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ENGINEERING DESIGN GRAPHICS DIVISION

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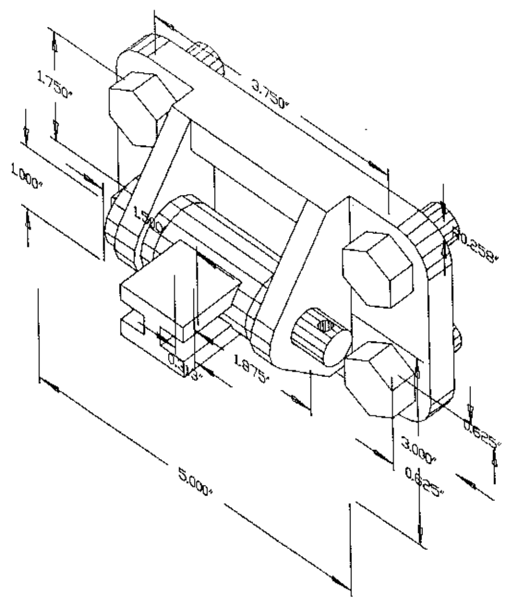

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A Visualization and Orthographic Drawing Test Using the MacIntosh Computer

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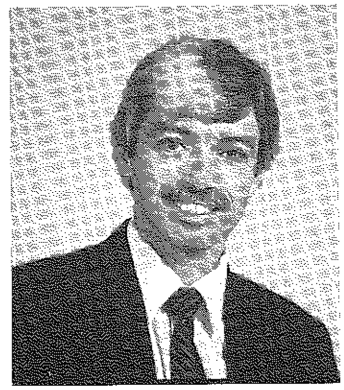

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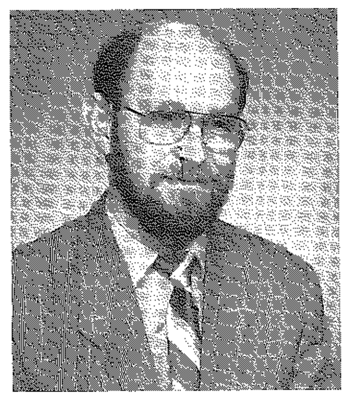

(recipients of the 1989-90 Oppenheimer Award)

An examination to determine a student's visualization capabilities has been developed which uses orthographic drawings displayed on the MacIntosh computer. This examination, the Spatial Visualization Test (SVT), has two versions, both developed to measure visualization ability, time to visualize, and reaction time. The SVT indicates the learner's ability to visualize complex 3-dimensional objects from the six principal views. All of these measures are automatically recorded by the computer during the testing process and results are printed after the student completes the test. This gives the student and his instructor an indicator of the student's ability to visualize and read orthographic drawings.

Statement of the Problem

Drawing, the technology of graphical representations, is used to express engineering ideas and as a means of communication in many other areas. The ability to represent the world graphically is based on a person being able to visualize the world in his or her own mind. Sigel[1] believes that a person does not naturally have representation ability. Visualization, according to Piaget and Inhelder[2], is a learned trait that is developed in a sequence of stages. The exact age that a child enters a stage will vary from child to child, but a child will develop through the stages in the reported sequence. Kangy[3] professes that to learn technical drawing or engineering graphics, the person must have spatial visualization skills equal to the desired task.

Spatial visualization is also a very important prerequisite for other seemingly unrelated areas. It has been reported that spatial visualization ability is related to achievement in mathematics[4], chemistry[5], biology[6], and science[7]. Languis, et. al.,[8] also found that imagery is important for language, memory, thinking, learning, and problem solving[8]. In the area of spatial visualization, persons in the top ten percent of ability have been identified as possessing a requirement for success in eighty-four occupations, as listed by the United States Employment Service. Eighty-five percent of these individuals are represented in four job categories: engineers, scientists, drafters, and designers.

Representing the world graphically is a fundamental communications skill used by engineers to change their conceptual designs into sketches or engineering drawings' according to Voland[9]. In a survey of industry and academic representatives of engineering graphics, Jensen[10] found that both groups rated spatial visualization as the most important of fourteen different skills. Bowers, et. al.[11], suggest that there is evidence that visualization is very difficult for many students.

The Test Development

The nature of the problem was to develop computer graphic models of 3-D images that can be used to access visualization skills and assist individuals with low spatial ability with remedial education. These computer models are to then be used to develop future research in visualization.

The SVT, developed under an Ohio State University Seed Grant[12], is for use on any MacIntosh Plus, SE, or Mac II computer with Hypercard. Surface 3-D models of thirty different cut-block shapes were created with Super 3D software. The six principal orthographic views of the model were extracted and saved. The Super 3D files were then brought into Super Paint for editing.

Hypertalk, a script or programming language, was used to create the SVT. Hidden lines were not included in Version 1 because it was used by mathematics and science teachers who had no engineering drawing background. Version 2 is in development and will include hidden lines and other improvements that were recommended from the pilot test.

How the Test Works

There are two equivalent forms of the SVT, each taking 30 to 45 minutes to administer. Developed for easy use, the test includes a tutorial to guide students through example problems. Indicating most answers simply requires moving the cursor to the desired display, followed by clicking the mouse button. Figure 1 shows the screen display that requests demographic information before the test is taken. Figure 2 indicates the screen appearance for the first question. An isometric view of the object is shown and the name of one of the six principal views is listed below the drawing.

At this point the subject must visualize how the requested view appears. After the examinee thinks he/she can identify the requested principal view, the mouse button is clicked and six possible answers appear in random order on the screen, as shown in Fig. 3. While the examinee is visualizing the object, the software activates a timer and records the amount of time from initial display of the isometric view until the mouse button is clicked (this is recorded as visualization time). Another timer starts after the possible answers are displayed to record the reaction time from the dis-

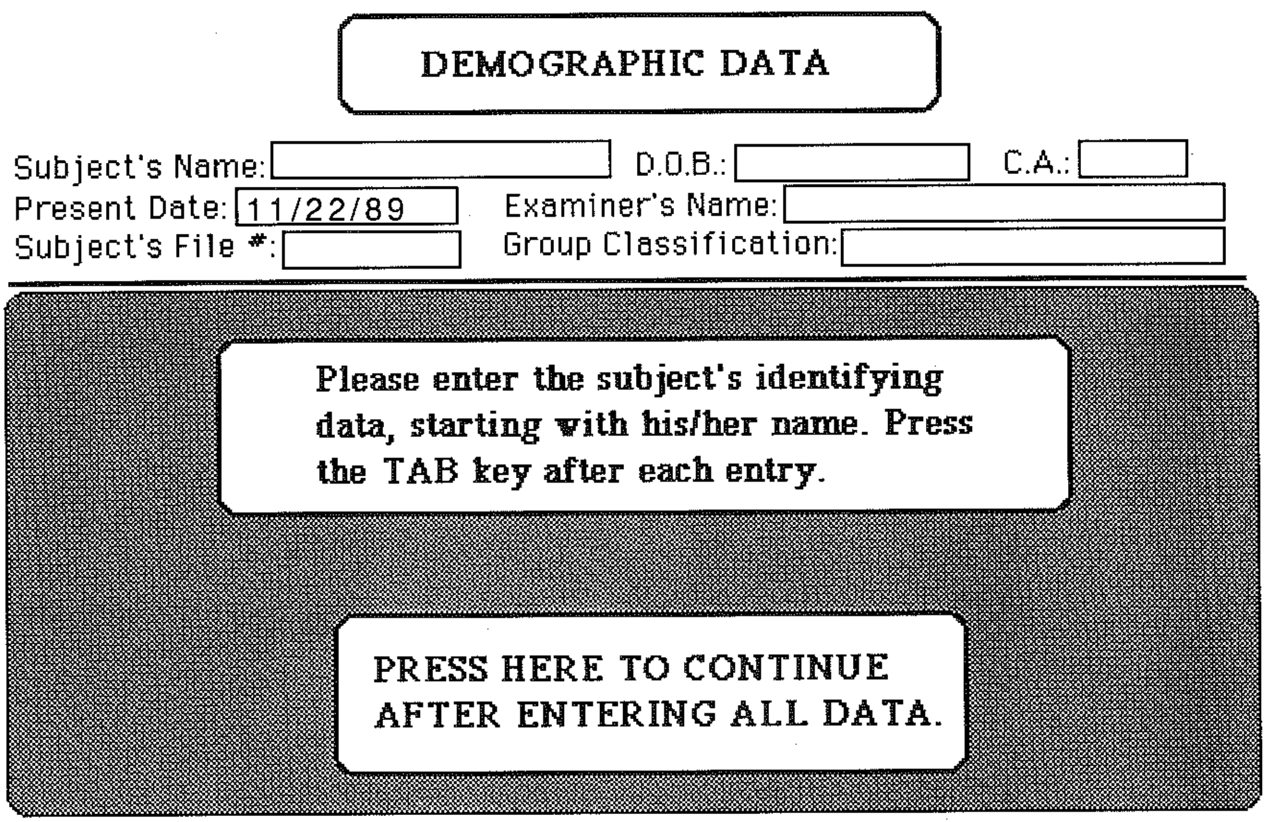

Fig. 1 Request for demographic information

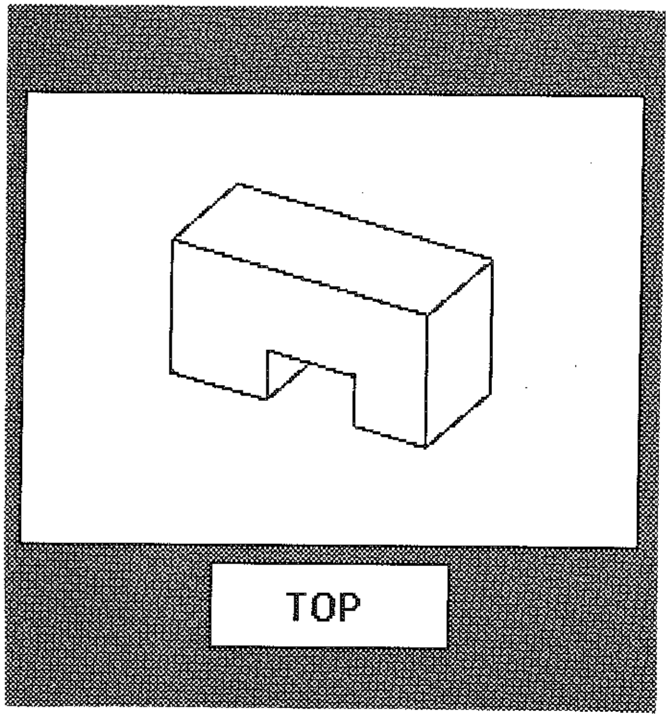

Fig. 2 Screen appearance for first question

play of possible answers to click of the mouse button (this is recorded as reaction time).

The cursor must be moved into the box believed to contain the correct answer and the mouse button is clicked. If the subject selects the correct answer, the word CORRECT is displayed on the screen and the next isometric view of an object is displayed. If the answer is incorrect, the word INCORRECT is displayed on the screen and the subject is given up to five additional opportunities to select the correct answer. The number of incorrect responses is recorded as well as the visualization and reaction time.

There are three sections in each of the two versions of the test and five different cut-block shapes in each section, for a to-

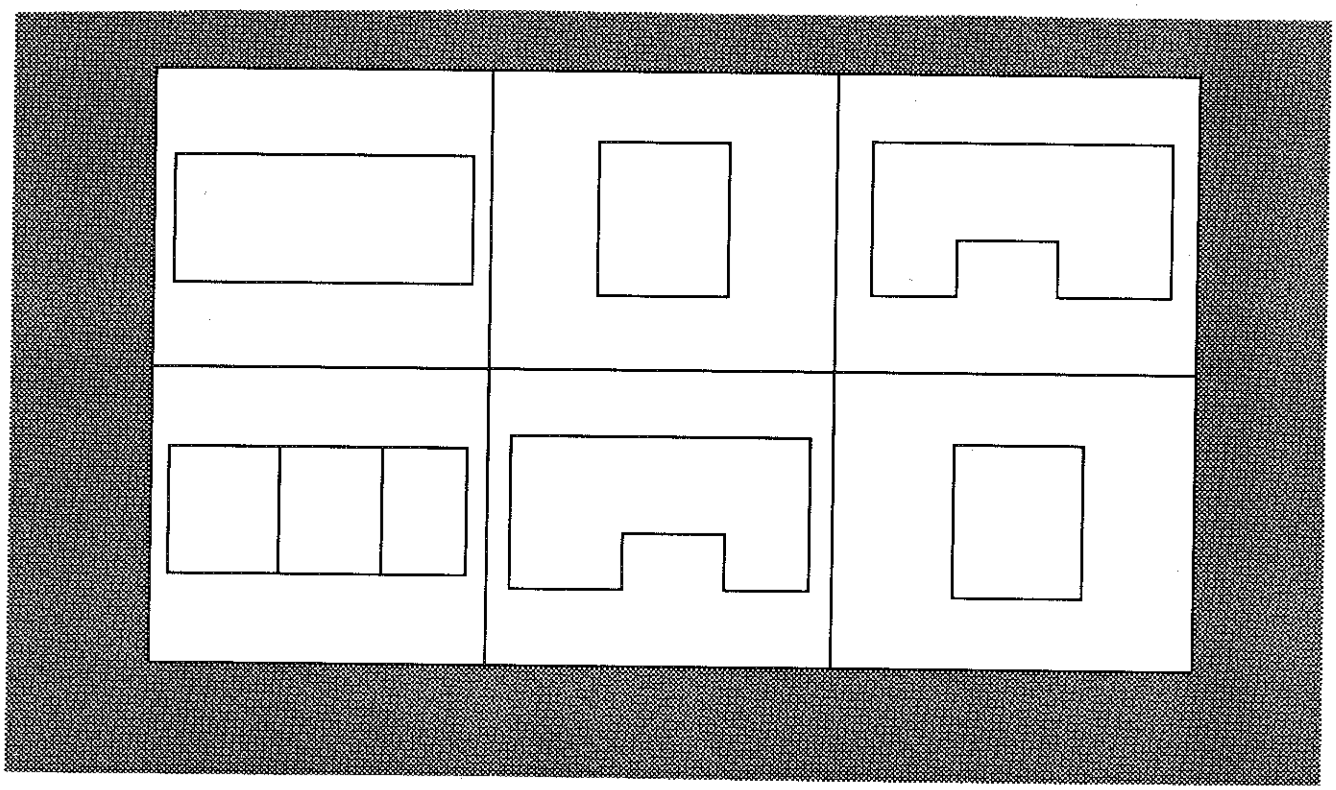

Fig. 3 Possible answers

tal of thirty shapes. The SVT tests, in random order, the examinee's visualization abilities for all six principal views of each cut block. After the test is complete, the SVT automatically compiles the results in the form of tables, as shown in Fig. 4. The first five stimuli recorded in Fig. 4 are for the five cut blocks in Section One of Form A of the SVT. Visualization and reaction times are listed for each stimulus. The examinee's response(s) are listed by type of view in the order that they were selected. If a response is correct, only one is listed. More than one response means that an incorrect answer was selected.

Figure 5 indicates the total number of incorrect responses and the mean visualization and mean response times that are automatically compiled by the SVT. The mean visualization and response times and total errors for each object are listed. This information is given for each form of the test.

Results of the Pilot Study

A pilot study was conducted during the 1989 Summer Quarter at Ohio State University on a group of thirty-seven mathematics and science teachers to test its validity and reliability. Another pilot study was conducted simultaneously on a group of eighteen engineering design graphics students at Ohio State.

The results of the pilot study indicate that the SVT may be useful to measure spatial visualization and knowledge of orthographic drawings. An item analysis of each stimulus was not complete for this report, but will

Visual Perspective Task

Subject's Name: Dan Miller D.O.B.: 7/7/56 C.A.: 32
Present Date: 6/27/89 Examiner's Name: Me
Subject's File #: 222222 Group Classification: High Visualizer

STIMULUS	OBJECT	VISUALIZATION TIME (SECONDS)	RESPONSE TIME (SECONDS)	SUBJECT'S RESPONSE (S)
1	3A	1.52	2.704	TP
2	3B	0.912	2.304	FT
3	3C	0.512	2.16	LT
4	3D	0.848	2.112	RT, BK
5	3E	0.64	2.064	RT
6	3A	0.608	2.384	RT, BM
7	3B	0.912	1.92	BK
8	3C	0.528	2.256	RT
9	3D	0.544	2.48	TP

Fig. 4 Test results

Subject's Name: terrence myles

	OBJECT	MEAN VISUALIZATION TIME SECONDS	MEAN RESPONSE TIME SECONDS	TOTAL SUBJECT ERRORS
	5O	2.72	3.677333	0
Form A Totals:	5P	3.634667	5.754667	1
	5R	2.645333	3.576	1
Total Mean Visualization Time:	5S	2.568	3.848	2
3.572444	5T	3.786667	3.842667	0
Total Mean Response Time:	5U	3.618667	3.146667	1
4.350222	5V	2.765333	5.496	0
Total Number of Errors:	5W	4.261333	3.962667	0
11	5X	4.378667	6.690667	0
	5Y	5.437333	6.778667	1
	5Z	5.138667	4.6	2

Fig. 5 Test results

be used to modify the SVT. Further pilot testing will be performed during the Autumn Quarter, 1989 at Ohio State University on engineering students.

Summary

More testing must be done on the SVT to determine if it is a valid and reliable instrument to measure visualization and orthographic drawing ability. Goals include the use of the SVT to:

1. measure visualization pre- and posttest capabilities,

2. measure the brain electrical activity of examinees during visualization processing, and

3. reeducate students who have low visualization or orthographic drawing ability.

The SVT should be useful for those in engineering and technical graphics who wish to pursue research in visualization or would like to determine their students' ability to visualize or understand orthographic drawings. Bertoline[13], Miller and Bertoline[14], Ross[15], Wiley[16], and others strongly advocate visualization research in engineering and technical graphics. The SVT provides our profession the tool necessary to pursue further research in visualization.

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Engineering Graphics as a Lecture Course?

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The results of an experiment in teaching engineering graphics using the traditional lecture-homework-laboratory technique are compared to a newer lecture-homework proposal. While the newer method reduces professor-student contact, it may prove to be as effective as the older method requiring laboratory instruction.

Introduction

Recent developments have affected the discipline of engineering graphics. Engineering education seems to be in transition from a more "board-oriented" to a more mathematical basis, and there appears to be a trend to put more of the burden of the learning process on the student. The growth and availability of computing power and computer graphics continues to necessitate changes in "basic" graphics courses. Engineering faculty are expected to create time to either teach more students or conduct more research. All of these factors have limited the material being covered by core graphics courses and the expectations of these core classes.

It is natural, in view of these changes and pressures, to ask the question, "Is it possible to teach engineering graphics, considered almost universally to be a lecture-homework-laboratory course, as a strictly lecture-homework course?" In an attempt to answer that question, an experiment was performed in which two sections of the introductory engineering graphics courses were taught using three one-hour lecture meetings per week for one semester. Two instructors collaborated on the project and each taught one experimental section as well as one control section that met for three two-hour periods. There were no other measurable differences in material presented, the intent being to duplicate the lecture for both types of classes.

Traditionally engineering graphics has been taught in a laboratory setting in which classes met for either two or three hours per week. This arrangement was required because of the "skills"-related topics covered and because engineering projects needed extensive manual documentation. Example topics in a traditional course include lettering, and geometric construction. These and other topics were taught with rather specific goals and students practiced until they were able to produce drawings which were "personality-free", correct and uniform in appearance and capable of duplication as blueprints.

It would be difficult to order chronologically all technological and economic pressures, but both have continuously influenced drawing procedures. Development of better light-sensitive dyes and improved ammonia development processes made inkwork unnecessary for working drawings. Simplified drawing standards eliminated "elegancies" of early drafting. Embellishments became expensive frills and were eliminated. Variable-width leads for mechanical pencils have made line contrast a trivial problem to a person exercising reasonable care. A wide variety of readily-available lettering machines have made excellent lettering a talent rather than an absolute necessity in many offices.

None of these things even begin to involve a computer, which properly utilized, has the potential for eliminating the drawing as a document needed for planning production. With the computer, the drawing may be completely bypassed, except as a verification tool of the machining process.

As the Computer Takes Over

Within the framework of a company's financial ability, formal drawing skills as such are becoming less important and hence, they are logically becoming less important educationally. The term "formal", when associated with drawing skills, should be emphasized as that which is becoming less important. As computers are assigned more and more documentation and manufacturing duties, sketching skills will become perhaps more important than ever, particularly when the operator is not an engineer. Lettering is a good example of one such "formal" concept.

Instruction in freehand Gothic lettering usually includes and once required "stroking". "Stroking" describes the direction and sequence of line drawing to best form a given letter in a way that all students would produce nearly identical letters with a quill pen(!). In a computer based environment, style control is accomplished by simply specifying text size and font. Instruction of freehand lettering is then more concerned with neatness and readability, not Gothic perfection. Similar statements can be made about other drafting topics, particularly line quality.

Similarly, while understanding the definition and consequences of the orthographic projection system is still important to a practicing engineer, increased computer power has also made possible the solution of many geometric properties by analytical methods which, until recently, would have been too involved for manual execution and too memory-hungry to accomplish even with a computer. Other topics, such as computer modeling and computer drafting, have been added to graphics courses because of their common use in industry.

All of the previously mentioned developments appear to be leading engineering graphics courses from a practice-oriented environment toward a more theoretical base. This transition may also indicate the possibility that graphics could now be covered in a one-hour lecture format with laboratory time replaced by homework.

In addition to these considerations, pressures to make educational institutions more "productive" makes time more precious every year. Reduction of class contact by fifty percent would produce large blocks of potentially useful research time, if indeed that reduction could be implemented without undermining course quality. It was therefore decided to undertake just such a study to determine the potential of this line of reasoning and the students' impressions of such a course.

Graphics at Iowa State University

The freshman level graphics course at Iowa State has experienced numerous changes. In the 1940's and 50's, students met for ten hours per week. The course was concerned with both delineation and "engineering hardware" familiarization. The present graphics course meets six hours per week with only about half of the course dealing with traditional graphics topics. Virtually no "hardware"; i.e., instrument work, is done in class. The rest of the course is related to design and computer graphics. A topic outline of the course is presented in Table 1.

Lettering and two- and three-dimensional sketching are the topics chosen to introduce engineering graphics. Drawings are copied to teach basics of engineering drawing and eye/hand coordination. The use of scales, instrument drawings, and computer programming expand the basic knowledge used in freehand work. Orthographic projection and solids interpretation are used to

TOPIC	TRADITIONAL TOPIC	NON-TRADITIONAL TOPIC	PERIODS
Introduction			0.5
2D Sketching	*		1.0
Lettering	*		0.5
3D Sketching	*		3.0
Scales	*		1.0
Instrument Drawing	*		1.0
Computer Drafting		*	2.0
Orthographic Projection	*		3.0
Solids	*		3.0
Computer Drawing (Basic)		*	2.0
Vector Methods		*	2.5
Geometric Modeling		*	1.5
Modeling/Analysis		*	2.0
Sections	*		1.5
Dimensioning	*		4.5
Design Drawings	*		3.0
Conceptual Design		*	9.0

Table 1 Engineering graphics at Iowa State University

introduce and develop visualization skills. Computer modeling, analysis, and vector methods are topics which allow not only an introduction to computer graphics systems, but also an introduction to how they work. Additional graphics topics allow a chance to introduce other important types of drawings and practices and to apply fundamentals to "practical" situations.

The structure of the course has gradually evolved to a point that most of the topics are presented in a lecture that lasts from approximately thirty minutes to one hour. The rest of the period can then be utilized as a lab where students work on problems, with instructors available for individual help. It is logical to question the need for the second hour of a two-hour meeting in a university-level course when a great deal of the material is mathematically oriented.

The One Hour Class

In view of the preceding factors, the authors proposed to determine if modern engineering graphics courses could be taught as lecture courses, if students could develop what few skills are required without the benefit of the "lab hour", and the modifications that might be required to implement such a drastic change.

Under the proposal, each author taught one traditional two-hour (control) section and one experimental one-hour section, limited to lectures with a few extra minutes for questions and only occasional opportunities to start homework before the hour ended. To assure a rational comparison, the experimental sections used the same course outline, were assigned the same homework, and took the same exams as the other sections. It should be mentioned that the contact time on exam days was extended to match the "designed time" of the exam. The only significant change was the number of class-contact hours.

To aid in the process of adapting to a one-hour class, each instructor added two office hours and the classroom was made available for the second hour to those who wished to continue working. The necessity of both of these will be addressed later.

Special Section Preparation

Preparing to make the format switch primarily involved modifying lecture material. The lectures were edited to fit the one hour (actually, fifty-minute) time limit. The same lecture was then used for both sections. Only a few lectures had actually to be reduced to fit the allotted time. Some topics that had been covered in "split" lectures were combined. An example of a split lecture is one involving the explanation of scales usage. With a two-hour class period, it is convenient to lecture on the engineer's scale and allow the students to work related problems during the first hour, then continue to the metric scale lecture and problems in the second hour.

The biggest switch in the lecture material was deciding what to present and how to present it. A laboratory format allows for a more individual approach that enables students to do a limited amount of self discovery. The lecture format has to be more structured to avoid leaving too many loose ends. Another aspect of lecture modification was to anticipate questions to minimize the number of individual problems.

Experimental Results

The results of this experiment are separated into two categories. The first group of results compare the exam results of the experimental and reference sections. These results are also compared to the other sections of graphics courses (Table 2). Also presented are the results of an end-of-semester survey taken in an attempt to obtain some kind of formalized opinion from the students involved.

For the purposes of this paper, the final exam is used for comparing test results. The final exam is comprehensive and covers the main components of an introductory graphics course - visualization, computer methods, and drawing conventions and practices. From the final exam, eight out of the nine questions were selected for use in the comparison. The ninth question was not selected because an alternate exam that some students took was sufficiently different in content that any comparison would be of minimal value. The selected questions are presented in Fig. 1.

SECTION	AVG. GRADE
1	3.07
2	3.03
3	3.02
4	3.02
5	2.96
6	2.94
7	2.85
8	2.81
9	2.79
10 (instr. 2, ref.)	2.68
11	2.68
12 (instr. 2, exp.)	2.67
13	2.67
14 (instr. 1, ref.)	2.65
15 (instr. 1, exp.)	2.62
16	2.57
17	2.56
18	2.46
19	2.07

Table 2 Grade summary for FR.E. 170, Spring 1988

A section-by-section comparison for each of the problems from Fig. 1 is presented in Figs. 2 and 3. These diagrams indicate the differences between the special sections, 1b and 2e, that met for one hour per week and the reference sections, 2b and 1e, that met for two hours per week. One instructor taught sections 1b and 2b; the other taught 1e and 2e. Moreover, a comparison of the bar graphs of Figs. 2 and 3 shows no clear-cut differences between the sections for the problems shown in Fig. 1. Only two of the problems (Nos. 2 and 4) showed each instructor's special section receiving a lower grade than his reference section. Five of the problems (Nos. 1, 3, 5, 6, and 7) had one instructor grade the special section higher while the other instructor scored the reference section higher. There was even one problem (No. 8) where each instructor's special section did better than his reference section. The averages for all the sections varied only by one to two points for each problem.

The sections had between 15 and

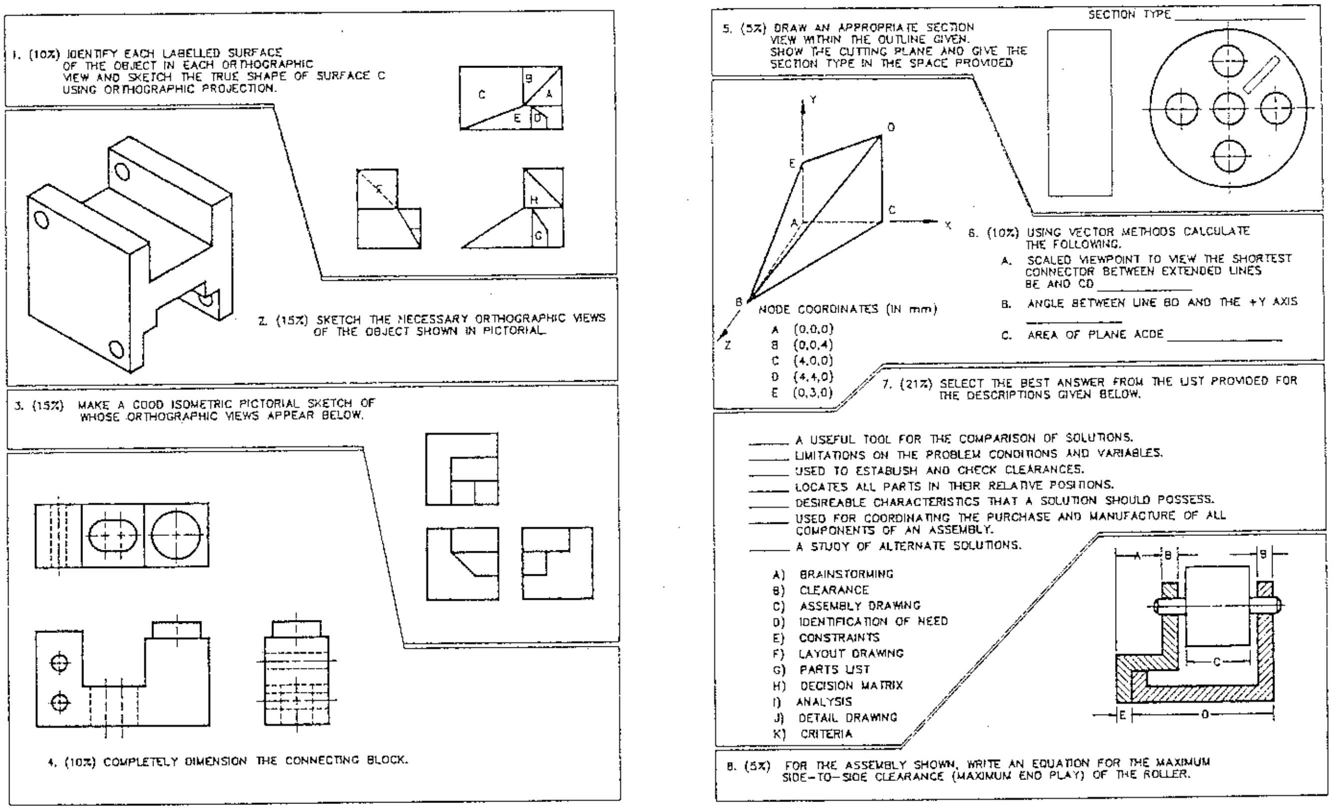

Fig. 1 Selected examination questions, Spring 1988

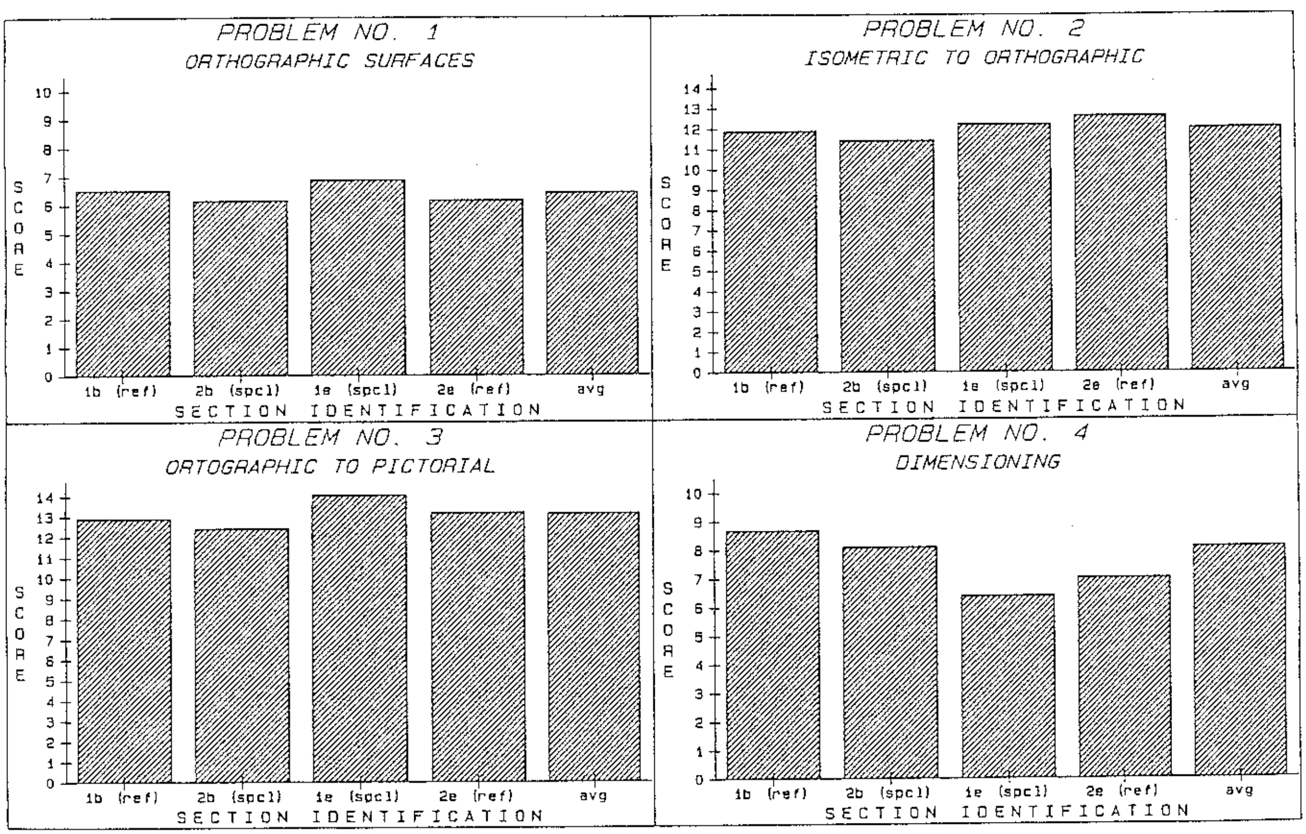

Fig. 2 Examination results, Spring 1988

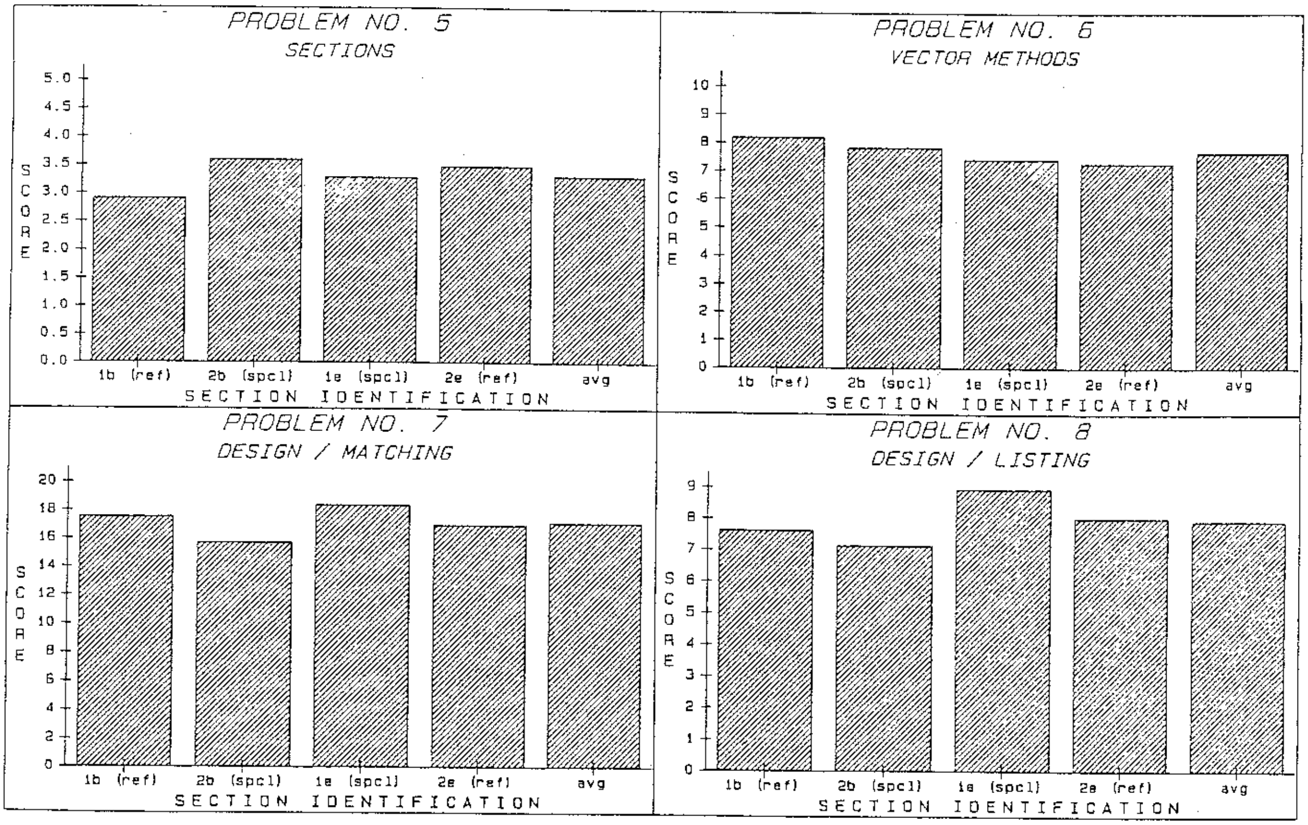

Fig. 3 Examination results, Spring 1988 (continued)

25 students. A section average can therefore be easily and significantly influenced by two or three scores that are either significantly above or below the average. To show typical class distributions, three problems were selected. The first problem deals with visualization. The distributions are shown in Fig. 4. Figure 5 indicates class distributions for a drawing practices problem and Fig. 6 is a comparison for a computer methods problem. These graphics show that in all cases the individual scores went from very low to perfect.

The results of a student survey are presented in Table 3. The questions presented are directed toward the students in the special sections. The survey was designed to sample a perception of each student's general feelings and to see how important the open laboratory time was.

The questions and corresponding comments provided concerning the open lab time indicated that most students made use of this period. It is unknown whether this may or may not have affected their work. Written comments indicated that laboratory time was more critical for computer work and team projects.

The general results from the survey were that the students thought that the one hour format was acceptable. Some of the comments given related to factors to consider when teaching the course again. Other comments addressed the original intent of the experiment. If the one hour format were to be adopted, the lecture becomes even more important than

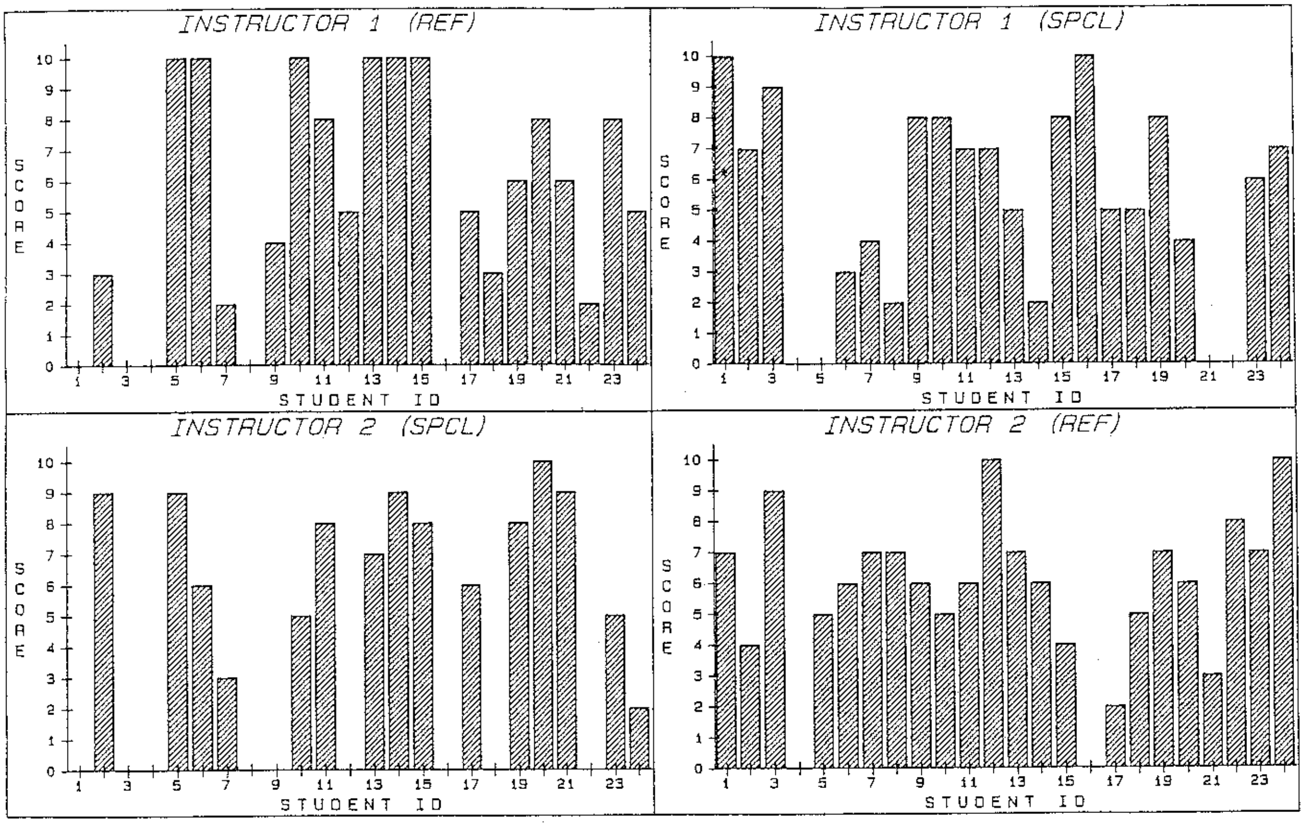

Fig. 4 Class distribution for problem 1 (Re. Fig. 1)

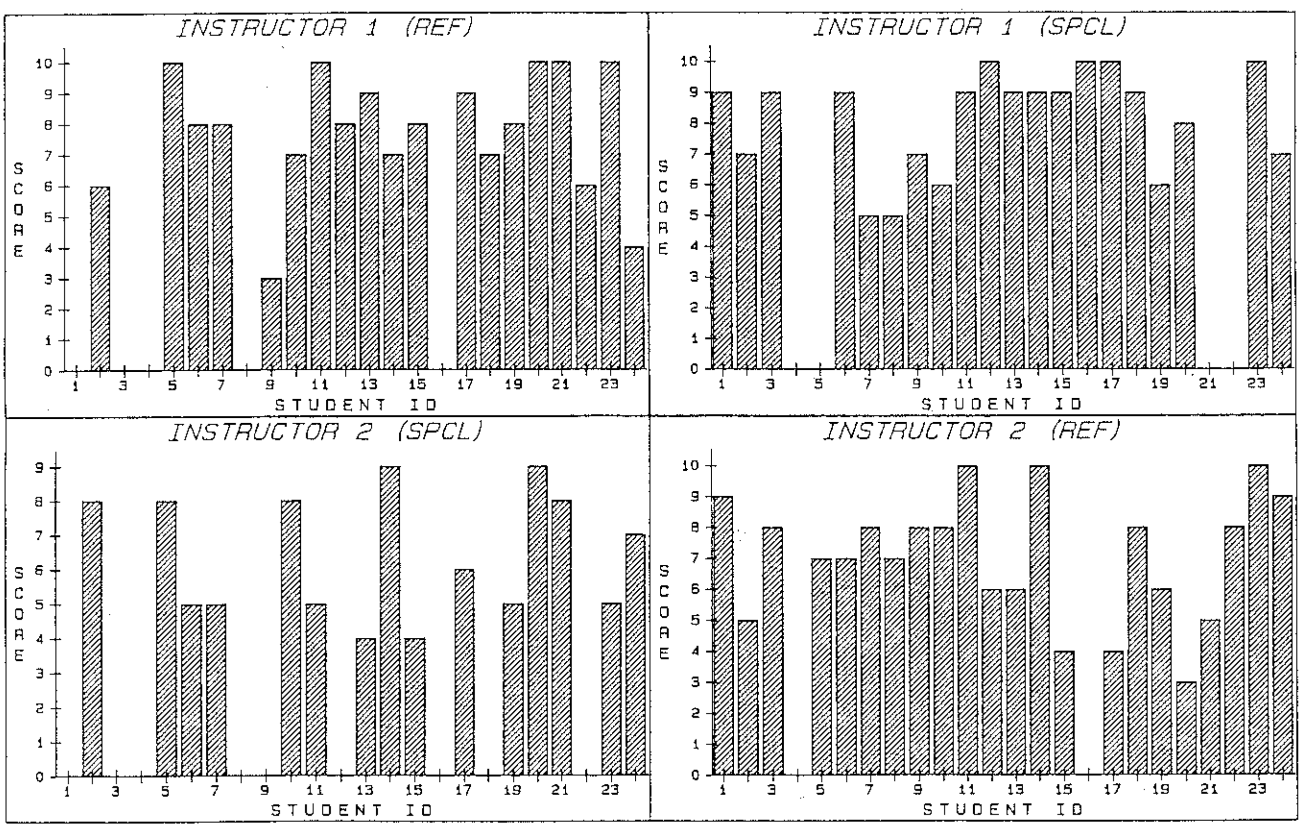

Fig. 5 Class distribution for problem 4 (Re. Fig. 1)

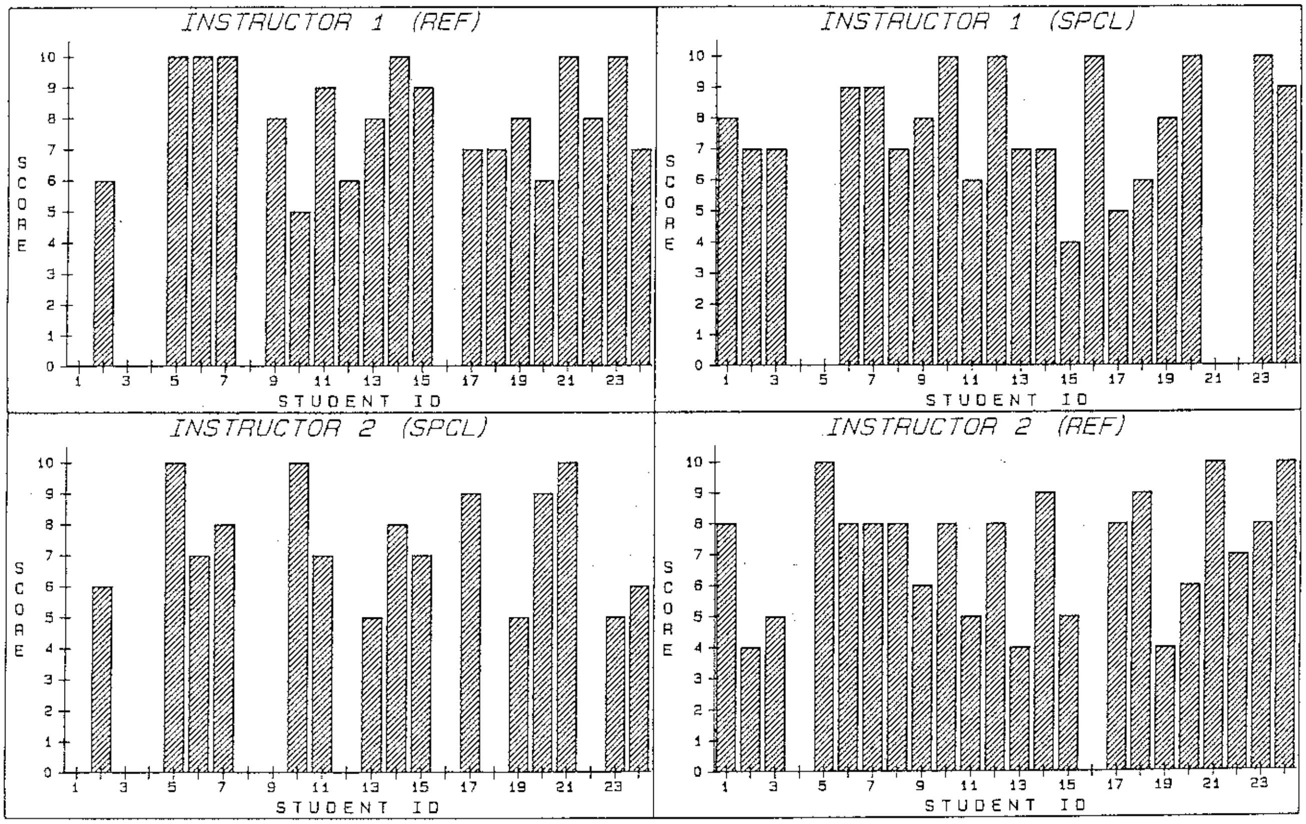

Fig. 6 Class distribution for problem 6 (Re. Fig. 1)

		YES	NO
1.	Did you use the class during the open hour?	25	5
2.	Would the absence of the open hour affect your progress?	13	17
3.	Were lectures adequate?	29	1
4.	Do you have the impression that anything of substance was left out?	11	19
5.	Was there adequate office hours provided?	24	6
6.	Did you have to study more?	5	25
7.	Did you get your money's worth?	25	5

Table 3 Student survey results

it is now. The lecture has to be structured sufficiently to ensure that the student can complete all work without further help. A common request was for more example problems. Limiting lecture time also results in reduction or elimination of lengthy "real-world" examples. A lecture-only class does not allow for skills development. In general, if a lecture-only course is going to be adequate, it must be because the "skills" requirement is really decreasing and that flexibility in scheduling is more important than structure.

Conclusions

It is the authors' conclusion that the content of the "modern" graphics course presented no real problems when taught in a lecture format, and that a larger, department-wide adoption could be made without insurmountable difficulties or consequences. In all likelihood, most of the students could adapt more easily than their instructors, who have grown accustomed to lecture-lab format. The authors found that students in the experimental sections did not use available office hours for consultation and help any more than other students and that the additional office hours were therefore not needed. Thus, in a small institution, the decision is probably determined by the instructor's personal preference and educational philosophy.

In a larger institution, where uniformity and conformity are important, the decision would be more difficult. It is important for students to mature and become responsible students and engineers. The lecture-lab format allows flexibility and an opportunity for guidance and gradual maturation.

The decision also must be based on whether a faculty member's time is best spent teaching in the classroom or at professional activities and research. While reduced contact obviously presents an opportunity to become more productive in measurable (and hence, popular) ways, it places a rather low value on one-to-one educational experiences.

The student must take a larger initiative to obtain assistance, and there is much less likelihood of an apprenticeship relationship ever occurring. Assuming the newly-found faculty time is utilized well, it might be expected, as has been suggested by various studies, that one should become a more effective/popular educator, bringing the cutting edge of knowledge into the classroom. Whether this quality is fully appreciated by first-year students or whether it would be perceived as ramblings by a person more interested in research than in teaching is not known.

There are then several advantages and disadvantages in either option. In the final analysis, the handwriting on the wall may be that such decisions are often defined by hard economic realities.

A Microcomputer Descriptive Geometry Tutorial

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In recent years, the number of computer graphics courses taught in the People's Republic of China has been growing rapidly. Many universities and institutes have set up computer graphics curriculum or added the contents of computer graphics to engineering drawing courses. In addition, many universities have begun research in the computer graphics area and have developed interactive software for learning descriptive geometry and engineering drawing. Significant accomplishments have already been achieved.

Introduction

After three years of research, a tutorial software system has been completed which can aid descriptive geometry instruction. This software includes extensive examples and is very convenient to use. Each engineering student may use it to familiarize himself with the principles of descriptive geometry, thus developing his spatial visualization ability and his ability to solve geometric problems. The software supplies exercises which students may solve through interactive procedures and with man-machine dialogues.

The software is named the Apple-microcomputer Tutor Descriptive Geometry System (ATDGS). It was developed on an Apple II computer using the Applesoft language and some binary coded files. Text files are also used. An integrated system was formed which runs reliably and rapidly. It is convenient to use and is easily illustrated to students. Even students who know nothing about computer graphics can use it after an introduction of only a few minutes. It has been used at Guangdong Institute of Technology for more than three years and at other universities in the People's Republic of China for teaching engineering drawing.

This software was approved by the China Automation Association in August, 1987 and has been honored as the best and most advanced software of its kind in the People's Republic of China.

Features of the Software

The software is designed to serve as a tutorial for engineering drawing and descriptive geometry. It furnishes exercises and corrects student supplied solutions automatically. It can illustrate the fundamental principles of orthographic projection, introduce many solution methods and procedures, and describe the features of geometric elements with 3-D cartoons. Correct solutions may also be displayed for the various examples.

The software was developed to allow the user to follow the sequence of a normal text on descriptive geometry or engineering drawing; basic concepts are illustrated first followed by more complex material. Program implementation is conducted through the selection of various menu items (Figs. 1 and 2). These menus allow the projection of points, lines, planes, curves, and curved surfaces. In addition, the intersection of a line and a plane, a plane and a plane, a curved surface and a plane, and curved surfaces may be determined. Also, the development of a surface may be displayed as well as the orthographic and isometric projections of solids (Figs. 3 - 15).

Correct student usage is ensured when activating each menu item by the display of specific instructions on how to use that menu item. To avoid input/output errors or other execution errors, the system has a set of automatic prevention and restriction means. Thus, once a problem is initiated, execution is never aborted until the computer is turned off. The software is meticulous in design and thus reacts rapidly to user commands. Each step lasts no more than five seconds, including elimination of hidden lines and planes for 3-D solids. Input and output data are limited and protected. If any input error occurs, a request for a second input of data appears on the screen. In order to select menu items, an automatic detective

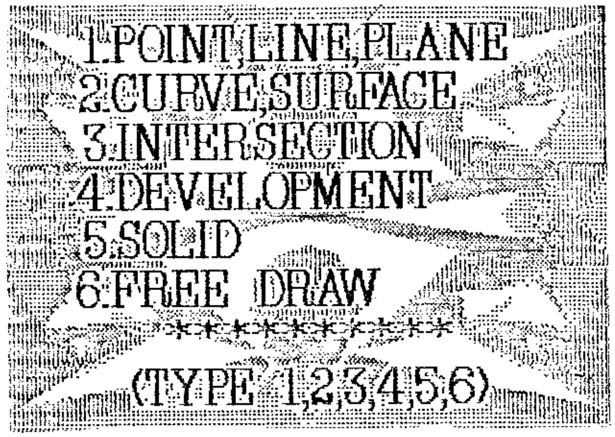

Fig. 1

(1) PROJECTION OF POINT AND LINE
(2) THE RELATIVE POSITION OF
TWO LINES
(3) PROJECTION OF A PLANE
(4) A POINT ON THE PLANE
(5) COMPLETE A PLANE
(6) THE TRUE LENGTH OF A LINE
(7) THE TRUE SHAPE OF A PLANE
WHICH WOULD YOU WANT ?(1,2,3,4,5,6,7)
<ESC> TO BACK MAIN MENU

Fig. 2

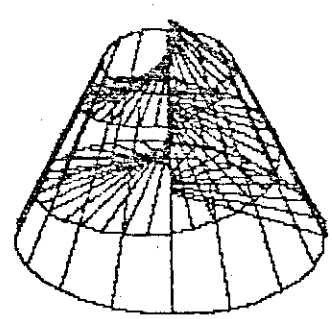

Fig. 3

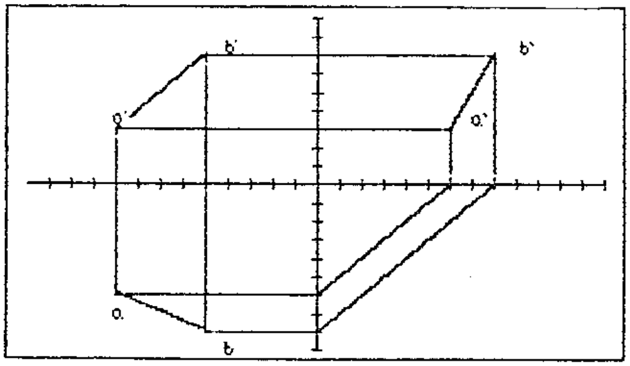

Fig. 4

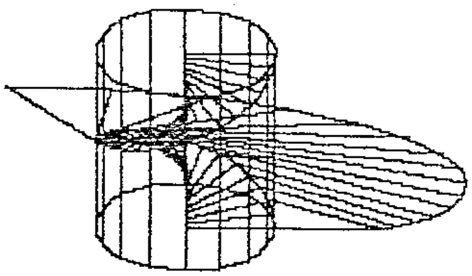

Fig. 5

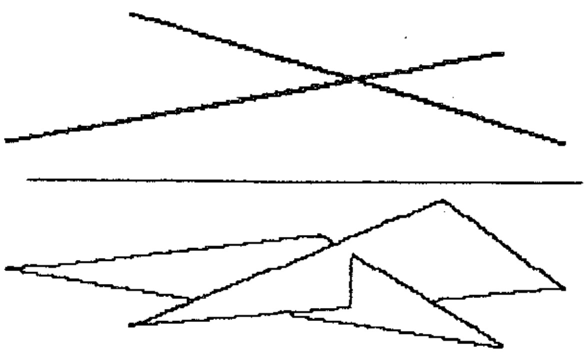

Fig. 6

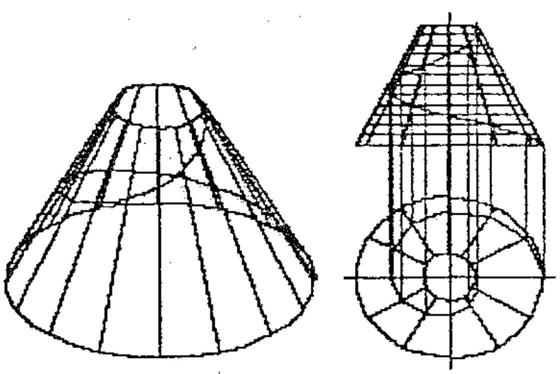

Fig. 7

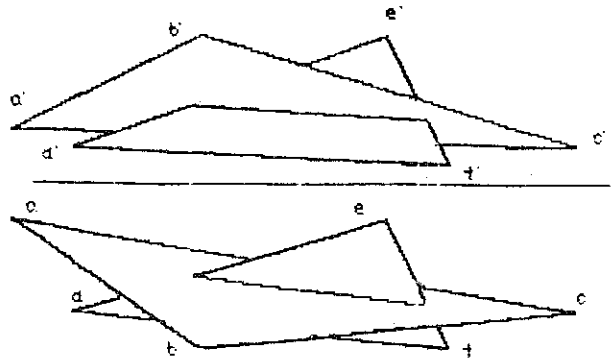

Fig. 8

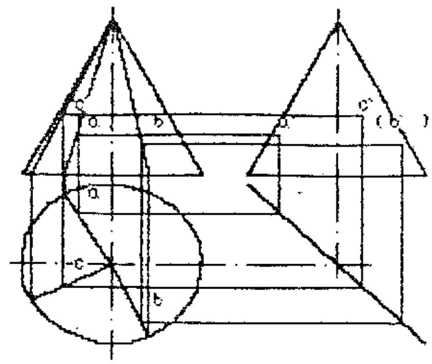

Fig. 9

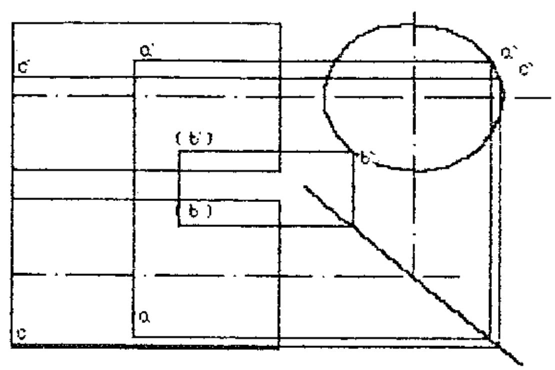

Fig. 10

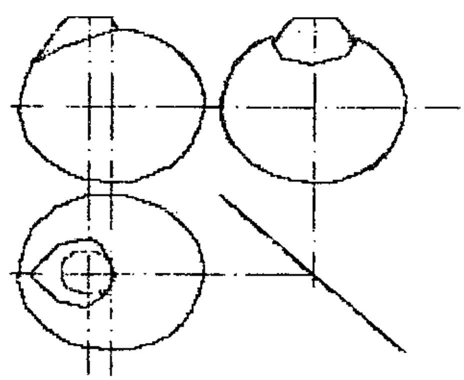

Fig. 11

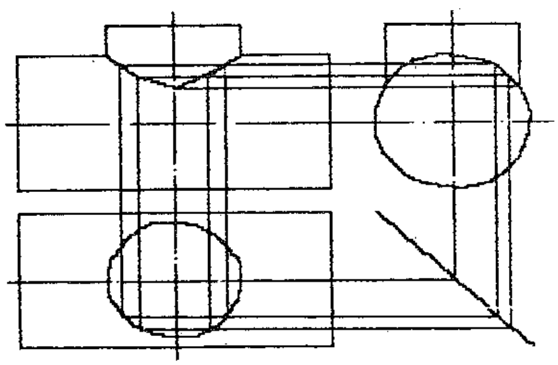

Fig. 12

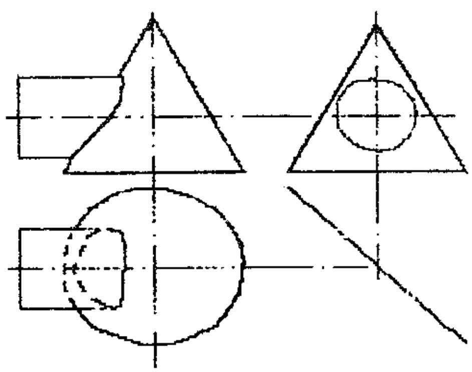

Fig. 13

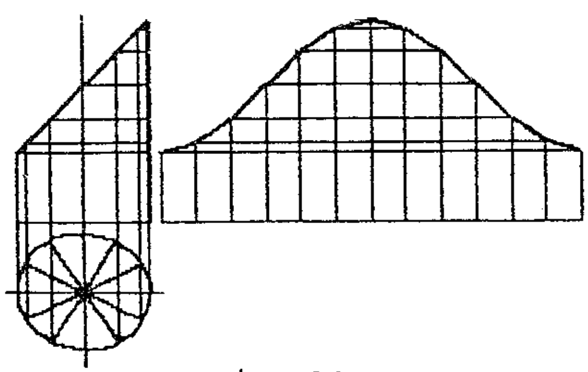

Fig. 14

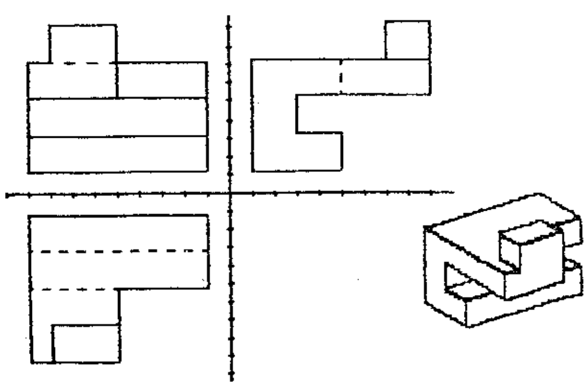

Fig. 15

function has been established, enabling one to press the ESC key or a special function key to return to the main menu or one of the submenus.

Generally, the system has 2-D and 3-D graphics capabilities and the ability to eliminate hidden lines and planes of concave or convex solids, and it functions in an interactive mode. In addition, it is able to modify a part, edit graphics, and clip and display text and graphics together. The response speed is faster than any other method.

Software Configuration

The software is formed in six boxes or modules, each module containing many models or construction frames (Fig. 16). The main menu selects the appropriate modules and the submenus select the appropriate models. To decrease response time, the disk operating system has been modified so that it operates three times faster than normal.

Each model is relatively independent, but all models share the same data base and resources. Menu actions are chained to each other dynamically so there are no repetitions. Most graphics data is stored in data text files. Adding new data files or modifying data files can create new graphics without inputing a new program. The software also supplies a model allowing the input of solid model data, thus allowing its orthographic and isometric projections to be displayed, thus developing a new exercise.

A free-drawing model is available to help students design geometric objects, to write letters,

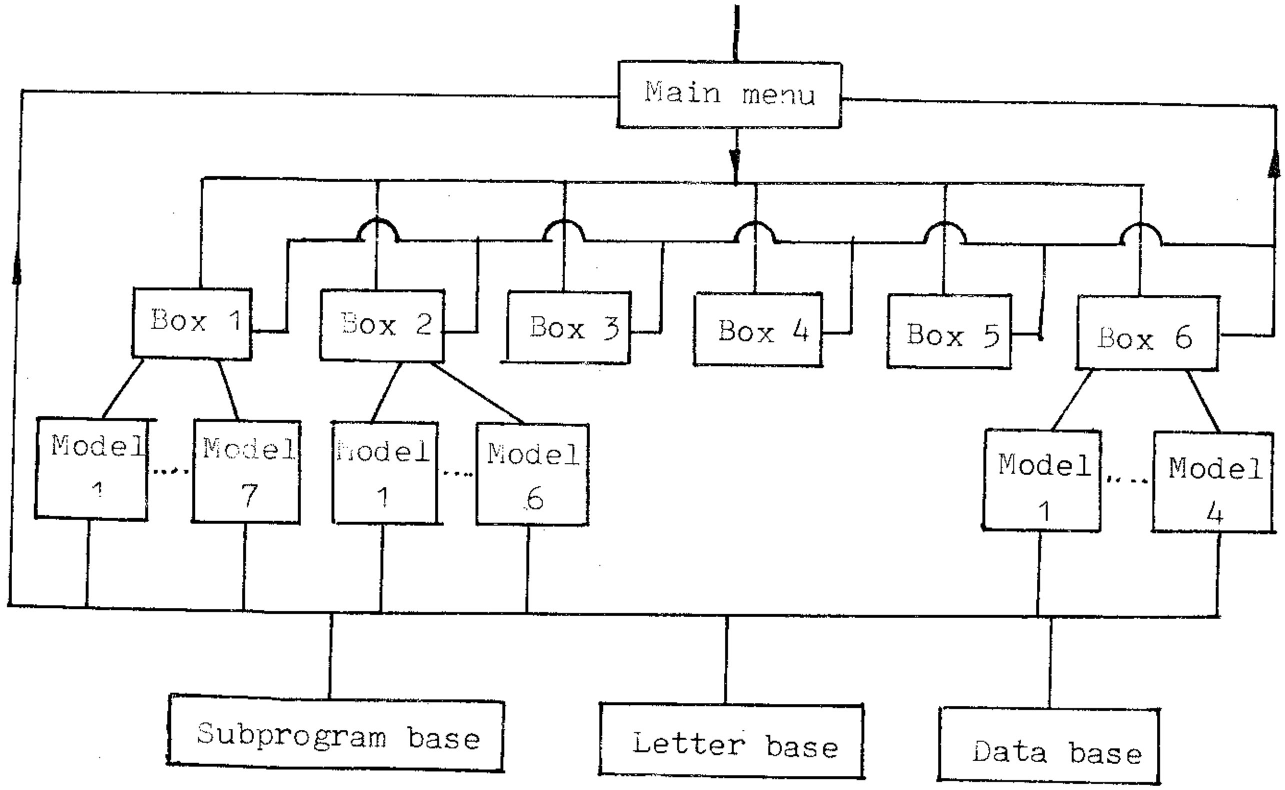

Fig. 16 Software Schematic

and to visualize pictures and patterns. By utilizing function keys and the cursor, various line types may be displayed on the screen. The student may then create, erase, edit, delete, etc. their own creations, thus enabling them to gain a knowledge of the software capabilities (Figs. 17 - 24).

The software is stored on two sides of a single disk. After booting, the main menu appears on the screen and prompts the student to select a menu item. With the aid of instructions displayed on the screen, students may initiate actions desired.

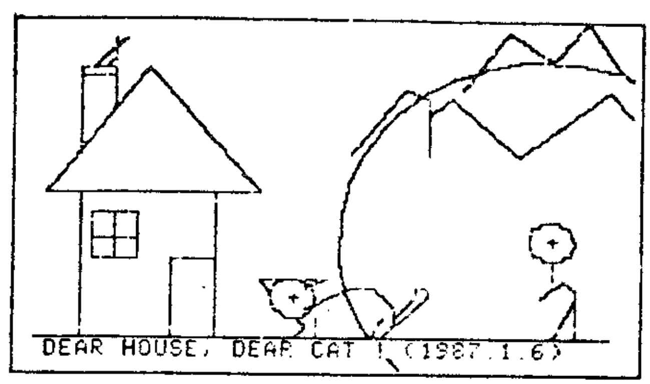

Fig. 17

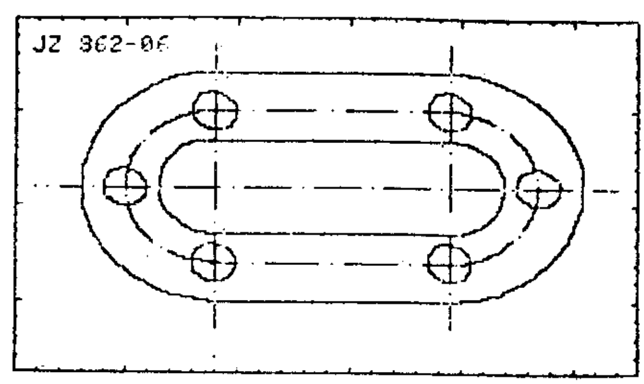

Fig. 18

Conclusion

At the Guangdong Institute of Technology, all students who majored in mechanical building and in environmental engineering from

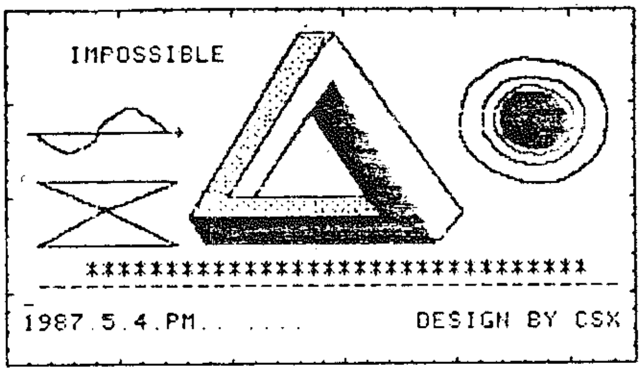

Fig. 19

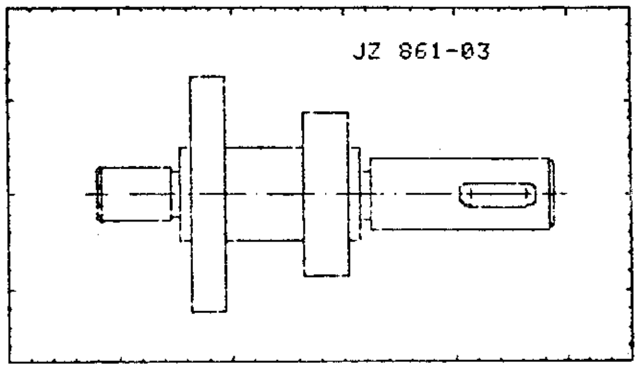

Fig. 20

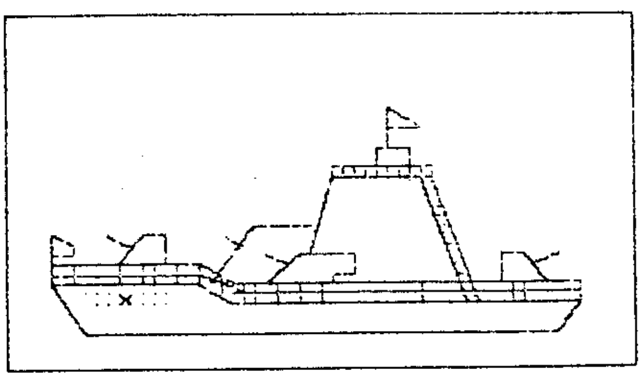

Fig. 21

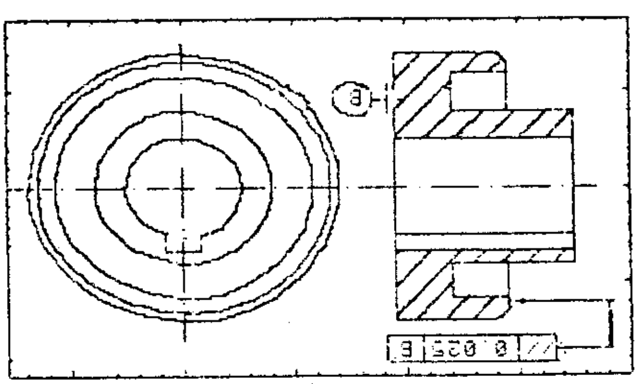

Fig. 22

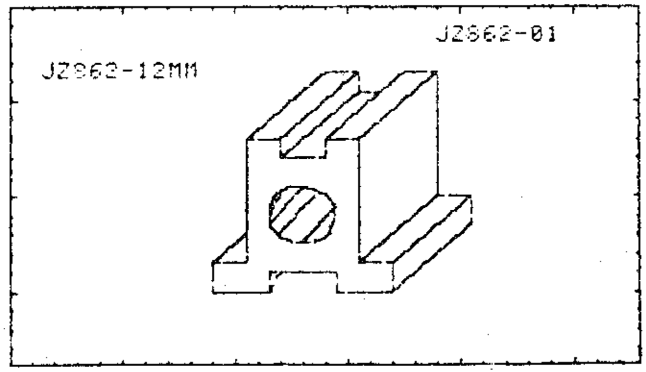

Fig. 23

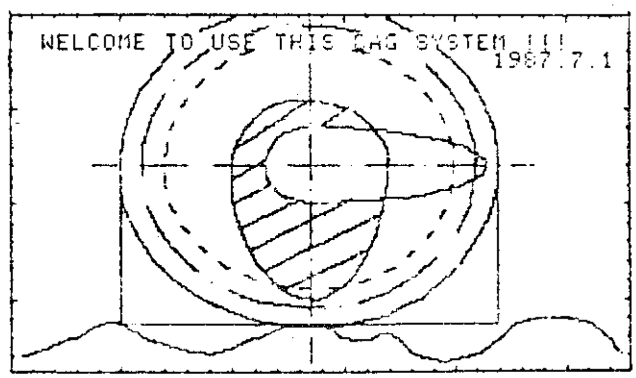

Fig. 24

1986 through 1988 used this software. Each student is allocated 16 to 20 hours of computer-terminal time each semester. The course work is divided into five or six experiments, requiring the completion of various exercises and the preparation of reports. The students have been most enthusiastic in their use of the software, and it has proven successful in the study of descriptive geometry and engineering drawing, as well as in allowing them to become familiar with the operation of the computer. It seems to have combined the presentation of knowledge with entertainment, bringing together drawing conventions and computer data, thus aiding the student to relate graphics to number manipulation. This new method of study allows each student to use the computer from his initial introduction to engineering drawing to the completion of his studies. Comparisons between students who have used this software to those who have used conventional pencil and paper methods indicates better results for those learning by using computer graphics.

Effects of MicroCAD On Learning Fundamental Engineering Graphical Concepts: A Qualitative Study

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Students' reactions and performances are examined when taught engineering geometry concepts using a standard microcomputer-aided drafting (microCAD) software package. Two purposefully sampled groups were investigated: one group had extensive to moderate computer experience and the other had limited to no computer experience. Data were collected using videotapes, individual and group interviews, and document analysis. Interpretations and conclusions were deduced by coding and categorizing data into emerging trends. Recommendations are given for teaching engineering graphics courses using microCAD.

Introduction

After completing a microcomputer-aided drafting (microCAD) test, Allen and Robert were asked how they felt about the test:

Allen: "I felt at home. I felt at ease. I felt like I had an advantage over the others because this was right down my alley!"

Robert: "I didn't know. If I did fiddle with it, maybe it would go bleep and wipe out my whole drawing!"

What made Allen feel "at home" with the microcomputer, and Robert, who seemed equally qualified, tense up and fear the microcomputer might "bleep out" his work?

During the fall term, 1988, two college-level introductory engineering graphics classes, each with about 48 students, were taught the same engineering graphical concepts; however, one class used manual instrument methods and the other class used microCAD methods.

For the first test, each class was given the same engineering geometry problem. Although the test score means for each class were about equal, the grade distributions were vastly different. In the manual class, the grade distribution was a normal bell curve with a standard deviation of 15.2, but in the microCAD class, it was an inverted bell curve with a standard deviation of 23.5 (of 48 grades, 19 were A's and 12 were F's). For some reason, the microCAD class had polarized results. Many students had no trouble completing the task, and many had such difficulty that they never completed the task.

Schaer and Trentham[1] showed that students entering college-level engineering graphics courses have a range of abilities in two- and three-dimensional perceptual skills that may affect performance on related course work. Also, some entering students had taken at least one high school drawing course, while most had no training in engineering graphics. These factors, and others, such as IQ and test preparedness, may help explain the normal distribution of test scores.

What theory could explain the abnormally polarized scores of the students in the microCAD class? A literature search revealed no findings on this technology's effect on performance in engineering graphics courses.

Computer experience may have enhanced some student's performances in the microCAD class. Perhaps these students had a more positive attitude about computers than students without computer experience. Or, maybe these students could transfer knowledge, such as keyboarding skills or command syntax, to the microCAD instructional environment.

While many graphics educators may subscribe to this theory, other factors should be considered. Leach[2] and Orr[3] believe microCAD software has a high degree of user-friendliness that minimizes the impact of a student's computer experience on learning new tasks. These authors also point out that microCAD software is highly specialized; therefore, the advantage of computer experience would be minimal. In support of this argument, a student interviewed for this study stated:

> "I've worked with various computers and word processors. I just want everyone to know it doesn't matter ... AutoCAD is totally different to a word processor or just typing. I think, even it you have worked on a computer previously, I'm in the same shoes that you are in."

These issues were investigated by applying qualitative research design to the microCAD class in the 1989 winter term. This class's format was similar to that of the 1988 fall quarter class in which the polarized scores were observed. The microCAD software package which the class used was Autocad Release 10 by Autodesk, Inc.[4]

Research Questions

Initially, the following questions were asked.

1. Was previous computer experience helpful to students who used the AutoCAD program to learn engineering graphics?

2. How does a student's previous experience, or lack of experience, using a computer affect his/her learning engineering gra-

phics with the AutoCAD program?

3. Are students comfortable learning engineering graphics in a microcomputer-based environment?

During data collection, additional research questions were formulated to investigate preparation for taking tests and the use of partners for completing daily assignments.

Research Methodology

The qualitative analytical research design[5] with case studies was used. With this design, work could focus on how and why the students reacted to the instructional method, by probing their attitudes, feelings, and inner thoughts, as well as by examining their test results. Differing from quantitative research which deals with large samples and asks what were the effects (by studying the quantity of behavior), qualitative research involves an in-depth investigation of a small sample to determine why the effects occurred (by studying the quality of behavior). A small, purposefully sampled group was most amenable to this qualitative investigation. The design did not address issues that could be quantified, and findings were not statistically generalized to a larger population.

Five students were studied. Data were collected from a combination of direct observation, videotape, and group and individual interviews during a five week period - about two weeks before and two weeks after the first test.

Questionnaires were given to the students at the beginning of the quarter. The completed questionnaires briefly profiled each student's previous mathematics courses and current grade point average (GPA). Using these profiles and a purposeful sampling method[5], four students were selected for the initial research sample. All of the students had a GPA above 2.7. All had similar mathematical backgrounds of four or more courses. Two students had extensive to moderate computer experience; two had limited to no computer experience. Thus, sample members differed only by experience, not by the other factors which could be potentially correlated with the performance measure.

After the first test, the sampling criteria were expanded to include the students' test performance. The researchers felt that further delineation of sampled students based on test results might give insight on how computer experience affected student performance. A review of the test scores substantiated the selection of the initial four students. Based on the new criteria, one more student was added to the inexperienced sample.

For data collection, students were placed in two groups.

<u>Experienced/High Test Scores</u> - students with extensive to moderate computer experience and with high scores on the first test.

<u>Inexperienced/Low Test Scores</u> - students with limited to no computer experience and with low scores on the first test.

Data Collection

Observations and interviews were the primary data collection methods. Students were not interviewed by their instructor, but by a "neutral researcher. To ensure objectivity, the data were triangulated with the following data collection methods:

Videotape - One student from each group was videotaped while solving the engineering geometry test problem using AutoCAD. Coded notes from tape observations were compiled. Videotapes were replayed during individual interviews to assist students recall their feelings and thoughts during the test. The videotapes also supported data obtained from direct observations.

Group Interview - A 15-minute, unstructured group interview of the five students was conducted immediately after the test. Before and during this interview, neither the students nor interviewers knew the students' test performance. The students were simply told, "Several students are being asked to get together and discuss their feelings and thoughts on using the computer to learn engineering graphics." The discussion was tape-recorded and then transcribed.

From the group interview information, using topics of concern voiced by the students, questions were developed for the ensuing individual interviews.

Individual Interviews - Forty-five minute, individual, structured interviews were conducted several days after the test. Each of the five students was asked fifteen questions, grouped according to the three research questions, in a consistent, objective, and structured format. In a supplemental session, the two videotaped students were shown preselected portions of the videotapes and were asked to reflect on what they were doing and how they felt.

Document Analysis - The engineering graphics test had two sections: short-answer questions (20 points), and an engineering geometry problem (80 points). The course instructor evaluated the types of errors and classified them according to probable computer-related or graphical concept-related errors.

Data Analysis Strategies

Using the transcripts of the group and individual interviews, summary videotape observation forms, field notes of direct observations, and test analysis, the researchers coded and categorized the data into a data base of six major categories:

Transfer - Skills, knowledge, or experience that were learned or used before entering class and that were helpful during the test. Subcategories: Graphical concepts, computers.

Attitude - Positive or negative feelings or thoughts. Subcategories: Graphical concepts, computers.

Poise - Composure, and stress of confidence levels during the test. Subcategories: Graphical concepts, computers, environment.

Strategy - Systematic approach to an objective. Subcategories: Test taking, test preparedness.

Performance - Work quality and accuracy. Subcategories: Graphical concepts, computers.

Partners - Attitude about using partners for microCAD sessions. Subcategories: Advantages, disadvantages.

Two matrices, the Data Coding Summary Sheet and Antecedent-Experiential-Results Matrix, were constructed. Data were weighed as having either a positive or negative impact on the category, then mapped and displayed about two axes. The Data Coding Summary Sheet axes were student sample and coded data categories. The Antecedent-Experiential-Results Matrix axes were student sample, and questionnaire categories, coded data categories, and test scores.

Interpretations and Conclusions

The following interpretations and conclusions were made:

Research Question 1: Was previous computer experience helpful to students who used the AutoCAD program to learn engineering graphics?

Despite the relative ease of learning AutoCAD and its proprietary command structure and syntax, students with computer experience generally learned engineering graphical concepts using AutoCAD easier than those with limited to no experience. Students with computer experience were aware of the transfer of skills and knowledge and stated so:

"I can see what they're saying, how if you've got two different programs, it's different, but there is the factor that if you have worked with computers before, you do feel more confident."

When interviewed, the inexperienced students had positive attitudes and felt that they were not disadvantaged at the onset of the term. One student stated:

"This is AutoCAD, it's different ... We're all at the same level."

Despite their positive attitudes, the inexperienced students' poise and performance levels fell extremely low in the testing environment, as this student's quote illustrates:

"When I got there I thought I knew what I was doing and everything. And you know, I started off pretty well, but as time went on, I asked myself: 'What am I supposed to do now, and what am I supposed to do after that?'"

These students were struggling on two levels - microcomputer use and graphical concepts. Compounding these problems with the normal stress of a testing environment generally resulted in loss of poise and confidence, and in frustration and intimidation. Students with computer experience could focus on using graphical concepts and on solving the test problem. Their confidence with computers alleviated and, in one case, counteracted the stress of test taking.

> "I felt at home. I felt I had an advantage over the others because this was right down my alley."

Differences between the experienced and inexperienced students were also evident through observations and document analysis. The videotapes showed the experienced students' initiatives and strategies in solving the test problem, and the inexperienced students' frustrations and inabilities in creating the geometry that led to 3- to 5- minute inactive periods. Test analysis of the inexperienced group showed they did not understand either graphical concepts, software commands, or coordinates resulting in incorrect dimensional proportions and tangencies of lines and arcs.

The primary objective of the engineering graphics course taken by the students was to learn the engineering graphical concepts in order to communicate through standard engineering drawing forms; a secondary objective was for students to learn the skills to create those drawings. Students with computer experience could concentrate more on learning the engineering graphical concepts, whereas students without computer experience had to learn graphical concepts in an unfamiliar environment that diverted their attention to learning computer skills.

<u>Research Question 2</u>: How does a student's previous experience, or lack of experience, using a computer affect his/her learning engineering graphics using the AutoCAD program?

During data collection, two themes were immediately evident that addressed this question: student attitudes and knowledge transfer.

Regardless of the experience, all the students' attitudes toward computers were positive. They realized the computer's potential as a problem-solving tool and were willing to learn the technology. During the individual interviews, the students were asked, "If you had a choice, would you choose to take an engineering graphics course using a microcomputer or using manual instruments?" All students responded with "microcomputer". One inexperienced student added:

> "The computer is the way of the future, if it's not already here. I've got to learn to work with the computer because I'm sure I will be working with them, so I would have taken the computer course."

Although the inexperienced students had positive feelings going into the test and had even established some confidence with their newly-acquired microcomputer skills, their poise and performance levels dropped dramatically during the test. One student stated:

"I was afraid to fiddle with the computer to maybe draw this or try that. Maybe it would go bleep or wipe out my whole drawing."

The testing environment compounded the problem, as one student noted:

"Well, at first I was all right. But once I saw everybody else banging away and I was not banging, I got a little nervous, a little scared."

The inexperienced students' lack of poise and confidence impinged on their insecurities with basic file management techniques. In contrast, the experienced students confidently experimented with alternate problem-solving methods. As one student expressed:

"If you don't understand the concepts, you can do two or three different things ... You can experiment with it, trying to get things right. I've always felt like you could make a mistake. You can always back up and change it."

In individual interviews, students with computer experience said that knowledge transfer was most related to file management techniques. Referring to knowledge transfer from other programs, one student said:

"A lot of the commands are the same or very similar, like QUIT, and STOP, and SAVE, and HELP, and a lot of that sort of thing."

During group and individual interviews, the commands that came up repeatedly were related to saving work and correcting mistakes; they were not specifically AutoCAD commands. Only one command was mentioned that was related specifically to creating or editing drawings.

Computer experience was unrelated to the students' attitudes toward computers, but graphics experience did affect their attitudes toward graphical concepts. Two students without engineering graphics experience felt they lacked the abilities to understand the material. One student expressed this frustration:

"Graphics and mechanical drawing are compiled from a lot of other things that I don't know ... I just don't have that line of thinking. I'm the one who wouldn't see a square; I think the word square..., but I can't visualize three-dimensional figures."

However, these same students had positive feelings toward their abilities and willingness to learn computer skills.

Computer experience does affect the students learning of engineering graphics with AutoCAD, mainly by giving them the knowledge and confidence of basic file management. This extended their abilities to concentrate on, and experiment with, graphical concepts.

<u>Research Question</u> 3: Are students comfortable learning engineering graphics in a microcomputer-based environment?

During the individual interviews, all students responded positively to the choice of learning engineering graphics with microcomputers versus manual instruments. Based on these data and on general observations during daily laboratories and analysis of daily assignments, the students were generally comfortable learning engineering graphics in the microcomputer environment. However, they were uncomfortable in the testing environment where pressure and stress lowered their confidence and poise levels. The students were affected differently, depending upon their experience levels, in three areas: computers, graphical concepts, and test taking. One student said:

"It was like practicing to play a tennis match - you get out and practice and you can hit any shot you want to, but when you get into a match, it really counts. You tense up ... choke."

Although the original research question dealt with the use of AutoCAD to learn engineering graphics, the observations and interviews were purposefully structured around the testing situation to elicit insightful student differencies and reactions. Interpretations of the interviews and observations are valid in the less intense everyday learning environment.

Other Findings

Because of space and equipment limitations, the students had to work with partners in the supervised laboratory periods; however, they were encouraged and given opportunities to work individually outside of class. Their attitudes toward working with partners differed and were directly related to the sampling criteria. After doing poorly on the test, the inexperienced/low-scoring students felt that partners hindered the learning process, particularly for hands-on microcomputer experiences. One student voiced the following concern:

"When you have a partner, that person becomes part of you. What they don't know, you might know, and what you don't know, they might know. And when it comes to taking the test, you are thrust out on your own - you don't have that partner to ask and confer with."

In contrast, the experienced/high-scoring students liked working with partners and felt that having two opinions was an advantage. "It's a good way to learn things," stated one student. High-performing students felt they controlled their own destinies regardless of their partner's abilities.

Test preparedness was in proportion to test results: better preparation resulted in higher scores. The students' test scores agreed with their interview responses on test preparedness for the short answer and microCAD sections. Of the two experienced/high-scoring students, one student said:

"I spent the two nights before up in the lab just working on my own stuff."

The other student stated:

"Well, I'm working on computers and AutoCAD so I can just blow that test off."

The resulting scores were 100 and 84, respectively.

One inexperienced student, who scored 39, stated afterward:

"I went back and studied from the book. I really didn't study any drawings."

The students' GPAs and mathematics experiences apparently had no predictable effect on test results, whereas their computer and graphics experiences did affect them.

Recommendations

The following recommendations are offered for persons who plan curricula or teach engineering graphics courses using computers:

1. Teach file management skills as a fundamental part of computer use. In the first lesson, devote adequate time to the concepts of files and drawing files. And, in the first few assignments, include software commands and operating system commands for saving, listing, copying, deleting, and viewing files. Students must be confident with saving their work before they learn fundamental graphical concepts.

2. Delineate the two instructional dimensions of graphical concepts and computer use. The students must understand that the computer is one of many tools used to communicate graphically and that graphical concepts stand independently of the media. At least occasionally teach the graphical concepts in an environment other than the computer laboratory, and with other media, such as sketches, chalkboards, manual instruments, or models.

3. If a partner or buddy system is necessary, assign team and independent work. Randomly assign partners and rotate or alternate them regularly (e.g., weekly). Assign work to be done with and without a computer, such as sketching on grids. Provide an "open laboratory" with computers for independent work on personal time.

4. Schedule later in the grading period tests that require a computer so that all students have adequate time to build skills and confidence. Devise tests that delineate graphical concepts and computer skills so that individual student's strong and weak areas may be isolated. Schedule early in the grading period tests that require manual drawings, sketches, or short answers.

5. Administer questionnaires or pretests to determine the entering students' computer and graphical experiences. Using these as class profiles, adjust the instruction accordingly. Offer remedial instruction early in the grading period for some students, possibly as an additional class period.

Future Research

Purposeful sampling of computer experience and test performance assured a wide range of student differences for this study. Data collection showed that the two experienced/high-scoring students also had some experience with graphical concepts; the three inexperienced/low-scoring students had little or no experience with graphical concepts. No correlation is implied, nor is such an inference valid, from this qualitative case study. However, a follow-up study should be conducted of two additional student groups: students with computer experience, but without graphical experience, and students without computer experience, but with graphical experience. Such a study may show more clearly how computer experience, or the lack of it, affects learning engineering graphics using microCAD software.

Acknowledgement

The authors thank the Auburn University Advanced Manufacturing Technology Center (AMTC) for its support and A. H. Honnell of the AMTC for assistance in preparing the manuscript.

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Representation of Projection and Coordinate Systems in Engineering Graphics

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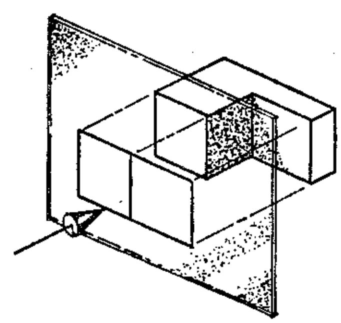
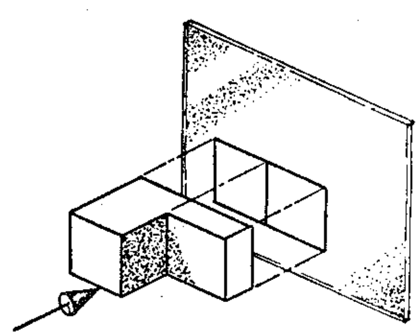
Inconsistencies have been noted in methods used to graphically depict first and third angle projection in engineering graphics texts. Also noted is the lack of attention to the inconsistency in the relationship of projection to coordinate systems. A comparison of the methods illustrated in several of the market's established textbooks is presented. During the period of transition from manually generated engineering graphics to computer generated two- and three-dimensional data bases, the adoption of a standardized graphical representation for projection and its relationship to X-Y-Z coordinate space is deemed useful for engineering graphics education.

Introduction

Each semester on university and college campuses across the country, thousands of students purchase tens of thousands of engineering graphics and CAD textbooks. At an appropriate moment in each introductory course, students are introduced, often hastily, to the simple but elegant principle of orthographic third angle projection as shown in Fig. 1(a). Although third angle projection is standard in the United States, if a textbook happens to contain references to both third and first angle projection, Fig. 1(b), additional explanations concerning the international method may be required. In an attempt to help students clearly grasp these elusive concepts, instructors at all levels proudly display their



(a) Third Angle Projection



(b) First Angle Projection

Fig. 1

plexiglass projection boxes, glossy overhead visuals, slick wooden models, elegant CAD (chalk-aided drafting) illustrations, and of late, video projected computer graphics images. Having apparently conquered this topic, for all but a few students, the instructor charges ahead into the uncharted, mysterious territory of visualizing and manipulating three-dimensional geometry.

Thoughtful engineering graphics educators may pause at this point in the course to ponder some profound questions. What is projection and why is it included in our courses? Why do Europeans and Asians use first angle projection? Why won't first angle just go away? What about second or fourth angle projection? How does projection relate to the inconsistent mixture of X, Y, Z co ordinate reference systems found in computer graphics and CADD software? Are projection and reference planes necessary with 3D computer graphics software which lets us directly revolve the object? Why can't we just deal with the direct view[1] method, as shown in Fig. 2, like George Hood used to do? Having gone through this questioning loop numerous times, one conclusion reached is that some exposure to projection is inevitable, if for no other reason, because of the growing international nature of engineering.

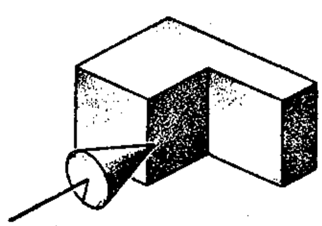


Fig. 2 The Direct View Method

Recently an attempt was made to graphically depict first and third angle projection together in a single consistent model. Unfortunately, efforts to do this pointed out that texts are in need of review and standardization. The methods depicted in textbooks are inconsistent, incomplete, and in some cases, misleading or confusing for students attempting to grasp the whole concept.

First Angle Projection

The development of a precise technique for utilizing projection to graphically describe or analyze engineering problems is generally attributed to the Frenchman Gaspard Monge[2]. An illustration from his *Geometrie Descriptive* manuscript of 1795, shown in Fig. 3, demonstrates the initial use of first angle projection. This illustration, which projects plan and elevation geometry onto two planes, may also depict the origin of representing space as four quadrants. Although a classified military secret for nearly thirty years, this technique eventually achieved wide acceptance and remains as the standard method still used in European and Asian engineering and engineering education practice.

First angle projection also served as the standard for engineering graphics in the United States until third angle projection began to gradually replace its use in the late 1880's. Fig-

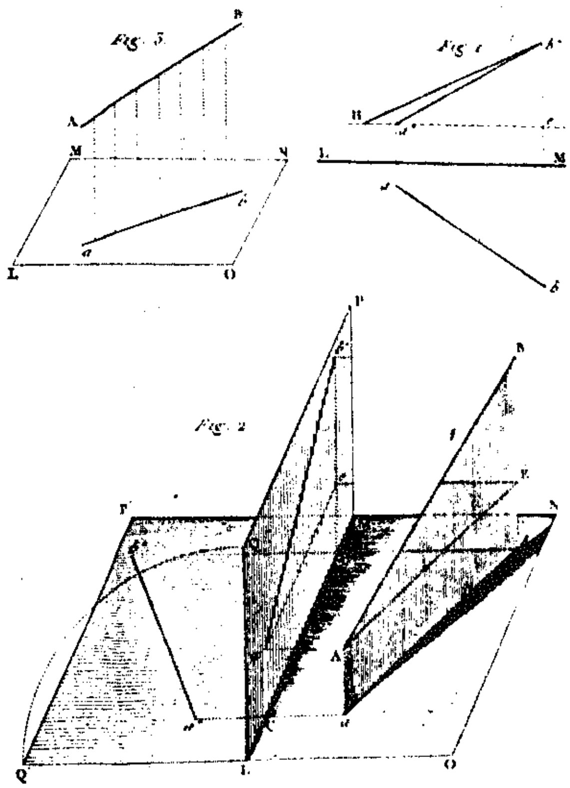


Fig. 3 Plate I from Monge's *Geometrie descriptive* of 1795

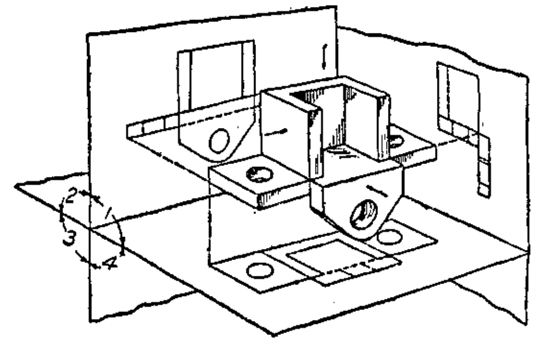


Fig. 4 First Angle Projection

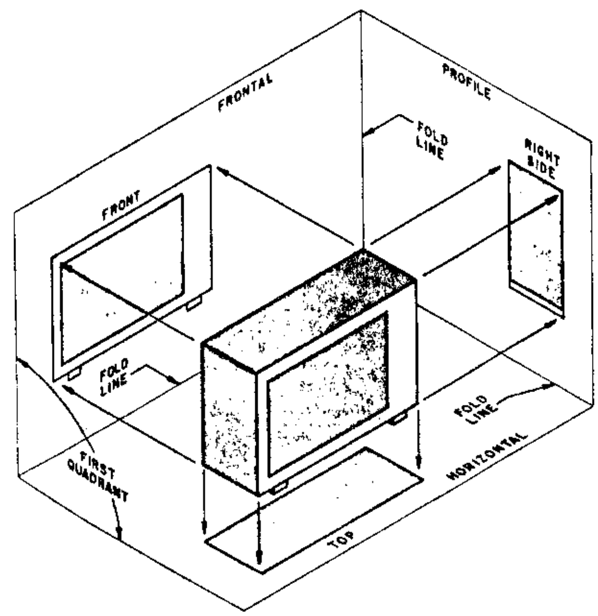


Fig. 5

ure 4, from Thomas French's *Engineering Drawing* text of 1918[3], depicts first angle projection and identifies four quadrants for projection. Professor French also noted, in his 1918 text, the curious mixture of first and third angle projection used by the British in which the right side view is shown in third angle projection[4]. This technique is illustrated in Fig. 5. Modern text illustrations consistent with French's description include Hammond, et. al.[5] (Fig. 6(a)) and Luzadder[6] (Fig. 6(b)). A reverse notation for quadrants with only two planes of projection are shown by Eide, et. al.[7] (Fig. 6(c)), but the end results are consistent.

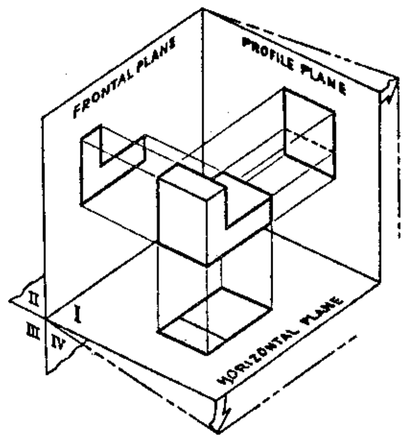
First angle projection may be thought of as projection of an object to a plane. The cardinal rule that must be applied for true first angle projection is to always place the object between the observer and the plane of projection.

Third Angle Projection

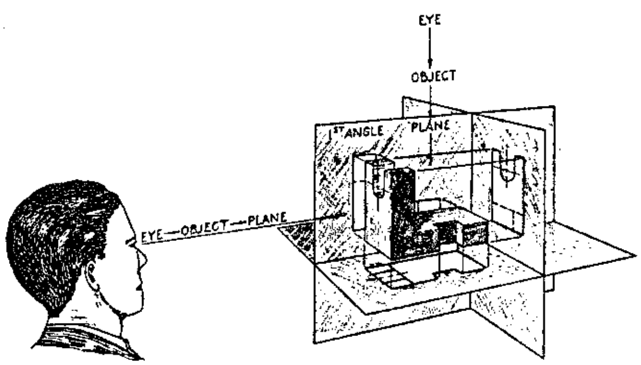
Third angle projection differs from first angle projection only in the location of the plane of projection. Again there is only one cardinal rule to follow - always place the plane of projection between the observer and the object.

This simple technique has been illustrated consistently by French[3] (Fig. 7(a)), Higbee[8] (Fig. 7(b)), Earle[9] (Fig. 7(c)), Giesecke[10] (Fig. 7(d)), and Yankee[11] (Fig. 7(e)).

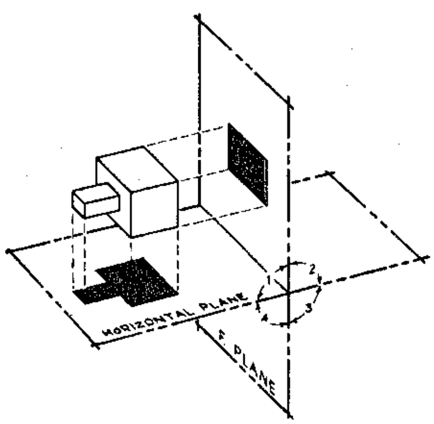
Consistent with the quadrants of projection used in first angle projection, modern text illustrations from Olivo[12] (Fig. 8(a)) and Eide, et. al.[7], (Fig. 8(b)) are shown. A reverse notation for quadrants with only two



(a) Hammond

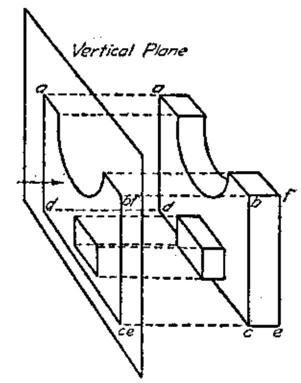


(b) Luzadder

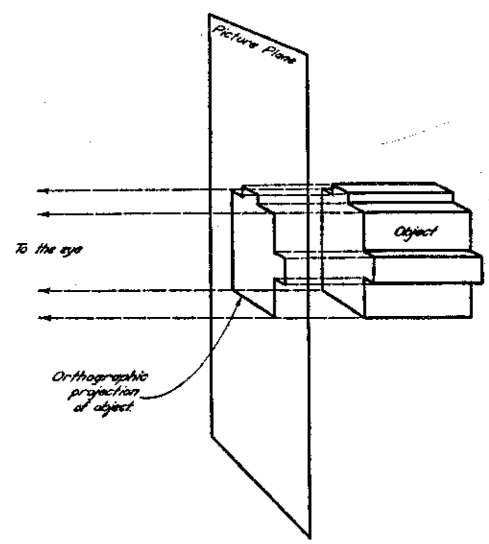


(c) Eide, et. al.

Fig. 6 First Angle Projection Models

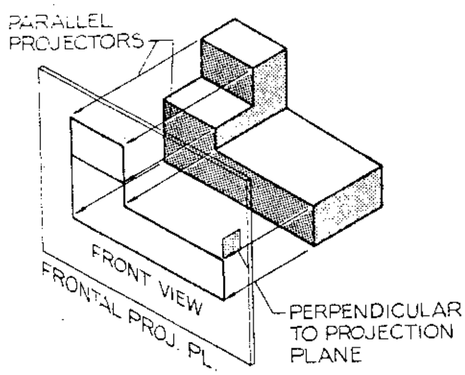


(a) French

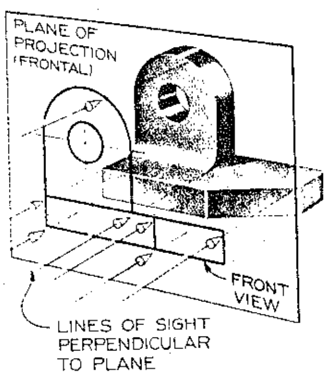


(b) Higbee

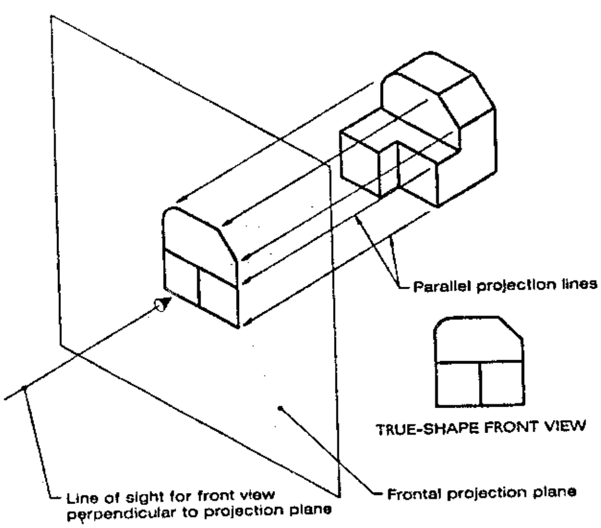
Fig. 7 Third Angle Projection Models



(c) Earle

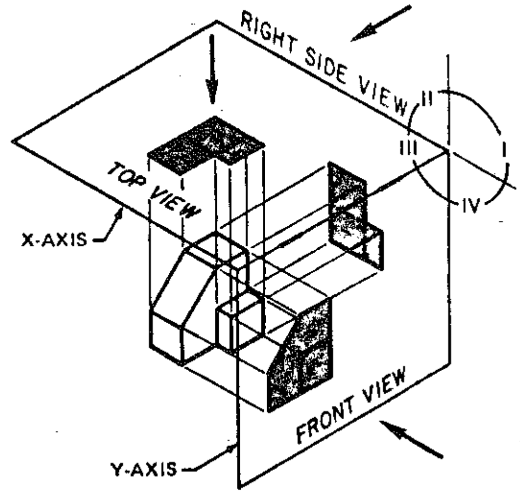


(d) Giesecke

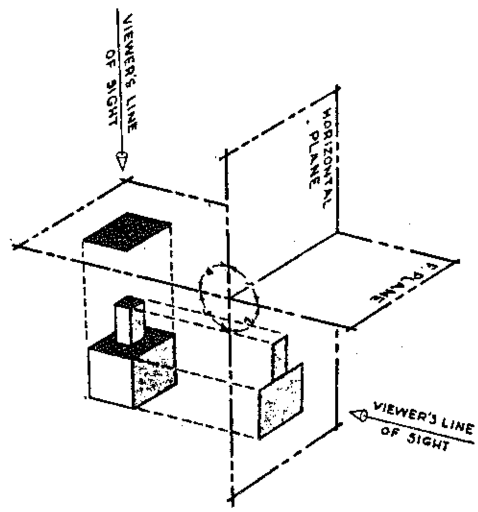


(e) Yankee

Fig. 7 (continued)



(a) Olivo



(b) Eide, et. al.

Fig. 8 Two Plane Third Angle Models

planes of projection are shown in the Eide illustration, but again, the end results are correct.

Division of Space by Projection Planes

The systems of first and third angle projection apparently derived their names from the quadrants that are formed by intersection of one horizontal and one vertical plane in space, as previously illustrated (Fig. 3). Consistent with the two-plane method are descriptions by French, Vierck, and Foster[13] (Fig 9(a)), Olivo[12] (Fig. 9(b)), and Eide, et. al.[7], (Fig. 9(c)).

The inclusion of a third plane of projection is illustrated by Higbee[8] (Fig. 10(a)), Luzzader[6] (Fig. 10(b)), Spence[4] (Fig. 10(c)), and Dobrovolny and O'Bryant[14] (Fig. 10(d)). These illustrations imply, but do not specifically name, the other quadrant set that exists on the opposite side of the profile plane. The illustration by Dobrovolny and O'Bryant does, however, include an additional profile plane to account for both left and right side profile views.

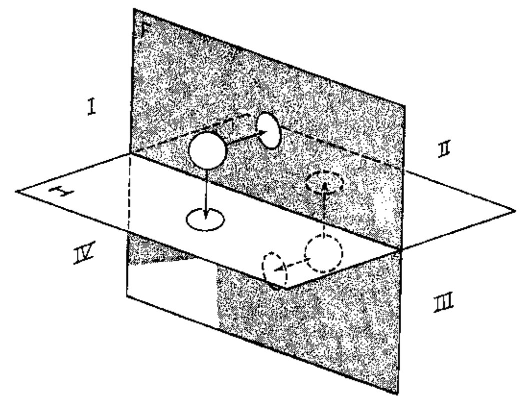
Unfolding the Transparent Glass Box

Probably the most common technique for illustrating the tangible existence of third angle projection is to model it as a transparent, hinged glass box containing the six common views of an object. A variety of physical models have been built to show this relationship. The technique is well documented, as shown by French[3] (Fig. 11(a)), Earle[9] (Fig. 11(b)), Giesecke[10] (Fig. 11(c)), Spence[4] (Fig. 11(d)) and Yankee[11] (Fig. 11(e)).

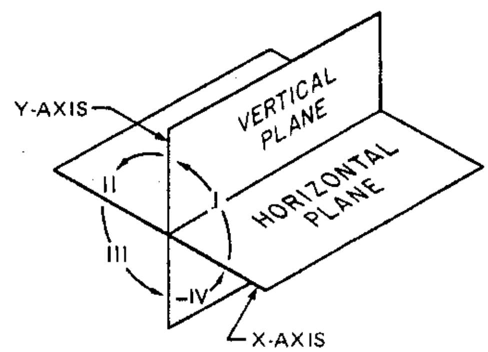
It is important to note the common characteristics of all third angle glass box models:

1. the front view plane is the central or primary view

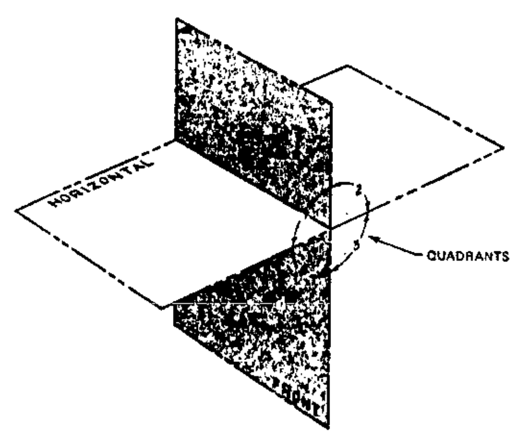
2. the other five planes of the box all swing outward, away



(a) French, Vierck, & Foster

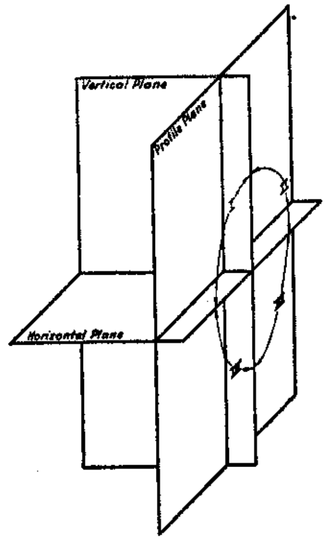


(b) Olivo

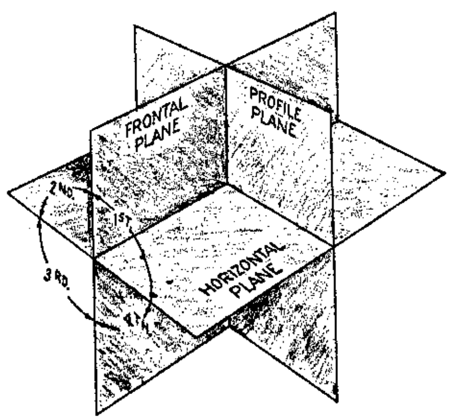


(c) Eide, et. al.

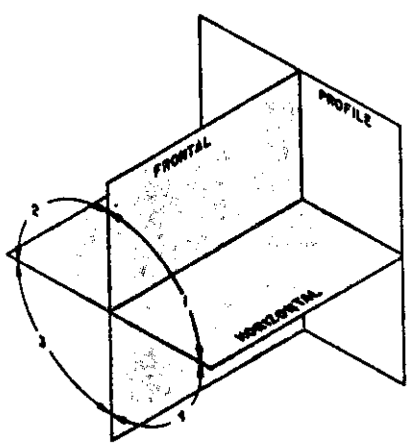
Fig. 9 Division by Two Planes



(a) Higbee

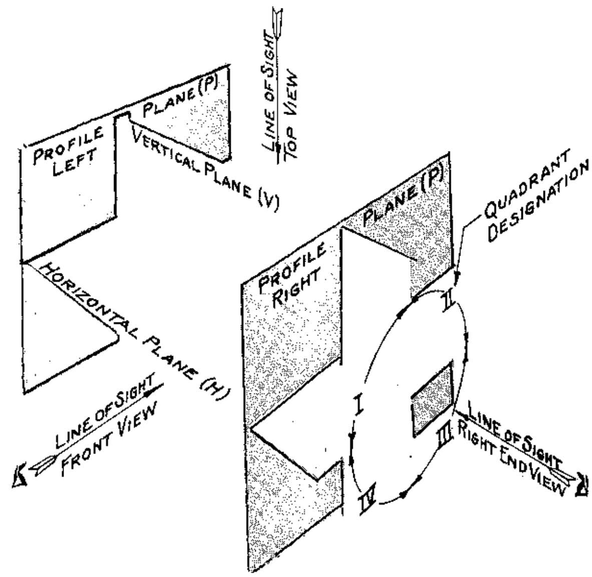


(b) Luzadder



(c) Spence

Fig. 10 Division by Three Planes



(d) Dobrovolny & O'Bryant

Fig. 10 (continued)

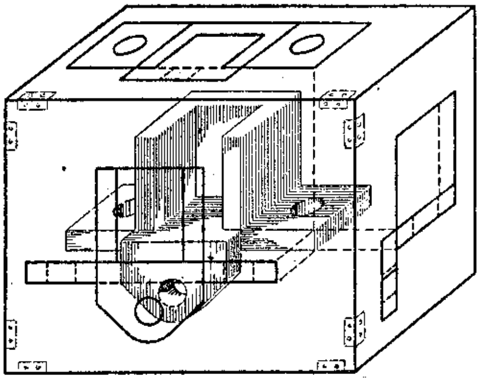
from the center of the box and toward the observer

3. when the box is opened to a single flat plane, it is assumed in all six views that the plane of projection always lies between the observer's eye and the object.

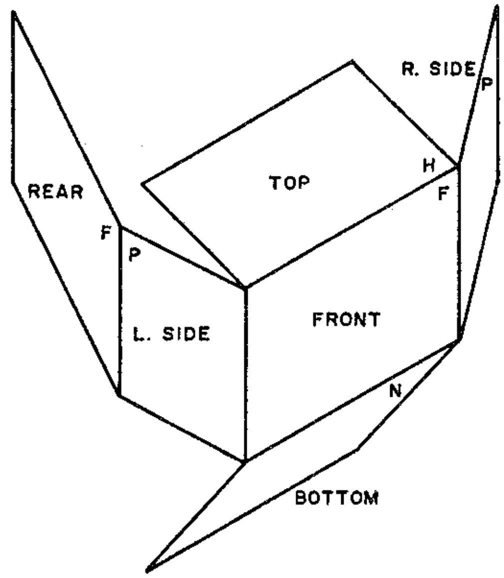
If first angle projection is considered to be the inverse of the third angle projection, then one logical scenario for designing a first angle projection box would be to have it hinged in an exact reverse of the third angle box. Based on this premise, a graphical model illustrating the folding sequence of a first angle projection box is shown in Fig. 12.

As with third angle projection boxes, it is important to note the common characteristics of all first angle glass box models:

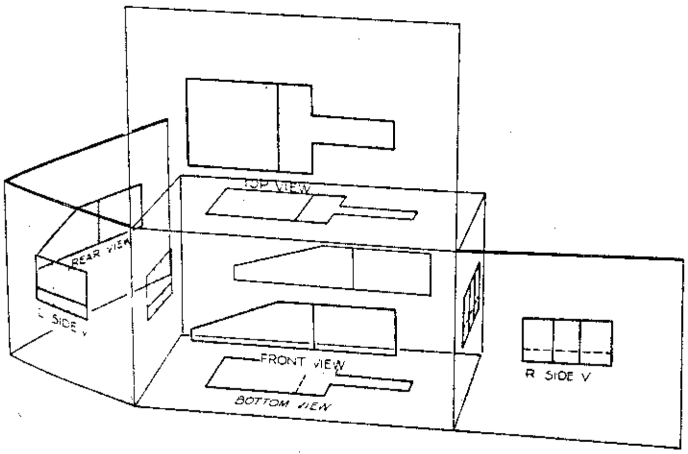
1. the front view plane is the central or primary view



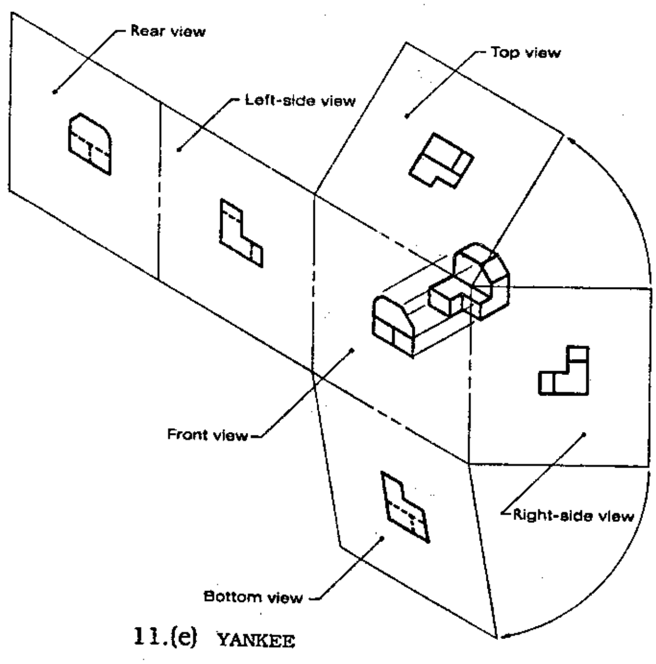
(a) French

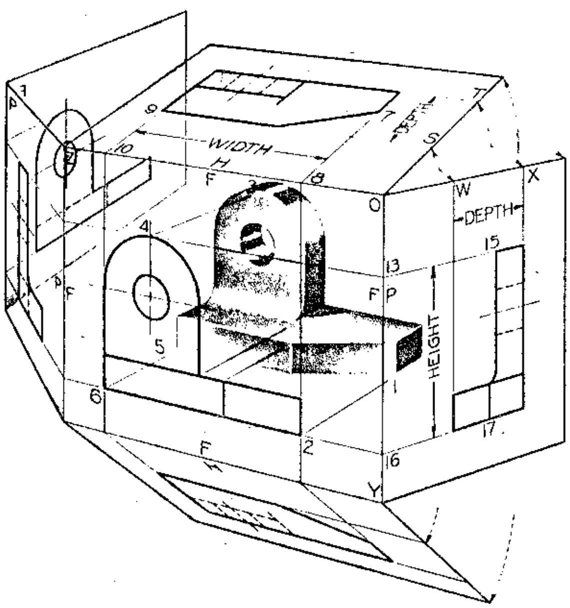


(d) Spence



(b) Earle





(c) Giesecke

(e) Yankee

Fig. 11 Third Angle Glass Box Models

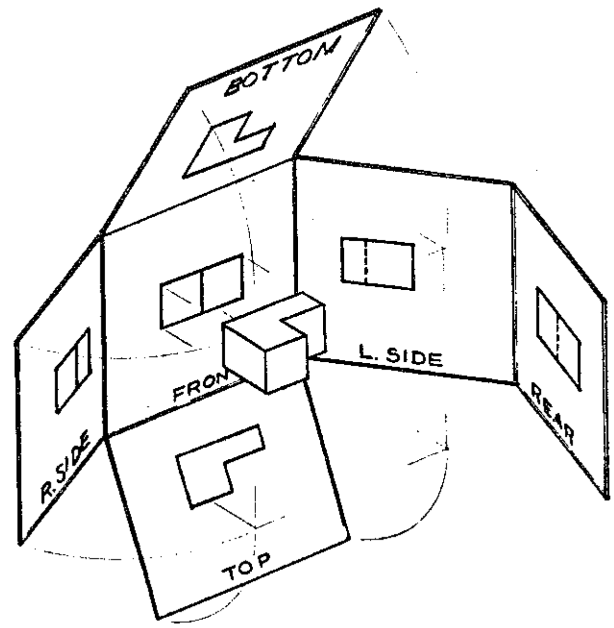


Fig. 12 First Angle Projection Box

2. the other five view planes of the box all swing outward, away from the center of the box and away from the observer, and

3. when the box is opened to a single flat plane, it is assumed in all six views that the object always lies between the observer's eye and the plane of projection.

Computer Graphic Coordinate Systems

Individuals trained to work using first or third angle projection should find two-dimensional computer-aided drafting a natural extension of their experiences on the drawing board. The addition of an X and Y coordinate system and highly precise and quick geometric construction methods compliment either first or third angle projection equally.

In imagining three-dimensional computer graphics, those trained to use third angle projection may tend to think of the object as existing inside the computer and being projected onto the screen. This assumption appears to be consistent with those developing and explaining algorithms for three-dimensional object description, as shown by Foley and Van Dam[15] (Fig. 13)

Learning to use 3D computer graphics software for modeling and design is a rather different experience from traditional drawing. The student or user quickly learns to work directly in a world focusing on revolving and manipulating objects. With the exception of temporary construction planes, there is less need for projection. The emphasis appears to be on geometric model building facilitated through user defined construction planes. The use of construction or work "planes" to define geometric profiles for 3D operations is illustrated in Fig. 14. Figure 14(a) shows the creation of a

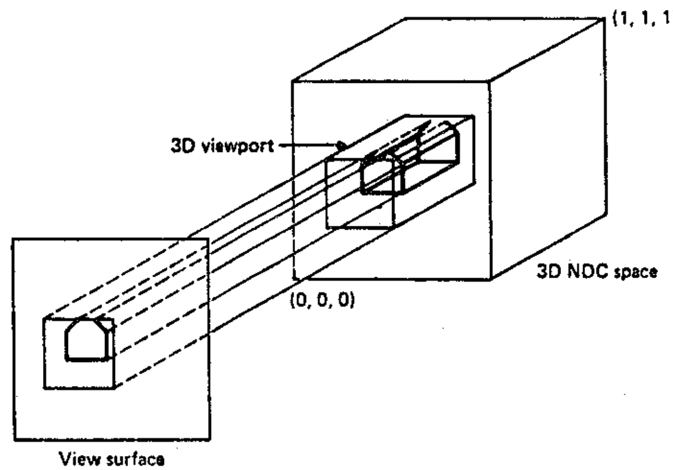
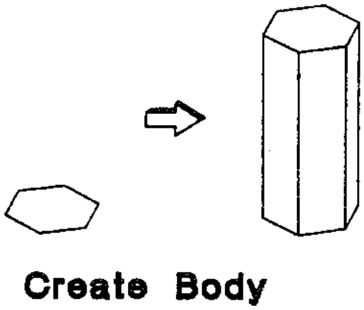
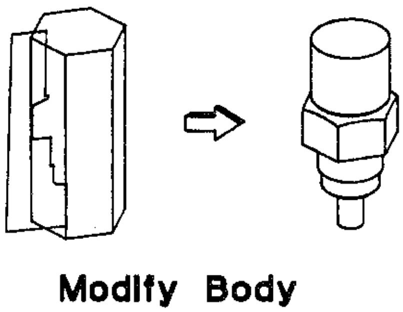


Fig. 13 Projection of Normalized Device Coordinates



(a)

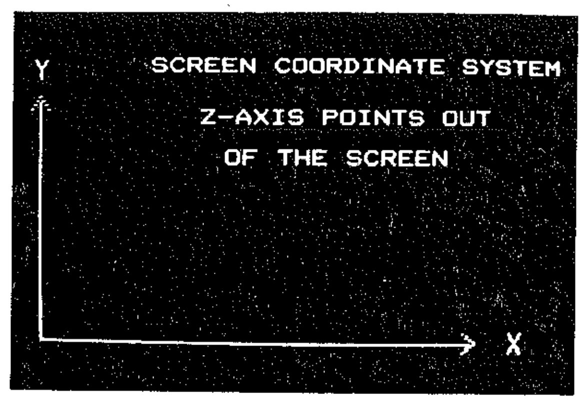


(b)

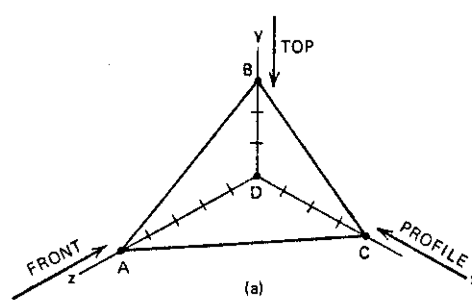
Fig. 14 User Defined Construction Planes (Hewlett-Packard)

hexagonal prism by extrusion along an axis.[16] Figure 14(b) shows the removal or subtraction of geometry by defining the profile of the part and revolving the workplane about the axis of the part. The presence of construction planes should indicate that a clear understanding of projection and reference planes are likely to remain as critical visual thinking skills.

Visualizing for students and users of 3D CADD software is typically based on an orientation to a predefined X-Y-Z coordinate system. Most systems make the X and Y axes parallel to the screen with the Z axis normal to the screen and parallel with the user's line of sight. Although coordinate systems may be user defined, the default position for most 3D CADD systems is a right-hand rule model in the first quadrant. As shown by Eide[7] in Fig. 15(a), the positive Y-axis points up, the positive X-axis points to the right, and the positive Z-axis points out of the screen toward the user. This coordinate system is commonly referred to as the world or absolute coordinate system. Ideally, in mechanical drawing, the orientation of this coordinate system is also keyed with the front, top, and right side views as shown in Fig 15(b). To assist the user in keeping track of the relative position of the 3D object as it is rotated in space, many software packages also show



(a)



(b)

Fig. 15 3-D Screen Coordinate System (Eide) the tripod of the world coordinate system displayed in addition to the object.

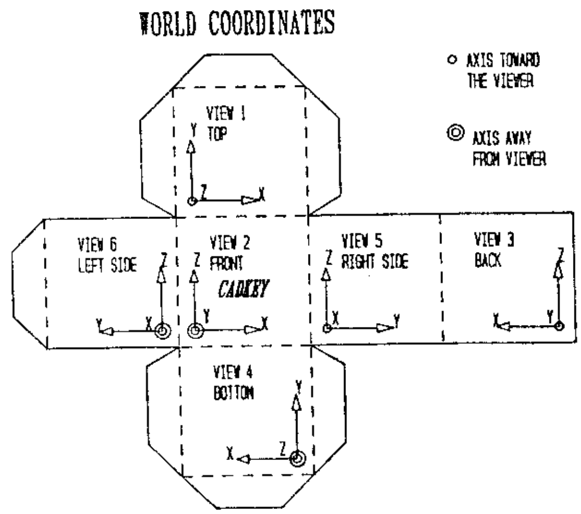
In some 3D CADD systems, the default view is the top view. This is contrary to the front view as principal view in mechanical drawing and should be considered as the user begins the creation of a 3D file. Resetarits and Bertoline[17] illustrate (Fig. 16(a)) the method of orienting world coordinates to the respective views of an object using CADKEY. A similar technique is used in AutoCAD for constructing or extruding 3D geometries, as illustrated by Das[18] (Fig. 16(b)).

Conclusions and Recommendations

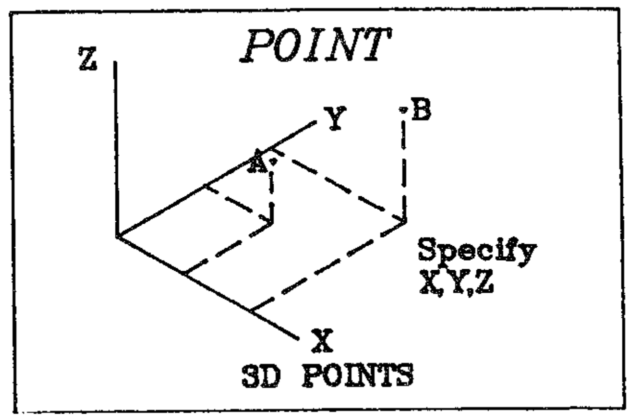
This article contains an initial examination of the existing methods for graphically illustrating projection and coordinate systems for manual and computer-aided drafting and design. From this survey, the following observations have been drawn:

Because an object may be created and located arbitrarily with respect to a 3D CADD world coordinate system, the X-Y-Z coordinates should not be absolutely related to a standardized model for the first and third angle projection.

Solids are normally associated with three axes, X, Y, and Z. The projection of a solid object should therefore require three mutually perpendicular planes for description: X-Y, X-Z, and Y-Z. This is especially important with respect to projection.



(a) CADKEY



(b) AutoCAD

Fig. 16 AutoCAD and CADKEY Coordinate Systems

In order to make a complete graphical model for describing both first and third angle projection in describing solids, it is suggested that the model contain and depict eight octants of space as opposed to only four quadrants.

A complete projection box which hinges correctly for the first angle projection would be useful for students to compare and contrast with the third angle Goss projection box.

Even in a world of total 3D computer-aided design, the ability to clearly understand projection and reference planes is a critical thinking skill which is essential for graphical analysis and description.

There are only two logical methods of projection which are fully consistent in view generation. Why? Because, in any projection system the object is either in front of or behind the plane of projection. All other quadrants (or octants) of space surrounding the three planes contain mixtures of first and third angle projection, as noted of British drawing by Thomas E. French[3] in 1918.

Based on the logic of these conclusions, the following specific recommendations are made:

The Engineering Design Graphics Division should appoint an ad hoc committee to develop a complete standardized method for graphically illustrating and modeling the following:

(1) A uniform octant-based master projection model showing both first and third angle projection.

(2) A glass box folding method which depicts both the third angle glass box and an international glass box model showing first angle folds. The two glass boxes should be illustrated so as to nest in the octant-based master projection model.

(3) A method of illustrating the X-Y-Z world coordinate systems most commonly used in 3D computer graphics which does not imply a fixed relationship between first and third angle projection and positive or negative coordinate location for objects.

This technique should be presented to the Division for possible adoption. This standard can then be submitted to ANSI, textbook publishers, software development firms, and other agencies having need of such information.

Corrections to the organization and presentation of the material in this study would be appreciated. Continued efforts to develop and standardize the paradigm on which graphics educators operate is critical to the longevity and growth of the profession.

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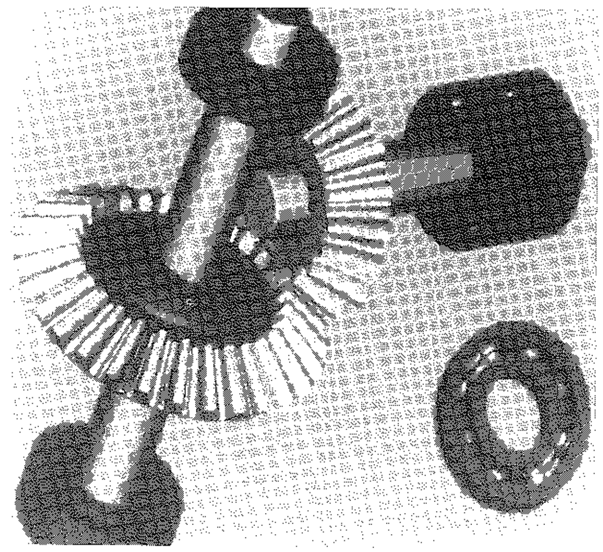

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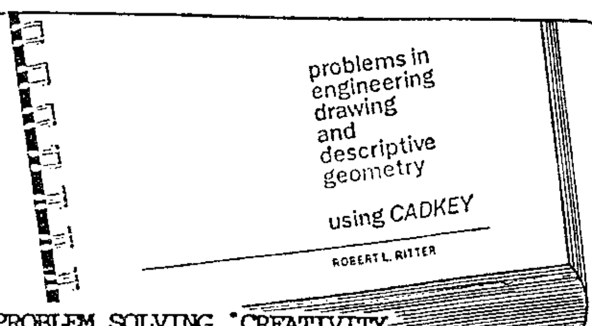

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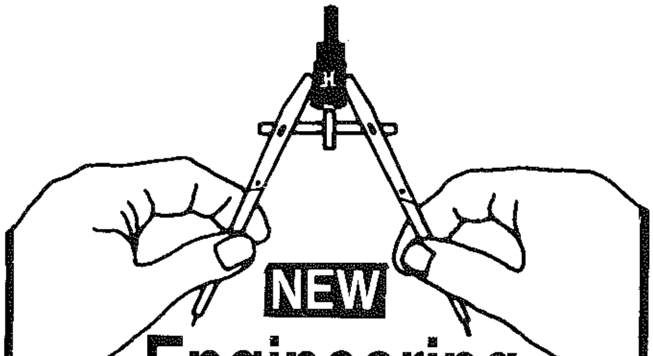

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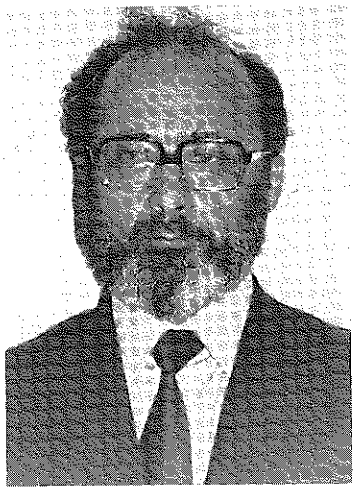
A Remembrance

Abram Rotenberg



Word is received of the passing of Abram Rotenberg. Abe is survived by his son Joe, an electrical engineering student at the University of Melbourne, Australia.

I think most agree that Abe had one of the world's finest engineering graphics minds. His papers occupy a unique place in graphics development because of his attempts to systematize the manner in which descriptive geometry problems and solutions, and all engineering graphics problems and solutions, are analyzed and established as true. Abe abhorred imprecision and ambiguities. His approach was "old world", through the scientific method rather than mere visualization and intuition - although his intuitive insights were surpassing. If Monge told us the how, Abe proved the why. He often focused on applying to engineering graphics and descriptive geometry the equivalent of the mathematical and geometric conditional invariant. His last published work of which I am aware advocated a definition of descriptive geometry in terms of a conditional invariant.

I became acquainted with Abe some fifteen years ago during my tenure as the Puzzle Corner editor for the *EDG Journal*. One of the Corner's most gratifying experiences was publishing Abe's "First Descriptive Geometry General Solution To The Problem: Determine All Directions In Which Any Two Skew Lines In General Positions May Be Viewed Such That They Appear Equal In Length", dubbed The Rotenberg Solution.

Abe's quietness and passion for precision belied a very human person. Once at a mid-year meeting at which he won the Oppenheimer Award, he advised me when I was feeling particularly inadequate, "Do not prepare too much." Another insight into his character came at the International Conference on Engineering and Computer Graphics in the People's Republic of China. There he publicly chided the hosts for their refusal to allow entry permits to Israelis.

Abe was born in Poland in 1921, "relocated" to Siberia by Stalin, migrated to China, Canada, the United States, and Australia. He lectured at the Tashkent University, USSR, at Princeton University, and since 1959, at the University of Melbourne.

The lack of Abe's presence somewhere on the planet is felt by all who knew him. I shall miss him very much.

Pat Kelso

Chairman's Message

by
Frank Croft

For those members of the division who could not attend the Mid-year Conference in Tuscaloosa, I can only say that you missed one of the best meetings I can remember. Jim Weiss did an outstanding job as host and the division owes Jim a big "Thank you". Also, the technical program was outstanding, thanks to the efforts of Bruce Rogers.

Aside from the program and the great times had by all, the division made some important decisions that will, hopefully, keep it moving forward in the years to come. The executive committee approved a proposal to develop a membership directory for the EDGD. Ed Boyer of Ohio State is the person heading this project. The directory will be pocket size and contain address and telephone information of each member of the EDGD. This directory will be updated annually to reflect the current membership. Ed hopes to have the first directory to each member in time for the Annual ASEE Conference in Toronto. I believe this directory is a step forward for the division. There have been many occasions when I needed to contact a division member and I didn't have his/her address or telephone number. A directory of this nature will enhance everyone's ability to communicate.

ASEE celebrates its 100th anniversary in 1993. As the oldest division within ASEE, the EDGD has a rich and varied history. To commemorate the 100 years of ASEE, Bill Rogers and several other "elder statesmen" of the EDGD, have undertaken the responsibility of writing the division history. The division is looking forward to seeing its history recorded and we thank Bill and his friends for volunteering their time in this endeavor.

The bylaws of the division have not been updated since 1984. Yes, the division has bylaws and we are, for the most part, functioning under them. Due to some unusual circumstances over the past six months, I have appointed, with approval from the executive committee, an ad hoc committee to review the bylaws and offer revisions that will eventually have to be approved by the membership at large. The committee is made up of four past chairman: Bill Rogers, Bob LaRue, Larry Goss, and Rollie Jenison. They will report to the executive committee at the Annual ASEE Conference in Toronto.

Lastly, the division has dissolved the Metrication Committee. This action was taken at the request of the chairman of the committee, Ed Mochel. Due to the growing concern with graphics standards in all forms, the division has established a standards committee, chaired by Ed Knoblock. This committee will examine all standards with regard to graphical communication and strive to have significant input into the process with regard to establishing such standards. This committee is extremely important to the division as we go forward into the coming decade.

After reading these comments, you may feel as though you really missed something if you did not attend the EDGD Mid-year Conference in Tuscaloosa. You can ensure that you do not miss anything again by planning to attend the Annual ASEE Conference in Toronto and next year's Mid-year Conference in Tempe, Arizona. The division is moving forward and input from every member with their varied talents is desired and needed.

Fourth International Conference on Engineering/Computer Graphics and Descriptive Geometry

Sponsored by ASEE's Engineering Design Graphics Division and the Florida International University, Miami, Florida.

June 11-15, 1990.

Topics: Descriptive geometry, theoretical graphics, computer graphics, kinematic geometry and other applications of geometry, engineering computer graphics, computer-aided design, computer-aided geometric design, computerized descriptive geometry, graphics and computer graphics teaching techniques, graphics exercises and computers in engineering graphics education.

Contacts: Steve M. Slaby, Civil Engineering & Operations Research Department, Princeton University, Princeton, NJ 08544: (609) 452-4654 and/or Dr. Oktay Ural, Civil & Environmental Engineering Dept., Florida International University, Miami, Florida 33199, (305) 554-2824.

Calendar of Events

by
Bill Ross

1990 4th International Conference on Engineering/Computer Graphics and Descriptive Geometry
June 11-15, 1990
Miami, FL
(see previous section)

1990 Annual ASEE Conference
June 24-28, 1990
Toronto, Canada

1990-91 EDGD Mid-year Conf.
Nov 18 - 20, 1990
Tempe, AZ

1991 Annual ASEE Conference
New Orleans, LA

1991-92 EDGD Mid-year Conf.
Norfolk, VA

1992 Annual ASEE Conference
Toledo, OH

1992 5th International Conference on Engineering Graphics and Descriptive Geometry
August 17-21. 1992
Melbourne, Australia
Contact:
Larry Goss
Univ. of Southern Indiana
8600 University Blvd.
Evansville, IN 47712

1992-93 EDGD Mid-year Conf.
San Francisco, CA (tentative)

1993 Annual ASEE Conference
Urbana, IL

1993-94 EDGD Mid-year Conf.
Evansville, IN (tentative)

Nominees for Division Officers

by
Bob Foster

The following persons have been nominated for the positions indicated. Ballots will be mailed in February.

Vice-Chairman (1990-91)

VERA ANAND

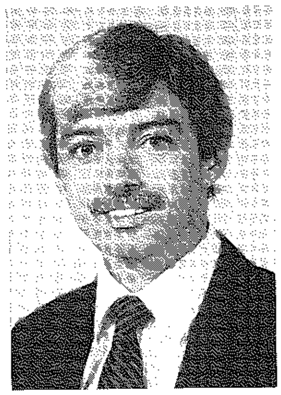
Vera, an Associate Professor and Coordinator for the Engineering Graphics Program at Clemson University, obtained her undergraduate degree in Civil Engineering from the University of Brazil and her graduate degree from Northwestern University. Actively involved with the ASEE/EDGD for the past five years, she has served as Program Chairman for the 1985 Annual Conference and is presently chairman of the International Relations Committee and Director: Professional and Technical Committees. In addition, she has moderated sessions and made presentations at several EDGD meetings. During 1989 she received a grant from the National Science Foundation to conduct a workshop on the use of computer graphics in undergraduate engineering design.

JOHN DEMEL

John is Professor and Chair of the Department of Engineering Graphics at Ohio State and also serves as Associate Dean half time. Prior to teaching at Ohio State, he taught at Texas A&M University and at Savannah State College. He is a registered professional engineer in Texas. John earned his BS degree in mechanical engineering at the University of Nebraska and his MS and PhD degrees in metallurgy at Iowa State University. Within the EDGD, he has made numerous presentations, winning the Oppenheimer Award at one mid-year conference. He has taught workshops with Bob LaRue and has served as Circulation Manager of the *EDG Journal*. John has also co-authored two textbooks and several workbooks in the graphics area.

Director: Professional and Technical Committees (1990-93)

GARY BERTOLINE



Gary, an assistant professor of Engineering Graphics at Ohio State University, has been on the faculty for two years. Before going to Ohio State, he was an assistant professor at Wright State University. He received his B.S. at Northern Michigan University, his M.Ed. at Miami University, and his Ph.D. at Ohio State University. While at Wright State he developed the CADD lab and courses. At Ohio State he integrated CADD into engineering graphics and is pursuing research in visualization. He has authored numerous textbooks and papers. He has been active in ASEE, serving as treasurer and vice-chairman of the North Central Section and in the EDGD serving on the Industrial Relations Committee. He will be the Program Director for the 1990 midyear conference to be held at Arizona State University and is on the board of review for several journals. Currently, Gary is one of the directors of an engineering graphics curriculum development project funded by SIGGRAPH.

DEL BOWERS

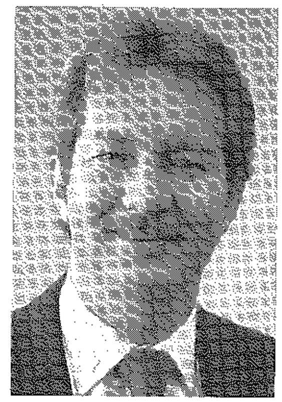
Del is an Associate Professor of Interactive Computer Graphics and Coordinator of Freshman Engineering Graphics at Arizona State University. He has been a member of ASEE since 1983. Recent professional activities include presentation of papers at national and regional conferences, journal articles, and contributions to workbooks and textbooks. Ongoing research activities include investigation of teaching methods to improve visualization and creativity.

Director: Zone Activities (1990-93)

LARRY GENALO

Larry received his B.S. degree from Hofstra University and his M.S. and Ph.D. degrees from Iowa State University. His Ph.D., obtained in 1977, is in applied mathematics and systems engineering. He has taught in the Department of Freshman Engineering at Iowa State since 1976. The freshman year courses in engineering problem solving and FORTRAN programming and in engineering graphics and design have been his special interest. Each of these courses includes an extensive laboratory component. Larry has been active in ASEE since 1976. He was the Chair of the Freshman Programs Constituent Committee in 1988-89 and previously served as its Program Chair. He is currently the secretary/treasurer for DELOS and has been active in the Engineering Design Graphics Division, winning the Oppenheimer Award in 1985.

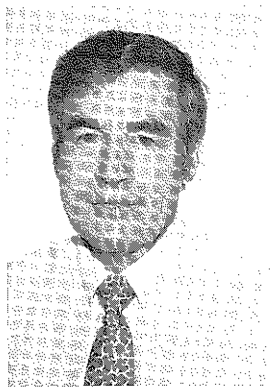
BILLY WOOD



Billy is currently Director: Zone Activities for the EDGD. He is a Teaching Specialist in the Engineering and Computer Graphics Area of the Mechanical Engineering Department at the University of Texas at Austin. He has taught for ten years at the UT - Austin and for four years at Texas A&M University. His Bachelor of Science degree was obtained in engineering technology in 1974 and his Master of Architecture was obtained in 1977, both from Texas A&M University. He is a member of the ASEE, the Society of Automotive Engineers, and the Tau Sigma Delta National Architectural Honor Society. Billy has authored nineteen publications in the areas of automotive design, architectural design, computer graphics and CADD. He has published three CADD laboratory manuals, an architectural study, an engineering graphics textbook, and an interior design workbook. Besides his teaching responsibilities, he is responsible for managing the CADD facilities in the Mechanical Engineering Department.

Advertising Manager - The EDG Journal (1990-93)

MICHAEL MILLER



Mike is an Assistant Professor of Engineering Graphics at Ohio State University. He has taught computer graphics and programming full time for four years. He has been active in ASEE and the EDGD since 1985 by presenting papers, serving as a program moderator, reviewing papers for publication in the *Engineering Design Graphics Journal*, and participating in the computer graphics committee.

DENNIS SHORT

Dennis is a tenured Associate Professor in the Technical Graphics Department in the School of Technology at Purdue University's main campus in West Lafayette, Indiana. He received his B.A. degree from Purdue in 1980 and his MSed in 1983. Dennis is a member of ASEE and SME and is a Certified Manufacturing Engineer in the area of CAD. As an active participant in the EDGD, he has presented papers at recent mid-year meetings and at the 3rd International Conference on Descriptive Geometry and Engineering Graphics at Vienna in 1988. He has also published in the *EDG Journal*. His work has included serving as a faculty advisor for a monthly student publication which was self-supported by advertising revenues.

International Computer Graphics Calendar

by
Vera Anand

Mar 12 - 15, 1990
EDAC '90 - The European Design Automation Conf., Glasgow, U. K. Contact EDAC 90 Secretariat, CEP Consultants Ltd., 26-28 Albany St., Edinburgh EH1 3QH, U. K.

Jul 8 - 12, 1990
CATS '90 - Internat. Conf. on Computer Aided Training in Science and Tech., Barcelona, Spain. Contact Prof. E. Onate, Centro Internacional de Metodos Numericos en Ingenieria, Jorge Girona Salgado, 31. 08034 Barcelona, Spain. Ph. 34-3-205 70 16/204 82 52.

Aug 6 - 10, 1990
SIGGRAPH 90, Dallas, TX, Contact: David D. Loendorf. Ph. (505) 665-0866.

Aug 28 - 30, 1990
ICED 90, International Conf. on Engineering Design, Dubrovnik, Yugoslavia. Contact: HEURISTA, Conf. Dept., Postfach 102, CH-8028 Zurich, Switzerland.

Sep 3 - 7, 1990
Eurographics '90 - A conf. and exhibition sponsored by the European Assoc. of Computer Graphics, Montreaux, Switzerland. Contact Eurographics '90, Conf. Secretariat, Paleo Arts et Spectacles, Case postale 177, CH-1260 Nyon, Switzerland. Ph. (41) 22 62 13 33.

For further information, contact Vera Anand, 302 Lowry Hall, Clemson Univ., Clemson, SC, (803)-656-5755.

Call for Help

As part of our celebration of the 100th anniversary of the founding of the Society for the Promotion of Engineering Education (now the American Society for Engineering Education) in 1993, a special issue of the Engineering Design Graphics Journal is planned. Bill Rogers has agreed to undertake, with the help of Bob Hammond and Bob LaRue, a compilation of the history of our Division (Engineering Drawing, Engineering Graphics, and Engineering Design Graphics). It is believed that previous histories of the Division have been written and published in the *Journal* or elsewhere. We seek copies of any previous histories, historical notes, and other material, both archival and anecdotal, which will aid us in compiling an accurate up-to-date history for this 1993 anniversary issue of the *Journal*.

Please send material to:

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or call:

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All material will be returned to the sender after completion of the compilation. Significant contributions will be acknowledged and attributed in the *Journal*.

Call for Papers

EDGD 1990-91 Mid-year Conference
November 18 - 20, 1990
Arizona State University
Tempe, AZ

Visualizing Engineering Design Graphics in the 90s: The Gateway to the 21st Century

Suggested topics:

Engineering design graphics in the 21st century

Curriculum issues for the 90s

Sketching in the EDG curriculum: A renewed emphasis

Engineering design graphics: An historical perspective

A research agenda for EDG

Visualization applied to EDG

Future trends in hardware and software

Abstracts of 250 words are due July 1, 1990. Submit to:

Gary R. Bertoline
Program Chair
Dept. of Engrg. Graphics
The Ohio State Univ.
240 Hitchcock Hall
Columbus, OH 43210

(614) 292-7930

Notice of acceptance mailed by July 30, 1990. Completed papers for Proceedings are due Sep 15, 1990.

Call for Papers

on

Geometric Modeling in Engineering Education

for the Winter, 1991 issue of the *EDG Journal*

sponsored by the EDGD Geometric Modeling Committee

The purpose of this issue is to provide a number of articles dealing with educational as well as research and application issues in the emerging field of geometric modeling in engineering. Topics of interest include:

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Innovative ideas for teaching geometric modeling in the freshman graphics course

Geometric modeling applications in the various areas of engineering

Other topics on geometric modeling and design

Submit papers to:

Prof. Nadim Aziz
Engrg. Graphics Program
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Clemson Univ.
Clemson, SC 29634

not later than July 1, 1990.

Reflections from the 1989-90 Mid-year Meeting

by
William Rogers
Professor Emeritus, VPI&SU

The 1989-90 Mid-year Meeting of the Engineering Design Graphics Division is, as they say, history. And, like any other after-the-fact commentary, what I have to say will be highly subjective.

The advance planning, registration, organization, sleeping and eating facilities, conference and banquet rooms, and related paraphernalia can be described in one word: outstanding. Jim Weiss, Bruce Rogers, Chairman Frank Croft and those assisting them did their job well. They have earned our thanks and commendation. But, this is not news. For many years our mid-year meetings have been characterized by efficient planning and organization. We expect things to run smoothly and are seldom disappointed.

The ladies program and related non-technical activities were diverse, taking advantage of the local attractions. Some of these activities appeal to some, not to others. To each his own, whether it be a steel mill, dog track, museum, historic restoration, shopping mall, etc., etc. It is regrettable that there is not more time in the packed schedule for individual divertissements. For example, an afternoon free for walking around the beautiful campus of the University of Alabama would have been most enjoyable ... It is not always raining in Tuscaloosa. A good after-dinner speaker is hard to find. We had a great one, and we thank host Jim Weiss for arranging the appearance of Eddie Conyer.

There is no doubt that the quality of our technical presentations has improved significantly over the past twenty or so years, due in no small part to the motivation provided by the Oppenheimer Award. Presentations at this meeting ranged from outstanding to mediocre, with more in the good to excellent category than in the fair to poor. The Oppenheimer Award judges were faced with difficult decisions. The winner well deserved the award; however, had another one of two or three outstanding presentations scored the highest, the selection would have been most difficult to refute.

Our meetings, both annual and mid-year, have always provided a forum for frank and open discussions of our mutual goals and problems, both local and national, encountered in attempting to achieve these goals. And, if the wind was right, we might have learned something which could be applied to good advantage back on our home campus. This is still true, but I sense the presence of an element of hypocrisy. Perhaps it has always been with us and I have only just now reached the degree of cynicism required to detect it. In my humble judgement, the content of the papers has not kept pace with the improvement in the quality of the presentations. A minister of some fame was once described as a man who could say nothing with great eloquence. The same might be said of some of our technical speakers. Fortified and supported by a variety of computer-based technology, remote-controlled slide projectors, and other mysterious and costly hardware, the presentations have reached an unprecedented and heretofore unattainable level of visual and auditory eloquence. There have always been technical papers that, I readily admit, I did not understand. Either I did not, because of my own ignorance of the subject, understand the technical aspects of the paper, or I failed to grasp the point the speaker was trying to make. But, I was optimistic that the content of the paper was making sense to somebody. There have been times, however, when I wondered if we were not all nodding gravely and admirably at the "emperor's new computer".

It is difficult, perhaps impossible, for a program and/or editorial committee to be one hundred percent effective in accepting material for presentation or publication that is pertinent, timely, and substantive, and to satisfy the varied opinions in this regard. And it is certainly impossible to control what the speaker will say once given the podium. At that point, about all the moderator can do is control the allotment of time. The moderators in recent years have done a commendable job in this respect.

The number of papers accepted for presentation needs to be curtailed. Everybody wants to say his piece and "earn" a trip to the meeting. How does the program chairman say to a friend or colleague, "I am sorry: your paper does not fit the theme or emphasis of this meeting". And a great abstract does not guarantee greatness in the paper. At the Alabama meeting there were too many papers, with no time for questions or a general discussion.

I suspect that too many of our technical speakers are using our division and our meetings, not as the aforementioned forum for the exchange of ideas and problems of mutual concern, but as a platform for self-promotion. Perhaps it has always been so, but I have never before felt this strongly about it. The institutional pressure to "publish or perish", the limited availability of publications and platforms, and the higher standards required have left many of those with little or nothing to say, but with a compelling urge to speak. Do we, the Engineering Design Graphics Division, and indeed, ASEE as a whole, provide that opportunity? Are we being used as an available platform, the "Hyde Park" of technical education, where anybody can, by self-invitation, speak on any subject even remotely relevant to our sphere of interest? I hope not.

When those of us, particularly those of us financially underwritten from institutional funds, are called upon by colleagues, department heads, and deans to answer, "Well, what did you get out of this 'boondoggle'?" The correct and most straightforward response is probably, "Nothing!" - certainly nothing that can be quantified, placed in neat columns on a laundry list and stored on a disk for future use. There may be those who can do this. I have tried, and failed miserably, to share with my skeptical colleagues my increased wisdom and knowledge gleaned from faithful and dutiful attendance at the technical sessions of this or some other society meeting. It is somewhat akin to describing a sunrise to an habitually late riser. To identify the immediate tangible results from attendance at our division meeting might be compared to an investment in a mutual fund. Money invested in a mutual fund does not result in a quick profit.

How much profit can be realized from a mutual fund in a week, a month, a year? Not much! However, by investing small amounts and reinvesting all the dividends and interest, a substantial profit can be realized over time. Attending our division meetings (or the meetings of any other professional society) on a one-time basis or once or twice over a period of years yields little in the way of tangible dividends. However, consistent attendance over a long period of time with active participation in both the technical and executive aspects of the society will build an equity from which many valuable advantages accrue. The most valuable of these advantages is being a recognized part of a nation-wide/worldwide network of professional colleagues able to provide mutual support and aid in solving individual problems. Being widely known in this, or any other profession, may not be an essential element in tenure and promotion considerations, but it never hurts. Advancement is not so much dependent upon who one knows, but rather on who knows what one knows. Whatever success I may have achieved over a 40-year career in engineering graphics education was materially aided by my active participation in the EDGD of ASEE and consistent attendance at the annual and mid-year conferences. Did the institutions funding my travel to these "boondoggles" get their money's worth? I think so. There is an immediate public relations benefit by having a respected member of a national society bearing the logo and representing his institution at society gatherings. The institution can bask in the reflected glow of a faculty member elected to a major office in a national society. And, over time the faculty member does return to the institution a significant bonus through his evident professional growth resulting from society contacts. A prominent faculty member representing an institution at a national conference will attract competent young faculty to that institution. While the short-term gain may be too small to measure, the long-term dividends are great and should not be underestimated. Deans, department heads - it is well worth the time and small amount of travel money needed to send the best of your faculty to our meetings, whether they are there to "recite" or not. It recharges the batteries to share experiences and realize that, "Others have the same problems I do and maybe we at 'Old Siwash' are not doing such a bad job after all!"

None of this harangue should be construed as negative criticism of those responsible for the planning and implementing the just-past mid-year meeting at Tuscaloosa or any other past meetings, or of the present or past officers of the Division.

You are doing a splendid job of carrying on a long and honored facet of engineering education in the noble tradition of our distinguished predecessors in engineering drawing/graphics/design. Nor am I being critical of our newest graphic tool, the computer and its magical software. We must move forward with the best tools available to us at any given time - and the tools are getting better all the time.

If I understood and remembered correctly, the core of the Oppenheimer Award-winning paper, so ably presented by Gary Bertoline from The Ohio State University, was that we need to identify and clearly define our subject matter and stick with it. The tools we use become inefficient and obsolete and are replaced by new and better tools. The subject matter remains.

Editor's Note: A similar "Re-flections" authored by William Rogers appeared in Vol. 20, No. 1 of the Journal.

Position Wanted

In the technical graphics and descriptive geometry area. Possess both teaching and industrial experience in the U.S. and abroad. Ph.D. obtained in engineering graphics and descriptive geometry. Areas of interest in mechanical and structural engineering design. Write: c/o Editor, EDG Journal, EF - VPI&SU, Blacksburg, VA 24061-0218.

Survey Results - EDG Curriculum Modernization Project

by

Ron Barr and Davor Juricic

A continuation of the NSF-sponsored project[1], initiated to design, develop, test, and promote a modern curriculum for engineering design graphics, included a survey on a preliminary 15-week (nominal) curriculum schedule given to each panel member for their opinions. Results of the two-part survey, which were presented at the mid-year meeting in Tuscaloosa, are given below.

A. Adequacy of Coverage

Rating scale: 1 to 5

1 - too high
3 - about right
5 - too low

Week No.	Topic	Avg.	St. Dev.
1	Role of Graphics in Engrg.	3.25	0.433
	Lettering Exercises	2.88	0.599
	Freehand Sketching Exer.	3.50	0.707
	Sketching Lines, Circles, Arcs	3.50	0.707
	Loading and Viewing CADD Dwg.	3.13	0.599
2	Geometric Line Constructions	3.13	0.927
	Use of Scales	3.38	0.992
	CADD Functions I	3.13	0.331
	Manual Tool Constructions Ex.	3.13	0.927
	Reading the Scale Ex.	3.38	0.857
	Setting up 2-D CADD Workplane	3.25	0.433
	2-D CADD Primitives	3.50	0.500
3	Tangency Constructions	2.88	0.781
	Conical Sections Constructions	2.25	0.661
	CADD Functions II	3.00	0.500
	Manual Tool Tangencies Ex.	2.38	0.696
	Manual Tool Conic Sections Ex.	2.13	0.599
	Ellipse Sketching Ex.	2.50	0.500
	CADD Tangency Ex.	2.75	0.661

4	Descriptive Modeling	3.13	0.331
	Types of Engr. Models	3.13	0.331
	Pictorial Sketching	3.25	0.433
	Straight Axon. Sketching	3.25	0.433
	CADD Conic Sections Ex.	2.88	0.599
	CADD Spline Ex.	2.75	0.433
5	Types of Geometric Models	3.38	0.484
	Wireframe, Surface, Solids	3.50	0.500
	3-D Base Primitives	3.50	0.500
	Curved Axon. Sketching	2.75	0.433
	Load and View Solid Model	3.38	0.484
	3-D Viewing Control Ex.	3.25	0.661
6	Unary Operations in SM	3.25	0.433
	Boolean Operations in SM	3.25	0.433
	Isometric Sketching	3.25	0.433
	Use of Isom. Ellipse Template	2.50	1.000
	Oblique Sketching	3.25	0.433
	Build SM with 3-D Primitives	3.50	0.500
7	Feature-Based SM	3.25	1.199
	Extrusion and Sweeping SM	3.25	1.199
	Parametric SM	3.13	1.053
	Pictorial Sketch From Model	3.00	0.866
	Build SM Using Feature Basis	2.88	0.781
8	Projection Theory	3.50	1.118
	Multiview Drawings	3.50	0.866
	Multiview Layout from SM	3.25	0.829
	Multiview Sketching Ex.	3.38	0.857
	Build SM and Obtain Multiview	3.50	0.707
9	Manufacturing Processes	2.75	0.661
	Detail Design	3.25	0.661
	Manufacturing Files from SM	2.63	0.484
	Missing Lines Sketching Ex.	3.38	0.696
	Build SM with Fillets and Rds.	3.38	0.484
	Produce Manufacturing File	2.63	0.484
10	SM Geometric and Mass Properties	2.50	0.866
	Mesh Generation for FEA	2.13	0.781
	Design Modification Sketch Ex.	2.88	0.331
	Analyze SM for Mass Properties	2.50	0.866
11	Conventions in Multiview	3.50	0.707
	Auxiliary Views	3.25	1.090
	Auxiliary View Sketching	3.13	1.053
	Auxiliary View Layout from SM	3.25	1.090
	Editing CADD Layouts from SM	3.71	0.700
12	Sections and Conventions	3.38	0.696
	Sketching Ex. in Sections	3.50	0.707
	Sectioning in SM and 2-D CADD	3.38	0.857
13	Dimensioning Practices	3.75	0.968
	Sketching Ex. in Dimensioning	3.38	0.857
	Dimensioning in SM & 2-D CADD	3.38	0.696
14	Engineering Production Drwgs.	3.13	0.599
	Graphics for Data Reporting	3.13	0.599
15	Short Design Project	3.25	1.479
	Project Planning and Sketching	3.25	1.090
	Solve Project with SM and CADD	3.25	1.090

B. Scheduled Place in Curriculum

Rating scale: 1 to 5

1 - too soon
3 - about right
5 - too late

1	Role of Graphics in Engrg.	3.25	0.433
	Lettering Exercises	3.25	0.433
	Freehand Sketching Exer.	3.25	0.433
	Sketching Lines, Circles, Arcs	3.25	0.433
	Loading and Viewing CADD Dwg.	3.00	0.500
2	Geometric Line Constructions	3.25	0.433
	Use of Scales	3.25	0.433
	CADD Functions I	2.88	0.599
	Manual Tool Constructions Ex.	3.25	0.433
	Reading the Scale Ex.	3.13	0.599
	Setting up 2-D CADD Workplane	2.63	0.857
	2-D CADD Primitives	2.88	0.599
3	Tangency Constructions	2.88	0.927
	Conical Sections Constructions	2.75	1.090
	CADD Functions II	3.00	0.500
	Manual Tool Tangencies Ex.	3.13	0.781
	Manual Tool Conic Sections Ex.	3.13	0.781
	Ellipse Sketching Ex.	3.25	0.661
	CADD Tangency Ex.	2.88	0.331
4	Descriptive Modeling	3.25	0.433
	Types of Engr. Models	3.25	0.433
	Pictorial Sketching	3.50	0.707
	Straight Axon. Sketching	3.38	0.484
	CADD Conic Sections Ex.	2.75	0.433
	CADD Spline Ex.	2.50	0.707
5	Types of Geometric Models	3.00	0.500
	Wireframe, Surface, Solids	3.00	0.500
	3-D Base Primitives	3.00	0.500
	Curved Axon. Sketching	2.88	0.927
	Load and View Solid Model	2.88	0.599
	3-D Viewing Control Ex.	3.00	0.707

6	Unary Operations in SM	2.75	0.433
	Boolean Operations in SM	2.75	0.433
	Isometric Sketching	3.50	0.707
	Use of Isom. Ellipse Template	2.88	0.599
	Oblique Sketching	3.50	0.866
	Build SM with 3-D Primitives	2.88	0.599
7	Feature-Based SM	2.88	0.599
	Extrusion and Sweeping SM	2.75	0.661
	Parametric SM	3.00	0.866
	Pictorial Sketch From Model	3.00	0.707
	Build SM Using Feature Basis	3.13	0.927
8	Projection Theory	3.38	0.696
	Multiview Drawings	3.50	0.707
	Multiview Layout from SM	3.50	0.707
	Multiview Sketching Ex.	3.38	0.696
	Build SM and Obtain Multiview	3.50	0.707
9	Manufacturing Processes	2.50	0.707
	Detail Design	2.38	0.696
	Manufacturing Files from SM	2.88	0.927
	Missing Lines Sketching Ex.	3.00	0.707
	Build SM with Fillets and Rds.	2.75	0.829
	Produce Manufacturing File	2.13	0.781
10	SM Geometric and Mass Properties	2.50	0.707
	Mesh Generation for FEA	2.43	0.728
	Design Modification Sketch Ex.	2.63	0.857
	Analyze SM for Mass Properties	2.88	0.927
11	Conventions in Multiview	3.63	0.696
	Auxiliary Views	3.50	0.707
	Auxiliary View Sketching	3.50	0.707
	Auxiliary View Layout from SM	3.50	0.707
	Editing CADD Layouts from SM	3.63	0.696
12	Sections and Conventions	3.38	0.696
	Sketching Ex. in Sections	3.38	0.696
	Sectioning in SM and 2-D CADD	3.25	0.433
13	Dimensioning Practices	3.63	0.696
	Sketching Ex. in Dimensioning	3.63	0.696
	Dimensioning in SM & 2-D CADD	3.50	0.500
14	Engineering Production Drwgs.	3.25	0.829
	Graphics for Data Reporting	3.00	0.500
15	Short Design Project	3.25	0.661
	Project Planning and Sketching	3.38	0.857
	Solve Project with SM and CADD	3.38	0.484

[1]Barr, R. and Juricic, D.,"Survey Results - EDG Curriculum Modernization Project", *EDG Journal*, Vol. 53, No. 3, Autumn, 1989.

Axis Systems - A Response

by

Jon Duff

I must thank Professor Blakney for raising the issue of axis systems[1]. The understanding of geometry (and thereby its representation with graphics) is fundamentally linked to being able to manipulate the geometry relative to directions in space. However, graphics educators in general have not used this concept of axes other than to explain planes of projection. In fact, axis specification in modern graphics is the antithesis of planes of projection. If one continues to think in terms of planes of projection, he may never understand axes. Several statements concerning the state of axis use in engineering graphics may be made:

1. Historically graphics educators have not stressed the manipulation of geometry relative to axes. Instruction has been characterized by planes of projection, fold lines, and miter lines.

2. Future graphics instruction, even in manual graphics, will be characterized by rotation, translation, and scaling of geometry relative to one or more axes.

3. There is not a single axis system. There are instead axis systems characterized by world, device, and user-specified directions.

4. There is no industry-standard or educational-standard axis

system or systems. That is, the assignment of axes to views, and axes to directions in space continues to be variable.

5. Our lack of leadership in this area has caused others - most notably computer graphics software vendors - to develop their own standards.

For students to be able to understand how geometry performs in space, an understanding of the location of that geometry relative to some axis system is paramount. Many have expressed the frustration of manipulating geometry, say through a rotation, only to arrive at totally unpredictable results. The answer usually lies in the fact that the rotation was done about a different axis system than one had in mind - about the device Z axis when what was really wanted was the rotation to occur about the world Z axis. The implication is that to efficiently use today's tools to produce engineering graphics, one must have a thorough understanding of the complexity and variability of axis systems.

[1]Blakney, W. G. G., Axis Systems - Something New?, *Engineering Design Graphics Journal*, Vol. 53, No. 3, Autumn, 1989.

Review of SilverScreen® Solid Modeling Software

by
Mary Jasper

"Somebody said that it couldn't be done,
But he, with a chuckle, replied..."

We all know the old poem above, and by no small coincidence, the words of this poem apply to a new software which just appeared on the market nationally this summer. Some of us were fortunate enough to see SilverScreen demonstrated at the ASEE Annual Conference in Lincoln, Nebraska. (At the same meeting, I overheard one educator say to another that it would be almost impossible to have a Boolean algebra solid-modeling software on a DOS-based computer.) If you did not take advantage of the special purchase price for a site license ($150.00) during the annual conference, then **shame on you!** For this low, low price, friends and graphics educators, you could have received an unlimited site license for SilverScreen and one of the most powerful software packages available today.

A product of Schroff Development Corporation of Shawnee-Mission, Kansas, SilverScreen is pure 3-D and pure solid-modeling. The SM portion uses Boolean algebra with unions, junctions, differences, etc. (So, it <u>can</u> be done!) The 3-D aspect of SilverScreen is always resident, so there's no more importing and exporting as with some CAD programs. A four-way screen split allows one to see the top, front, and right-side views in typical projection graphics, and the "NE" quadrant of the split screen shows either an isometric view or a perspective view of the object being constructed. This is one of the most valuable aspects of the program when considering visibility education of freshman engineering students. As surfaces are swept or holes "drilled" or 3-D polygons subtracted from the solid, the actions show up in all four views, at the same time.

A full range of colors (16) and patterns for hatching are available. SilverScreen supports several different translators including "SmartCAM", a software language used with many CNC manufacturing operations. Even with a "286" computer, the regeneration is much faster, even with hidden lines and shading, than some of the other CAD programs the reviewer has used. SilverScreen offers a menu selection called "quick-Hide" which hides lines and fills the surfaces with one of the colors available. There is also a file utility called Script Files, which can be used for presenting and reviewing the steps involved in building a three-dimensional object from "scratch". The total SilverScreen program, with all the demonstration files (mechanical and architectural) and Script files, slideshows, etc., only takes about 4Mb hard disk space - which is amazing, considering the many utilities of the program.

Using a structured "tree" file system, the program adds primitives, groups the primitives into object groups, places these object groups into larger object groups, and, finally, groups everything together into a drawing. Several drawings may be imported into a window structure which can accommodate up to 9 windows. The windows may be individually "zoomed" and/or "panned". The menu structure is "context-sensitive", which means that the display will show only those menus which are usable at that particular stage in the drawing process.

SilverScreen supports a full range of input devices, both digitizers and "mice". However, because the program is new, there are just a few output devices supported by SilverScreen. As the popularity of the program develops, Schroff Development Corporation will probably add more plotters and graphic printers to the list of drivers in the program. Schroff is currently offering a demonstration package of the software, and a short tutorial. Much information on these products may be obtained from:

Schroff Development Corp.
P. O. Box 1334
Shawnee-Mission, KS 66222
(913) 262-2664

Position Available

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Assistant or Associate Professor of General Engineering - Tenure Track (Beginning Fall, 1990) The Penn State University, University Park, PA. Benefits package provided, including health insurance, life insurance, retirement plans, etc. Educational opportunities available for full-time faculty members and dependents.

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Qualifications:

Required - MS degree in engineering, instructional experience, knowledgeable in computer languages, CAD, basic experimental methods;

Preferred - PhD or terminal degree in engineering or related field, professional registration and/or industrial experience, record of scholarly activities.

Send letter of application, resume, and names of three references to:

Dr. Robert J. Foster
Dept. of Engrg. Graphics
The Penn State Univ.
245 Hammond Bldg.
University Park, PA 16802

(814) 865-2952

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Miss Zuo Zongyi of the People's Republic of China wishes to come to the USA to pursue her studies. She has both research, teaching, and industrial experience. Her most recent industrial work has involved the development of a CAD die cutting system. For further information contact:

Miss Zuo Zongyi
Guangdong Institute of Tech.
Dept. of Engineering Drawing
729 East Dongfeng Road
Guangzhou
People's Republic of China
510090

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(signature)

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*27	Mechanical Engineering (Machine Design, Thermodynamics, Power)	$2.00
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This Journal is devoted to the advancement of engineering design graphics technology and education. The Journal publishes qualified papers of interest to educators and practitioners of engineering graphics, computer graphics, and subjects related to engineering design graphics in an effort to (1) encourage research, development, and refinement of theory and application 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.

Submission of Papers and Articles

Submit complete papers, including an abstract of no more than 200 words, as well as figures, tables, etc. in quadruplicate (four copies) with a covering letter to J. B. Crittenden, Editor, Engineering Design Graphics Journal, EF - VPI&SU, Blacksburg, VA 24061. All copy must be in English, type double-spaced on one side of each page. 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 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 seek editorial comments from their colleagues before submission of papers.

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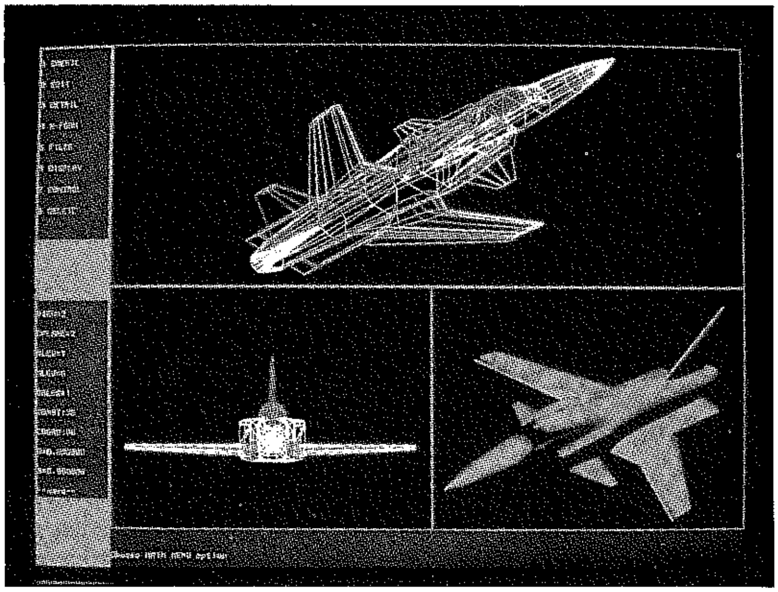

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