professional usefulness may be evaluated in terms of its success in these directions. Its value as a skill alone does not justify its inclusion in a curriculum. The ability to convey ideas by drawing should be measured at an appropriate time and where deficient should be developed so that its use is evident in reports presented in advanced courses. Another ability to be developed in this study is spatial visualization. Since most creative engineering work is initiated by the process of illustrating ideas by sketches, it is believed that an experience in the use of technical sketching that may be obtained in drawing offers the opportunity for initiating the creative process. (p. 12)

Hoelscher (1950) commented that spatial visualization ability is developed preeminently by descriptive geometry. He claimed that most problems are solved by analytical processes, then visualized. His observation was that most students have difficulty understanding accurate three-dimensional concepts ...an ability that takes experience and time.

R. R. Worsencroft's (1955) *The Effects of Training on the Spatial Visualizing Ability of Engineering Students*, is one of the few experimental research-based reports. Worsencroft defined spatial visualization ability as "the forming of images in terms of three dimensions; in short, of visualizing physical entities." (p. 7) He added that spatial visualization is recognized as an essential ingredient in all fields of design. The objectives of this study were:

> 1. to determine in incidence of visualization in engineering students and whether they possess it as a group;
> 2 to evaluate statistically the amount and significance of improvement of visualization ability during the freshman year in engineering, as against the general freshman group;
> 3. to determine any study experiences responsible for visualization ability development.

Engineering and non-engineering students were given *The Spatial Relation Test.* Freshman received the survey as well as a demographic questionnaire the first week of the semester and again at year end. The study concluded:

> 1. Engineering students possess greater visualization ability than non-engineering students.
> 2. Visualization improvement for non-engineering students did not statistically occur.
> 3. Engineering students visualization abilities improved greater than non-engineering students.
> 4. An analysis of scholastic experiences between the two groups showed that engineering students had courses in shop and drawing which the non-engineering students did not have.
> 5. Since the shop courses did not specifically address the development of spatial visualization abilities it was concluded the primary factor in the development of engineering students spatial visualization abilities was the drawing courses that they were exposed to. (p. 12)

In 1955 in *Graphics In An Expanding Scientific Age*, A. S. Levens responded to the 1953 ASEE report, *Evaluation of Engineering Education*, by pointing out the values of graphics training. Development of perceptive ability, visualization ability, the power to analyze and solve three-dimensional problems, the inspiration of young engineers, and the development of punctuality, resourcefulness, initiative, orderliness, and the ability to work with others are key to the engineering curriculum.

Raymond Kliphart's 1957 article, *Descriptive Geometry Courses which Comply With the Evaluation Report*, also addressed the 1953 ASEE *Report on Evaluation of Engineering Education*. He contended that a descriptive geometry course must comply to the report:

> It seems to me that visualization may be thought of in three aspects. First there is native ability in mental imagery. Can the student visualize familiar non-technical items such as his desk, the campus flag pole or the Union Building? There is wide variation in mental imagery from person to person. Secondly, there is the matter of accuracy in mental imagery. Can the student count the number of drawer handles on his desk when visualizing the desk? Can he estimate the height of the flag pole? Can he sketch the Union Building in reasonable proportion and with proper number, spacing, and size of windows from his mental image? Can he visualize an equilateral triangle inscribed in a circle and estimate the area of the circle which is inside the triangle and outside the triangle? Finally, there is the aspect of generalization in mental imagery. Can the student visualize general and limiting conditions of a verbally described space configuration? (p. 23)

He presented examples of descriptive geometry problems that could develop visualization abilities. Of special interest is his use of mental imagery with practical concrete examples.

R. R. Worsencroft (1957) maintained in *Objectives of Engineering Drawing in Engineering Education* that an engineering drawing course should have four objectives:

> 1. development of spatial visualization and analyzing abilities;
> 2. instruction in orthographic projection;
> 3. fundamental elements of conventions, standards, and dimensioning; and
> 4. acceptable standards of drafting techniques.

He referred to the 1953 ASEE *Report on Evaluation of Engineering Education* and noted that engineering drawing is the only study concerned primarily with the development of visual thinking and analysis. He referenced L. L. Thurstone's paper on *The Mechanics of Thinking* and used three of his space theory factors: (the first space factor which is the ability to imagine a solid object as it looks in a different direction, the second space factor which is the ability to imagine a three-dimensional configuration which has internal displacement among parts, and the third closure factor which is the ability to keep a configuration in mind, in spite of distracting surrounding detail) and how they relate to engineering drawing. He stated:

> Now it is evident that these three factors of visual thinking will be quite specifically affected by improvement in spatial, or three dimensional visualization. Thus our first, and most important objective in the basic courses should be to develop the student's ability to (a) visualize spatially, and (b) apply this process in analyzing problems of engineering design. The value of engineering drawing lies primarily in the degree of success it can claim in developing this latent and essential visualizing ability. And I believe it has been satisfactorily established that drawing can and does develop it. (p. 32-33)

He further stated, "I think that we may fairly conclude from these facts that engineering drawing is the salient factor in any significant increase in visualization ability among engineering students; that it can fulfill the requirements of our first objective, and in fulfilling these requirements becomes an essential subject for engineers." (p. 33) He concluded with, "The emphasis should be on spatial visualization, experience in creative thinking, and ability to convey ideas." (p. 34)

A short note from the editor, Irwin L. Wladaver, is also of interest, although no replies were published:

> One of the virtues attributed to descriptive geometry is that it develops in students the ability to visualize in three dimensions. We believe that this is correct, but correct only to the extent that visualization is taught deliberately and directly. In our opinion, the ability to visualize will not develop as an incidental by-product. Does anyone have any evidence either way? Professor Kliphardt deals with this matter to some extent in his current article. Do you agree with what he has to say? (p. 34)

The 1960's

During the 1960's engineering graphics educators seemed to forgot about spatial visualization research and its importance for the advancement of engineering students spatial abilities. The lack of research in spatial visualization coupled with a decline in spatial visualization curriculum development came at a time when many engineering graphics programs and departments were being eliminated. Engineering graphics educators curriculum focus during this period was on the implementation of design in engineering graphics classes. For almost a nine-year period from 1967 until 1976 not a single article or mention of spatial visualization research or curriculum was mentioned in any articles that appeared in the *Engineering Design Graphics Journal.*

A. S. Levens (1960) in *Graphic Science - A New and Challenging Frontier* briefly reviews the history of graphics in the engineering curriculum. He noted that emphasis in other content areas caused a decline in graphics requirements.

In 1963 Mary Blade wrote in an editorial for the *Journal of Engineering Graphics* stating that engineering graphics teachers must modernize their curricula to serve the students better. "It is this ability to visualize and perceive spatial concepts which particularly differentiates the engineering student and practitioner from others and is his special province in the creative solution of engineering problems." (p. 1)

In *A New Approach to Teaching Graphics*, Maurice Hamilton (1963) observed that students most often struggle visualizing three-dimension objects presented in two dimensions. He advocated isometric pictorials to help the students develop visualization abilities. In an limited study he used the *Minnesota Paper Board Test* to measure the students' visualization ability but discarded results because the test only measured two-dimension ability. He then designed his own test to measure three-dimensional thought by presenting two views of an object and having the student choose the third view. He found a significant difference in favor of the group who was presented isometric pictorials over those who received traditional instruction He concluded that isometric pictorials are more effective to teach visualization easier and faster.

Spatial visualization was frequently referenced in the *Journal of Engineering Graphics* summary of the *Engineering Graphics Course Content Development Study* (1965) supported by the National Science Foundation. The report noted, "Engineering graphics is one of three modes of expressing thought and manipulation of ideas and technical information. Graphics is used as an aid to visibility and as a memory-fixing device while ideas are being considered and refined." (p. 13) Two other references noted: " It is also important that the engineer should develop the ability to visualize - to form a mental image of vision." (p. 14) "Engineers who develop the ability to visualize geometrical and physical configurations and think in graphical images have a decided advantage in creating and instructing others in achieving actual production of design. There are numerous engineering problems that in many cases the graphical solution is much quicker, more vivid, and even more practical." (p. 14) The report concluded with an outline for engineering graphics course structure and faculty requirements. It stated, "The ability to think in terms of spatial relations, to express such thoughts graphically, and to grasp quickly the concepts of additional ideas is a vital need of the engineer." (p. 45)

In the report, *Comments on the Goals of Engineering Education*, the Engineering Graphics Division of ASEE responded to the document, *Goals of Engineering Education Report*. The response reaffirmed the division's support of engineering graphics courses, specifically the development of communication skills through descriptive geometry as well as three-dimensional spatial visualization ability. The paper pointed out many independent studies have determined the need for engineers to possess effective graphic communication skills in sketching, drawing, and three-dimensional visualization. The use of graphical methods allows many problems to be solved more easily than by other analytical methods.

A. S. Levens (1966) proposed a curricular approach emphasizing open-ended conceptual design projects to develop a "thought model" for students. Levens claimed that because design is a mental process, graphics is an integral portion and sketches should be used to record conceptual ideas. First, students must form a mental image of physical and geometrical configurations so curricula must help them develop effective visualization powers. He described the thought model as:

> ... consisting of tracing and describing related points, lines, planes, and surfaces, in the air, by use of the hands. The construction of imaginary figures is accomplished by verbal descriptions. The orthogonal representation of these figures is made on the blackboard. The two-dimensional representation, however, is made only after the student has the experience of "seeing" and "manipulating" the visualized three dimensional configuration. In this way it is possible to create geometric space relations which are so fully visualized that the students can come forward and add items, describe elements, analyze and solve problems — employing the imaginary figure. (p. 14)

Levens (1966) added, "With confidence in his ability to visualize a problem the student is then prepared to advance to ever more complex problems requiring visualization and employ graphic technique to problems not ordinarily thought to be susceptible to such methods." (p. 14) He showed data on a series of studies leading to his conclusion that the "thought model" helps students' visualize physical and geometrical configurations.

The Influx of Psychological Research and Other Theories

Spatial visualization research made a resurgence during the mid to later half of the 1970's. It should be noted that the first article to refer directly to spatial visualization was a reprint of a 1913 article written by Thomas E. French who advocated the importance of spatial abilities. This article was followed by a series of articles that were research based articles on the importance of spatial abilities for engineering students and how spatial ability advancement was a central focus of engineering graphics. The foundations of these articles were based on spatial

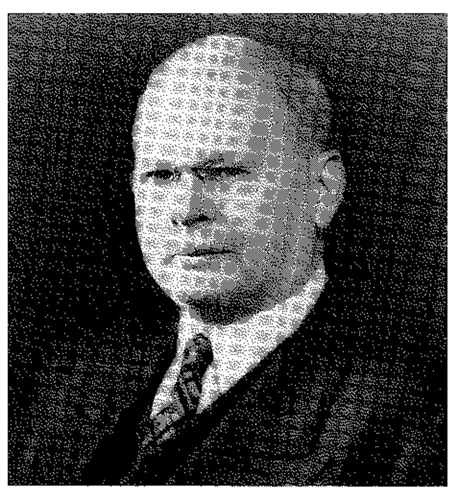

Figure 7
Thomas E. French

> Graphics is an integral part of design and design is the key element that differentiates the engineer from the scientist. Designs are visualized and presented graphically; thus an individual who has not developed a feeling for graphics cannot function effectively as an engineer. He or she must be able to visualize a problem in both two and three dimensions. (p. 21)

Figure 9 Jon M. Duff

Jon M. Duff (1979) in *Visual Perception: The Problem of Creating Virtual Space,* described the problem of the existence of three dimensions on two-dimensional surfaces and how this limits students and professionals from reaching their full potential as designers and engineers. He contended that virtual space is the core of engineering graphics and that the creation of virtual space cannot be different from the reading of virtual space. He explained that individuals fall into three different ability areas concerning their ability to create virtual space and that these different groups must be considered when designing engineering graphics instructional activities.

The Return of Spatial Visualization Research in Engineering Graphics

Although spatial visualization research had resumed with specific individuals who were engineering graphics educators in the mid to late 1970's a continued focus in the engineering graphics literature did not develop until the mid 1980's. Again a lapse of over five years did not allow engineering graphics to be able to continue to justify its importance in the engineering curricula as the single most important course for advancing spatial abilities. Except for one article in 1981 it was not until the mid to late 1980's that a renewed emphasis of research in spatial visualization and curriculum proposals that emphasized its importance appeared in the engineering graphics literature.

W. J. VanderWall (1981), in the article *Increasing Understanding and Visualization Abilities Using Three-Dimensional M*
described the inherent value of using
dimensional models as a learning tool f
dents. He contended that the benefits
models far outweigh the time involved
ducing them. He gave examples of how
models could be produced.

In the article, *Cognitive Processi*
the Teaching of Engineering Graphics,
Bowers (1986) presented left-brain
brain theories for use by engineering
ics instructors to teach drawing an
develop spatial visualization abilities
two-course graphics sequence at A
State University utilizes these theorie
focus of the first course - development
tial visualization - is on right-mode bra
cessing with exercises that use vario
ricular techniques, including com
graphics, to teach representational d
and develop visualization techniques.

The results of the descriptive surv
Impact of Computer Graphics on Instr
in Engineering Graphics were presen
Jon Jensen in 1986. In this article in
al and academic respondents ranked
teen items for their importance for eng
Both sets of respondents ranked spatia
alization as the most important ability
dent can develop to be a successful en
This survey was important from the
point that practicing engineers felt th
tial abilities were a essential skill for p
ing engineers.

S. E. Wiley (1989) noted in the
Advocating the Development of
Perception as a Dominant Goal of Tec
Graphics Curricula, that many visual
ula including engineering graphics ha
ited professional status because of a l
research base. This observation is con
by the engineering graphics professio
speak of visualization but do not have
research base to support these ideas.
contended that visual perception shou
cede other visual goals because it
them possible. He wrote that the eng
ing graphics profession should not limi
to the development of visual perc
through drawing exercises but start wi
models followed by photographs of the
views of an object, perspective pictorial
ings, 2-D mulitivew drawings, and
with the presentation of 3-D isometric
ings. He concluded that these step

Fi

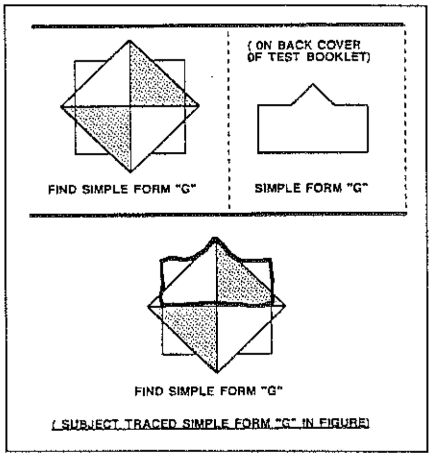

Figure 10 Sample of the *Group Embedded Figures Test*

enhance a students' development of visual perception.

In *Visualization in Graphics: Time for a Change?* James Shahan and Roland Jenison (1989) wrote that computer-based procedures should supplement traditional methods. Regarding the elimination of descriptive geometry, they noted it as a basic principle and "...cornerstone of all engineering programs." (p. 29) They stated that people who visualize can recognize a three-dimensional object and represent it appropriately for design and analysis. This ability is enhanced in the study of both traditional graphics (descriptive geometry and orthographic projection theory) and computer graphics. (p. 29)

G. R. Bertoline and D. C. Miller (1990) in *A Visualization and Orthographic Drawing Test Using the Macintosh Computer*, wrote about a test that both evaluates and helps students to develop spatial visualization abilities. They noted that visualization is developed in various stages as individuals mature, and that this ability is of vital importance for many unrelated areas including engineering, and that it varies from individual to individual. They distributed this test for future research studies in spatial visualization for engineering graphics educators.

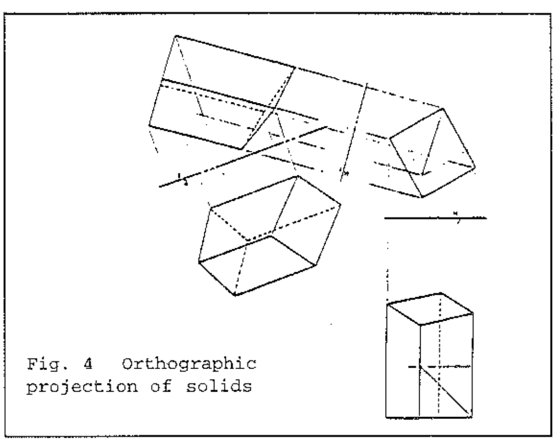

Figure 11 Visualization in Graphics

In the article, *Computer Graphics and the Development of Visual Perception in Engineering Graphics Curricula*, S. E. Wiley (1990) presented two curriculum models to develop visual perception. In the mechanically-orientated visual perception model, he contended that curriculum should be structured sequentially:

1. real objects
2. photographs
3. linear oblique perspectives
4. 3-D isometrics
5. Goss boxes
6. 2-D orthographics
7. 3-D axonometrics

Exercises would start with simple to complex problems and progress from realistic to abstract back to realistic problems. He contended that without the progression from real objects to abstract line representations many students would not be able to advance their spatial abilities.

Wiley further contended that with the computer-graphics orientated visual perception curricular model, exercises would start with simple to complex problems and progress from realistic to abstract back to realistic problems using computer graphics and real models. Sequence for the computer centered curriculum would be:

1. real objects
2. scanned objects
3. 3-D color animations
4. static wire-frame models
5. 3-D isometrics
6. 2-D orthographics, and 3-D axonometrics.

He concluded that 3-D solid models and animation, if affordable, could possibility help develop visual perception abilities (1990).

In *An Hierarchy of Visual Learning*, Wiley (1990) proposed that meanings of visualization need to be clarified. He presented a model of visual learning including visualization. He observed three primary stages to visual learning–cognition, production, and resolve–that can be divided further into hierarchical stages. Wiley concluded that study of this model would resolve much of the confusion about visualization which would allow engineering graphics educators to develop and implement their curricular models that would emphasize spatial visualization as a central theme.

W. Rodriguéz (1990) in the article *A Dual Approach to Engineering Design Visualization* presented a freshman engineering graphics course that stressed design visualization and documentation concepts as a dual approach. In this course traditional and computer graphics concepts followed complementary paths that merged into an integrated design visualization/documentation phase. Rodriguéz explained course objectives, description, administration, and advantages and encouraged its implementation.

W. J. VanderWall (1991) gave the results of a study that incorporated the use of video tape presentations of the concepts of engineering graphics. The experimental group was exposed to the video tapes while the control group was not. One of the hypothesis of the study compared exposure of the video tapes with visualization proficiency as measured by a orthographic readings test. The author determined that exposure to the video tapes of basic engineering graphics concepts did not have a statistically significant difference than the regular engineering graphics curriculum for students visualization proficiency.

In the 1991 article *Static vs. Dynamic Visuals in Computer-Assisted Instruction,* P. J. McCuistion reported the results of a study that compared two methods of presenting graphic images (statistic or dynamic) which could enhance student achievement and spatial abilities. He reported that the objectives of the study were to ascertain if a series of static or dynamic visuals would allow students to achieve higher performance test scores and / or higher mental rotation test scores. McCuistion reported that the students who viewed the statistic presentations achieved slightly higher scores on performance tests while students who viewed the dynamic presentations made larger gains on the mental rotations tests. He concluded that dynamic visual presentations should be implemented to advance the spatial abilities of students and that more research in this area should be undertaken.

C. L. Miller and G. R. Bertoline (1991) wrote an article entitled *Spatial Visualization Research and Theories: Their Importance in the Development of an Engineering and Technical Design Graphics Curriculum Model,* in which they contended that engineering graphics educators must go beyond traditional curriculum research and base future studies on existing research in psychology, art, mathematics, and other disciplines. They reviewed existing research and how it could be used for the development of spatial visualization research in engineering graphics. They contended that without a sound research base any claims made by engineering graphics educators could not be defended and would not be accepted.

In the Spring 1992 edition of the *Engineering Design Graphics Journal* J. A. Leach wrote the article *Utilization of Solid Modeling in Engineering Graphics Courses.* In this article he contended that engineering graphics should be considered as a body of knowledge and that spatial visualization should be one of the major components of this body of knowledge. He also contended that solid modeling brings a new capacity to engineering graphics education that enhances the capability of spatial ability advancement. He outlined a strategy implementing solid modeling into the engineering graphics curriculum. He added that the use of solid modeling to advance spatial abilities is distinctly different than the ability to create or read a conventional engineering drawing.

E. N. Weibe (1992) in the article *Scientific Visualization: An Experimental Introductory Graphics Course for Science and Engineering Students* described a course that was being developed that explored a broader role of graphics in science and technology. The foundation and the central focus of this course was scientific visualization and it guided

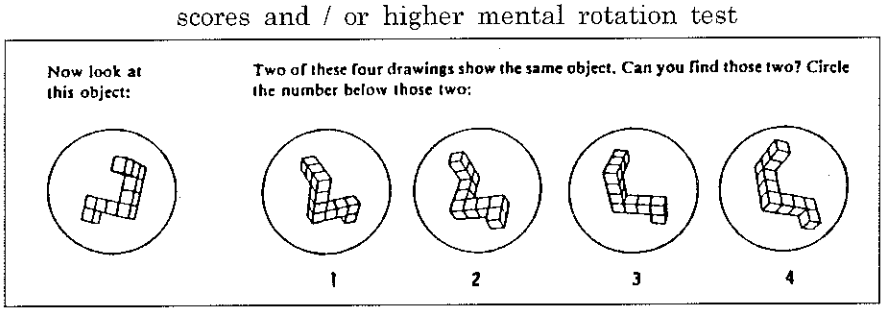

Figure 12 Sample question from *Mental Rotation Test*

the development and implementation of the it. Weibe described the strategy of the course, its organization, the role of hardware and software and its content. He conclusions and contention were that visualization is an important portion of a course similar to his or to any engineering graphics course.

C. L. Miller in the 1992 article *Enhancing the Spatial Abilities of Freshman Engineering Graphics Through the Use of Real and Computer-aided Models* described a research study that involved the use of real and computer-generated models. This study investigated the use of real and computer-generated models and the learning styles of visual and haptic, to determine if an interaction of instructional treatment and learning style advanced the spatial abilities of engineering students. The researcher concluded that supplementing traditional engineering graphics instruction with real and computer-generated models allows students to further advance their spatial abilities as compared to traditional engineering graphics instruction.

In the article *Effect on Spatial Visualization: Introducing Basic Engineering Graphic Concepts Using 3D CAD Technology* T. J. Sexton explained his study which involved the use of 3D wireframe modeling capability in fostering spatial visualization abilities while introducing basic projection theory. This study compared the use of traditional instructional methods of projection with 3D wireframe model approach of teaching basic engineering graphics concepts and advancing spatial abilities. Spatial visualization ability was measured by the mental rotations test (MRT). Sexton concluded that the new 3D CAD approach did not prove to be more effective in increasing the visualization ability of students over the traditional methods but he also concluded that the 3D CAD method was as effective as the traditional approach.

In a 1993 article titled *Visualization of Three-Dimensional Form: A Discussion of Theoretical Models of Internal Representation*, E. N. Wiebe (1993) discussed a number of theoretical models that explain the process of three-dimensional forms. He summarized and compared these models and explained the appropriateness of dynamic and static imaging techniques that can be used to advance a students visualization abilities. He recommended further experimentation into the use of dynamic and statistic imaging techniques to determine which might support a learning environment that would allow for the advancement of spatial visualization abilities.

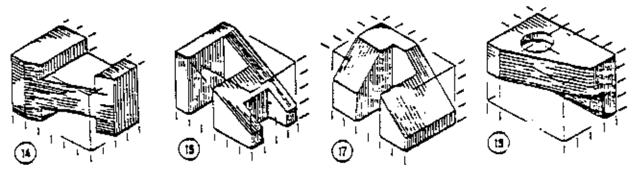

Figure 5. Week three problems.

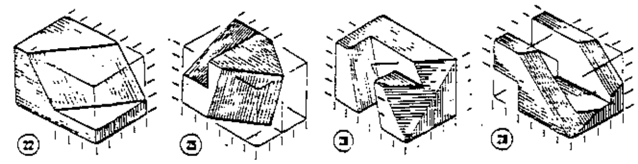

Figure 6. Week four problems.

Figure 13 Sample Problems from Miller's Study

W. A. Ross and S. Aukstakalnis (1993) in the article *Virtual Reality: Implications for Research in Engineering Graphics* gave an overview of virtual reality systems and suggested that virtual reality could be a future key for the advancement of students visualization abilities. The authors also gave various scenarios on how virtual reality could be incorporated into the engineering graphics curriculum.

In the 1993 paper *A Structure and Rationale for Engineering Geometric Modeling* by G. R. Bertoline the author proposed an engineering graphics curriculum model that was based on the categorization of human knowledge. The author also presented several models that further defined a basis for the the engineering graphics curriculum. Of central importance was the needs of the learner and the importance of visualization abilities for learners.

In the 1993 article, *Trends and Techniques in Imaging Science*, D. Bowers presented a curriculum model for imaging science. The three main areas of the model are applications, subject matter, and learned capabilities. The author further broke down each of these three areas. Bowers contended that visualization is one of the most important areas under learned capabilities. He also proposed that the importance of visualization and how many textbooks and problems do not help students to advance their visualization abilities. He contended that visualization is an integrative, holistic learned capability that is best advanced by non-analytic graphics procedures. This is especially true with beginning students or with students with poorly developed spatial abilities.

R. Devon, et al. (1994) in the article *The Effect of Solid Modeling Software on 3D Visualization* described a study that measured the effect of a solid modeling curriculum on the development of 3D visualization skills in freshman engineering students. In this study wireframe CAD was compared with solid modeling CAD to determine if one was better at advancing students 3D visualization abilities as measured by the mental rotations test (MRT). They concluded that exposure to a solid modeling curriculum did advance students spatial abilities more so than the exposure of wireframe modeling.

In the 1994 article, *Visual Perception, Spatial Visualization and Engineering Drawing*, J. Roorda examined the process of visual thinking, imagining, and engineering drawing with psychological studies in visual perception. He gave thoughts on the "mechanics" of transforming mental images and how these relate to the interpretation, understanding, and preparation of engineering drawings. The key points of this paper were placed into an engineering graphics context through the use of students drawing interpretation as shown through freehand sketches.

W. Rodriguéz (1995), in the article *Principles of Design and Communication* contended that principles guide successful design. He proceeded to expand upon the different processes and principles that influence successful design implementation. He stated that visualization is equal to perception plus imagination plus communication. Thus, he observed that visualization abilities are of major importance and actually lead design communication. He gave a working example of a successful design and a historical overview of graphics and the importance of visualization to graphics.

In the results of a 1995 research study titled *The Relationship of Previous Experiences to Spatial Visualization Ability* J. A. Deno determined that non-academic activities has the most positive significant relationship to spatial visualization ability of men, but not women. In this study, Deno attempted to determine if background experiences discriminated among subjects on spatial visualization ability. A significant sex-related difference between male and female subjects was also found on the mental rotations test (MRT). The author recommended further research into background experiences to determine if other factors may be involved.

Conclusions

In conclusion, claims that the inclusion of visualization exercises and research in the engineering graphics curriculum is a recent trend must not be taken seriously. Visualization research in engineering graphics was a cornerstone for the development of the Engineering Design Graphics Division. It is suggested that any researcher who intends to pursue research in visualization within the context of engineering graphics must be familiar with the research already completed and conclusions that have been already reached. Without this information, one may be "reinventing the wheel" in visualization research in engineering graphics. Further, visualization research is instrumental for the survival of current engineering graphics programs and courses. Without a sustained effort in spatial visualization research it will be difficult to justify the existence of engineering graphics programs and possibly engineering graphics courses. Spatial visualization abilities are a key factor in the development of successful engineers, and engineering graphics curricula must continue to be the cornerstone for the advancement of spatial visualization abilities.

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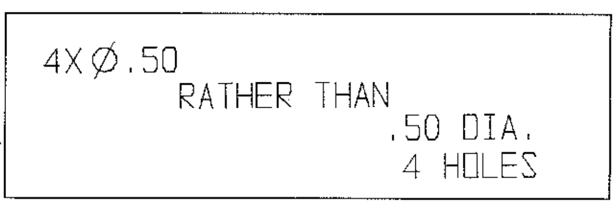
STANDARDS CORNER

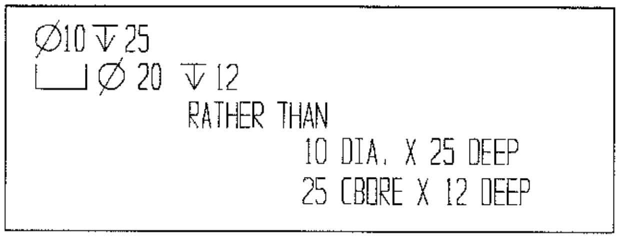
Fritz Meyers

This is the first column in a series planned for our readers to keep them posted on changes in standards which govern engineering documentation. The primary document affecting dimensioning is ANSI Y14.5M-1994 We lived under the 1982 version of this document until last year. Many years of work and discussion are represented in the 1994 version. Pat McCuistion, an active member of EDGD, is a member of this committee and several of its sub-committees.

The changes are not major from the standpoint of graphics instruction, however they do demonstrate a steady movement of the United States toward international standards. The opening General section includes the statement, "The International System of Units (SI) is featured in this Standard because SI units are expected to supersede United States (U.S.) customary units specified on engineering drawings." English words in dimensions are limited: features such as counterbores, countersinks, and multiple features are given with symbols and numerical values. An example is shown below:

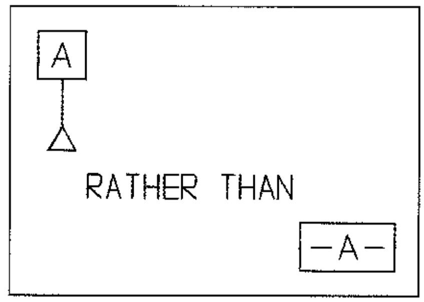


Another example is demonstrated in dimensioning counterbores:



Many progressive instructors and practicing engineers have been using the symbolic notation for years. It appears we should all move in this direction. Recently I visited a large, well-known manufacturer and found that they are still using aligned dimensions on their CAD drawings. If we teach our students the current standards they can help move industry forward.

Geometric dimensioning and tolerancing occupies most of the pages of Y14.5M and it was in this area that much of the time was spent in revision. For basic courses in graphics the impact is minimal; for in-depth courses there are significant changes. These will be covered in later columns. The most obvious change for beginning GD&T is the datums symbol. The new symbol is:



The "S" for Regardless of Feature Size has been eliminated from the feature control frame. Principal changes in the standard are noted in Appendix A, included in the volume with the standard. Another major change in this edition is the addition of a new volume, Y14.5.1M-1994, Mathematical Definition of Dimensioing and Tolerancing Principles. This provides a mathematical basis for the tolerancing practices.

Please call or E-mail us with comments, recommendations, or questions about standards affecting engineering design graphics.

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EDG DIVISION NEWS AND NOTES

CHAIR'S MESSAGE GARY R. BERTOLINE

What we cut out to put these new things in is probably why we're having problems.

Tim Sexton
Ohio University
52nd Annual EDGD MidYear Meeting

I just completed reading the latest issue of Computer Graphics World which featured articles about surface modeling and designing large assemblies. Halfway through the articles, I realized very few engineering design graphics programs include instruction in surface modeling or 3D assemblies. Yet, the articles were expounding the use of them in engineering design.

Many engineering design graphics courses do not mention surface modeling, let alone 3D modeling of assemblies. Let's face it, we all spend an inordinate amount of time on very traditional topics, such as reading scales, ASME standards, auxiliary views and so forth. We also realize we are forced to teach *All there is to know about graphics, but were afraid to ask* in a two or three hour semester course. This is a totally unreasonable task, bound to have any instructor confused and frustrated as to what to keep and what to throw out of the course. I believe there is a special place in heaven for all the graphics instructors who have survived the last 25 years in engineering education. Given the monumental task of teaching engineering students all there is to know about geometry, projection theory, standards, and tools, then throwing on top of that the fact that many students are nearly visually illiterate, it's a wonder we have not all given up.

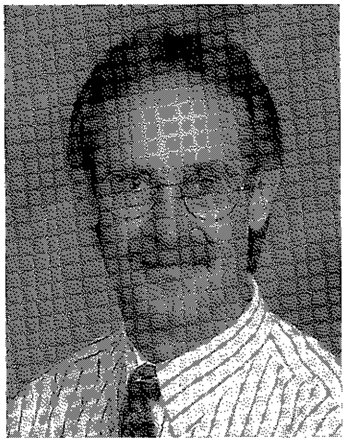
The fact is we, as a group of dedicated professionals, believe what we do is of great value to practicing engineers in spite of what ABET and some engineering deans and faculty might think. The truth is design engineers are better at what they do if they know geometry and how to use it, have a high degree of visualization ability, and understand how to use the computer hardware and software necessary to create elegant, cost effective, and safe designs. It is time we stand up as a profession and express our displeasure with the treatment graphics has been given in the last quarter century.

However, before we do that, we must get our own house in order. Quite frankly, some of the criticism and displeasure leveled against our profession is warranted. Time spent in your classroom teaching every nuance of dimensioning standards is time that could be spent teaching geometry and how it is produced with CAD. Twenty years from now, when your engineering students are in mid-career as engineers, they will need knowledge of geometry more than they will need 20-year-old standards. The challenge facing the Division today is to create a model graphics curriculum that has relevance to us, our discipline of engineering, and, more importantly, to our students.

Gary R. Bertoline
Chair, EDGD

edgd Officer Candidate Slate 1997

Vice-Chair



James A. Leach

Jim is an assistant professor at the University of Louisville Speed Scientific School and Director of the Authorized AutoCAD Training Center. He holds a Bachelor of Industrial Design and Master of Education from Auburn University. Before teaching at the University of Louisville, Jim worked as an industrial designer in Atlanta, Georgia for 3 years and then taught engineering graphics for 13 years at Auburn University. As coordinator of Engineering Graphics at Auburn University, Jim is credited with developing the CAD labs and courses. As an ASEE/EDGD member since 1984, he has served as Director of Liaison Committees, member of the *EDG Journal* Board of Review, and two terms as Secretary/Treasurer. Jim authored the *AutoCAD Instructor* and *AutoCAD Companion* textbook series from Irwin Publishers. Other professional activities include several presentations, journal articles and workbooks.

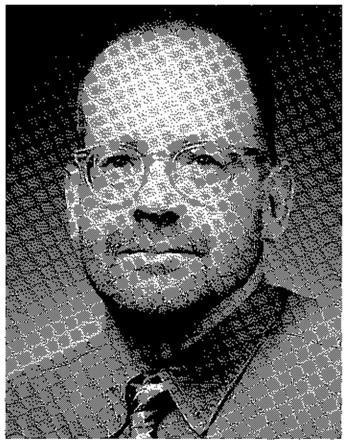
Mary A. Sadowski

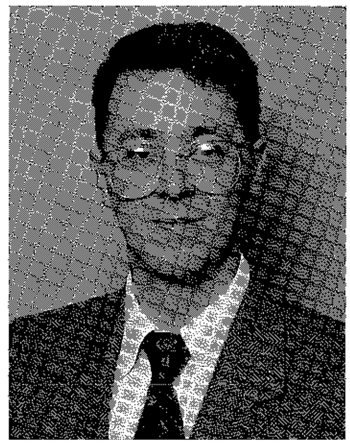
Mary Sadowski is a Professor of Technical Graphics in the School of Technology at Purdue's main campus in West Lafayette, Indiana. She received her B.S. at Bowling Green State University in Ohio, her M.A. from The Ohio State University, and her Ph.D. from Purdue University. At Purdue, her activities include teaching graphics, animation, electronic publishing, Web design and development, and color illustration. She was actively involved in the development of the Purdue Technical Graphics baccalaureate program and designed several of the new courses needed to implement the program.

Mary has been an active presenter in the Engineering Design Graphics Division and NSPI (National Society for Performance and Instruction) conferences for the past 11 years. She has written and presented especially in the area of creative thinking, design layout, and publishing. She recently presented a paper at the 7th International Conference on Engineering Computer Graphics and Descriptive Geometry in Krakow, Poland.

Mary is currently serving her second term as Director of Publications for the EDG Division and has therefore been editor of The *Engineering Design Graphics Journal* for the past five and a half years.

Secretary-Treasurer





Jim Shahan

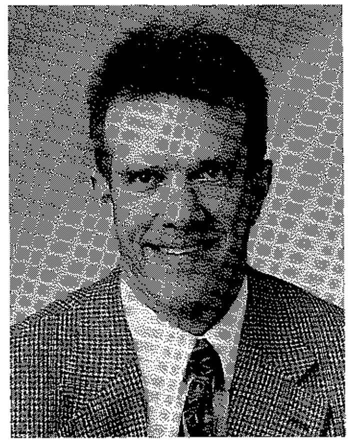
Jim is an Assistant Professor of Agricultural and Biosystems Engineering at Iowa State University. He has been teaching at ISU for twelve years, recently teaching Engineering Graphics, Structural Engineer-ing, and computer programming (C / UNIX). Previous experience includes work as a Contractor, Farm Automation Manager, and Product Engineer.

Jim has been a member of ASEE/EDGD since 1984. He was program co-chair for the EDGD 1995-1996 50th MidYear Meeting in Ames Iowa, and is currently the Treasurer of the National Design Graphics Competition. Current academic interests include rendering and animation of geometric models, and custom applications of CAD programs (AutoCAD and SilverScreen) utilizing: Custom menus, command scripts, slide shows, LISP, and C programming. Jim received his B.S. (1979) and M.S. (1985) degrees in Agricultural Engineering from Iowa State University and is a licensed Agricultural Engineer.

Eric Wiebe

Eric N. Wiebe has been a Lecturer in the Graphic Communications Program at North Carolina State University for the past eight years. He received his M.A. in Industrial Design at North Carolina State in 1987. His graduate work in Industrial Design focused on the role of computer graphics and CAD in the design process. After completing his Masters, Mr. Wiebe helped develop a photorealistic rendering and modeling system for architectural and design professionals and worked as a private consultant.Since joining the faculty at NC State, Eric has been actively involved in the ASEE-EDGD and curriculum development issues, including the development of a 3-D solids modeling course. He has attended and presented papers at every EDGD Mid-Year Meeting since joining in 1989. For the past two years, he has been interim Director of Professional and Technical Committees for the EDGD and on the board of review for the *EDG Journal*. He instituted and manages the et-graphics listserve and was co-chair of the 51st Annual EDGD MidYear Meeting. .Eric is author or co-author of four textbooks on technical graphics and numerous research articles. He is currently working as a consultant to the furniture industry on the use of CAD/CAM tools in manufacturing and design. Eric is also a member of ADDA and the Human Factors and Ergonomics Society.

Director of Publications



Judy A. Birchman

Judy Birchman is an Associate Professor inthe Department of Technical Graphics at Purdue University. She is a graduate of Purdue University with a Masters Degree in Interior Design. Before joining the Department of Technical Graphics, she worked as a kitchen designer and an architectural illustrator.

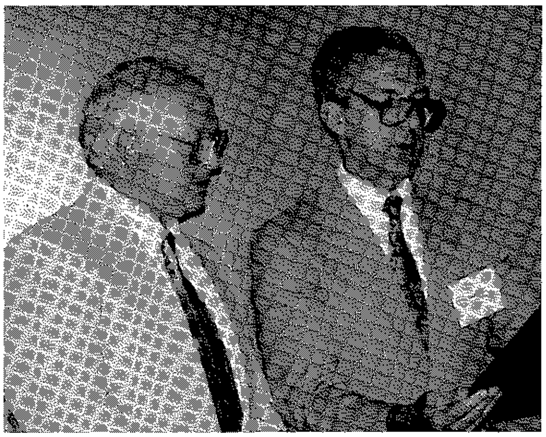
A member of the Technical Graphics Department since 1974, she has taught courses in drafting fundamentals, perspective drawing, computer-aided drafting and desktop publishing and design. Professor Birchman has a strong interest in course development and design and has developed course manuals for several TG courses as well as co-authoring and producing three CAD workbooks for different grade levels. Professional activities include presentations and workshops on both design and CAD topics.

Judy is the Technical Editor of the *Engineering Design Graphics Journal*. She supervises the paper review process for the *Journal* and the EDG papers for the ASEE Annual Conference Proceedings. Other activities for the division include designing the network Home Pages for the *EDG Journal* and the EDG Division.

Currently, her interests are multimedia and interactive authoring systems as well as alternate publishing outlets including the World Wide Web and CD-based publishing.

Craig L. Miller

Craig L. Miller is an associate professor in the Department of Technical Graphics at Purdue University. He received his Bachelor of Science and Master of Education from Bowling Green State University and his doctorate from The Ohio State University. Dr. Miller is very active in American Society for Engineering Education (ASEE)-Engineering Design Graphics Division(EDGD), having served on various committees and serving for the last three years as the advertising manager for the *Engineering Design Graphics Journal*. Craig has been honored with the Frank Oppenheimer Award for the best paper at the EDGD Mid-Year Meeting in 1991. Craig has presented over twenty papers at professional conferences in North America and Australia. He is a co-author for the Richard D. Irwin Graphics Series, and has authored papers in journals on engineering and technical graphics, CADD, and visualization research.



Engineering Design Graphics Division

1996 Distinguished Service Award

Presented to **Roland D. Jenison**

ASEE Annual Conference
June 25, 1996
Washington D. C.

Prepared by A. R. Eide
Presented by John Barry Crittenden

The Engineering Design Graphics Division of ASEE is extremely pleased to present this year's Distinguished Service Award to Roland D. Jenison. Rollie is a Professor of Engineering Fundamentals and Multidisciplinary Design at Iowa State University.

Rollie was born and raised on a farm in north-central Iowa. Contrary to the opinion o many, he did graduate from Belmond High School primarily due to the efforts of the baseball coach changing grades to maintain his eligibility. He elected to attend Iowa State due to it outstanding athletic reputation, and enrolled in engineering. He graduated in 1961 with a B. S. in Aerospace Engineering.

Rollie began his teaching career almost immediately after graduation as an instructor in Industrial Engineering and later the College of Engineering Technical Institute. He started teaching and simultaneously worked on his M. S. in Aerospace completing that program in 1965.

In 1972, Rollie was recruited by the Kansas Technical Institute to be head of the Mechanical Technology Department, but returned to Iowa State in 1975 as a faculty member in the new and recently created Department of Freshman Engineering. Rollie became a prominent and central figure in that department providing leadership in a variety of areas, including orientation, advising, and the development of lower-division courseware. He was also instrumental in the integration of computers into lower-division activities.

The department name was changed in 1989 from Freshman Engineering to Engineering Fundamentals and Multidisciplinary Design and Rollie continued to provide leadership, by being selected as Interim Chair from 1989-91.

Although Rollie has demonstrated a wide range of significant accomplishments, one of his most important contributions has been classroom teaching. He is well recognized as one of the college's "top" teachers. This statement can be easily documented by a partial list of his teaching awards.They include:

The Department Instructor of the Year Award,
The Superior Engineering Teacher Award from the College of Engineering,
The ISU Foundation Outstanding Teaching Award, and
The Excellence-Teaching-Award from the Iowa State Legislature.

Rollie has also served the Division in many important ways. He has written six articles that appeared in the *Engineering Design Graphics Journal,* 11 articles that have appeared as proceeding, and he has given 24 presentation at national meetings that applied to aspects of the Division. Rollie has served as chair of several Division Committees, Director of Programs, reviewer for the *Journal,* chair of the United States Organizing Committee for the Sixth International Conference on Engineering Computer Graphics and Descriptive Geometry, Vice-Chair and Chair of the division, and most recently, coordinator for the EDG Division's 50th Anniversary MidYear Meeting at Iowa State University.

As of July 1, 1996, Rollie will be the Iowa State University College of Engineering Synthesis Coalition Primary Investigator and a Professor of Aerospace Engineering and Engineering Mechanics.

It is with extreme pleasure that I present to the Division membership the 1996 recipient of the prestigious Distinguished Service Award, Rollie Jenison.

1996 Distinguished Service Award

Acceptance by **Roland D. Jenison**

Thank you, members of the Engineering Design Graphics Division, for the prestigious honor and special recognition. Thanks to the nominating committee for selecting me to be added to a distinguished list of 46 outstanding individuals who are a part of the best organization within ASEE and all of engineering education. Thanks to you Barry, for your introduction and kind remarks on my career accomplishments.

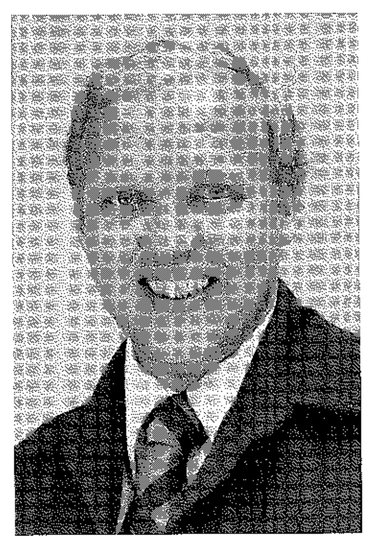
I didn't know how long this response should by so I dug out the *Journals* with the responses of some recent honorees. I found out that Garland Hilliard had 1173 words in his. Mine has about the same. I was not able to attend the banquet when the award was given to Garland in Edmonton. However, given our respective talking rates, I should finish in about half the time Garland used.

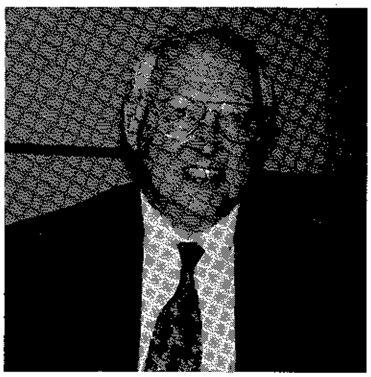
I stand before you tonight a very fortunate, grateful, and humble individual. I am fortunate to have been born to wonderful parents, raised in a family environment, and encouraged and supported in achieving a college education. I am fortunate to have a wife, Phyllis, for 36 years who worked to support my education, has provide continuous love through good times and less than the best of times, and unfailing encouragement for all the goals I have set. It was not possible for Phyllis to be here tonight, but she sends her greetings to each of you. We are fortunate to have two wonderful children who have now established their own lives and provided four grandchildren for Phyllis and I to spoil. Grandchild number five is a few months away.

I have been fortunate in having colleagues who share common goals, face and conquer similar problems, and provide the mentoring that has enabled me to achieve a measure of success in engineering education. Yogi Berra, that oft-quoted philosopher, is reported to have advised one to, "When you come to a fork in the road, take it." At each major career decision point, I have been fortunate to take the appropriate fork in the road leading me to greater challenges and corresponding rewards for accepting the challenges.

As an example of my good fortune in selecting the correct fork in the road, I would like to relate to you how I first got into teaching. As a baccalaureate aerospace engineering graduate in 1961, with a working wife and baby daughter, and with three offers to work on the west coast, it appeared there was just on fork in the road open to us, the west fork. Then on one of the last days of my senior year, a professor asked me over coffee if I had thought abut graduate school which in the post-Sputnik era, was becoming a stronger consideration for graduating seniors plus promising additional monetary benefits. "How do I support my family?" I asked, since I had not applied for any type of aid. "I heard the Industrial Engineering Department was looking for teachers for the freshman engineering problems course." A few days later, I accepted a full-time nine-month position for $5,000, teaching engineering problem solving and slide rule and entered graduate school. (By the way, the money was considerably less than any of the offers to work in the aerospace industry). I had chosen the teaching fork in the road and have never looked back. I cannot explain why this choice seemed to be the best, but I was very excited. I know many of you can cite similar forks which have guided your career.

I moved from the freshman engineering problem solving course to the two year engineering technology program in





1963. This gave me an opportunity to teach mathematics, engineering mechanics, graphics, and design. The teaching of design gives one the correct perspective on the purpose for all other courses in a technical curriculum. Design brings out creative abilities, appreciation for the engineering team, and motivation for study in almost any area. It is too bad that all design, including capstone, cannot be taught first, but I guess that is like being able to live our retirement years first so we can be young and frisky with all that money. In 1972, I joined ASEE, another wise choice of forks in the road.

In 1975, I took another fork and returned to Iowa State to work in Freshman Engineering for Arv Eide. This fortunate choice brought me back to four year engineering education and my first contacts in EDGD and all you great educators and friends who have indeed enriched my career much more than I can ever hope to repay. My attendance at these meetings germinated new ideas for topics and teaching methods from you and other members of EDGD. Having the opportunity to make presentations at our meeting and publish articles in the *Journal* was instrumental in my promotion as professor. The combination of support from Iowa State and EDGD was a synergistic combination for which I will be eternally grateful. Although I cannot possibly name all of the persons who have helped me along the way, I take this opportunity to thank each and every one for their support.

I have been know to listen to a country western song or two during my working and leisure hours. A current top-30 song has words that go something like this, "the only thing that stays the same is, everything changes". Although this line may not be etched in history like, "if the phone don't ring, you'll know it's me", it does state a message that has impacted us tremendously in engineering design graphics.

In the past 20 years, as a member of this great division, I have observed and been a part of many changes.

- ❖ Engineering Graphics, as credits in an engineering program, has been cut more than half, in some cases to zero with graphics integrated into other courses.
- ❖ The set of pencils with a wide range of lead types, is now a keyboard and a mouse.
- ❖ The engineering drawing is now an electronic grouping of bytes.

Is change the only constant?

- ❖ We don't write letters anymore, we exchange email.
- ❖ We used to discuss problems and debate teaching techniques with our university colleagues over coffee, now we also do this with colleagues in Austria, Japan, and Australia as well as those in the USA through email without the coffee.
- ❖ We used to spend hours in the library researching areas of interest, now in minutes we access on the Web more information than we can ever hope to digest.

Is change the only constant?

- ❖ We still meet as a Division once a year at our MidYear Meeting.
- ❖ We still meet as a Division once a year at the Annual ASEE Meeting.
- ❖ We still develop graphics lesson plans and teach to the best of our ability.
- ❖ We still mentor younger faculty as they teach us how to survive in this information revolution!

Does this mean we are out of synch with everyone also because we are not changing?

Not by any means! Because of the constancy of the purpose of this Division, the caring and dedicated membership, and the continuing fellowship at our national meetings, we are a stabilizer for young educators and a catalyst for continued education reform in engineering design graphics. This why I am very proud to stand before this group and accept this honor on behalf of all of you have taken the graphics education fork in the road. I continue to stand ready to serve this Division in any way possible.

Thank you very much.

Rollie Jennison

Plan to attend

1997 CIEC

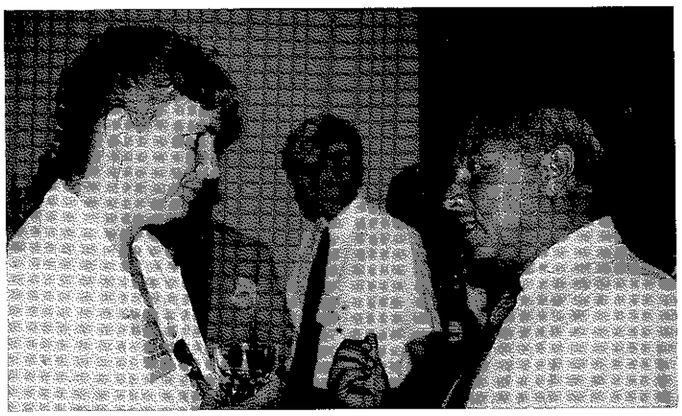
ASEE

Conference for Industry and Education Collaboration

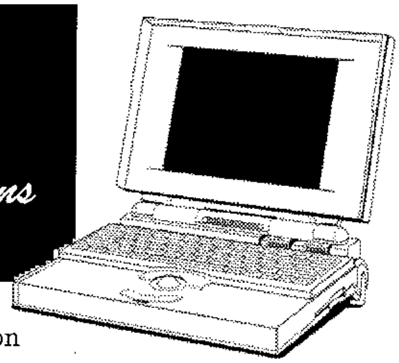
January 27-31

Tampa, Florida

for information contact:
Ken Gowdy (913) 532-5590
http://www.engg.ksu.edu/CPDD/97ciec.html



Hands-On CADKEY
A Guide to Versions 5, 6, and 7



Author: Timothy J. Sexton
Publisher: Irwin
Date: 1995
ISBN: 0-256-17141-6

Reviewed by Nathan Hartman
Purdue University

Companies are constantly looking for ways to keep their workers competent and up-to-date. This task is becoming increasingly difficult due to the number of new software packages released each year, as well as the revisions to existing software. Training and continuing education has never been more important. But with shrinking budgets and time constraints, where do companies find adequate help in this area? Instructors at today's technical colleges and universities are also caught in a similar dilemma. They face a growing student population with depleted funding and *old* technology. In many courses they are torn between teaching the necessary technology which gives students the working tools to feel comfortable, and teaching the body of the academic subject matter. What do they do?

In the field of engineering design graphics, the previous scenarios are not uncommon. Instructors and employers need solutions that keep their students and employees competent in the latest techniques. *Hands-On CADKEY* by Timothy Sexton can help with this problem. The book is well written in language that is easy to understand even for the beginning user. I must admit that prior to this review, I had never used CADKEY. I was familiar with several other CAD packages, so most of the techniques used by CADKEY were not foreign. As with any CAD package, the language that each uses to describe its own commands is often quite unique. Sexton states that the book is intended to address two audiences: students enrolled in courses that use CADKEY as the primary software, and individuals with a background in engineering graphics who are trying to learn CADKEY on their own. I happen to fall into the second category, and I must say that I am quite impressed with the book.

The book is divided into eight sections with an appendix of commands and an index at the end. This type of book organization is compatible with an appropriate teaching sequence for CADKEY. The first section begins by giving an overview of who should use this book and why, and then goes on to cover the basic layout of the book and how it should be used. One of the many good things about the book is that it provides meaningful tutorials for each chapter. The chapters are divided into the content material and the tutorial. The content portion contains a focus, outline of commands used, and a list of topics. This is followed by the tutorial section of the chapter which includes a focus, rationale, objectives, and the step-by-step instructions to accomplish the task. Many of these tutorial files are contained on a floppy disk that comes with the book. Each chapter is also accompanied by numerous illustrations and screen captures from the software. This is an invaluable feature, because it is important for the student to see an example of what it is they are doing. Sexton also does a good job of covering multiple releases of CADKEY. Realizing that not all users upgrade on schedule, *Hands-On CADKEY* covers releases five, six, and seven in an organized and easy-to-follow manner.

Section Two of the book deals with several of the basics of the CAD software: the basic drawing environment, file types, environment manipulation, and printing and plotting. These topics are covered thoroughly in an attempt to make the beginning user more comfortable in a potentially uncomfortable situation. Accompanying illustrations are plentiful, and the tutorials are appropriate. Section Three covers a staple of any CAD package, and that is basic geometric construction. With each CAD package having its own quirks about how geometry is constructed, Sexton does a nice job of exploring all of the options a user has in CADKEY. Illustrations of each command are placed adjacent to the examples avoiding the need to turn pages several times to find the examples.

Once geometry is created it is sure to be edited, and that is the focus of Section Four. This section thoroughly covers translating, moving, copying, and scaling which seem to be the most common of the editing commands. The tutorials that Sexton provides here and elsewhere focus on the most commonly used options within these commands. Section Five covers topics that occur once the geometry has been constructed and edited. These include adding and editing text, dimensioning, and 2D sectioning. At the end of most of the chapters is an illustrated chart showing the construction and editing commands covered, as well as illustrated examples of each command. For schools and companies that focus on the creation of 2D drawings, these topics and the proficiency thereof are essential. Sections Two through Five cover the basic parts of CADKEY, while final three sections cover advanced commands and techniques.

Three-dimensional modeling is introduced in section Six. *Hands-On CADKEY* does an excellent job of introducing and explaining the advanced drawing environment in CADKEY. User-defined views, multiple viewports, coordinate systems, as well as wireframe modeling and the definition of new views and construction planes are all covered here. Knowledge of the definition of new views and construction planes are essential topics for the construction of accurate 3D models. In Section Seven, multiview drawings are introduced, and coverage of how they are generated from 3D models in CADKEY is given. This is important, as we see the shift of engineering design graphics from pure 2D construction to the extraction of data from the 3D database. Section Seven also covers how to *clean up* the views once they have been extracted from the model, since this rarely happens according to standard practices. Finally, Section Eight explores the subjects that are considered advanced command sequences in CADKEY. Conics, surfacing and meshing techniques, analysis, file formats, rendering, and advanced drafting techniques are covered. Knowledge of these commands can make the life of the advanced user considerably easier. These commands enable efficiency, better visualization, and ease of communication between several parties and are a must in today's fast-paced engineering design environments.

If CADKEY is the software of choice for an engineering graphics class, then I think that *Hands-On CADKEY* would be an excellent choice for an accompanying text. I also think that it would serve as an excellent reference or training material for professionals in the workplace. The book is written in a manner which is not intimidating to a new user, and it provides plenty of practice and help on the journey through the software. Having used several different CAD software packages, I can think of numerous occasions when I wished for a book like this, and for CADKEY, Timothy Sexton has given us one.

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

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

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

COMPUGRAPHICS '96
Fifth International Conference on
Computational Graphics and Visualization
Techniques
December 15-19, 1996
Nogentel Nogent-sur-Marne
Paris , FRANCE
Contact: Harold P. SANTO
P. O. Box 4076
Massama,2745 Queluz,PORTUGAL
Tel. + AM + Fax :+351-1-439-2571
Internet :chpsanto@beta.ist.utl.pt

1997 ASEE IL-IN Section Conference
March 14-15, 1997
IUPU - Indianapolis, Indiana
Conference Chair: V. Raju
Purdue School of Engineering and
Technology, Indiana University Purdue
University Indianapolis, IN
799 West Michigan Street
Indianapolis, Indiana 46202
RAJU@TECH.IUPUI.EDU
phone: 317-274-3429
FAX: 317-274-4567

WSCG'97
The Fifth International Conference in
Central European Computer Graphics and
Visualization 97
February 10-14, 1997 in Czech Republic in
cooperation with IFIP working group on
Computer Graphics and Virtual Worlds.
Contact:Vaclav Skala
Computer Sci.Dept.,
Univ.of West Bohemia
Univerzitni 22, Box 314,
Plzen, Czech Republic
e-mail: wscg97@kiv.zcu.cz

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
SPONSORS: IEEE Computer Society
IEEE Education Society
ASEE ERM Division
In cooperation with the University of Pittsburgh
Chairs:
Cynthia J. Atman: atman@engrng.pitt.edu
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

1997 Conference for Industry & Education Collaboration of the American Society for Engineering Education
January 27-31, 1997
Hyatt Regency Tampa Hotel
Tampa, Florida USA
http://www.engg.ksu.edu/CPDD/97ciec.html
Ken Gowdy: 913-532-5590
kgowdy@dengr.ksu.edu
Dr Wayne R. Hager,
College of Engineering
Penn State University
University Park, PA 16802
Tel (814)-865-7589 Fax (814)-863-7229
http://www.ecsel.psu.edu/setce/

ASEE/EDGD 1996 Conference

edgd National Design Graphics Competition

On June 23, 1996, the National Design Graphics Competition (NDGC) was held in Washington, DC as a part of the annual American Society for Engineering Education (ASEE) Conference. Seventeen (17) entries from ten (10) colleges and universities in the United States were judged on how well they followed a set of guidelines for designing a lawn mower jack. The competition is open to students enrolled in freshmen engineering classes.

The project included an abstract (10 points), a ten (10) page written report (75 points), and a graphics portfolio (100 points). Twenty (20) points each were awarded for presentation quality and a workable solution. An average of three judges scores for each entry was used to determine first, second, and third places.

The 1996 winners were:

Place	School	Advisor	Team Members
First	Northern Arizona University	Steven Howell	Scott Corapi Jason Kordus Joshua Platt
Second	Colorado School of Mines	Robert Knecht	Nicole Abbott James Heskins Brett Maughan Matthew Pisha Jenny Wolfschlag
Third	Ohio Northern University	Subhi Bazlamit	Kyle Boggs Ken Lewis

Team members on the first three finishing teams receive appropriate certificates and computer drawing software from Autodesk and Addison-Wesley. The sponsoring schools also win software and plaques. All other team members receive certificates of participation.

The project for 1997 is a totally automatic computer mouse ball cleaner. It must clean ten (10) computer mouse balls unassisted in five (5) minutes or less. For more information contact Patrick J. McCuistion at 614-593-1457 (phone), 614-593-9382 (fax), or pmac1@ohiou.edu (e-mail).

The corporate sponsors for the NDGC are Autodesk and Addison-Wesley. The ASEE division sponsors are Engineering Design Graphics, Design in Engineering Education, and Freshmen Programs.

edgd Resolution

Submitted by Larry Goss

Whereas the annual meeting of the Engineering Design Graphics Division has occurred in conjunction with the American Society for Engineering Education Annual Conference at the Sheraton Washington Hotel in Washington, D. C. and the ASEE Washington office has provided us with a sutiable forum for the exchange of ideas, concepts, methodologies, and conviviality;

And whereas Professor Fritz D. Meyers of The Ohio State University, as Program Director and acting as program Chairman, has attracted scholars from across the United States who presented excellent and thought provoking papers;

And whereas Irwin Publishing represented by Katherine Hepburn, Tom Casson, Scott Isenberg, and Betsy Jones, has hosted the social hour for our awards banquet;

And whereas the spouses and families of our division members have enjoyed the special tours and family events of this meeting including sites of historic interest in our nation's capitol;

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

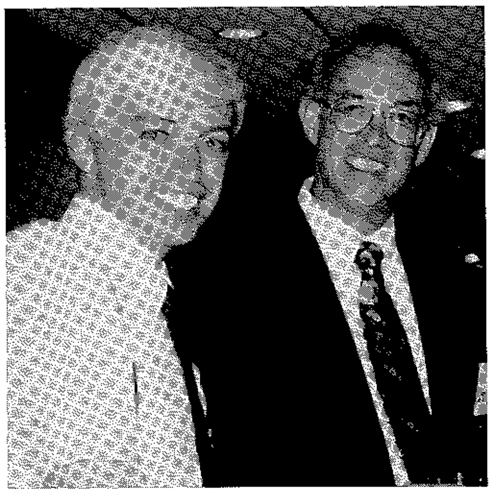
Copies of this resolution shall be transmitted to these individuals and shall be spread on the records of the division.

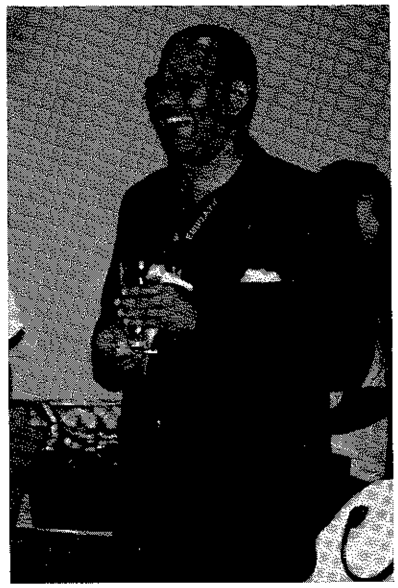
1996 Annual Meeting Resolution Committee,

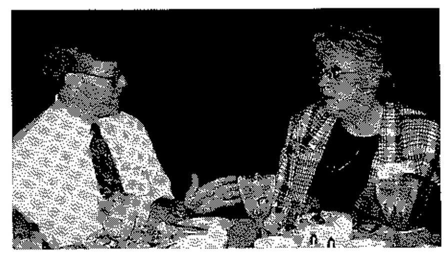
Larry Goss

Hightlights from Washington, 1996

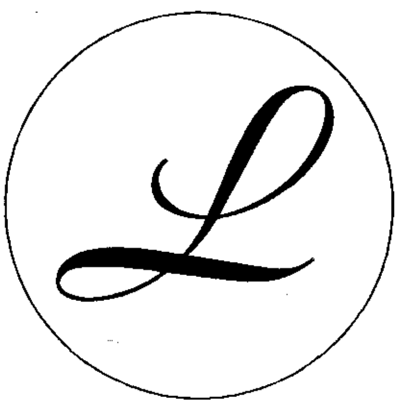
ENGINEERING DESIGN GRAPHICS DIVISION ASEE







When you think of Milwaukee, do you think of this?



1997 ASEE Annual Conference and Exposition, June 15-18, 1997
Milwaukee, Wisconsin

There's more to Milwaukee than Laverne and Shirley!

Recently ranked #14 in Fortune Magazine's "Best Cities in Which To Live and Work", Milwaukee is a city full of amenities with a small town feel. Milwaukee welcomes the 1997 **ASEE Annual Conference and Exposition** with exciting festivals, enchanting Lake Michigan, genuine, midwestern hospitality and an international flair.

At the conference, June 15-18, you'll have the chance to stroll along the Third Street Pier and jump on the riverboat rides at the Society-Wide Picnic, complete with German cuisine and an authentic Oompah band! Take a tour of Harley-Davidson or hob-nob with Tommy Thompson, Wisconsin's governor, at the exposition's Focus on Exhibits reception.

In addition, you can tap your feet to the Mississippi Mudcats at the Awards Banquet, attend the Plenary Session with renowned speaker Carol Bartz, CEO of Autodesk, Inc., and take advantage of the restaurants and shops in Milwaukee's ethnically diverse neighborhoods in your free time.

These are just of few of the things the ASEE Conference promises! Milwaukee is affordable, scenic, festive, safe and exciting--*"a great place on a great lake"*. Come alone or bring the whole family! Plan now to attend June 15-18, 1997! More information will be mailed with the March issue of *ASEE PRISM* or visit ASEE's website **www.asee.org** for info today!

Department of Technical Graphics Purdue University

Faculty Positions in Technical Graphics
Full-time, Tenure-track, 10 month appointments beginning Fall 1997

The Department of Technical Graphics at Purdue University is accepting applications for tenure track positions at the West Lafayette campus and Statewide Sites for Fall 1997. The positions require a Master's Degree and industrial experience; Ph.D. preferred. Experience with 2D/3D computer graphics tools appropriate for undergraduate education is required. Candidates should have expertise in at least one of these areas: 1.) Engineering Design Graphics, 2.) Interactive Multimedia, 3.) Computer Animation, 4.) Page Design and Layout, 5.) Graphic Design, 6.) Technical Illustration, 7.) Commercial/educational WWW publishing, 8.) Virtual Reality, and 9.) Digital Video and Photography. A strong interest in undergraduate teaching and curriculum development is expected. Rank and salary determined according to qualifications and experience. The Department's Technical Graphics BS degree program includes over 30 undergraduate and graduate courses in the areas of engineering design graphics, illustration, and publishing media with over 400 BS students. The department also serves over 2,000 students every year in the Schools of Engineering, Technology, and Liberal Arts.

Send resume and list of at least three references to:
Donna Goetz,
Faculty Search Committee,
Department of Technical Graphics,
1419 Knoy Hall, Purdue University,
West Lafayette, IN 47907-1419.

Direct questions to:
Gary R. Bertoline
Purdue University
1419 Knoy Hall, Room 363
West Lafayette, IN 47907-1419

Ph 317-494-4585
Fax 317-494-9267
e-mail:
grbertol@tech.purdue.edu
http://www.tech.purdue.edu/tg

Department of Mathematice, Science, and Technology Education North Carolina State University College of Education and Psychology

Search For Department Head

Position: Department Head: Full Professor, Twelve Month position
Starting Date: July 1, 1997

Setting: North Carolina State University is located in Raleigh, has 27,000 students and is in close proximity to Duke University and the University of North Carolina at Chapel Hill. The Department of Mathematics, Science and Technology Education is one of five departments in the College of Education and Psychology. The departmental undergraduate programs include: a BS and teacher licensure for middle grades and high school in mathematics, science, and technology; a minor in Graphic Communications emphasizing the selection and application of graphic techniques; and a minor and non-teaching BS in Technology Education. Graduate degrees are offered in Technology Education (MS, MEd, EdD), science Education (MS, MEd, PhD), and Mathematics Education (MS, MEd, PhD). Additionally the department administers the doctoral program in Occupation Education. Currently there are 320 undergraduate majors and 110 graduate students in the department. The Department has 16 full time tenure-track faculty, 6 full time lecturers and visiting lecturers, and 5 full time visiting instructors. Additional units within the Department include the Center for Research in Mathematics and Science Education (CRMSE) and the Environmental Science Education Initiative. The College in conjunction with the local public school system is in the process of developing a public middle school (6-8) to be housed on the University campus.

Qualifications: Earned doctorate in mathematics, science or technology education or related field Demonstrated record of scholarly research, publications and grantsmanship Public school and university teaching experience and ability to work collaboratively with public school districts and university units Evidence of successful experience with preservice teacher education programs

Responsibilities: Provide leadership for the Departmentís academic programs Administer the Departmental budget, including personnel, scholarships Lead the Department in developing national recognition Facilitate program and curriculum development for the Department Support professional development of faculty, staff and students Represent the Department to the Dean, the University, and the Community

Salary: Competitive and commensurate with qualifications and experience; twelve months.

Procedure: Review of applications will begin December 10, 1996 and will continue until the position is filled. Applicants should send letter of application, current curriculum vita, and three letters of reference to:

Dr. Jack Wheatley, Interim Department Head
Mathematics, Science, and Technology Education
Box 7801, NC State University
Raleigh, NC 27695-7801
(919) 515-2238
FAX (919) 515-1063

NATIONAL DESIGN GRAPHICS COMPETITION

Date: 1 August, 1996

Dear Colleague,

On behalf of the sponsoring divisions of the American Society for Engineering Education (ASEE) and the corporate sponsors, I want to invite you to submit student design projects for the National Design Graphics Competition (NDGC). This event will be held in conjunction with the 1997 ASEE Annual Convention, 15-18 June, in Milwaukee, WI.

Please find the enclosed guidelines and registration forms for this event. These guidelines should answer most of your questions. The project this year is a computer mouse ball cleaner. Cleaning mouse balls is one of those jobs that never seems to get done until the entire mouse is so gummed up it won't work. It's an irritating problem. I hope you enjoy the project.

The graphic part of the project is the major component of the competition. The graphics must augment the written report and present a chronological graphic record of the project. Any graphic form is acceptable including sketches, photographs, graphs, detail drawings, assembly drawings, etc.

Please realize that the main reason for this competition is for students to gain a good understanding of the design process. Only 20 points out of 250 are related to a workable design. This project is a vehicle to allow your students to learn a design sequence that will stay with them for the rest of their lives. I hope to see you and your student entries in Milwaukee.

If you would like to help judge the competition in Milwaukee, please contact me at:
Phone - 614-593-1457 Fax - 614-593-9382 e-mail - pmac1@ohiou.edu.

Sincerely,

Patrick J. McCuistion, NDGC Chair

P.S. The 1996 winners were: 1st Place, Northern Arizona University; 2nd Place, Colorado School of Mines; and 3rd Place, Ohio Northern University. The winners and their schools won a considerable amount of Autodesk software. Congratulations to all participants and a special thanks to the judges, Addison-Wesley and Autodesk for providing guidance, prizes, and finances.

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ENGINEERING DESIGN GRAPHICS
DESIGN IN ENGINEERING EDUCATION
FRESHMAN PROGRAMS

NATIONAL DESIGN GRAPHICS COMPETITION

1997 COMPETITION GUIDELINES

The National Design Graphics Competition (NDGC) will be held June 15, 1997, in Milwaukee, WI, in conjunction with the American Society for Engineering Education (ASEE) Annual Conference. In addition to the competition, a display of the entries will be held.

I. Design Project:

Design an electro-mechanical device to clean 22 millimeter diameter computer mouse balls. The device must be totally automatic (no human activity allowed after the ball enters the device). It must be able to clean 10 balls unassisted, one ball at a time. A dirty ball must enter one orifice and a thoroughly cleaned ready-to-use ball must exit from a different orifice. The maximum time a ball is allowed inside the device is 30 seconds. The total volume of the device must not exceed 5000 cubic centimeters. Any cleaning features or fluids should be easily inserted and removed and be environmentally safe. The maximum operating noise level is 50 decibels at 1 meter. No harmful or objectionable fumes are allowed from its use.

II. Project Contents:

Each project entry should contain the items in sections A-C. The possible point value for each part of the entry is noted after the description. The highest judged average point value will be used to determine the winners. One copy of the abstract, written report, and all graphics must be submitted for each entry.

- - Do not send original work - -

A. ***Abstract:*** An abstract page typed on 8.5" X 11" white paper shall accompany each report. It must include the project title, school name, participating student names, date completed, estimated time to complete, and a coherent narrative of no more than 250 words. The type font should be no less than 12 point size. 10 points

B. ***Written Report:*** The written report shall be type written on no more than 10 - 8.5" X 11" white paper pages. The print must be double spaced, on one side only, be 10-12 point font size, and not encroach on 1" borders on all four sides of each page. The report shall be a segmented narrative that completely describes the results of the activities of the team members in the following: 1) *Problem Statement*, 2) *Preliminary Ideas*, 3) *Refinement*, 4) *Analysis*, and 5) *Final Solution*. Each section is worth 15 points (75 points total). No graphics are permitted in the written report, but all graphics must be referenced.

C. ***Graphics:*** A chronological graphic record of the project must be grouped separately from the written report. Pertinent graphics are required for each phase of the design project except for the problem statement. Each graphic must include the minimum of a title, date, and name of the person who is responsible for it. The point values for the different segments are: 1) *Preliminary Ideas, 20 pts,* 2) *Refinement, 20 pts,* 3) *Analysis, 20 pts,* and 4) *Final Solution, 40 pts.* (100 points total)

D. ***Additional Scoring***: A *Workable Solution* to the problem and the *Presentation Quality* of the entry are worth 20 points each. *Adherence to the design* project specification is worth 25 points.

III. Project Team/Entry Limitations:

A. The team must have at least 2 members but no more than 5 members. Each team member must be enrolled in the same Freshmen level class where this design project is introduced.

B. The maximum number of entries per school or branch campus is 3.

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NATIONAL DESIGN GRAPHICS COMPETITION

IV. Project Interest and Registration Forms

Please find the entry forms on the back of this page. The Project Interest Form must be received no later than 1 March, 1997. The Registration Form and entry fee for each design team must be received no later than 1 June, 1997.

V. Entry Fee:

An entry fee of $10.00 must accompany each Registration Form. Only checks drawn from U.S. banks will be accepted. Entry fees are not refundable.

VI. Entry Submission Date and Time:

All project entries must be submitted at the judging session or at the main conference hotel registration area before 8:30 a.m. (Central Time Zone), 15 June, 1997. Transporting the project(s) to the conference is the sole responsibility of the entering school.

VII. Judging:

Judging will be based solely on the items listed in sections I - VI. Any items intended solely for the display will not be judged. Each project will be judged by at least three judges. Judging will start on Sunday morning 15 June, 1997, at 9:00 a.m. and be completed the same day. All decisions made by the judges are final.

VIII. Display Location and Schedule:

Location:	Wisconsin Convention Center
Set-up:	15 June, between 2:00 p.m. and 4:00 p.m.
Display hours:	9:00 a.m. - 5:00 p.m. 16 & 17 June Project security is the responsibility of the entering schools.
Removal:	18 June, between 10:00 a.m. and 12:00 noon Removal and return of projects is the responsibility of the entering schools. Projects not removed will not be returned.

IX. Display contents:

The displays must include the abstract, written report, and graphics. An 8.5" X 11" placard with the school and advisor names will be provided for each entry. The displays may utilize any additional medium of communication but must fit on table space no larger than 36" wide X 18" deep.

VII. Awards/Prizes:

Team members from the First, Second, and Third place teams will receive appropriate certificates and prizes. All other students will receive certificates of participation. The award winning schools will receive plaques and prizes.

Please direct questions to:

Patrick J. McCuistion, 124D Stocker, Ohio University, Athens, OH 45701-2979
Phone - 614-593-1457 FAX - 614-593-9382 e-mail - pmac1@ohiou.edu

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FRESHMAN PROGRAMS

1997 ASEE NATIONAL DESIGN GRAPHICS COMPETITION
PROJECT INTEREST FORM
Milwaukee, WI

Our institution is considering submission of student design projects:

Number of Freshman projects ____ (3 permitted)

Contact person at your institution:

Full Name: ____________________

Address: ____________________

____

Phone: ____________ Fax: ____________ e-mail: ____________

Please mail to: Patrick J. McCuistion, Ohio University, 124D Stocker Center, Athens, OH 45701-2979

This form due by March 1, 1997

---------------------------- CUT ALONG THIS LINE ----------------------------

1996 ASEE NATIONAL DESIGN GRAPHICS COMPETITION
REGISTRATION FORM
Washington, D.C.

All the information on this form should be the same as you wish it to appear on any award.

Advisor(s): ____________________

School: ____________________

Address: ____________________

____

Phone: ____________ Fax: ___ ____________ e-mail: ____________

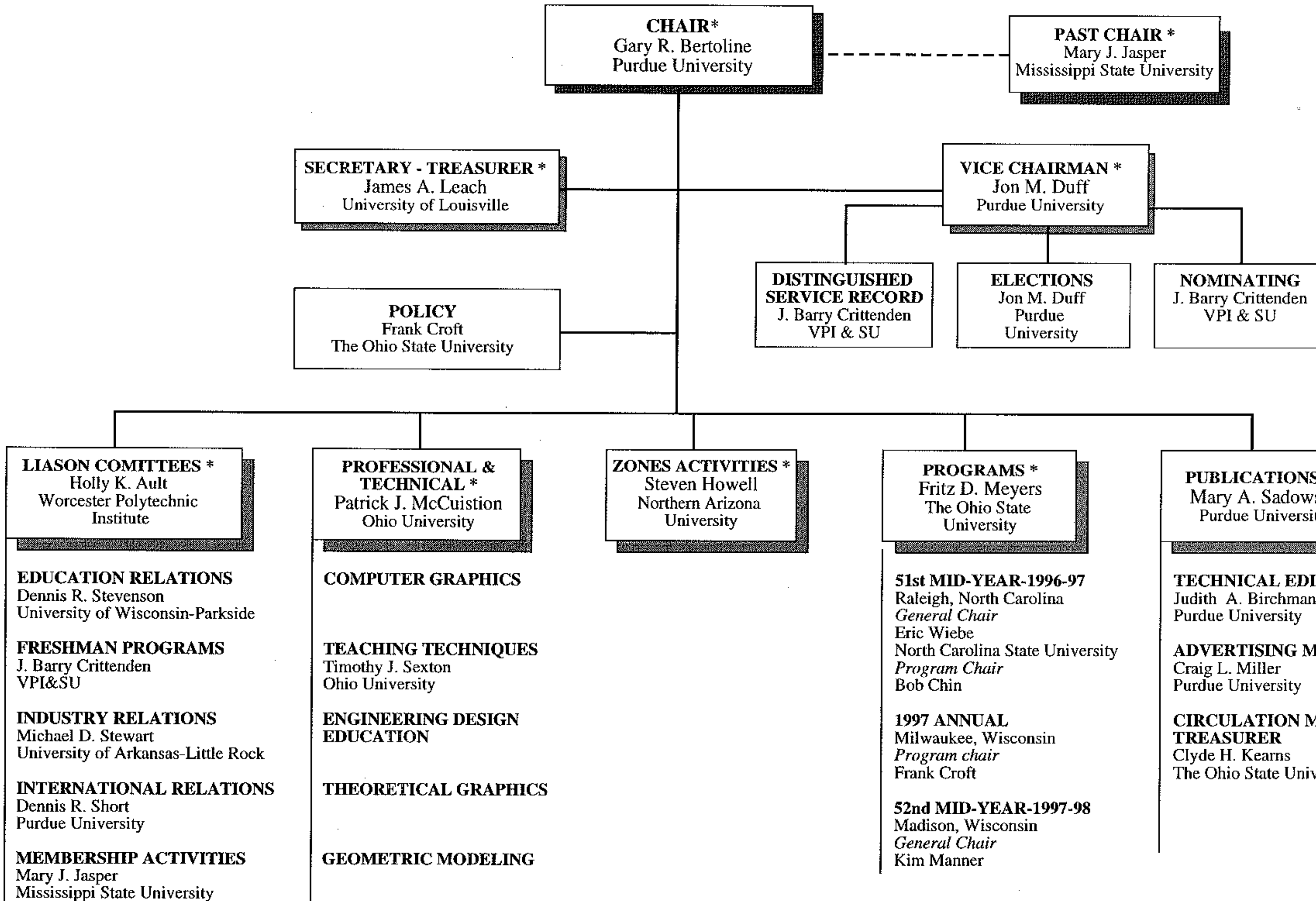
Team Members: ____________ ____________
(limit of five)
____________ ____________

____

Please mail to: Patrick J. McCuistion, Ohio University, 124D Stocker Center, Athens, OH 45701-2979

This form due by June 1, 1997

ENGINEERING DESIGN GRAPHICS DIVISION of ASEE



ORGANIZATION CHART 1996 - 1997

*** Executive Committee member**

Submission Guidelines

The *Engineering Design Graphics Journal* is published by the Engineering Design Graphics (EDG) Division of the American Society for Engineering Education (ASEE). Papers submitted are reviewed by an Editorial Review Board for their contribution to Engineering Graphics, Graphics Education and appeal to the readership of the graphics educators. By submitting a manuscript, the authors agree that the copyright for their article is transferred to the publisher if and when their article is accepted for publication. The author retains rights to the fair use of the paper, such as in teaching and other nonprofit uses. Membership in EDGD-ASEE does not influence acceptance of papers.

Material submitted should not have been published elsewhere and not be under consideration by another publication. Submit papers, including an abstract as well as figures, tables, etc., in quadruplicate (original plus three copies) with a cover letter to

Mary A. Sadowski, Editor
Engineering Design Graphics Journal
1419 Knoy Hall / Technical Graphics
Purdue University
West Lafayette, IN 47907-1419
FAX: 317-494-9267 PH: 317-494-8206
email: masadows@tech.purdue.edu

Cover letter should include your complete mailing address, phone and fax numbers. A complete address should be provided for each co-author. Use standard 8-1/2 x 11 inch paper, with pages numbered consecutively. Clearly identify all figures, graphs, tables, etc. All figures, graphs, tables, etc. must be accompanied by a caption. Illustrations will not be redrawn. All line work must be black and sharply drawn and all text must be large enough to be legible if reduced. The editorial staff may edit manuscripts for publication after return from the Board of Review. Upon acceptance, the author or authors will be asked to review comments, make necessary changes and submit both a paper copy and a text file on a 3.5" disk.

Page Charges

A page charge will apply for all papers printed in the *EDG Journal.* The rate is determined by the status of the first author listed on the paper at the time the paper is received by the Editor. The rates are as follows:

$5 per page for EDGD members
$10 per page for ASEE, but not EDGD members
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The *EDG Journal* is entered into the ERIC (Educational Resources Information Center), Science, Mathematics, and Environmental Education/SE at:

The Ohio State University
1200 Chambers Road, 3rd Floor
Columbus, OH 43212.

Article copies and 16, 35, and 105 mm microfiche are available from:

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300 Zeeb Road
Ann Arbor, MI 48106

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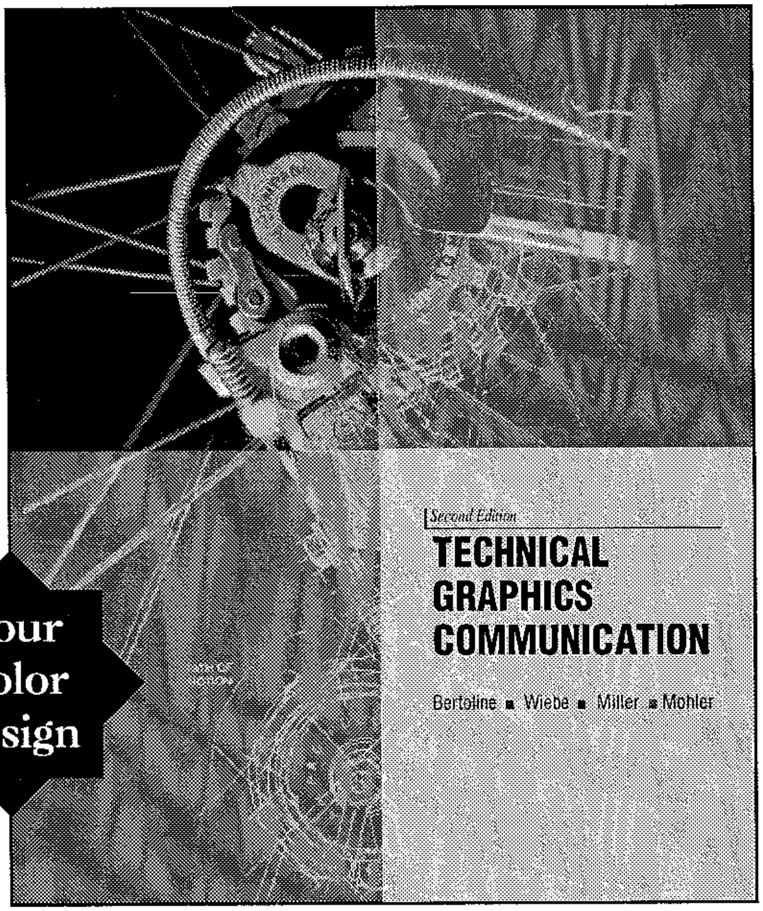
Clyde Kearns
The Ohio State University
2070 Neil Avenue
Columbus, OH 43210

Now you have a choice.



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