THE ENGINEERING DESIGN GRAPHICS JOURNAL

american society for engineering education
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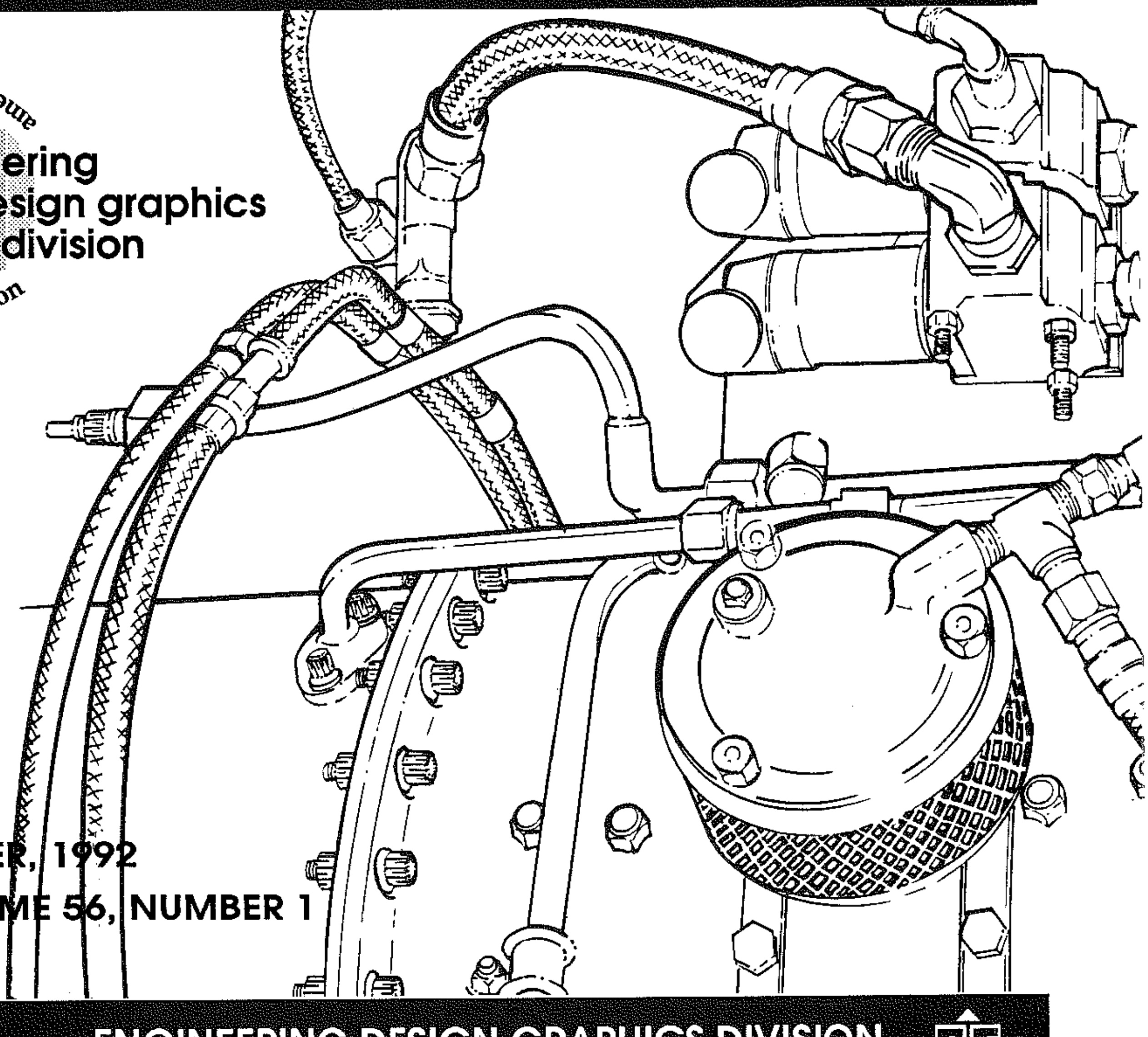

WINTER, 1992
VOLUME 56, NUMBER 1

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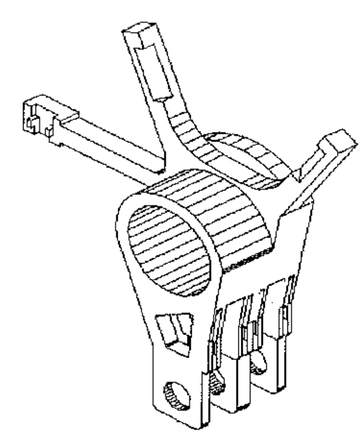

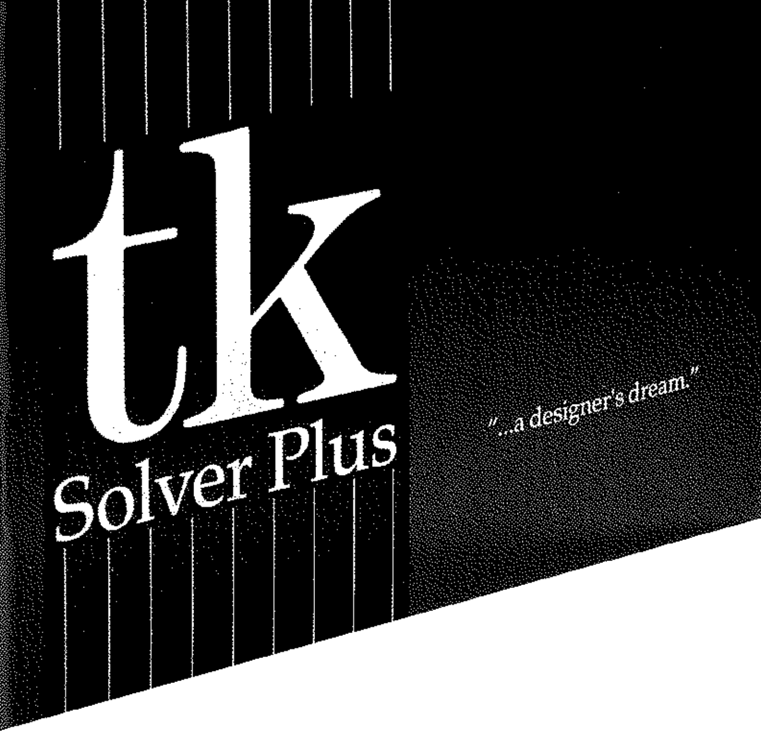

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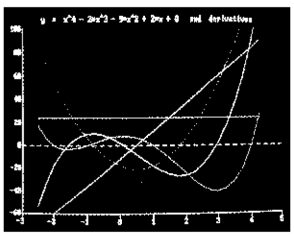

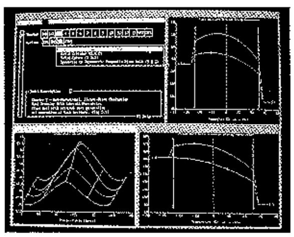

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THE ENGINEERING DESIGN GRAPHICS JOURNAL

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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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My first experience with EDG was the midyear meeting in Pittsburgh where the banquet entertainment was some guy who was scheduled to speak about the History of Glass. After turning green on the back seat of the van on the bumpy roads, and seeing the history of glass as banquet entertainment, I began to wonder if I had made a mistake. I wondered if, indeed, this was the group that was going to help me sort out my feelings about engineering graphics education. Well, the van sickness went away, and to this day, I consider that night's entertainment one of the best I have experienced in what has become numerous EDG banquets at both the midyear and the national conferences.

I don't remember the exact papers given at that conference, but I do remember that CAD (or was it CADD?) was really in its infancy for engineering graphics. Through the years I have watched and listened as we have matured into the electronic age. We have progressed through single stations (I remember when our department purchased its first Apple II), classroom set-ups, and multiple classrooms. We listened and talked about all kinds of hardware. It seemed for a while that your status was directly proportional to how many acronyms you could use in a single presentation. Occasionally, some brash young thing would get up and show us that many of the things we held sacred could now be taught on the computer. (Sometimes we didn't like to hear these things.) Many papers and presentations were involved with the programming of graphics rather than the using of graphics. When it appeared that most of the engineering graphics labs across the country had finally crossed into the electronic age, it seemed that maybe we could begin thinking again about graphics education. However, something else came up. A variety of CAD packages now appeared on the scene and we as a group became involved in a discussion of which packages were best for doing different things. We didn't hear too often that one package or another was purchased because it fit our budget or our hardware. More often we heard about how we used the package in the classroom.

The current focus seems to be on modeling. Our hardware and our software are now sophisticated enough for educational labs to take the plunge into modeling. With modeling there seemed to come a lot of questions. "Now," I said to myself, "we're going to get back to the business of graphics education." But wait, it seems that the questions seem to revolve around the approach for modeling. Should it be a top-down approach or a bottom-up approach? Should it be our students' first encounter with graphics, or should it be the carrot for a job well done? Should our students ever have to use a pencil for graphics again, or will everything be input directly into the computer?

If we look into the future we may see that soon we will be able to literally talk to the computer making today's input devices (mouse, keyboard, etc.) a thing of the past. Just as I'm beginning to get more and more confused about graphics education I watch my local news station and what do I see but virtual reality. Now we all know that virtual reality is currently out of our reach. We've all heard about things that can be done using virtual reality, and realize that it makes everything we are doing look obsolete. But, virtual reality in the classroom is light years away, right? The local news program showed how people could participate in virtual reality games for a dollar a minute. Show the world how to make money with a product and it will be developed with lightning speed.

And so, back to graphics education. We cannot let the tail wag the dog. We must continually ask ourselves why? We must be concerned with concepts as well as approaches. The best approach is useless if it does not address the needs of the learner. In the race for electronic supremacy, let us not lose sight of the need to provide the world with graphically literate engineers.

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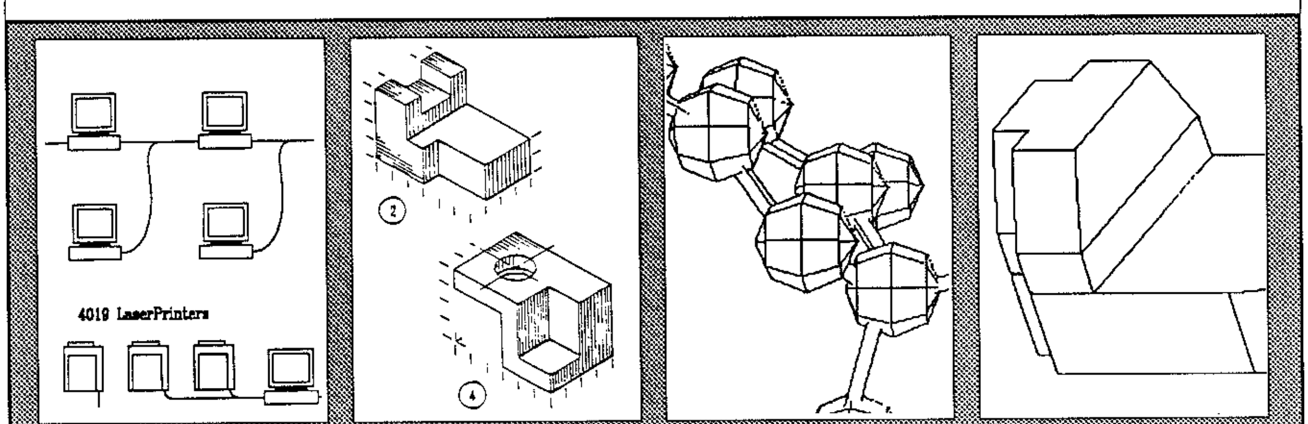
EDG NEWS

• *Cover illustration by* ***Nicole Cassman***



been created to handle common subjects that are necessary parts of the knowledge base for all engineering students. The Department of Freshman Engineering, which began in 1974, taught the Engineering Design Graphics course to all first-year engineering students. This course, now taught by the Division, introduces the design process to cross-disciplinary teams of students. The students study the steps of design and work as a team on a design project culminating in a final written and oral report. The typical engineering student would next undergo such an intensive design experience in the senior capstone course offered in a disciplinary environment.

Year	Topic	Expertise-Discipline
Freshman	Introduction to the design process, computer graphics, team projects, communications and presentation skills, numerical methods, open-ended problems	Division
Sophomore	Workstation environment, design and methodology, communications and presentation skills, numerical methods	Division
	Project management	IE
	Geometric Modeling	AerE, ME
Junior	Simulation, design cycle methodology, communication and presentation skills, numerical methods, optimization	Division
	CAD	AerE, ME
	Reliability, statistical modeling, quality control, ergonomics, costing	IE
Senior	Ethics, product liability, socio-humanistic implications, international aspects	Division
	CAD	AerE, ME
	Networking	EE/CpE
	Experimental testing and vericification	AerE, EE/CpE
	CAM	IE, ME, EE/CpE

Table 1. The Integrated Curriculum

Several engineering departments, in order to infuse more realism in the senior capstone course, have increased industrial participation in the selection and sponsorship of these projects. The Electrical and Computer Engineering Department has been instrumental in this effort. Many industrially sponsored projects in that department have, while meeting with marked success, demonstrated shortcomings in the engineering curriculum as it relates to design. The following important areas to be addressed in developing a successful senior design experience were noted (Genalo, 1988).

1. An industrial-class fabrication facility and networked CAD/CAM/CAE stations at the university are necessary. This may sometimes be provided by the industrial sponsor, but many of these projects are developed by smaller companies which lack the facilities.

2. An integrated four-year design curriculum needs to be developed. Design methodology, reliability, statistical product modeling, project management, cost accounting, software engineering, and life-cycle management are examples of topics each student should be taught before entering the capstone course. This is the so-called "design toolbox."

3. A mechanism for staffing multi-disciplinary projects must be developed. Many of the industrially-specified projects failed because they were attempted by a disciplinary-based team of students. The lack of training, talent, and interests of students in areas outside their discipline proved detrimental to the projects.

4. Faculty motivation to participate in these projects must be provided. Today's career tracks tend to discourage such participation.

5. Graduate students need to be incorporated in these design teams. This will provide greater technical expertise on the project, a source of support for graduate students, and a "practice-trained" master's degree student. Initial experience has shown that an added advantage is that the exposure to a graduate student has helped in

recruiting the undergraduates for advanced education.

6. Solicitation of industrial support must be well organized. The interaction between the students and the "real world" industrial sponsor provides motivation that is of equal, or greater, value to the financial support provided.

In the last two years a committee studied the described problems. One outgrowth of that study is a cross-disciplinary design effort described in reference (Flugrad, 1990). Another outgrowth is a comprehensive plan, described in reference (Eide, 1989), for integrating the "design toolbox" into the curriculum, providing for industrial support, improving the facilities, and facilitating the cross disciplinary staffing that is required.

INTEGRATED DESIGN TOOLBOX

The newly formed Division of Engineering Fundamentals and Multidisciplinary Design will be a home for design taught and performed in a cross-disciplinary setting. This Division will provide faculty to serve as project facilitators for the student design teams. The Division also oversees college level computing labs which will be used to provide the industrial-class design workstations necessary to the success of these projects. The topics included in the design toolbox will be taught in several of the disciplinary departments as well as in the Division. Table 1 shows the topics to be included in a design toolbox, the year of the curriculum in which they fit, and the unit (Department or Division) which will probably have responsibility for teaching them.

"The newly formed Division of Engineering Fundamentals and Multidisciplinary Design will be a home for design taught and performed in a cross-disciplinary setting."

This list is not a final one. It never will be. Each year it must be reviewed and updated. This list represents tools which all engineers should have in their "design toolbox." Some of the topics listed for the senior year should be covered in a lecture series given at the beginning of the capstone design course. The instructors teaching the integrative four-year coursework will, themselves, represent a multidisciplinary team. The lecture series in the capstone course, for example, will bring speakers from industry and the humanities, as well as engineers, into the classroom.

Expertise	Discipline
Operations research, human factors manufacturing	IE
Manufacturing, packaging, mechanisms, materials, structures	ME
Mathematical modeling, physical systems, simulation, dynamical analysis	AerE
Electronic devices, networks, software engineering, VLSI	EE/CpE

Table 2. An Example Team

engineer's design to the draftsperson. Today, these sketches are being replaced by computer drawings. This situation has lead to the urgent need for the introduction of the fundamentals of geometric modeling as well as conventional computer aided analysis during a structural engineering student's undergraduate education. In response to this need, CAD/CAE applied to structural engineering education is appearing in the structural engineering curriculum. This appearance is being achieved by three methods:

1. using internally developed or commercial software in existing analysis and design courses;
2. in unique courses which require that students develop software for specific structural engineering and design applications and
3. in unique courses which present an overview of the use of computers and the mechanics of computer software in the structural engineering industry.

"An integral part of the use of computers to solve these problems is geometric modeling. Graphics are used to input the problem and to interpret the output."

Courses implementing method 1 are strongly sensitive to the instructor's preferences in regard to the nature and extent of the use of software in his/her class. Thus, structural analysis and design courses' content in regard to computer usage varies tremendously among institutions. Method 2 is sometimes disguised in senior and graduate level courses labeled "Matrix Structural Analysis" or "Computer Aided Design of..." where a large percentage of homework exercises are devoted to developing one or more personal computer programs. The values of these exercises lie in the sharpening of the students' programming skills. Unfortunately, many students enter these classes without prior knowledge of the amount of computer programming required and are usually overwhelmed by the assignments. Method 3 courses, if carefully outlined, developed and continually modernized, can be a valuable elective course for structural engineers. It is this type of course which is discussed herein.

History of Computer Aided Structural Engineering at the University of Utah

A sequence of two, three quarter-hour computer aided structural engineering courses are currently offered annually at the University of Utah, CE 517 and CE610. CE610, "Computer Aided Analysis and Design of Structures" was first introduced during the 1983-84 academic year. Its catalogue description read:

computer implementation of stiffness method for general framed structures; special topics for the stiffness method, substructuring methods; reanalysis techniques; computer aided design procedures; automated design of structures; introduction to optimization techniques in structural design.

This essentially was a course in the stiffness method of structural analysis. A course entitled "Matrix Structural Analysis" did not appear until the following academic year. Hence, after 1984 many topics included in CE610 were redundant to the material presented in Matrix Structural Analysis and/or in finite element courses. Optimization was the only subject presented which was unique to CE610.

CE517, initially entitled: "Computer Design of Concrete Structures" was offered the following year, 1984-85. It's catalogue course description read:

Design of reinforced concrete structures by computerized techniques. Use of computer graphics in portrayal of results. Emphasis on the use of existing programs.

As the course description and title indicate, CE517 was specifically applicable to concrete structures. By the 1987-88 academic year it was desired to revise this course to be less concrete specific and the title of the course was changed and is currently entitled: "Computer Aided Analysis and Design of Structures". Its catalogue course description reads:

Techniques for the analysis and design of structural systems under static and dynamic conditions. Use of the computer and computer graphics during the analysis/design process.

At this time CE610 was also renamed and is currently entitled: "Advanced Computer Aided Analysis and Design of Structures." Its catalogue course description reads:

Special topics in the analysis and design of structural systems under static and dynamic conditions. Substructuring techniques, structural buckling, procedures for the determination of dynamic response. Introduction to structural optimization and/or random vibration of structures. Computer aided analysis/design procedures. Automated analysis/design of structures. Numerical procedures.

The prerequisite for CE517 is Steel Design I and Matrix Structural Analysis and its corequisite is Dynamics of Structures and Earthquake Engineering. The prerequisites for CE610 are Dynamics of Structures and Earth-quake Engineering and CE517.

These two, three quarter-hour computer aided analysis and design courses have the capability to give structural engineering students a solid introduction to the use of computers in solving structural analysis and design problems. An integral part of the use of computers to solve these problems is geometric modeling. Graphics are used to input the problem and to interpret the output. In the past, lecture material for the class primarily consisted of explanations on how the programs performed various analyses (static, dynamic, buckling, etc.). Lecturers were usually not qualified to give the student accurate background on the graphical mechanics of structural engineering software. Geometric modeling was normally slotted in the "if time permits" category in the course syllabus and hence, the topic was often not covered. In courses where computer aided structural analysis is the main focus, information presented on computer aided drawing must be general yet concise.

Integrating Geometric Modeling into Computer Aided Structural Engineering Courses

The goals relating to geometric modeling education in computer aided structural engineering courses at the University of Utah are to give students who have had no prior education in geometric modeling, a basic literacy in this area and introductory graphical programming skills. This is accomplished by integration of the following into the courses' content:

1. the history of computer graphics, generally and specifically applied to structural engineering
2. the mechanics of computer graphics
3. the use of preexisting structural engineering software which have graphical pre- and post processing capabilities.

Items one and two require lecture time and homework assignments specifically dedicated to geometric modeling. This time should be allocated in proportion to the significance of graphics in structural design. The optimum time is subjectively decided by individual structural engineering educators.

"At the University of Utah, 20% of the courses' contact hours is allotted to geometric modeling on computers."

At the University of Utah, 20% of the courses' contact hours is allotted to geometric modeling on computers. Therefore, during a 3-quarter-hour course (30 contact hours), 6 quarter hours are allocated to computer graphic topics, exclusively; a total of 12 lecture hours are available for computer graphics. The first course's hours are utilized by beginning with presentations of introductory information including the history of computer graphics and concluding with simple graphical programming lectures. The second course delves deeply into the mechanics of 3D computer graphics and solid modeling. The portion of each course's syllabi devoted to computer graphics is presented in Table 1. A more detailed explanation of material is presented here.

In the one hour devoted to the historical aspect of geometric modeling a tracing of the development of computer graphics hardware from 1945 to the present day is presented. The history of the use of computer graphics in the engineering industry with specific applications to structural engineering is also discussed. The development of computer graphics in structural analysis software packages paralleled these programs' general development; with each new release greater

Hardware, Software, and Curriculum Decisions for Engineering Graphics Instruction Using CAD

W. L. Lorimer & D. K. Lieu
Department of Mechanical Engineering
University of California
Berkeley, California

Abstract

The integration of personal computers into engineering graphics instruction is particularly difficult at the freshman level. In Spring 1990, the Mechanical Engineering Department at the University of California, Berkeley converted its basic engineering graphics course, which traditionally enrolls approximately 300 students per year, entirely from drafting board to PC based CAD. In establishing a large graphics laboratory, the instructors were careful in the selection of hardware and software, and the design of networking and access systems. IBM AIX was used as the primary operating system to provide networking, assignment file access, and file security for examinations. To provide software and file compatibility with student home PC's, the CAD software was DOS-based, operating under AIX. Recommendations for laboratory facility design and adaptation of traditional graphics curriculum are forwarded based upon this experience.

Introduction

The power of computers for scientific and engineering applications has long been recognized. While isolated computer solutions have commonly been included in upper level engineering courses, the teaching of programming skills is generally relegated to a separate course administrated through a computer science department. With computer technology emerging as a prominent force in nearly every aspect of modern society, the separation of computer courses from traditional academic curricula is no longer sensible. The integration of computers is challenging at all academic levels, but none so challenging as at the freshman level, where the students have little technical sophistication.

In Spring 1990, the Mechanical Engineering Department at the University of California, Berkeley converted its freshman Graphical Communication course, E28, on a pilot basis from drafting board to PC based CAD. The course traditionally enrolls three hundred students per year, although for the first semester with CAD instruction, the size of the class was limited to sixty. By Fall 1990, enrollment was increased to 180 students per semester, or 360 students per year. The conversion was complete in the sense that all homework assignments, laboratories, and examinations were executed on the computer. Instructors made no attempt to alter the traditional curriculum for the pilot semester, but used their experiences to formulate future facility and curriculum design strategies.

E28 is a required course for all freshman mechanical and civil engineering students, and a popular option for other majors. The curriculum includes principles and applications of descriptive geometry, drafting techniques, and engineering drawings - topics typical of traditional engineering graphics curricula. In addition, E28 introduces concepts of algebraic and transcendental equations, functional scales and empirical relations, graphical presentation of data, and the engineering report. The course is organized such that students attend two one-hour lectures and one three-hour laboratory each week. Lectures, presented to all the students together, are dedicated to the introduction and explanation of basic concepts. Laboratories, each seating thirty students, challenge students to apply concepts under the supervision of a teaching assistant. During a typical laboratory, students complete and submit solutions to three problems. In addition, four to six homework problems are assigned each week. Engineering design methodology is introduced toward the end of the semester when students undertake a group project for which they must design a simple device and create a full set of working drawings.

Laboratory Hardware

The first of two PC based computer laboratories was installed for Spring 1990 instruction. Based on the experience of that semester, the hardware was modified, and a second laboratory installed. Each lab consists of thirty IBM PS/2 Model 70 computers networked with a PS/2 Model 80 fileserver. The standard Model 70 was upgraded with a 80387 math co-processor and memory expansion from four to eight Mbytes. The Model 80 fileserver, which functioned (1) as a monitor of system performance and client status, (2) as the root for remote loading of assignments, and (3) as a network printserver, was equipped with a 314 Mbyte disk and ten Mbytes of memory. To provide an adequate high-volume print environment, a second server, dedicated solely to print queuing, was added to the network. Three IBM 4019 LaserPrinters, each rated at 10 ppm, were selected as hardcopy units. The configuration of the laboratory is shown in Figure 1. Each lab is equipped with an additional "open" workstation available to run CAD and generate color plots.

Software

Although the push in curriculum modernization is in the direction of 3-D and solid modeling, the software selected for E28 was IBMCAD (version 1.2), a DOS-based 2.5-D drafting and engineering package. Instructors regarded the construction of isometric and oblique views in a 2-D environment as key to understanding the concepts of orthographic projection and to developing visualization skills. The simplicity of 2-D software and the extensive on-line help facilities provided with IBMCAD allowed students to become proficient CAD users in minimal time. IBMCAD also provides compatibility with other PC based drafting packages, including CADAM and AUTOCAD.

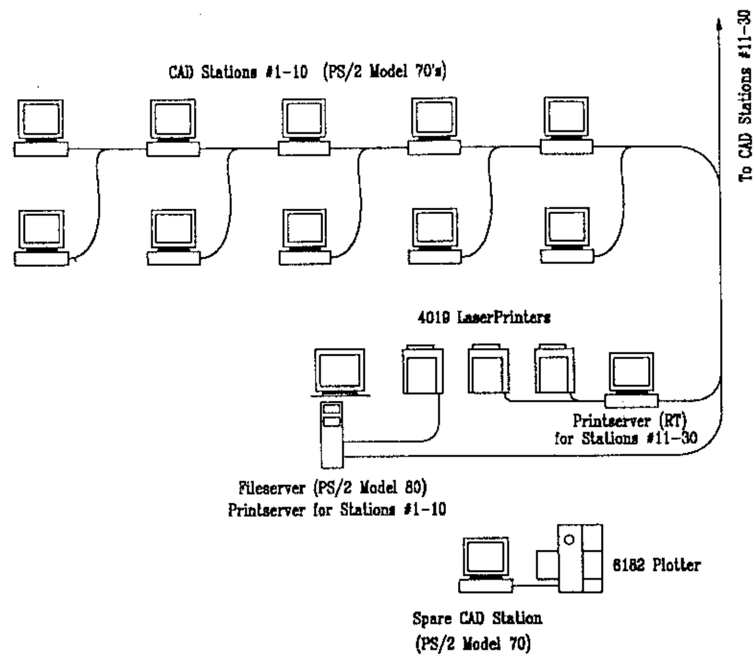


Figure 1. E28 Design Laboratory Computer Network Configuration

In a curriculum modernization project sponsored by NSF, Barr and Juricic (1990) encourage the introduction of solid modeling in modern engineering design graphics (EDG) curricula, but point out that many of the essential features of 2-D CAD and solid modeling packages are similar; i.e., geometric construction, object transformations, primitives, and editing features. Furthermore, they note that (a) although many industries are investigating solid modeling options, most are comfortable with 2-D CAD, and (b) even though modern design processes will begin with a 3-D solid model, the need for 2-D engineering drawings in final production will prevail. In light of these observations, introduction of a 2-D package in the freshman course is appropriate. The skills students develop using 2-D CAD will facilitate the introduction of solid modeling in subsequent courses.

To handle file security and network printing, and to establish compatibility with U.C. Berkeley campus UNIX systems, IBM to students, while spreadsheets were virtually unknown. In the area of drafting, Figure 4 indicates nearly half of the entering students had previous experience on a drawing board, but 78% had no previous exposure to CAD. Leach and Gull (1990) conducted a study of two classes that were taught identical graphics concepts and given identical exams. One class used manual instruments; the other used CAD. Their observations indicate that prior computer experience plays a significant role in how well students learn engineering graphical concepts. Students who possess confidence with file management and feel comfortable in a computer environment are able to concentrate their attention on learning graphical concepts and consequently perform better in a CAD-based course.

Figure 5 indicates the success of E28 CAD boot camp. Fifty-six percent of the students rated boot camp patterns and drafting assignments as an "effective" or "very effective" method of learning CAD. Individual hands-on style learning was, in fact, selected overwhelmingly by the students as the best means of learning CAD. Figure 6 indicates that individual practice supplemented by TA-directed laboratory instruction, and working in groups provides an expedient CAD instruction plan.

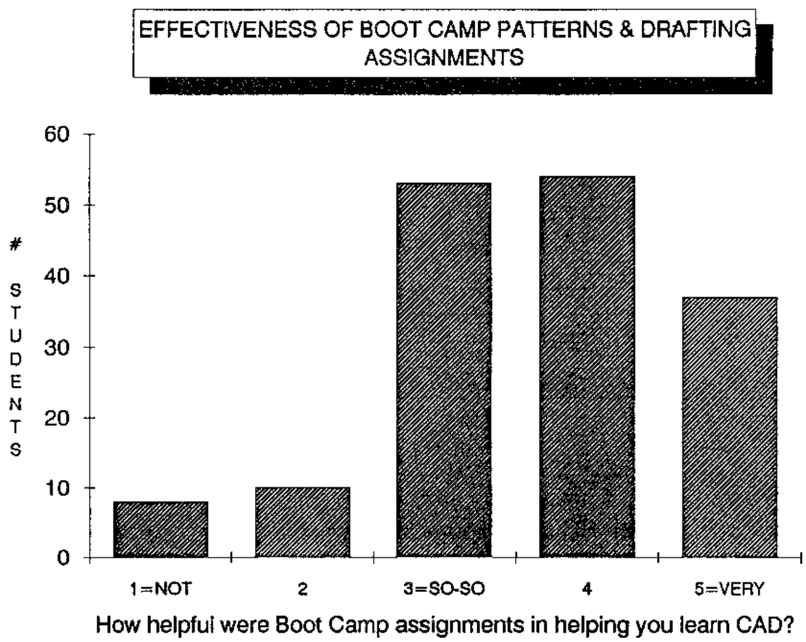


Figure 5. Students' reaction to boot camp style CAD training

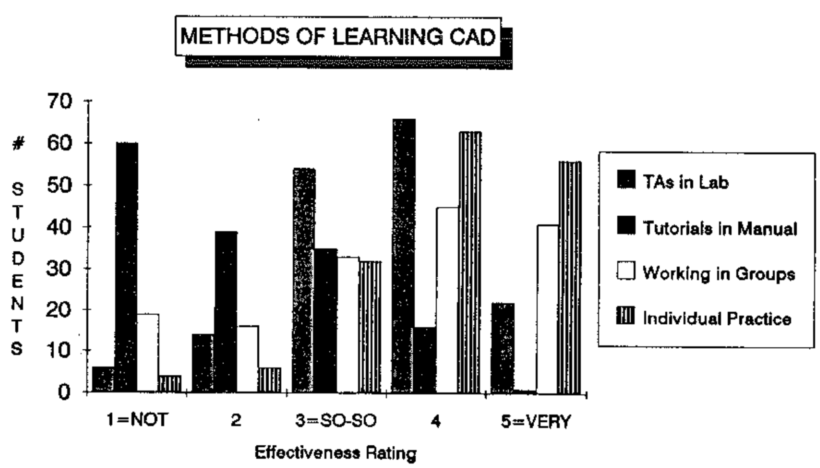


Figure 6. Effectiveness of various methods of CAD instruction

CAD as a Teaching Tool

The benefits of the computer far outweigh the problems associated with adding CAD training to the syllabus. In addition to gains in speed and accuracy associated with computer solutions, computers may be utilized as teaching tools. Instructors used macros, recorded sequences of IBMCAD commands, to animate solutions to some of the more difficult homework problems. In pre-CAD semesters, final solutions were posted, but students rarely had the opportunity to see how they were constructed. Using CAD, students ran macros to re-create solutions step-by-step, at their own paces. Of these students, 76% found the macros illuminating.

Exams

In keeping the commitment to a total conversion to CAD, and maintaining a methodology consistent with lab and homework problems, examinations were administered on the computer. Two three-hour exams were given during the fifteen-week course: one in the eighth week and one at the end of the semester. Each exam consisted of a two-hour CAD portion and a one-hour written portion. During the CAD portion, students were required to construct solutions to three descriptive geometry problems. No credit was given for hand calculations or sketches, although hard copies of the problems were distributed. The printouts aided students in planning their solution strategy, since paging between drawings is not very efficient in CAD. The written portion of the exams entailed sketching and short-answer questions covering principles of descriptive geometry, interpretation of engineering drawings, dimensioning, functional scales, and empirical equations.

Performance on a CAD exam, according to Leach, is influenced by a student's prior computer experience. This effect is not reflected in the class average, but rather in the distribution of grades. The distribution in his manual class was a normal bell curve, but the CAD class had polarized results. Many CAD students without computer experience failed because (1) their computer skills were not developed enough to solve problems on the computer, and (2) their understanding of the material was weak since they devoted more of their study time to learning CAD. These results suggest that exams given on the computer should be delayed until later in the semester. The level to which E28 students succeeded in gaining confidence with CAD is shown in Figure 7. Seventy-three percent of the students reported feeling "confident" or "very confident" with computers and IBMCAD by the eighth week. The results of the midterm exam, given in Figure 8, show no polarization of CAD test scores. Although the standard deviation of CAD scores was slightly higher than that for written scores, it appears that by the eighth week inefficiency with CAD was not an additional burden when students were trying to understand the concepts of the traditional class material.

Grading Options

An important decision in implementing CAD is determining how to evaluate student performance. CAD solutions may be evaluated in either hardcopy or softcopy form. Grading hardcopy is the more efficient and

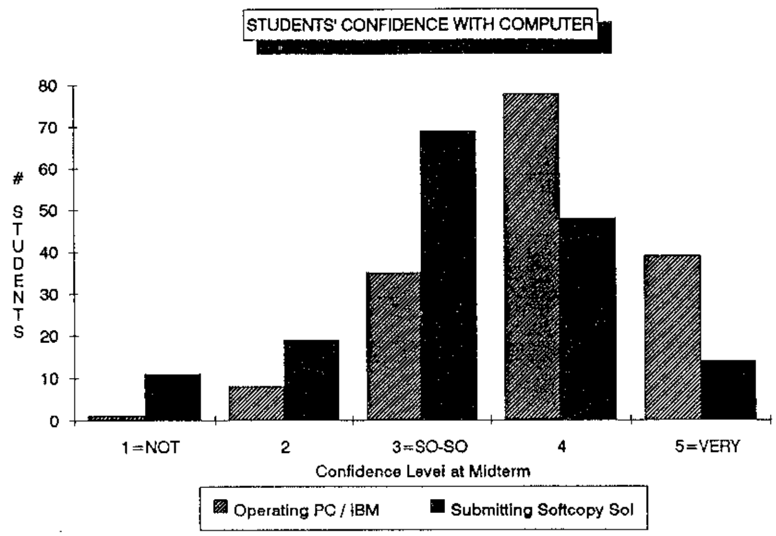


Figure 7. Students' confidence with computers and CAD at midterm

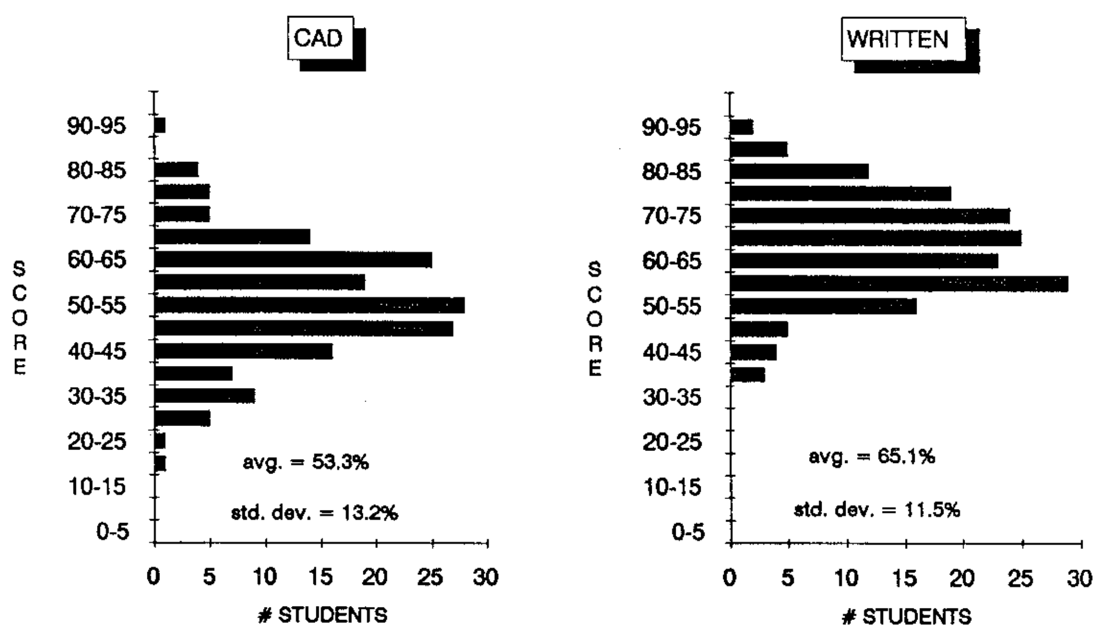


Figure 8. Grade distributions for written and CAD portions of midterm examination

Early Influences of the U. S. Military Academy on Engineering and Engineering Graphics Education in the United States

William L. Ross
Department of Industrial Technology
&
William A. Ross
Department of Technical Graphics
Purdue University
West Lafayette, Indiana

ABSTRACT

In 1802, Congress authorized the establishment of a military academy at West Point, New York. Although the first graduates of the military academy were neither professional soldiers nor engineers, the early curriculum at the institution included practical courses designed to meet the technical needs of the country. In 1817, "descriptive geometry" was introduced at West Point, and by the Year 1820, the academy had established the first engineering program in the United States. The intent of this article is to address the evolution of the engineering program and its drawing component at West Point, the influence of Sylvanus Thayer on the curriculum of the military academy, and the effect that the early faculty and graduates had upon other institutions of higher education.

INTRODUCTION

The profession of engineering dates back to mankind's earliest times. However, the records of history do not appear to contain any mention of the formal education or training of engineers until 1747 when, in France, Jean Rodolphe Perronet was charged with the responsibility of providing education in the technical areas concerned with building bridges and highways. The school established for this purpose, Ecole Nationale des Ponts et Chaussees, is generally acknowledged to be the first engineering school.

The late eighteenth and early nineteenth century was a time of significant historical change in the Western World. Technologically, the development of the steam engine and advancements in the textile industry led to changes in world economics. Politically, the authority of European monarchs was challenged by ideas expressed by the Age of Enlightenment while changes in technology forced further changes in the way people were governed. The American Revolution was the most significant challenge to the eighteenth century political status quo.

During the eighteenth century, technological advances in the art of warfare brought about further changes in the politics of the day. Untrained noblemen found it increasingly difficult to retain their positions as officers in the various European armies without becoming competent in the area of scientific knowledge. The refusal of many aristocrats to master this type of knowledge resulted in sons of poorer nobility, or minor gentry, (e.g., Gaspard Monge', Napoleon Bonaparte, etc.) being given the opportunity for additional education.

Gaspard Monge', the Father of Descriptive Geometry and the son of a French businessman, benefitted from the changing times. Monge' demonstrated extraordinary ability in mathematics and science as a young boy. Consequently, he was recommended for appointment to the school for army officers at Mezieres. Because of his father's humble background, Monge' was found unsuitable for training as an officer. However, in recognition of his significant potential, Gaspard was offered a position as a student "draughtsman" in the office for fortification design (Booker, 1963, p. 86). His genius was soon recognized by the institution Commandant and Monge' was reassigned as a student of, and later an assistant to, the professor of physics.

HIGHER EDUCATION IN AMERICA PRIOR TO 1800

Prior to the revolution, American universities and colleges were founded in religious origins. Most colonial schools were patterned after the English models of Oxford and Cambridge. The curriculum of these schools included classical study in Greek, Latin, Hebrew, and other courses designed to either train their students for the clergy, or in the words of Benjamin Franklin, "to carry themselves handsomely and enter a room genteely..." (Rudolph, 1962, p. 20)

Several of the American universities and colleges inherited by the United States from the colonies had added courses in mathematics or natural philosophy, however, institutions of higher education still did not address the practical needs of the new nation. A number of the country's early leaders, including George Washington, called for the creation of a national university which would focus upon "the shaping of patriotic citizens and of able civil servants" (Rudolph, 1962, p. 42).

1826	Charles Davies, first professor of engineering at West Point publishes expanded text on Descriptive Geometry
1824	Rensselaer Polytechnic Institute, first civilian school of engineering established
1821	Crozet's *Treatise on Descriptive Geometry* text published in English
1820	Engineering course sequence established at West Point
1817	Sylvanus Thayer appointed Superintendent of West Point
1816	Professor Claude Crozet introduces Descriptive Geometry
1815-1816	U. S. Military Officers study operation of French Military - Engineering Schools
1812-1815	War of 1812
1803	U. S. purchases Louisiana Territory from France
1803	Congress approves appointment of first "Drawing" instructor at West Point
1802	U. S. Military Academy established by Congress
1795	Gaspard Monge' publishes *Geometrie Descriptive*
1790	George Washington calls for establishment of a National University
1775-1783	American Revolution
1747	First school of engineering established in France Ecole Nationale des Ponts et Chaussees

KEY DATES and EVENTS

built by West Point graduates. The faculty, recruited by Thayer, wrote textbooks that dominated the subjects of mathematics, chemistry, and engineering during the 1800s.

"Eventually, the early influences of Mongean descriptive geometry introduced through West Point gave way to the development and rise of third angle projection in the United States."

In the area of descriptive geometry, a second and more extensive text on descriptive geometry was published in 1826 by Professor Charles Davies at West Point, probably after Crozet had left the Academy to become Chief Engineer of the State of Virginia. In America, as in Great Britain, descriptive geometry was taken up very early by the military, though its Mongean form became diluted over the years with indigenous drawing practices.

Eventually, the early influences of Mongean descriptive geometry introduced through West Point gave way to the development and rise of third angle projection in the United States. Joshua Rose formally promoted this "new system", on which current engineering graphics education is based, in his book entitled Mechanical Drawing Self-Taught published in Philadelphia in 1883 (Booker, 1963). Contemporary techniques for graphically creating, displaying, and manipulating geometry are being developed in computer aided drafting and design based on this same model.

Textbooks written at West Point were used at Rensselaer Polytechnic Institute while the first instructors of the Lawrence Scientific School at Harvard and Sheffield Scientific School at Yale were Academy graduates. Horace Mann, a leading American educator and a member of the Academy's Board of Visitors during the mid-1800s, stated that

> *The committee would express the opinion that when they consider the length of the course and the severity of the studies pursued at the Academy, they have rarely, if ever, seen anything that equalled either the excellence of the teaching or the proficiency of the taught.*
>
> (Ambrose, 1966, pp 82-83).

REFERENCES

Ambrose, S. E. (1966). *Duty, Honor, Country: A History of West Point.* Baltimore: John Hopkins Press.

Booker, P. J. (1963). *A History of Engineering Drawing.* London: Chatto & Windus Ltd.

Burns, E. M. & Ralph, P. L. (1964). *World Civilizations,* 2. New York: W. W. Norton & Company, Inc.

Griess, T. & Luvaas, J. (1904). *The Centennial of the United States Military Academy at West Point, New York.* New York: Greenwood Press.

Morrison, J. L. (1986). *The Best School in the World: West Point, Pre-Civil War Years, 1833-1866.* Kent, Ohio: The Kent State University Press.

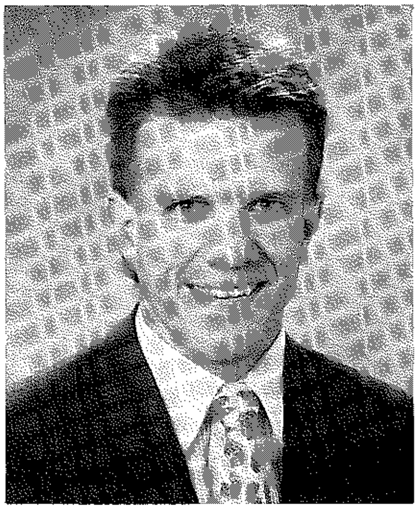
Reynolds, T. S. (1976). Gaspard Monge' and the Origins of Descriptive Geometry. *Engineering Design Graphics Journal,* 40 (10), 14-19.

Ricketts, P. C. (1895). *History of the Rensselaer Polytechnic Institute 1824-1894.* New York: John Wiley and Sons.

Rudolph, F. (1962). *The American College and University.* New York: Vintage Books.

Enhancing Visual Literacy of Engineering Students Through the Use of Real and Computer Generated Models

1991 Oppenheimer Award Recipient



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Engineering Design Graphics
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Norfolk, Virginia
November 6, 1991

Craig L. Miller
Purdue University
Technical Graphics Department
Purdue University
West Lafayette, Indiana 47907

Abstract

Engineering graphics educators are continually looking for strategies to implement more effective instruction. Technology is advancing rapidly in its ability to provide educators with a wealth of potential tools for providing many different experiences. The utilization of the computer and other instructional technology tools in educational settings must be controlled by the existing literature in learning styles, and instructional systems design. The use of technology has come into the engineering graphics curriculum with limited identifiable research efforts in these areas. 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 developed and advanced the spatial abilities of engineering graphics students.

Introduction

The ability to spatially visualize solutions to problems is an important skill for individuals in many diverse professions. Jensen (1986), in a survey of professional engineers in educational and industrial settings, found that spatial abilities are the most important engineering graphics concept that an individual should possess to be successful in the engineering profession. Bertoline (1988) notes that spatial ability attributes are important for the seemingly unrelated areas of achievement in mathematics (Maccoby & Jacklin, 1974), chemistry (Talley, 1973), biology (Lord, 1985), and science (Small & Morton, 1985).

Even though spatial abilities are indeed important for many fields, secondary schools and universities continue to emphasize a verbal approach to learning (Horton, 1982). Bertoline (1987) notes that students are given little or no formal instruction in the use and development of spatial abilities. Liben (1981) contends that background experiences and McGee (1979) claims that sexual differences may cause many individuals to initially possess lower spatial abilities, but they note that spatial abilities can be developed and enhanced through formal educational and informal experiences. If one of the goals of engineering education is to successfully prepare individuals for various engineering professions, instructional approaches should be developed that allow students to augment and advance their

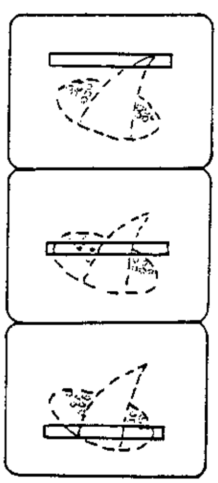
Purpose and Hypotheses of the Study

The purpose of this study was to determine the effectiveness of using computer-generated surface models and real models to develop students' spatial abilities when compared to using traditional methods for engineering students classified as visual or haptic perceptual types. The following research hypotheses for this study were tested at = 0.05:

1. Lowenfeld's claim that 47 percent of the population are visuals, 23 percent are haptics, and the remaining 30 percent are indefinites will hold true for the population drawn for use in this study.
2. The experimental instructional methods and media (traditional supplemented by real models, and traditional supplemented by computer-generated surface models) will interact with the learning style (visual-haptic mode) of the students, allowing for a greater increase in spatial abilities than would have occurred with the traditional engineering graphics instructional methods or media.
3. The measurement of visual-haptic aptitude will not correlate with the measure of spatial ability.

Instructional Setting for the Study

Technical Graphics 108 during Fall Semester 1990 was a one-hour traditional sketching-based engineering graphics course that consisted of a one-hour lecture and a one-hour laboratory meeting once a week. It was offered to all freshman engineering students and covered the topics of visualization, orthographic multiview sketching, pictorial isometric sketching, and orthographic reading. All formal instructional content was presented during the one-hour lecture. The one-hour laboratory did not introduce any new instructional content but was designed so that the students were able to work on their homework assignments and receive additional help from an undergraduate teaching assistant.



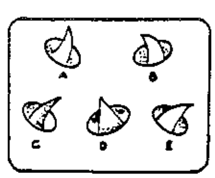


Figure 1. Illustration of a test question and answers from the Successive Perception Test 1.

Instrumentation

Two standardized instruments were used in this study: The Successive Perception Test I (United States Army Air Corps, 1944) and the Mental Rotations Test (Vandenberg & Kruse, 1978). The Successive Perception Test I was used to determine the visual/haptic perceptual type of the subjects in the population; thus it was used to assign subjects to the treatment groups.

The Successive Perception Test I (SP1) contains 38 items. Three items are practice items and 35 are the actual test items. The SP1 consists of black abstract line drawing symbols drawn on separate pieces of white cardboard. The white cardboard pieces on which the symbols were drawn (symbol cards) are then placed, one at a time, into a white opaque cardboard cover plate in which a horizontal rectangular window had been cut. The SP1 film shows the symbol cards as they are pulled through the cover plate, thus exposing small sections of the symbol until the entire symbol has been displayed. The entire symbol is shown through the window in one and one-half seconds. The subject can see only that part of the symbol that is displayed inside the window. As the symbol passes through the window the subject must remember the entire design and pick the corresponding symbol from five alternatives (see Figure 1).

The Mental Rotations Test (see Figure 2) was used to measure the spatial ability of the subjects. Although there are various measures of spatial ability, the Mental Rotations Test was selected for use in this study because this test has been empirically proven to be a valid and reliable test of spatial ability. The Directory of Unpublished Experimental Mental Measures shows validity correlations with other spatial tests to range from .31 to .68 (Goldman & Osborne, 1985, p. 238). Vandenberg and Kruse (1978) report that this test has only shown low correlations with tests of verbal ability. The Directory of Unpublished Experimental Mental Measures reports that this test has reliability ratings of .88 with the Kuder-Richardson 20 technique and the one-year test-retest correlations were .83 (Goldman & Osborne, 1985, p. 238).

Development of the Instructional Materials

Sixteen color rendered computer-generated objects were developed from the textbook pictorials. A programmed macro was also developed that would allow the user to select an object and rotate it in any direction with the use of two keystrokes.

Sixteen sets of twenty-five wooden blocks of the figures were also developed. The real models were solid wooden blocks. The surfaces were painted to match the computer-generated models and they were the same size as the computer-generated models.

Administration of the Successive Perception Test I

The entire population of Technical Graphics 108 was administered the Successive Perception Test I during the first laboratory session. From the results of this test the students were to be classified as either being haptic or visual perceptual types. L. A. Ausburn (1979) classified individuals as visuals if they scored a 21 or higher, or haptics if they scored 14 or less on this test. She based these scores on Lowenfeld's (1945) theory of visual/haptic perceptual type.

After reviewing the data of the Successive Perception Test I, a decision was made to redefine visual/haptic perceptual type for this study because there would not have been enough haptic students present in the population to allow a sample to be drawn. The mean score of the Successive Perception Test I was 21.493 with a standard deviation of 3.956. Because these values were relatively consistent throughout the population, a haptic perceptual type was defined as scoring a 17 or below and a visual perceptual type was defined as scoring a 25 or higher on the Successive Perception Test I.

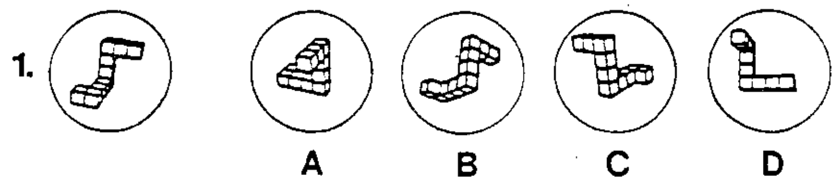


Figure 2. Illustration of a test question and answers from the Mental Rotations Test.

Selection of the Sample

The population (497 subjects) from which the sample was drawn consisted of freshman engineering students enrolled in Graphics for Engineers (Technical Graphics 108) during the Fall Semester of 1990 at the West Lafayette, Indiana, campus of Purdue University. The sample selected for the study was based upon the adjusted visual/haptic scale as determined by the Successive Perception Test I. The sample (150 subjects) involved students who were identified as possessing strong visual (75 subjects) or haptic (75 subjects) aptitude. Individuals classified as visuals (25 or higher on the Successive Perception Test I) were randomly placed into either the traditional exercise (n=25), the computer-generated model group (n=25), or the real model group (n=25). This same procedure was also used to randomly assign the haptic subjects (17 or lower on the Successive Perception Test I) into the traditional exercise (n=25), the computer-generated model group (n=25), or the real model group (n=25).

The experimental laboratory sessions were in place of their regularly scheduled one-hour laboratory sessions. The experimental laboratories were offered at alternative times to the regular laboratory sessions. This was necessary because of the logistical constraints of laboratory space being available during the study. Although the students had to attend a laboratory session at a different time than their normal laboratory time, all laboratory sessions, both traditional and experimental, were 50 minutes in length and a student could attend only one laboratory session each week. The size of the traditional laboratories ranged from nine to nineteen students. This was

Bertoline, G. R. & Miller, D. (1989). A visualization and orthographic drawing test using the Macintosh computer. *Proceedings of the 1989 Annual Mid-Year Meeting of the Engineering Design Graphics Division of the American Society for Engineering Education.* Tuscaloosa, Alabama.

French, T. E. (1913). The educational side of engineering drawing. Paper presented at the Annual Conference of the Society for the Promotion of Engineering Education. University of Minnesota.

Horton, J. (1982). Introspection and visual thinking for instructional technology. *Educational Technology,* 13, 6.

Jensen, J. J. (1986). The impact of computer graphics on instruction in engineering graphics. *Engineering Design Graphics Journal,* 50, (2), 24-33.

Languis, M. L. (1983). Learning effectiveness through applied research in technology for students with communicative disorders. United States Department of Education Proposal.

Liben, L. S. (1981). Spatial representation and behavior: Multiple perspectives. In Liben, L.S. & Patterson, A. H. & Newcomb, N. (Eds.), *Spatial Representation and Behavior Across the Life Span* (pp. 3-36). New York: Academic Press.

Lord, T. R. (1985). Enhancing the visuospatial aptitude of students. *Journal of Research in Science Teaching,* 22, 5, pp. 395-405.

Lowenfeld, V. (1939). *The Nature of Creative Activity.* London: Routledge and Kegan Paul.

Lowenfeld, V. (1945). Tests for visual and haptical aptitudes. *American Journal of Psychology,* 58, 100-112.

Lowenfeld, V. & Brittain, W. L. (1987) *Creative and Mental Growth.* New York: Macmillan Publishing Company.

McGee M. G. (1979). *Human Spatial Abilities. Sources of Sex Differences.* New York: Praeger.

Maccoby, E. & Jacklin, C. (1974). *The Psychology of Sex Differences.* The Stanford University Press.

Miller, C. L. (1990). A historical review of visualization in engineering graphics. Paper presented at the annual Mid-Year Meeting of The Engineering Design Graphics Division of the American Society of Engineering Education. November 1990, Tempe, AZ.

Orth, H. D. (1941). Establishing and maintaining standards of excellence in drawing. *Journal of Engineering Drawing.* 5, (1), 7-10.

Piaget, J. & Inhelder, B. (1967). *The Child's Conception of Space.* New York: The Norton Library.

Rowe, C. E. (1938). Methods and teaching of descriptive geometry. *Journal of Engineering Drawing,* 2, (1), 1-3.

Rowe, C. E. (1945). Basic models as an effective aid in teaching descriptive geometry. *Journal of Engineering Drawing,* 9, (1), 7-10.

Salomon, G. (1970). What does it do to Johnny? *Viewpoints,* 46, no.5, 1970, 33-62.

Simoneau, J., Fortin, C., & Ferguson, R. J. (1987). Using 3-D industrial software in a teaching environment. *Proceedings of the 1987 Annual Mid-Year Meeting of the Engineering Design Graphics Division of the American Society for Engineering Education.* Austin, Texas.

Small, M. Y. & Morton, M. E. (1983). Spatial visualization training improves performance in organic chemistry. *Journal of College Science Teaching,* 12, 41-43.

Talley, L. H. (1973). The use of three-dimensional visualization as a moderator in the higher cognitive learning of concepts in college level chemistry. *Journal of Research in Science Teaching,* 10, 263-269.

United States Army Air Corps (1947). J. J. Gibson Ed. *Motion picture testing and research. Army air force aviation psychology research program reports, report no. 7.* Washington, D. C.: U.S. Government Printing Office.

Vandenberg, S. G. & Kruse, A R. (1978). Mental rotations, a group test of three-dimensional spatial visualization. *Perceptual and Motor Skills,* 47, 599-604.

Vander Wall. W. J. (1981). Increasing understanding and visualization abilities using three-dimensional models. *Engineering Design Graphics Journal,* 45, (2),72-73.

Young, C. H. (1952). The descriptive geometry three-dimensional project. The Cooper Union Engineering School-day session. *Journal of Engineering Drawing,* 16, (2), 13, 15, 39.

Zavotka, S. (1985). *Three dimensional computer graphics animation: A tool for spatial skill instruction.* Unpublished doctoral dissertation, The Ohio State University.

Scientific Visualization: An Experimental Introductory Graphics Course for Science and Engineering Students

Eric N. Wiebe

Graphic Communications Program
North Carolina State University
Raleigh, NC

ABSTRACT

A new course, 'Scientific Visualization', has been offered by the Graphic Communications Program at North Carolina State University. The purpose of the course was to expose undergraduates to the use of computer based graphics as both a problem-solving and communicative tool in engineering, the sciences and other technical areas. Rather than focus on the more traditional areas of engineering graphics, this course explored a much broader role of graphics in science and technology. A single section of the course is offered to 14 students in a lab equipped with 7 Macintosh II computers and a broad range of graphics software packages. The course consisted of lecture, demonstrations, field trips and both in-class and out-of-class lab work on the computers. In addition, there were readings in current applications of graphics in various scientific and technical fields. Recommendations are given to the future direction of this course and its role in the engineering design graphics curriculum.

INTRODUCTION
Motivation for the class

Beginning in the Spring 1990 semester, the Graphic Communications Program at NC State University chose to engage in an exploration of the future direction of technical graphics in higher education. Rather than simply focusing on the instructional nuances of teaching Computer Aided Design and Drafting (CAD/D), current thought on the role of graphics in science and technology was explored. The experimental class, 'Scientific Visualization,' was a vehicle for exploring a new paradigm for an introductory course in technical graphics. The goal was to develop a course in which students in varied technical and scientific disciplines would be exposed to a broad range of graphics-based tools and to develop visualization skills — both important to their future success in their professions (Bertoline, 1989; Cunningham, 1990).

The engineering professions have followed the Information Age in a movement away from the tangible and towards the conceptual and theoretical. In this way, these professions have moved closer to the hard sciences in their approach to research and professional practice. Arriving as part of the Information Age in the late 20th century was the advent of affordable computer technology capable of producing extremely sophisticated graphics. This technology allows those in the sciences, engineering and related technical fields to produce images that lend a new way of evaluating theoretical problems. The same technology also creates virtual objects on the

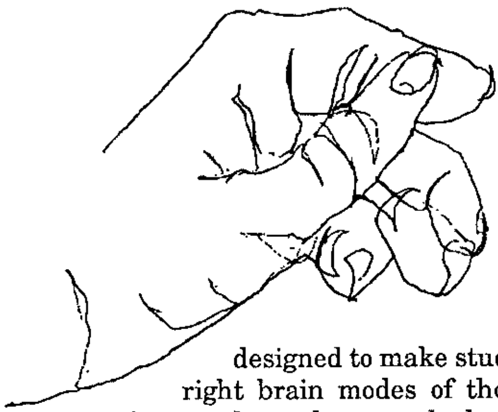


Figure 1

designed to make students aware of right brain modes of thought. In the first week, students worked strictly on hand sketching exercises for homework (Fig. 1) with their lab time spent orienting themselves to basic Macintosh operation. The MacPaint software package was introduced during the second week of class to complement the hand sketching exercises. As an archetypal Macintosh graphics package, it introduced students to the design and layout of other graphics packages used in the course. By adapting some of Edward's visualization exercises to be done in MacPaint, students continued their work with visualization while learning about computer graphics tools. After MacPaint, MacDraw II was introduced to the class with the third week's assignment being to design a personal weekly class schedule with the package. It was during this week differences were drawn between two basic kinds of graphic data structures: bit-map (as represented by MacPaint) and object-oriented (as represented by MacDraw).

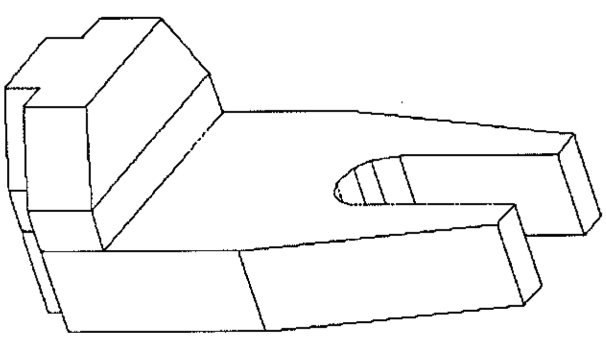


Figure 2

3D Visualization

After the initial exercises in visualization, the class moved into visualizing and manipulating virtual 3D objects. This was done using a 3D "sketching" software package, Swivel 3D. Rather than beginning with generating 3D forms, the first week using this software package was spent viewing and manipulating an existing 3D object (Fig. 2). During the second week of this segment, the students began to make their own virtual objects in Swivel 3D. The students were introduced to the basic concepts of generating forms and then asked to design an object synthesized from at least six 3D forms.

Robot Arm Project

The organization of object primitives into a hierarchical tree in Swivel 3D allowed for additional instructions as to how segments of the tree were "joined"; tree segments could be locked so there was no relative movement at all or allow constrained linear or rotational movement. The skills of viewing and generating objects were brought together with these articulation techniques in a two-week project designing a robot arm (Fig. 3). After an initial brainstorming session where the basic specifications for the robot arm were developed, the arm was broken down into six logical components and a 2- or 3-student team assigned to each component.

Molecular Modeling

Though still concerned with 3D modeling, this segment on molecular modeling took the class from human scale objects to micro scale ones. There was also a shift from working with a relative coordinate system to an absolute one. Given an edited copy of X-ray crystalography data of a molecule, the assignment was to construct a "ball and stick" model of the molecule using the given Cartesian coordinate and connectivity information (Fig. 4). The students not only had to locate each atom at its precise location, but also label it with an appropriate name for later identification. Because the students had no initial picture of what the molecule looked like, they had to rely solely on their transformation of numerical data and topological information into a graphic model. The second week of this segment extended this concept by again taking edited crystalographic data and constructing a unit crystal cell from the previously constructed molecule.

Medical Imaging

This segment of the course marked the move away from 3D to 2D graphics and from object-oriented data formats to pixel-based ones. The software used for this portion of the class was a free software package distributed by the National Institutes of Health (NIH) called Image. Image was designed to edit and process color and grey scale images, extract measured data and display the resulting images. The first assignment of this segment was to generate and notate density line plots of images of electrophorises gels (commonly used in the biological sciences). The purpose was to explore the translation of pixel-based images into graphs and finally into numeric information. The next assignment worked with an electron microscope image of a rat lung. Students were to measure and visually highlight red blood cells and capillaries by identifying and manipulating the grey-scale density values of these elements in the image.

Other In-Class Curriculum Materials and Field Trips

In addition to completing the weekly lab assignments, the students were periodically required to read trade journal articles and a textbook (Friedhoff, 1989) on closed reserve in the library. This gave them an in-depth exposure to some industrial and research applications of graphic techniques discussed in class. Because the articles were coming from trade journals rather than research journals, the writing style and content was relatively accessible to the students. Field trips were another way that the students were able to get exposure to actual graphical applications. These field trips were taken to both research labs on campus and to private companies.

CONCLUSIONS

Being a course that not only used computer software, but many different ones, very much influenced the development of the course (Table 1). As was mentioned above, the sheer number of software packages being introduced to students over a 15-week period demanded a highly consistent user interface that lent itself to a soft learning curve. The Macintosh platform was the only computer platform available that could provide this and, even still, software had to be chosen carefully in order to make sure that it adhered to Apple's interface guidelines. This consistency between software packages had many advantages. For instance, with each succeeding software package introduced, the class as a whole was able to quickly assess the types and quality of the graphic tools available and integrate them into a repertoire of existing tools.

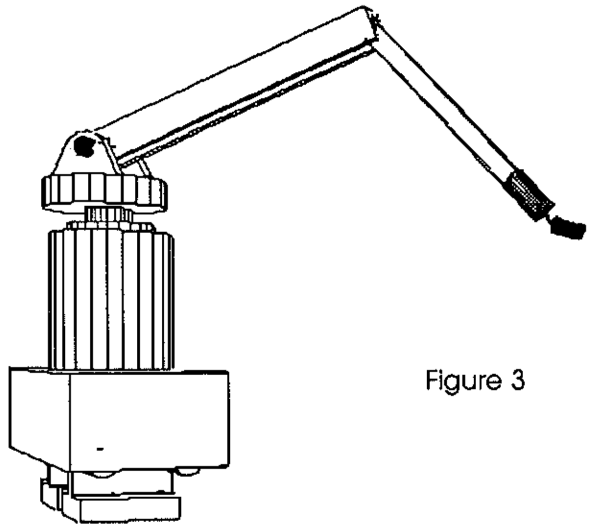


Figure 3

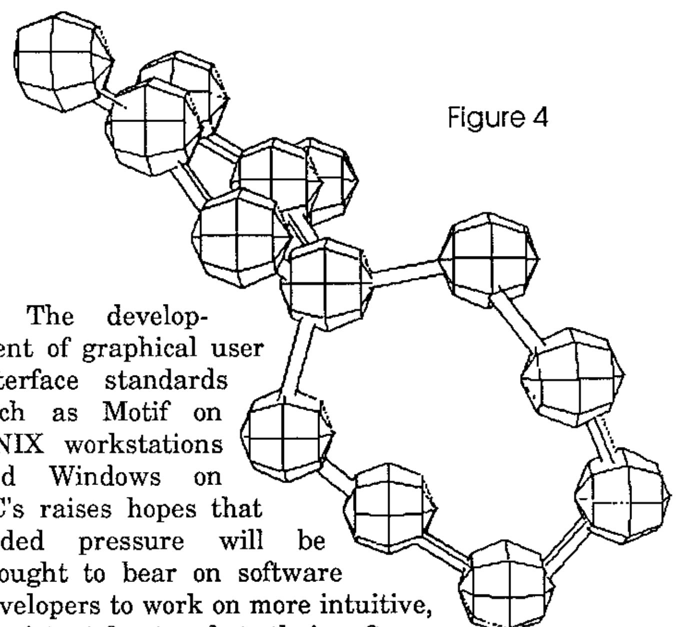


Figure 4

The development of graphical user interface standards such as Motif on UNIX workstations and Windows on PC's raises hopes that added pressure will be brought to bear on software developers to work on more intuitive, consistent front ends to their software packages. There is the added benefit that these new user interface standards also include some level of support for inter-application communications; encouraging a more "tool"-based approach to software usage.

SOFTWARE	APPLICATION
MacPaint	2D pixel-based drawing
MacDraw II	2D object-oriented drawing
Swivel 3D	3D sketch modeler
NIH Image	2D pixel-based image processing
Theorist	Symbolic math
The Game of Fractals	Fractal image generation
MacroMind Director	Animation

Table 1

One of the primary goals of this course was to improve visualization abilities; to be able to mentally perceive and manipulate 2D and 3D forms and patterns. It is hoped that improvement of these abilities would in turn lead to the tendency of using more holistic, right-brained techniques in problem solving. In the subjective judgment of the author, there was considerable improvement in the visualization ability of the students over the course of the semester.

What portion of 'Scientific Visualization' belongs in a survey course really depends on how the educational mission of engineering design graphics is defined. If the survey course should only include graphics that impact on the mainstream engineering profession and even more narrowly on mechanical and civil engineering, then there are certainly many portions of the 'Scientific Visualization' course that are not relevant. Even with this more narrow focus, the first seven weeks of the course has the potential of being integrated into the more traditional survey course or developed into a course of its own. This new class would focus on right-brain thinking and 3D visualization. This focus would also reduce the number of software packages to 2 to 3 from 7 covered during the 15 weeks.

For all of the material covered, there is still other material worth examining. As an example, by the fourth week of the course, the students were applying color to their work, yet there was virtually no discussion in class on the use of color. Another element of the course that deserves further exploration is that of the role of animation in visualization. The subject of animation appeared regularly in the lecture component of the class. The students began to explore it in labs beginning with the robot arm project and then again in their final projects. Animation in the context of this course cannot easily be relegated to an isolated segment of the course. As with the issue of color, the value of animation as both a vehicle for improving visualization skills and a problem-solving technique needs to be evaluated against the time constraints in the course.

REFERENCES

Bertoline, G. R. & Miller, C. L. (1989). Spatial Visualization Research and Theories: Their Importance in the Development of an Engineering and Technical Design Graphics Curriculum Model. ASEE/EDGD Proceedings of the Mid-Year Meeting, 1989, 95-104.

Cunningham, S., et al. (1990). Visualization in Science and Engineering Education. in Nielson, G. M. (Ed.). Visualization in Scientific Computing. Washington, DC: IEEE Computer Society Press. 48-57.

Edwards, B. (1989). Drawing on the Right Side of the Brain. Los Angeles: Tarcher.

Friedhoff, R. & Benzon, W. (1989). Visualization: the Second Computer Revolution. NY: Harry Abrams.

Grady, S. (1989, March). Here Comes the Visualization Workstation. Computer Graphics Review.

McCormick, B. H., Defanti, T. A., Brown, M. D. (Eds.). (1987). Visualization in Scientific Computing. Computer Graphics (ACM Siggraph), 21 (6).

Nishimura, Y. & Sato, K. (1985). Dynamic Information Display. Visible Language, 19 (2), 251-271.

Sadowski, M. A. (1989). Right Brain Thinking. ASEE/EDGD Proceedings of the Mid-Year Meeting, 1989, 53-59.

Tovey, M. (1986). Thinking Styles and Modelling Systems. Design Studies, 7 (1), 20-30.

Wiley, S. E. (1989). Advocating the Development of Visual Perception as a Dominant Goal of Technical Graphics Curricula. Engineering Design Graphics Journal, 53 (1).

Wiley, S. E. (1990). Computer Graphics and the Development of Visual Perception in Engineering Graphics Curricula. The Engineering Design Graphics Journal, 54 (2).

Interactive Computer Graphics Software For Teaching CADD

John G. Cherng
Mechanical Engineering Department
University of Michigan-Dearborn
Dearborn, MI 48128

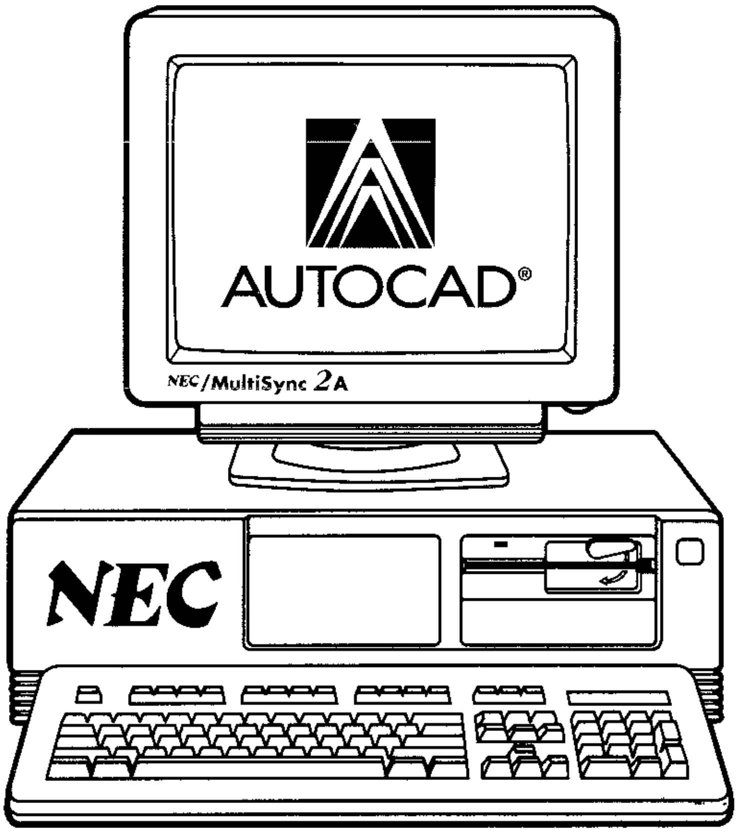
Wen J. Wu
Mechanical Engineering Department
University of Toledo
Toledo, OH 43606

Abstract

This paper presents the methodology and approaches that are employed to develop interactive computer graphics for teaching CADKEY in a freshman Computer-Aided-Design-Drafting (CADD) course. The software was written in the CADKEY Advanced Design Language (CADL). The software consists of CADL subroutines (i.e., CADL files) and macros to provide the student with descriptions, examples, and exercises for several key functions of CADKEY.

The software is interactive, self-explanatory, and menu driven in nature. No additional system configurations are needed. Students communicate with the software by responding to the prompts and taking properly instructed actions. Many unique features were built into the software so that the training process will appear interesting and challenging to the student. The experience received from using this software and the availability of the software are provided in the paper.

editors note: On page 15 of Vol. 55, NO. 3 of the Autumn 1991 Issue of the *Engineering Design Graphics Journal*, John G Cherng and Wen J. Wu's addresses were incorrect. The addresses should read as seen here.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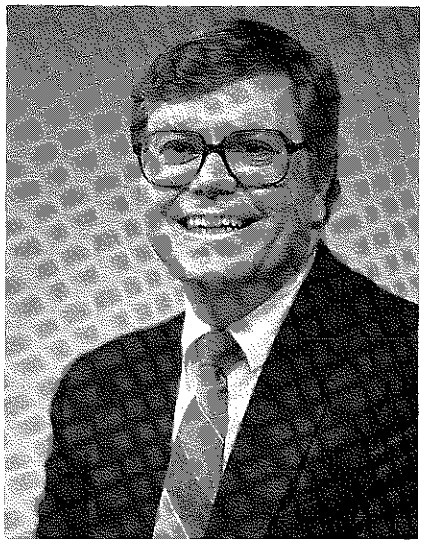


Chairman's Message by John T. Demel

In our general society, the word communication includes written and oral communications. When a person cannot write or speak using standard English, that individual is considered to be uneducated. If they cannot read, write, or speak English, then they are considered to be illiterate. I would challenge you to find any of your engineering or other academic or industrial colleagues to disagree with the previous two statements. They probably would agree also that students need formal classes to learn how to communicate.

Once you have established that English literacy is necessary for common communications, ask these same academic colleagues whether they feel that engineering graphics is necessary for engineering communications. (Curricula in many schools indicate that it is not because it is not included/ required.) I have heard such comments as 'graphics is not important,' 'they can learn that on their own,' and perhaps more importantly, 'I hated engineering graphics when I was a student.'

In the engineering world, one of the key forms of communication is the engineering drawing. Whether it is created, transmitted, and read on paper or through electronic media, the same set of standards apply. Any engineer or technician reading an engineering drawing will interpret the drawing in the same way provided that standards are followed in the drawing and the reader knows the standards. Therefore, an educated engineer is one who can create and supervise the creation of correct drawings. As we saw in Norfolk at the EDGD Mid-Year Meeting, it takes a lot of drawings to build an aircraft carrier.

I believe that we need to work with our industrial colleagues to establish the importance of accurate engineering communication. Such communication requires written, oral, and graphical skills and knowledge. The engineers in industry recognize the role of the engineering drawing in construction, testing, manufacturing, and quality control. The electronic systems may dictate that the standards will change and the media will change but a solid model with no dimensions for checking purposes does not yet provide enough information for each individual in the design to quality control process to check what needs to be done.

In the last issue, I commented on the NSF Engineering Education Coalitions and the need for the professors who constitute this division to play a part as the new curricula are being designed. We need to work with our professional and industrial colleagues to ensure that communications (particularly graphical communications) is included in the engineering curricula. If we are to compete in a global economy, we, as a nation, cannot afford to produce illiterate engineers.

Do some library research to find out whether our fiercest competitors - Japan and Germany - include engineering graphics in their curricula. Write to me or our Journal Editor, Mary Sadowski, and tell us what you find.

As a closing note, the Mid-Year Meeting in Norfolk was a big success. Our thanks go to Moustafa Moustafa and Barry Crittenden as host and technical session chair respectively and to the other Old Dominion University staff who contributed.

1992 ASEE
Design Graphics Division
Annual Conference
University of Toledo
Seagate Center
Toledo, Ohio
June 21 - 24, 1992

The Glass Capitol of the World and the home of the Mud Hens, Toledo, Ohio, is the site of the 1992 ASEE Annual Conference. Currently in the planning stages, the EDGD program will include five technical sessions, the annual business luncheon, and the annual awards banquet. Come, participate, and enjoy.

Program Chair:
Doug Frampton
Engineering & Science Tech. Div.
The University of Akron
120 Shrank Hall South
Akron, Ohio 44325-6104

Seminars

Saturday, June 20 12:30 - 4:30

ASEE/SDRC
I-DEAS Solid Modeling Workshop

Instructors:
Dr. Robert Mabrey
Tennessee Technological University
Mark Lawry, Technical Support Mgr., SDRC University Consortium
Saturday, June 20 12:30 - 4:30
Sunday, June 21 8:00 - 12:00

ASEE/EDGD ***Geometric Dimensioning & Tolerancing***

Instructor:
Patrick J. McCuistion
Ohio University
This workshop focuses on a basic understanding of geometric dimensioning and tolerancing as a means of specifying engineering design requirements with respect to the actual "function" and "relationship" of part features. Overhead transparencies and actual parts are used to explain the different geometric characteristics relative to their functional tolerance zones.

Technical Sessions

• Monday, June 22

8:30 - 10:15 am **Session #1238**
Visualization/Solid Modeling: Past, Present, Future

10:30 - 12:00 noon **Session #1338**
Future Directions for Engineering Design Graphics

12:30 - 2:00 pm **Session #1438**
Engineering Graphics: Curriculum Issues I

6:00 - 8:00 pm **Session #1838**
Engineering Design Graphics Division Executive Committee Meeting

• Tuesday, June 23

8:30 - 10:15 **Session #2238**
Engineering Design Graphics: Teaching Design Strategies

12:30 - 2:00 pm **Session #2438**
EDGD Annual Awards Banquet

• Wednesday, June 24

Session #3428
EDGD Business Luncheon

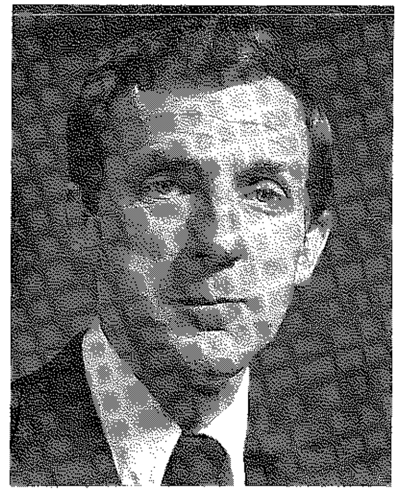
Nominees for Division Officers (1992-92)

The following persons have been nominated for the positions indicated. Ballots will be mailed this spring.

Ron Barr, Chairman, EDG Nominating Committee

Vice-Chair 1992 - 1993

Jerry V. Smith



J. Barry Crittenden

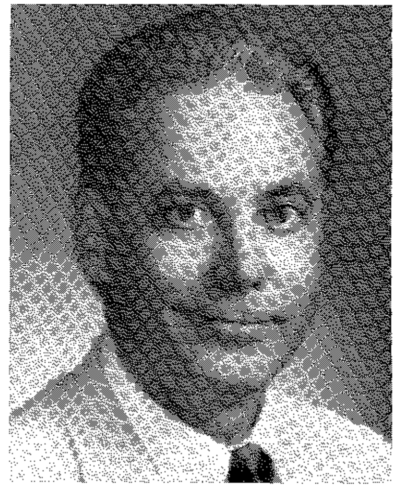
Jerry is Professor and Department Head of Technical Graphics at Purdue University. Over the past thirty-two years, he has been responsible for the development and coordination of numerous courses and has taught eighteen of the thirty courses offered by the department. He was instrumental in the research, selection, and purchase of the equipment for five traditional drafting/drawing labs, five CADD labs, and eighteen faculty offices in the Knoy Hall of Technology. He has co-authored two text/workbooks for CADD software packages and has given numerous presentations at various professional society conferences. He is a member of the American Design Drafting Assoc. (ADDA), the National Computer Graphics Assoc. (NCGA), and the Computer and Automated Systems Assoc. (CASA) of the Society of Manufacturing Engineers (SME). Since 1982 Jerry has served EDGD as Program Director for the 1984 mid-year conference and as advertising manager of the EDG Journal.

Barry is an Associate Professor in the Division of Engineering Fundamentals at VPI & SU. He has been a member of the EDGD/ASEE since 1974 and has been active in the Division, serving as Program Chairman twice (most recently for the 1991-92 Mid-Year Conference in Norfolk), Secretary-Treasurer (1985-88), and Director: Publications (1988-1991) which included the position of Editor of the Engineering Design Graphics Journal. He participated for three summers in the NASA/ASEE Summer Faculty Fellowship Program, one summer being devoted exclusively to CAD/CAM. Besides being a member of ASEE, he is a member of the American Institute of Aeronautics and Astronautics and the Virginia Academy of Science. After completing his formal education (BS in 1965, MS in 1972, and Ph.D. in 1976), he became a registered professional engineer in Virginia.

Director of Programs 1992 - 1995

Michael D. Stewart

Mike is an Associate Professor of Engineering Technology at the University of Arkansas at Little Rock. He is the director of the Center for Computer Aided Design and Manager of the U.A.L.R. CAD Training Center. He earned his BS and MS in Industrial and Technical Education in Nebraska. Mike has written and presented papers at EDGD conferences, and other national conferences, and is currently co-authoring "Solid Modeling with SilverScreen". Mike has been working with solid modelers since 1985, and is active in the curriculum development area, most recently concerning the modern EDG curriculum models. He did beta testing of the NSF modern curriculum EDG model. As Director of the Center for C.A.D., he was responsible for the selection and purchase of the computer equipment and software when it opened in 1985. He has continued to upgrade and expand the Center since then. As Manager of the CAD Training Center, he coordinates, schedules, and teaches AutoCAD and Intergraph training classes to industrial clients. His research interests are in solid modeling, coordinate measuring machine interfaces to CAD databases, and CAD/FEA analysis. In addition to being a member of the ASEE and EDGD since 1984, he is the founder and past President of the Arkansas MicroCAD Users, founder and President of the Arkansas Chapter of the National Computer Graphics Association (NCGA), and member and faculty advisor for the Society of Manufacturing Engineers (SME).



Deloss H. Bowers

Until this fall, Del was an Associate Professor of Interactive Computer Graphics and Coordinator of Freshman Engineering Graphics at Arizona State University. He recently made the move to the Colorado School of Mines where he is working to integrate graphics into the engineering curriculum. He has been a member of ASEE since 1983. Recent professional activities include presentation of papers at national and regional conferences, journal articles, and contributions to workbooks and textbooks. Ongoing research activities include investigation of teaching methods to improve visualization and creativity.

Submission of Papers and Articles for the *Engineering Design Graphics Journal*

Submit papers, including an abstract of no more than 200 words, as well as figures, tables, etc. in quadruplicate (original plus three copies) with a cover letter to:

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Technical Graphics/Knoy Hall
Purdue University
West Lafayette, IN 47907-1419.

Use standard 8-1/2 x 11 inch paper only, 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. Therefore, ensure that all the line work is black and sharply drawn and that all text is large enough to be legible if reduced to single or double column size. High quality photocopies of sharply drawn illustrations are acceptable. The editorial staff may edit manuscripts for publication after return from the Board of Review. Galley proofs may not be returned for author approval. Authors are therefore encouraged to send editorial comments from their colleagues before submission of papers.

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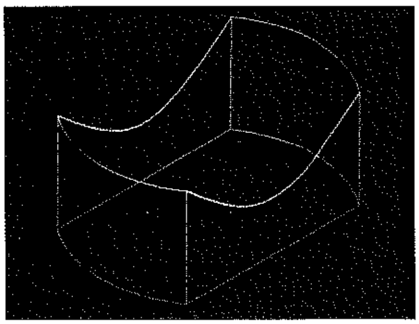
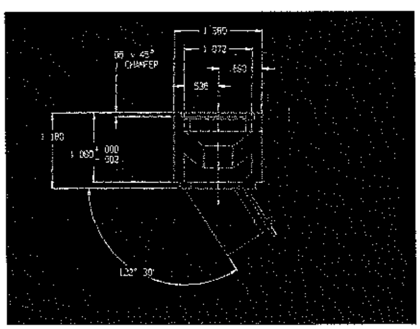


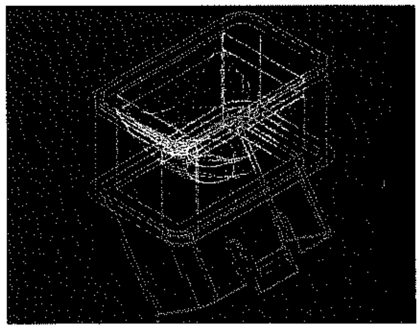
Problem #1

Problem #1: How do you translate your "bright idea" into a form others can understand? CADKEY gives you *all the tools you'll need —from wire-frame to CADKEY SOLIDS®*—to create complex designs quickly and easily. The parabolic curve pictured above may look simple, but it's a design our competition *can't* handle. Ask them.



Problem #2

Problem #2: Need to convey your idea to engineers in Zurich and CNC machinists in Seoul . . . with accuracy in the *ten thousandths?* CADKEY'S ANSI, ISO, DIN and JIS compliance assures clarity and reliability *anywhere in the world.*



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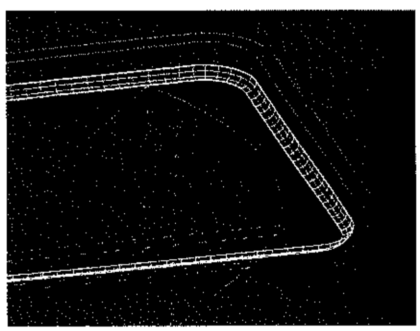
Problem #3: Want to make design changes? With CADKEY'S *transformation, editing, and detailing functions,* adjustments are no problem. Details and dimensions are *simultaneously and automatically updated.*



Problem #4

Problem #4: Will the design work? CADKEY goes way beyond simple polygon meshing to *true surface definition.* Ask our competition if they can handle variable radius fillet blends or surface intersections.

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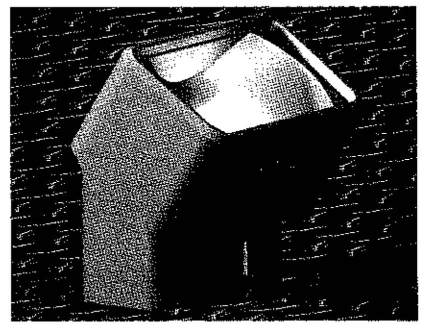

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