THE RELATIVE IMPORTANCE OF GRAPHIC SKILLS DEVELOPMENT IN UNDERGRADUATE ENGINEERING PROGRAMS

By

ROBERTO ALEXANDRE SCHLEMM

Bachelor of Science
Universidade Federal de Paraná
Curitiba, Paraná, Brazil
1972

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1973

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF EDUCATION
December, 1980

THE RELATIVE IMPORTANCE OF GRAPHIC SKILLS

DEVELOPMENT IN UNDERGRADUATE

ENGINEERING PROGRAMS

Thesis Approved:

Lloyd D Briggs
Thesis Adviser

[illegible]

Harold J. Polk

William E. Segall

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. Lloyd D. Briggs, Chairman of the Advisory Committee for his patience and friendship. His encouragement, counsel, assistance, and willing contribution of time, during the author's total graduate program, goes far beyond the call of a professor's duty.

A deep appreciation is also expressed to other members of the Advisory Committee, Dr. Cecil W. Dugger, Dr. Harold J. Polk, and Dr. William E. Segall for their assistance and encouragement.

Throughout the professional development of the author, Professor Aramis Demeterco has been a real inspiration and morale booster. Few people could owe one man what the author owes Professor Aramis Demeterco.

The writer is also indebted to Professor Ir. Firmino Bonato, Professor Ocyron Cunha and Professor Ivo Mezzadri for making the continuing of his studies possible.

A special gratitude is extended to Engineer Marcos Olandoski whose friendship and help will always to cherished.

In addition, the writer is grateful for the scholarship provided by the Coordenação do Aperfeiçoamento de Pessoal de Nivel Superior (CAPES) over the last two years without which the doctorate program could not have been completed.

And last, the author wishes to express his love and appreciation to his wife, Sonia, and his two daughters, Alessandra and Claudia, for

their endurance and patience, and to apologize to them for the sacrifices they encountered throughout this endeavor.

TABLE OF CONTENTS

Chapter | Page

LIST OF TABLES

CHAPTER I

THE RESEARCH PROBLEM

Introduction

Admission to higher education in Brazil is determined exclusively by the candidate's performance on the college entrance examination (Exame Vestibular). With the unification of the college entrance examination, as recommended in Article 21 of the 1968 University Reform Law, and adopted in 1972, the drafting exam was eliminated and, as a consequence, the study of drafting in Brazilian high schools almost disappeared.

One contemporary trend in engineering education in Brazil, as well as in the United States, is the gradual disappearance of graphics from the Bachelor's Degree curriculum. Where it still survives, it has shrunk badly in terms of both content and time devoted to it. One of the reasons for such a change is that as science and technology grow and expand, so do demands for additional courses in the engineering curriculum. Uusually, these are advanced courses and, when they are added in the senior year, they create backwards pressure toward the freshman year where courses are reduced or eliminated. Many engineering educators believe graphics is not rigorous enough to be included in college curricula and some question the relevance of graphics to the modern engineer's work. Others, however, think it is fundamental--like French (1976) who stated:

> Finally, let us have drawing taught well and understandingly for its own sake, for the sake of the subjects following, and for the students' sake, for whom, with the power it awakens it really becomes drawing in relation to life (p. 35)

Statement of the Problem

Graphics is basically a means of communication with some possibilities for problem solving. Drafting in the engineering curriculum combines these two functions and provides a coherent and integrated body of knowledge such as that which exists in other engineering subjects.

With the exception of mechanical drawing, which is relevant to only a small minority of practicing engineers, few texts agree on what should be included in a graphic course.

The problem with which this study was concerned was the lack of information about what graphic skills are needed in undergraduate engineering programs.

Need for the Study

In many engineering programs, graphic courses were taught in such a way that considerable emphasis was placed on the introductory chapters dealing with basic concepts and construction techniques. The exercise classes were devoted mostly to tricky problems which called for sophisticated solutions that were largely irrelevant to industrial practice. The final unit of the course, in which the above techniques normally are used for practical problems with close relevance to modern technology, now is superficially covered or omitted altogether, because of the limited time available to the teacher. The resulting course leaves the student with some graphical techniques, but without a clear understanding of how they are applied.

Purpose of the Study

The purpose of this study was to obtain information from professional engineers and engineering educators for determining specific content elements appropriate for inclusion in graphic courses in undergraduate engineering programs.

Research Questions

This study attempted to answer the following questions:

1. What is the relative importance of graphic skills development in undergraduate engineering programs?
2. What information elements should be included in graphic courses in undergraduate engineering programs?
3. Is there a significant difference of opinions among Practicing Engineers and Engineering Educators in regard to which graphic skills should be developed in undergraduate engineering programs?

CHAPTER II

REVIEW OF LITERATURE

According to Heacock (1964), some years ago a small group of graphic teachers proposed wider horizons in the teaching of graphics to all engineering students in order to provide the best preparation for creative design. For this purpose they recommended that instruction in basic engineering drawing and descriptive geometry be supplemented by teaching advanced graphics, including an introduction to various applications of graphics that can be used to advantage in other engineering courses. These applications include graphic vector analysis, charts and diagrams for visual interpretation of various kinds of quantitative relationships, graphic analysis for solving technical problems, calculating charts and nomographs, graphical calculus and elementary design projects.

Further, Heacock said that a Committee on Advanced Graphics was appointed in the Engineering Drawing Division of the American Society for Engineering Education and adopted the following policy:

> -To collect and analyze new graphic methods that have been employed to advantage in all scientific fields;
>
> -To classify and integrate into a consistent pattern the underlying graphic principles involved;
>
> -To circulate this material in convenient form for use by teachers, engineers and scientists (p. 5).

After three years of research for the committee, as chairman, Heacock (1964) published a report in the form of a book, Graphic Methods for Solving Problems, which was designed as a reading guide to recent articles in the technical journals describing new graphic solutions of significant problems in engineering, science, business and industry. Many of these articles require a fair knowledge of the methods involved in order that may be read with full understanding. The book, therefore, contains eight chapters in which the various graphics principles and procedures are explained and illustrated by typical examples. An important feature is the comprehensive bibliography of more than 600 references to articles and reports on graphic methods.

During more recent years, the bibliography has been expanded to include all articles published in the technical journals which describe new methods for the solution of problems encountered in engineering and science, business and industry, with more than 3,000 references and 2,000 abstracts.

It is interesting to note that the traditional methods of graphic communication are rarely mentioned. On the other hand, graphic analysis, problem solving, and interpretation of quantitative relationships, by means of charts and diagramsn, are frequently used in a wide range of engineering and scientific applications.

Graphic vector analysis is widely used in many different kinds of engineering applications as an essential part of design procedure. Many articles demonstrate the clarifying value of the graphic approach as the most effective way to ensure complete understanding of complex relations of various kinds.

The field of application in which a graphic method has been used to advantage is usually indicated by the title of the article, or by the name of the journal in which it is published.

The largest number of articles describing useful graphic solutions is found in the field of mechanical engineering. Other fields of application, in the descending order of their number of articles, are electrical engineering, business and industry, civil, and chemical engineering. The smallest number of articles on graphic methods is found in aeronautical engineering.

Trapp (1970) during the fall of 1967, directed an inquiry to appropriate institutions of higher learning in the United States as listed in the Industrial Teacher Education Directory, 1966-67 edition, concerning aspects of the teaching of descriptive geometry in the particular college or university. Of the 208 schools contacted, 158 (76%) responded, with 110 (70%) indicating that descriptive geometry was taught by some department in the university. Four schools noted the subject was to be initiated in September of 1968.

A significant revelation of the survey was that 42 schools (27%) of those engaged in technical teacher preparation did not make descriptive geometry available to their students in any department of the college or university. In this group were included a number of state universities as well as state colleges.

Among the institutions offering descriptive geometry, the subject was taught as a separate course by 95%, while only 5% indicated that material from descriptive geometry was integrated into other courses such as graphics, mechanical drawing, drafting, and engineering drawing.

Approximately 80% of the institutions offering descriptive geometry required some form of introductory drawing as a prerequisite, such as: Engineering Drawing, Engineering Graphics, Technical Drawing or Basic Drawing.

French (1976) in writing about the need and value of drawing, quoted from an address by President Eliot of Harvard University:

> I have recently examined all the courses offered by the University, and I find but one (the course of theology) in which a knowledge of drawing would not be of immediate value (and even there, I think it might help in some cases).
>
> The power to draw is greatly needed in all the courses, and absolutely indispensable in some of them. A very large proportion of studies now train the memory, a very small proportion train the power to see straight and do straight, which is the basis of industrial skill (p. 32).

As to the value of drawing, he quoted again, this time from Dean Shaler:

> The value of drawing in all departments of science, not only as a language, but as a discipline of the mind, can hardly be overestimated. Many students entering Harvard University can think in one dimension, some few in two dimensions, but those who can think in three dimensions are exceedingly rare (p. 32)

There is concern in the drafting and design profession that computers will replace a large number of draftsmen and designers. However, there seems to be no apparent indication that computer aided drafting will cause less demand for draftsmen and designers. In a speech delivered to the Oklahoma Council of the American Institute for Design and Drafting (AIDD), Freling (1974) of Phillips Petroleum Company cited that the reason Phillips opted for an automated drafting system was to fill vacant technician slots.

There is evidence to indicate that computer-aided drafting does not reduce the labor force of designers and draftsmen, but rather deepens their design capabilities and frees them for more creative work. Farrel (1974), Manager of Design Drafting for RCA's Government Communications and Automated Systems Division, states that the implementation of design automation expanded the output of the drafting department to include producing software for numerically controlled machines. O'Neill (1974), a section supervisor for E. I. DuPont de Nemours and Company, stated that in a DuPont study, they found that only 20% of the draftsman's time is spent at the drawing board producing a drawing.

Slaby (1976) of Princeton University points out:

> Computer graphics in its early days was being sold to the public, to industry, to educators, and administrators as a concept and system that would eventually replace all draftsmen and that design would also be placed in the category of obsolete people
>
> Most of the promises of the past, including predictions for the future, have not materialized. Draftsmen and engineering designers continue to be the bedrock of industry and in my judgment this healthy state of affairs will continue as far as I can see into the indefinite future. If we take one of the most sophisticated areas of high technology, the space-satellite program, we see that the need for creative geometers and designers is a top priority, and as an example one only has to visit the jet propulsion laboratory in Pasadena, California to see the reality of this fact. Drawing tables with designers sitting at them with pencil and paper at their fingertips, doing creative engineering design based on fundamental geometrical principles and concepts are patently apparent (p. 34).
>
> If we do not lose sight of the fact that the bedrock of physical engineering design is descriptive geometry and engineering drawing, then we can progress into the future assured of our position of control and our position in engineering and engineering education. Many attempts have been made to relegate these areas of knowledge to the past but in the process those who have attempted to do this themselves have faded into the past (p. 38).

Educator's response to this era of computer-aided design technology will depend heavily upon the type of infulence exercised by industry. About that, Turner (1976) said:

> Of particular importance to the graduate design engineer is his proficiency in graphics and English as fundamental means of communication. It is extremely rare to find a graduate design engineer who has the required proficiency in engineering drawing, and who can write with accepted legibility without the use of lettering guides. It is often necessary to place the young engineer in the drafting department for at least one year under the supervision of a lead designer and hope that he will achieve proficiency through osmosis.
>
> Use of computers for automated drafting and design is becoming more feasible throughout the industry. Nevertheless, their contribution and effectivity is directly correlated to the inputs of the design engineer who needs to be thoroughly conversant with design graphics (p. 11).

About drawing interpretation, he pointed out that the interminable loss suffered by industry due to ambiguous practices, illegible drawings and inadequate tolerancing have reached significant proportions among today's embattled economy design engineers, often due to ignorance. Geometric tolerancing is the least anbiguous method of specifying design and is based upon the use of universally recognized geometric characteristic symbols. An engineer's education cannot be considered complete without a complete working knowledge of the subject.

Land (1976) emphasized the importance of updating graphics in keeping abreast of recent technological developments. He stated that graphics, as an essential means for design, analysis, and communications, will never become obsolete; on the contrary, "For the computerization of engineering design, the engineer must have a deeper knoweldge of graphic methods than in the past" (p. 33).

Wilhoit (1962) conducted a study on engineering graphics and the application to industry within a 250 mile radius of Miami, Oklahoma.

He collected data pertaining to engineering graphics simplification and the application and acceptance by industry. The approach made by this study was based on sound engineering graphics taken from recognized authorities in the field of study. He concluded that simplified drawing was a functional working drawing with purpose in each and every line, legend, note, and view placed on the drawing. The simplified drawing, he said, gives justification for the elimination of superfluous views, elaborate pictorials, hidden lines, and repetitive detail to relieve the time stress placed on today's engineers and draftsmen.

In a study conducted in 1972, McNeal (1972) reported that the units of instruction which were found to be in the most demand were basic drawing, machine drafting, structural drafting, graphical geometry, and design. Courses in less demand were map drafting and architectural drafting.

The most recent study conducted at the Oklahoma State University was accomplished by Hysaw (1978). His conclusion was that fluid power is very essential in design drafting and recommended application and design of a complete hydraulic system to better prepare graduates for job placement.

During the fall semester of 1979-1980, the State University of New York (1980) reviewed and revised the undergraduate Mechanical Engineering curriculum. A survey of their peer institutions had been made regarding the drafting question. The results based on a survey of available catalogs, showed that 86% of their peers offer drafting courses within engineering. In general, this is an elective course in the Freshman year, however, 62% of Mechanical Engineering Departments do require drafting.

In discussing the changes which they made, it was pointed out that, sometime in the mid-sixties, the teaching of engineering drawing became unfashionable and was dropped from many engineering curricula. The State University of New York (1980) stated that

> . . . while this may be justified for certain branches of engineering, the practicing Mechanical Engineer is continually involved with engineering drawings and must be comfortable working with them. Many of our Mechanical Engineering faculty hear complaints from graduating and past students regarding the lack of engineering drawing in the curriculum (p. 1).

They concluded that: (1) the proper place for an engineering drawing course is undoubtedly at the lower undergraduate level, prior to the Junior and Senior Mechanical Engineering coursework; (2) that the drafting course now is required at the high school, community college or university level, before acceptance into the Mechanical Engineering program at the beginning of the Junior year; and (3) that an introductory engineering drawing course will now be offered to help students meet this requirement. These revisions have been approved by vote of the department faculty and are planned to begin taking effect in September, 1980.

In view of this presented literature, it seems appropriate to investigate the research questions previously stated in Chapter I:

1. What is the relative importance of graphic skills development in undergraduate engineering programs?
2. What information elements should be included in graphic courses in undergraduate engineering programs?
3. Is there a significant difference of opinions among Practicing Engineers and Engineering Educators in regard to which graphic skills should be developed in undergraduate engineering programs?

CHAPTER III

METHODOLOGY

The purpose of this study was to obtain information from professional engineers and engineering educators for determining specific content elements appropriate for inclusion in graphic courses in undergraduate engineering programs.

Definition of Terms

Auxiliary Views--One or more views used to show true shape and relationships of features that are not parallel to any of the principal planes of projection.

Block Diagrams--A pictorial method of representing components and signals within a system, where blocks represent the components and lines show signal flow.

Computer Graphics--The graphical output of analytical data which has been processed by a digital computer.

Connection Diagram--A diagram which shows the connections of installation or its component devices or parts.

Contour--Is a theoretical line on the surface of the ground which at, every point passes through the same elevation.

Descriptive Geometry--Is the science of graphically solving problems involving space distances and relationships.

Dimension--A numerical value expressed in appropriate units of measure and indicated on a drawing along with lines, symbols, and notes, to define a geometrical characteristic of an object.

Erection Drawing--Shows procedures and operation sequence for erection or assembly of individual items or assemblies of items.

Flow Diagram--A graphical representation of a sequence of operations.

Graphics--The art or science of representing a three dimensional object on a two dimensional surface according to mathematical rules of projection.

Isometric Projection--A pictorial drawing in which the three principal faces and the three principal axes of an object are equally inclined to the plane of projection.

Nomograms--Consists of three or more scales arranged and graduated so that any straight line drawn to intercept the three scales will intercept them at scale values which are distinct solutions of the equation.

Oblique Projection--A projected view in which the lines of sight are parallel to each other but inclined to the plane of projection.

Orthographic Projection--A system of drawing, composed of images of an object formed by projectors from the object, perpendicular to desired planes of projection.

Perspective--A pictorial drawing made by the intersection of the picture plane with lines of sight converging from points on the object to the point of sight, which is located at a finite distance from the picture plane.

Printed Circuits--Any circuit formed by depositing a conductive material on the surface of an insulating sheet.

Schematic Diagram--A diagram which shows, by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement.

Sectional View--Is the one obtained by cutting away part of an object to show the shape and construction at the cutting plane.

Tolerance--A total permissible variation from design, size and location.

Selection of the Subjects

In order to select the sample, the writer used the table of random numbers found in Snedecor's text (1978) and randomly selected 300 members of the National Society of Professional Engineers (NSPE) listed in the 1980-81 Directory of Engineers in Private Practice and also randomly selected 300 members of the American Society of Engineering Education (ASEE) listed in the 1980 Individual Member Directory.

The Instrument

The writer, with the help of the Advisory Committee Chairman, developed a tentative questionnaire which was then presented to experts in the field. Each person was asked to review and refine the instrument by adding, deleting, and/or changing it in any ways necessary for its improvement.

Several skills were added to the questionnaire as a result of suggestions. After the review and revisions had been accomplished, the questionnaire was developed into an instrument comprised of 49 skills grouped in nine areas as follows: (1) Basic Drawing; (2) Machine Drafting; (3) Structural Drafting; (4) Architectural Drafting;

(5) Electrical and Electronics Drafting; (6) Map Drafting; (7) Pipe Drafting; (8) Design; and (9) Other. A list of the areas and the number of the corresponding skills is given in Table I.

TABLE I

AREAS AND NUMBER OF SKILLS

Area	Number of Skills
1. Basic Drawing	12
2. Machine Drafting	7
3. Structural Drafting	2
4. Architectural Drafting	3
5. Electrical and Electronics Drafting	5
6. Map Drafting	4
7. Pipe Drafting	3
8. Design	7
9. Other	6
Total	49

For each of the skills listed, the respondent placed a circle on the appropriate number of a five-point continuum scale. One point in the scale indicated not important and five points indicated extremely important. In addition to the skills listed, blank spaces were left for listing additional skills they thought were important. The instrument was then printed in two different colors in order to differentiate the two group responses. A copy of the questionnaire is included in the Appendix A.

Collection of Data

Data for this study were acquired by mailing the study instrument to each of the persons selected. A cover letter (Appendix B) explaining the purpose of the study and a self-addressed stamped envelope were sent to each mailed questionnaire.

In addition to indicating their responses by circling the appropriate number, some respondents added comments and listed additional skills (refer to Appendix C for comments and Appendix D for list of additional skills).

The criteria for judging whether a skill was important or not were established in consultation with the writer's Advisory Committee Chairman. An item was considered to be very important if the mean was 3.50 or higher. An item was considered to be important if the mean was 2.50 through 3.49. An item was considered to be not important if the mean was less than 2.5C.

Analysis of Data

The questionnaire comprised 49 graphic skills, to which the persons participating in this study responded on a five-point continuum scale, from not important to extremely important. The information was keypunched for computer processing as follows:

Not Important	1
Slightly Important	2
Important	3
Very Important	4
Extremely Important	5
No Response	0

The Statistical Package for the Social Sciences (SPSS) was used to perform the statistical analysis of the raw data. The mean, median, mode, standard deviation, range, as well as absolute and relative frequencies were computed on each item for the two groups participating in the study, using the subprogram Frequencies. The *t*-test was used to evaluate the statistical significance of the difference between the two sample means. The uncorrelated *t*-test was used, as when, "A researcher is not dealing with matched pairs or with two measures of the same individuals . . . he assumes no relationship between data in the two groups" (Popham, 1967, p. 144). The uncorrelated design was evaluated for differences between the two means at the .05 level of significance. (See Appendix F for listing of Computer Programs.)

Assumptions

For the purpose of this study, the following assumptions were made:

1. The selected participants possess expertise in the engineering graphic field.
2. The selected participants responded objectively and to the best of their ability.
3. The five point continuum used for the calculations is an interval scale.

Scope and Limitations

This study was restricted to identifying skills appropriate for inclusion in undergraduate engineering programs.

The participants in this study were limited to a random selection of the members of the Professional Engineers in Private Practice (PEPP), a division of the National Society of Professional Engineers (NSPE), and a random selection of the members of the American Society for Engineering Education (ASEE).

CHAPTER IV

RESULTS

Return Rates

The purpose of this study was to obtain information from professional engineers and engineering educators for determining specific content elements appropriate for inclusion in graphic courses in undergraduate engineering programs.

The participant sample in this study consisted of 300 members of the National Society of Professional Engineers (NSPE) and 300 members of the American Society for Engineering Education (ASEE) in the United States. The procedure was as follows: the names and addresses of the participants were obtained from the _1980-81 Directory of Engineers in Private Practice_ of the National Society of Professional Engineers, and from the _1980 Individual Member Directory_ of the American Society for Engineering Education, using the table of random digits of Snedecor's text (1978).

A questionnaire of identified graphic skills was mailed to each of the persons surveyed on April 11, 1980. At the deadline date for accepting the returned questionnaires, May 30, 1980, 51.33% of the questionnaires mailed to the NSPE members had been returned with two questionnaires not completed (see Table II).

TABLE II

NSPE MEMBERS PARTICIPATING IN THE STUDY

Item	Number	Percentage
Questionnaire Sent to NSPE Members	300	100.00
NSPE Member Returning Questionnaires	154	51.33
Unusuable Returns	2	0.66
Usable Returns	152	50.67

At the deadline for accepting the returned questionnaires, May 30, 1980, 49.33% of the questionnaires mailed to the ASEE members had been returned with 10 questionnaires not completed (see Table III).

TABLE III

ASEE MEMBERS PARTICIPATING IN THE STUDY

Item	Number	Percentage
Questionnaires Sent to ASEE Members	300	100.00
ASEE Member Returning Questionnaires	148	49.33
Unusuable Returns	10	3.33
Usable Returns	138	46.00

Analysis of the NSPE Data

The first step in analyzing this data consisted of computing the mean responses and their relative importance as determined by the established criteria; that is, an item was considered as very important if the mean was 3.50 or higher; important if the mean was 2.50 through 3.49; and not important if the mean was less than 2.50. The results are presented in Table IV.

It was determined that 42 items (85.7%) out of the 49 were considered important by the practicing engineers. Twelve (12) of the 49 items (24.5%) were rated very important. Eleven participants added comments to their responses (refer to Appendix C for comments), and 25 listed one or more graphic skills that they thought were important (see Appendix D).

Of the 12 items in the basic drawing area, four were considered to be very important and five were considered important. They considered Lettering, Sectional Views, Dimensioning, and Working Drawings as being very important. They considered Orthographic Projection, Sketching, Auxiliary Views, Isometric Projection, Intersection and Development as being important. Eleven respondents listed additions skills in this area.

In the area of Machine Drafting, four items out of the seven were considered as being important: Surface Treatment of Metals, Tolerancing, General Machine Drawing and Fabrication. Two of the participants added graphic skills important for that discipline.

One of the items in Structural Drafting, Detail Drawing was rated as very important and the other, Erection Drawing rated as important. Additional skills in this area were mentioned by nine respondents.

TABLE IV

MEAN AND IMPORTANCE OF SKILLS AS DETERMINED BY NSPE MEMBERS

Area and Skill	Mean	Rank
Basic Drawing		
**1. Lettering	3.56	(10)
*2. Orthographic Projection	2.88	(28)
*3. Sketching	3.36	(15)
4. Inking and Reproduction	2.36	(46)
*5. Auxiliary Views	3.09	(23)
**6. Sectional Views	3.75	(4)
**7. Dimensioning	3.96	(1)
**8. Working Drawings	3.90	(2)
*9. Isometric Projection	2.80	(30)
10. Oblique Projection	2.34	(47)
11. Perspective Drawing	2.48	(43)
*12. Intersection and Development	2.71	(35)
Machine Drafting		
*1. Surface Treatment of Metals	2.55	(42)
*2. Tolerancing	3.12	(21)
*3. General Machine Drawing	2.92	(27)
4. Casting and Forming	2.37	(45)
*5. Fabrication	2.97	(26)
6. Cams	2.30	(49)
7. Gears	2.33	(48)

TABLE IV (Continued)

Area and Skill	Mean	Rank
Structural Drafting		
**1. Detail Drawing	3.88	(3)
*2. Erection Drawing	3.37	(14)
Architectural Drafting		
*1. Residential	2.78	(32)
*2. Commercial	3.30	(16)
*3. Energy Conservation	3.22	(19)
Electrical and Electronics Drafting		
*1. Graphic Symbol	3.26	(18)
*2. Connections Diagram	3.21	(20)
*3. Printed Circuits	2.70	(36)
*4. Block Diagrams	3.07	(24)
**5. Schematic Diagrams	3.54	(11)
Map Drafting		
**1. Survey Practice	3.66	(5)
**2. Topography Maps	3.65	(6)
**3. Contour Maps	3.58	(9)
**4. Profile Maps	3.50	(12)
Pipe Drafting		
**1. Flow Diagrams	3.59	(8)
*2. Vessel Drawing	2.73	(34)
*3. Exchange Drawing	2.68	(38)

TABLE IV (Continued)

Area and Skill	Mean	Rank
Design		
*1. Hydraulic and Pneumatic	3.40	(13)
*2. Mechanism and Kinematics	3.06	(25)
3. Jigs and Fixtures	2.38	(44)
**4. Structural	3.63	(7)
*5. Machine	2.79	(31)
*6. Materials	2.83	(29)
*7. Solar	2.69	(37)
Other		
*1. Descriptive Geometry	3.29	(17)
*2. Graphical Integral	2.56	(41)
*3. Nomograms	2.62	(39)
*4. Vector Geometry	2.74	(33)
*5. Graphical Calculus	2.61	(40)
*6. Computer Graphics	3.10	(22)

*Important.

**Very Important.

All the three items in Architectural Drafting, residential, commercial, and energy conservation, were considered as important and five participants mentioned additional skills.

In Electrical and Electronics Drafting, one item was considered as being very important and the four others as being important. Seven respondents listed additional skills in this area.

All of the four items in the Map Drafting Area, Survey Practice, Topography Maps, Contour Maps and Profile Maps were considered as being very important. No additional skills were mentioned in this field.

In the Pipe Drafting area, one skill was considered to be very important and the two others were considered important. Four participants added skills in this discipline.

Of the seven items in the Design area, only one, Jigs and Fixtures, was considered as not important. Of those items, the respondents rated Hydraulic and Pneumatic, Mechanism and Kinematics, Machine, Material and Solar Design as being important. In addition, they considered Structural Design as being very important and six of them summed other graphic skills they thought very important.

All of the six skills grouped under the area Other, Descriptive Geometry, Graphical Integral, Nomograms, Vector Geometry, Graphical Calculus, and Computer Graphics were considered to be important, and only two respondents added other skills here.

The second step in analyzing the data consisted of grouping the responses considered important and very important in rank order as appears in Table V.

TABLE V

GRAPHIC SKILLS RANKED IMPORTANT AND VERY IMPORTANT BY PRACTICING ENGINEERS

Area	Item No.	Skill	Mean	Rank
Basic Drawing	7.	Dimensioning	3.96	1
Basic Drawing	8.	Working Drawings	3.90	2
Structural Drawing	1.	Detail Drawing	3.88	3
Basic Drawing	6.	Sectional Views	3.75	4
Map Drafting	1.	Survey Practice	3.66	5
Map Drafting	2.	Topography Maps	3.65	6
Design	4.	Structural	3.63	7
Pipe Drafting	1.	Flow Diagrams	3.59	8
Map Drafting	3.	Contour Maps	3.58	9
Basic Drawing	1.	Lettering	3.56	10
Electrical and Electronics Drafting	5.	Schematic Diagram	3.54	11
Map Drafting	4.	Profile Maps	3.50	12
Design	1.	Hydraulic and Pneumatic	3.40	13
Structural Drafting	2.	Erection Drawing	3.37	14
Basic Drawing	3.	Sketching	3.36	15
Architectural Drafting	2.	Commercial	3.30	16
Other	1.	Descriptive Geometry	3.29	17
Electrical and Electronics Drafting	1.	Graphic Symbol	3.26	18
Architectural Drafting	3.	Energy Conservation	3.22	19

TABLE V (Continued)

Area	Item No.	Skill	Mean	
Electrical and Electronics Drafting	2.	Connections Diagram	3.21	20
Machine Drafting	2.	Tolerancing	3.12	21
Other	6.	Computer Graphics	3.10	22
Basic Drawing	5.	Auxiliary Views	3.09	23
Electrical and Electronics Drafting	4.	Block Diagrams	3.07	24
Design	2.	Mechanism and Kinematics	3.06	25
Machine Drafting	5.	Fabrication	2.97	26
Machine Drafting	3.	General Machine Drawing	2.92	27
Basic Drawing	2.	Orthographic Projection	2.88	28
Design	6.	Material	2.83	29
Basic Drawing	9.	Isometric Projection	2.80	30
Design	5.	Machine	2.79	31
Architectural Drafting	1.	Residential	2.78	32
Other	4.	Vector Geometry	2.74	33
Pipe Drafting	2.	Vessel Drawing	2.73	34
Basic Drawing	12.	Intersection and Development	2.71	35
Electrical and Electronics Drafting	3.	Printed Circuits	2.70	36
Design	7.	Solar	2.69	37
Pipe Drafting	3.	Exchange Drawing	2.68	38
Other	3.	Nomograms	2.62	39

TABLE V (Continued)

Area	Item No.	Skill	Mean	Rank
Other	5.	Graphical Calculus	2.61	40
Other	2.	Graphical Integral	2.56	41
Machine Drafting	1.	Surface Treatment of Metals	2.55	42

Analysis of ASEE Data

The first step in analyzing this data consisted of computing the mean responses and their relative importance as determined by the established criteria; that is, an item was considered as very important if the mean was 3.50 or higher; important if the mean was 2.50 through 3.49; and not important if the mean was less than 2.50. The results are presented in Table VI.

It was determined that 31 items (63.3%) out of 49 were considered important by the engineering educators, being 3 (6.12%) out of 49 items rated very important. Seven participants added comments to their responses (refer to Appendix C for comments), and seven listed one or more graphic skills they thought were important (see Appendix D).

Of the 12 items in the Basic Drawing area, three were considered to be very important and six were considered important. They considered Orthographic Projection, Sketching, and Dimensioning as being very important. They considered Lettering, Auxiliary Views, Sectional Views, Working Drawings, Isometric Projection, and Intersection and Development as being important. Seven respondents listed additional skills in this area.

In the area of Machine Drafting, two of the seven items were considered as being important, Tolerancing, and General Machine Drafting. One of the participants added graphic skills important for this discipline.

One of the two items in Structural Drafting, Detail Drawing, was rated as important and two respondents added skills in this area.

TABLE VI

MEAN AND IMPORTANCE OF SKILLS AS DETERMINED BY ASEE MEMBERS

Area and Skill	Mean	Rank
Basic Drawing		
*1. Lettering	3.00	(11)
**2. Orthographic Projection	3.63	(2)
**3. Sketching	3.80	(1)
4. Inking and Reproduction	1.78	(49)
*5. Auxiliary Views	3.24	(8)
*6. Sectional Views	3.46	(4)
**7. Dimensioning	3.62	(3)
*8. Working Drawings	3.29	(6)
*9. Isometric Projection	2.93	(14)
10. Oblique Projection	2.47	(32)
11. Perspective Drawing	2.38	(37)
*12. Intersection and Development	2.60	(28)
Machine Drafting		
1. Surface Treatment of Metals	2.20	(43)
*2. Tolerancing	3.04	(10)
*3. General Machine Drawing	2.78	(20)
4. Casting and Forming	2.18	(45)
5. Fabrication	2.42	(33)
6. Cams	2.19	(44)
7. Gears	2.17	(46)

TABLE VI (Continued)

Area and Skill	Mean	Rank
Structural Drafting		
*1. Detail Drawing	2.67	(24)
2. Erection Drawing	2.39	(36)
Architectural Drafting		
1. Residential	2.09	(47)
2. Commercial	2.26	(41)
3. Energy Conservation	2.40	(35)
Electrical and Electronics Drafting		
*1. Graphic Symbol	2.97	(13)
*2. Connections Diagram	2.85	(16)
*3. Printed Circuits	2.69	(22)
*4. Block Diagrams	2.88	(15)
*5. Schematic Diagrams	3.08	(9)
Map Drafting		
*1. Survey Practice	2.68	(23)
*2. Topography Maps	2.71	(21)
*3. Contour Maps	2.79	(19)
*4. Profile Maps	2.64	(25)
Pipe Drafting		
*1. Flow Diagrams	2.83	(17)
2. Vessel Drawing	2.24	(42)
3. Exchange Drawing	2.01	(48)

TABLE VI (Continued)

Area and Skill	Mean	Rank
Design		
*1. Hydraulic and Pneumatic	2.57	(31)
*2. Mechanism and Kinematics	2.80	(18)
3. Jigs and Fixtures	2.27	(39)
*4. Structural	2.60	(27)
*5. Machine	2.62	(26)
6. Material	2.32	(38)
7. Solar	2.26	(40)
Other		
*1. Descriptive Geometry	3.26	(7)
*2. Graphical Integral	2.59	(29)
3. Nomograms	2.41	(34)
*4. Vector Geometry	2.99	(12)
*5. Graphical Calculus	2.58	(30)
*6. Computer Graphics	3.30	(5)

*Important.

**Very Important.

None of the items in Architectural Drafting were considered as important. Additional skills in this area were mentioned by two respondents.

All of the five items in Electrical and Electronics Drafting were considered as important and no additional skills were mentioned in this field.

All of the four items in the Map Drafting area, Survey Practice, Topography Maps, Contour Maps and Profile Maps were considered as being important. No additional skills were mentioned.

In the Pipe Drafting Area, one skill, Flow Diagram, was considered important and none of the repondents added skills in this field.

Of the seven items in the Design Area, four, Hydraulics and Pneumatic, Mechanism and Kinematics, Structural and Machine Design, were considered important. None of the participants added graphic skills important in this category.

Five of the six skills grouped under the area Other, Descriptive Geometry, Graphical Integral, Vector Geometry, Graphical Calculus, and Computer Graphics, were considered important. No additional skill was mentioned here.

The second step in analyzing this data consisted of grouping the responses considered important and very important in rank order, as appears in Table VII.

Analysis and Comparison of Both Groups of Data

This section was addressed in order to respond to research question three of this study which was to determine how the ratings of the graphic skills by both groups compared. In order to achieve this

TABLE VII

GRAPHIC SKILLS RANKED IMPORTANT AND VERY IMPORTANT BY ENGINEERING EDUCATORS

Area	Item No.	Skill	Mean	Rank
Basic Drawing	3.	Sketching	3.80	1
Basic Drawing	2.	Orthographic Projection	3.63	2
Basic Drawing	7.	Dimensioning	3.62	3
Basic Drawing	6.	Sectional Views	3.46	4
Other	6.	Computer Graphics	3.30	5
Basic Drawing	8.	Working Drawings	3.29	6
Other	1.	Descriptive Geometry	3.26	7
Basic Drawing	3.	Auxiliary Views	3.24	8
Electrical and Electronics Drafting	5.	Schematic Diagram	3.08	9
Machine Drafting	2.	Tolerancing	3.04	10
Basic Drawing	1.	Lettering	3.00	11
Other	4.	Vector Geometry	2.99	12
Electrical and Electronic Drafting	1.	Graphic Symbol	2.97	13
Basic Drawing	9.	Isometric Projection	2.93	14
Electrical and Electronics Drafting	4.	Block Diagrams	2.88	15
Electrical and Electronics Drafting	2.	Connection Diagrams	2.85	16
Pipe Drafting	1.	Flow Diagrams	2.83	17
Design	2.	Mechanism and Kinematics	2.80	18
Map Drafting	3.	Contour Maps	2.79	19

TABLE VII (Continued)

Area	Item No.	Skill	Mean	Rank
Machine Drafting	3.	General Machine Drawing	2.78	20
Map Drafting	2.	Topography	2.71	21
Electrical and Electronics Drafting	3.	Printed Circuits	2.69	22
Map Drafting	1.	Survey Practice	2.68	23
Structural Drafting	1.	Detail Drawing	2.67	24
Map Drafting	4.	Profile Maps	2.64	25
Design	5.	Machine	2.62	26
Design	4.	Structural	2.61	27
Basic Drawing	12.	Intersection and Development	2.60	28
Other	2.	Graphical Integral	2.59	29
Other	5.	Graphical Calculus	2.58	30
Design	1.	Hydraulic and Pneumatics	2.57	31

objective, Table VIII was developed and the t-test was used. The table includes the item number, graphic skills by area, and the mean and rank of each item by group. The table also includes a composite mean for each item. The writer believed that a visual comparison of the graphic skills and their mean responses would allow for reflection of any significant differences among the groups on the importance placed on the rated items.

Further analysis of the data in Table VIII allows one to see that in the area of Basic Drawing, both groups rated the same nine skills as being important or very important. These are the items identified in the table with two asterisks.

It was also revealed in the table that in the area of Machine Drafting, Tolerancing and General Machine Drawing, were considered as being important by both groups. Both groups agreed that Casting and Forming, Cams and Gears, were not important.

In the area of Structural Drafting, Detail Drawing was rated very important by the engineers and important by the engineering educators.

No item was considered important by both groups, in Architectural Drafting area.

Flow Diagrams, in Pipe Drafting, was considered very important by the engineers and as important by the engineering educators.

In the Design area, Jigs and Fixtures was considered as not important and Hydraulics and Pneumatics, Mechanism and Kinematics, Structural and Machine Design were considered as important by both groups.

Of the six skills groups under the area of Other, five of them, Descriptive Geometry, Graphical Integral, Vector Geometry, Graphical

TABLE VIII

MEAN RESPONSES BY GROUPS

Area and Skill	NSPE Mean	NSPE Rank	ASEE Mean	ASEE Rank	Composite Mean	Composite Rank	t
Basic Drawing							
**1. Lettering	3.56	10	3.00	11	3.30	7	4.62*
**2. Orthographic Projection	2.88	28	3.63	2	3.24	9	5.45*
**3. Sketching	3.36	15	3.80	1	3.57	4	3.51*
4. Inking and Reproduction	2.36	46	1.78	49	2.09	49	4.72*
**5. Auxiliary Views	3.09	23	3.24	8	3.16	15	1.25
**6. Sectional Views	3.75	4	3.46	4	3.62	2	2.70*
**7. Dimensioning	3.96	1	3.62	3	3.80	1	2.69*
**8. Working Drawings	3.90	2	3.29	6	3.61	3	4.88*
**9. Isometric Projection	2.80	30	2.93	14	2.86	25	1.07
10. Oblique Projection	2.34	47	2.47	32	2.40	41	1.02
11. Perspective Drawing	2.48	43	2.38	37	2.43	40	0.91
**12. Intersection and Development	2.71	35	2.60	28	2.66	32	0.84
Machine Drafting							
1. Surface Treatment of Metals	2.55	42	2.20	43	2.35	43	2.39*
**2. Tolerancing	3.12	21	3.04	10	3.08	18	0.46
**3. General Machine Drawing	2.92	27	2.78	20	2.84	26	0.87
4. Casting and Forming	2.37	45	2.18	45	2.27	45	1.43

TABLE VIII (Continued)

Area and Skill	NSPE Mean	NSPE Rank	ASEE Mean	ASEE Rank	Composite Mean	Composite Rank	t
Machine Drafting (Continued)							
5. Fabrication	2.97	26	2.42	33	2.67	31	3.52*
6. Cams	2.30	49	2.19	44	2.23	47	0.77
7. Gears	2.33	48	2.17	46	2.24	46	1.07
Structural Drafting							
**1. Detail Drawing	3.88	3	2.67	24	3.25	5	8.85*
2. Erection Drawing	3.37	14	2.39	36	2.92	23	7.28*
Architectural Drafting							
1. Residential	2.78	32	2.09	47	2.46	39	4.78*
2. Commercial	3.30	16	2.26	41	2.82	38	7.04*
3. Energy Conservation	3.22	19	2.40	35	2.83	37	5.05*
Electrical and Electronics Drafting							
**1. Graphic Symbols	3.26	18	2.97	13	3.11	16	1.93
**2. Connections Diagram	3.21	20	2.85	16	3.03	19	2.43*
**3. Printed Circuit	2.70	36	2.69	22	2.70	30	0.10
**4. Block Diagrams	3.07	24	2.88	15	2.98	21	1.25
**5. Schematic Diagrams	3.54	11	3.08	9	3.31	6	3.04*

TABLE VIII (Continued)

Area and Skill	NSPE Mean	NSPE Rank	ASEE Mean	ASEE Rank	Composite Mean	Composite Rank	t
Map Drafting							
**1. Survey Practice	3.66	5	2.68	23	3.20	13	6.79*
**2. Topography Map	3.65	6	2.71	21	3.22	11	6.58*
**3. Contour Maps	3.58	9	2.79	19	3.21	12	5.30*
**4. Profile Maps	3.50	12	2.64	25	3.10	17	5.74*
Pipe Drafting							
**1. Flow Diagrams	3.59	8	2.83	17	3.22	10	5.12*
2. Vessel Drawing	2.73	34	2.24	42	2.49	37	3.63*
3. Exchange Drawing	2.68	38	2.01	48	2.36	42	4.96*
Design							
**1. Hydraulic and Pneumatic	3.40	13	2.57	31	2.99	20	5.87*
**2. Mechanism and Kinematics	3.06	25	2.80	18	2.93	22	1.71
3. Jigs and Fixtures	2.38	44	2.27	39	2.32	44	0.84
**4. Structural	3.63	7	2.60	27	3.13	16	7.46*
**5. Machine	2.79	31	2.62	26	2.70	29	1.22
6. Materials	2.83	29	2.32	38	2.58	34	3.63*
7. Solar	2.69	37	2.26	40	2.48	38	3.04*

TABLE VIII (Continued)

Area and Skill	NSPE Mean	NSPE Rank	ASEE Mean	ASEE Rank	Composite Mean	Composite Rank	t
Other							
**1. Descriptive Geometry	3.29	17	3.26	7	3.28	8	0.17
**2. Graphical Integral	2.56	41	2.59	29	2.57	35	0.20
3. Nomograms	2.62	39	2.41	34	2.51	36	1.70
**4. Vector Geometry	2.74	33	2.99	12	2.87	24	1.83
**5. Graphical Calculus	2.61	40	2.58	30	2.59	33	0.17
**6. Computer Graphics	3.10	22	3.30	5	3.19	14	1.35

*Significant at .05 level of probability.

**Skill rated important or very important by both groups.

Calculus, and Computer Grahpics were considered as important by the practicing engineers and engineering educators.

The second step in analyzing this data consisted of grouping the responses considered important and very important in rank order, as appears in Table IX. Refer to Appendix E for printout of ranked top ten graphic skills.

TABLE IX

GRAPHIC SKILLS RATED IMPORTANT AND VERY IMPORTANT BY ALL PARTICIPANTS

Area	Item No.	Skill	Mean	Rank
Basic Drawing	7.	Dimensioning	3.801	1
Basic Drawing	6.	Sectional Views	3.615	2
Basic Drawing	8.	Working Drawing	3.610	3
Basic Drawing	3.	Sketching	3.568	4
Structural Drafting	1.	Detail Drawing	3.325	5
Electrical and Electronics Drafting	5	Schematic Diagram	3.307	6
Basic Drawing	1.	Lettering	3.296	7
Other	1.	Descriptive Geometry	3.276	8
Basic Drawing	2.	Orthographic Projection	3.242	9
Pipe Drafting	1.	Flow Diagrams	3.229	10
Map Drafting	2.	Topography Maps	3.220	11
Map Drafting	3.	Contour Maps	3.216	12
Map Drafting	1.	Survey Practice	3.209	13
Other	6.	Computer Graphics	3.202	14
Basic Drawing	5.	Auxiliary Views	3.162	15
Design	4.	Structural	3.130	16
Electrical and Electronics Drafting	1.	Graphical Symbols	3.114	17
Map Drafting	4.	Profile Maps	3.109	18
Machine Drafting	2.	Tolerancing	3.077	19

TABLE IX (Continued)

Area	Item No.	Skill	Mean	Rank
Electrical and Electronics Drafting	2.	Connections Diagram	3.030	20
Design	1.	Hydraulic and Pneumatics	2.991	21
Electrical and Electronics Drafting	4.	Block Diagrams	2.975	22
Design	2.	Mechanism and Kinematics	2.927	23
Structural Drafting	2.	Erection Drawing	2.924	24
Other	4.	Vector Geometry	2.867	25
Basic Drawing	9.	Isometric Projection	2.857	26
Machine Drafting	3.	General Machine Drawing	2.840	27
Architectural Drafting	3.	Energy Conservation	2.826	28
Architectural Drafting	2.	Commercial	2.820	29
Design	5.	Machine	2.699	30
Electrical and Electronics Drafting	3.	Printed Circuits	2.697	31
Machine Drafting	5.	Fabrication	2.664	32
Basic Drawing	12.	Intersection and Development	2.657	33
Other	5.	Graphical Calculus	2.593	34
Design	6.	Material	2.579	35
Other	2.	Graphical Integral	2.574	36
Other	3.	Nomograms	2.512	37

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to obtain information from professional engineers and engineering educators for determining specific content elements appropriate for inclusion in graphic courses in undergraduate engineering programs. The three research questions with which this study dealt were cited in Chapter I as being:

1. What is the relative importance of graphic skills development in undergraduate engineering programs?
2. What information elements should be included in graphic courses in undergraduate engineering programs?
3. Is there a significant difference of opinions among practicing engineers and engineering educators in regard to which graphic skills should be developed in undergraduate engineering programs?

The participant sample in this study consisted of 300 members of the National Society of Professional Engineers (NSPE) and 300 members of the American Society for Engineering Education (ASEE) in the United States. The questionnaire consisted of 49 graphic skills grouped in nine areas. Provisions were made for the respondent to write in other skills that he or she might feel pertinent to the subject.

The questionnaite was mailed to each of the persons surveyed on April 11, 1980. May 30, 1980 was set as a deadline for accepting returned questionnaires.

Of the 154 questionnaires returned by NSPE members, two were deleted from the study because they were not completed, yielding a total of 152 returns, or 50.67%.

Of the 148 questionnaires returned by ASEE members, ten were deleted from the study because they were not completed, yielding a total of 138 returns or 46%. The data collected from NSPE members revealed that 42 items (85.7%) out of the 49 were considered important by the practicing engineers. Twelve (24.5%) of the 49 were rated very important.

The data collected from ASEE members revealed that 31 items (63.3%) out of the 49 were considered important by the engineering educators. Three (6.1%) of the 49 were rated very important.

Thirty-seven graphic skills were rated important or very important by all respondents as one group.

Conclusions

Based on the data analyzed, the following conclusions were drawn:

1. Since the majority of the graphic skills were judged by both groups in a similar way, it is concluded that the list of skills in Table VIII is a valid display upon which the relative importance of graphic skills can be compared.
2. Since 37 graphic skills were rated important or very important by all respondents, it is concluded that these items listed

in order of priority in Table IX, would be appropriate to include in graphic courses in undergraduate engineering programs.

3. Since both groups rated important and not important items in a very similar way, differing merely in emphasis, it is concluded that there is no significant difference of opinions between the two groups in regard to which graphic skills should be developed in undergraduate engineering programs.
4. There was a significant difference in the two sample means, in regard to 27 graphic skills.
5. Since the pattern of the mean distribution of both groups was very similar, and the practicing engineers considered more items to be important or very important that did the engineering educators, it is concluded that the engineering educators rated the various graphic skills in a more conservative manner.
6. It is also concluded that the necessary importance was not given by the engineering eductors, to some items that the practicing engineers considered to be really important.

Recommendations

Truly comprehensive graphics courses must meet the needs of all students from all branches of engineering. To accomplish this does not require a major change of course content from what is presently taught; rather, it requires a change merely in emphasis. Therefore, based on data from this study, the following recommendations are made regarding graphic courses in undergraduate engineering curricula:

1. It is recommended that the emphasis be on graphics as a means of communications for all engineers, involving problems,

examples, and related applications from branches of engineering other than mechanical, in the teaching of traditional topics such as projection theory, auxiliary view, dimensioning, etc.

2. It is recommended that projection systems, symbols, conventions and formats be an integral part of graphic courses. Further, that is is important that the competent engineer recognize and understand the symbols and conventions used by engineering specialties other than his/her own.

3. Finally, while possibly less important than mathematical tools, graphics is still valuable in problem solving. This is especially true in design work; therefore, emphasis on developing knowledge of descriptive geometry is recommended for the beginning curriculum.

SELECTED BIBLIOGRAPHY

Beck, William E. "Automated Graphics in a Decentralized Corporation." A speech presented to the 1974 American Institute for Design and Drafting Conference, Chicago, Illinois, 1974.

Farrell, Art T. "Design Automation--Make It Work." A speech presented to the 1974 American Institute for Design and Drafting Conference, Chicago, Illinois, 1974.

French, Thomas E. "The Educational Side of Engineering Drawing." Engineering Design Graphics Journal, Vol. 40, No. 3 (Fall, 1976), p. 35.

Giachino, J. W. and H. J. Beukema. Drafting Technology. Chicago, Illinois: American Technical Society, 1978.

Giesecke, F. E., Alva Mitchell and H. C. Spencer. Technical Drawing. New York, New York: The MacMillan Co., 1978.

Harper, G. Neil. Computer Applications in Architecture and Engineering. New York, New York: McGraw-Hill, 1968.

Heacock, Frank A. Graphical Solutions of Technical Problems. Princeton University, New Jersey, 1964.

Hysaw, Jimmy Lee. "A Study of Information Elements for Inclusion in a Fluid Power Course for a Design Drafting Program." (Unpubl. M.S. thesis, Oklahoma State University, 1978.)

Land, Ming H. "Historical Development of Grahpics." Engineering Design Grahpics Journal, Vol. 40, No. 2 (Spring, 1976), p. 33.

McNeal, Edward V. "The Development of a Drafting and Design Program for the Adult Evening School at the Tulsa Area Vocational-Technical Center," (Unpub. M.S. thesis, Oklahoma State University, 1972.)

MacDonald, Stephen L. and Robert Wehil. "An Architechtural Design System Based on Computer Graphics." A speech presented at the National Conference on Architectural Psychology, Park City, Utah, 1966.

O'Neill, Phillip P. "Quantity Production of Computerized Engineering Drawings." Reprographics, Vol. 12, No. 8 (October, 1974), pp. 11-14.

Popham, James W. Educational Statistics. New York, New York: Harper and Row, 1967.

Slaby, Steve. "Geometry and Interactive Computer Graphics." Engineering Design Graphics Journal, Vol. 40, No. 2 (Spring, 1976).

Snedecor, George W. and William G. Cochran. Statistical Methods. The Iowa State University Press, Ames, Iowa, 1978.

State University of New York. Revisions to the Mechanical Engineering BS Program (January, 1980).

Sutherlin, Lewis T. "A Study of Information Elements for Inclusion in an Introductory Computer Graphics Course for a Design Drafting Program." (Unpub. MS thesis, Oklahoma State University, 1975.)

Trapp, Roy G. "Status of Descriptive Geometry in the United States." Engineering Design Graphics Journal, Vol. 34, No. 1 (Winter, 1970), p. 31.

Turner, Anthony E. "What Industry Needs in Design Engineers." Engineering Design Graphics Journal, Vol. 4, No. 2 (Spring, 1976), p. 11.

White, Fred and Tom Thomas. Computer Graphics Instruction Units. Stillwater, Oklahoma: Oklahoma State Department of Vo-Tech Education, 1973.

Wilhoit, John D. "Simplified Engineering Graphics and the Application to Industry." (Unpub. M.S. thesis, Oklahoma State University, 1962.)

APPENDIXES

APPENDIX A

QUESTIONNAIRE ADMINISTERED

GRAPHIC SKILLS DEVELOPMENT IN
UNDERGRADUATE ENGINEERING PROGRAMS

The purpose of this questionnaire is to determine the extent to which various graphic skills should be developed among student majors in undergraduate engineering programs.

For each of the skill areas listed below, indicate your response by circling the appropriate number.	1. Not Important	2. Slightly Important	3. Important	4. Very Important	5. Extremely Important
BASIC DRAWING					
1. Lettering	1	2	3	4	5
2. Orthographic Projection	1	2	3	4	5
3. Sketching	1	2	3	4	5
4. Inking & Reproduction	1	2	3	4	5
5. Auxiliary Views	1	2	3	4	5
6. Sectional Views	1	2	3	4	5
7. Dimensioning	1	2	3	4	5
8. Working Drawings	1	2	3	4	5
9. Isometric Projection	1	2	3	4	5
10. Oblique Projection	1	2	3	4	5
11. Perspective Drawing	1	2	3	4	5
12. Intersection & Development	1	2	3	4	5
13. Other ____________________	1	2	3	4	5
MACHINE DRAFTING					
1. Surface Treatment of Metals	1	2	3	4	5
2. Tolerancing	1	2	3	4	5
3. General Machine Drawing	1	2	3	4	5
4. Casting & Forming	1	2	3	4	5
5. Fabrication	1	2	3	4	5
6. Cams	1	2	3	4	5
7. Gears	1	2	3	4	5
8. Other ____________________	1	2	3	4	5
STRUCTURAL DRAFTING					
1. Detail Drawing	1	2	3	4	5
2. Erection Drawing	1	2	3	4	5
3. Other ____________________	1	2	3	4	5
ARCHITECTURAL DRAFTING					
1. Residential	1	2	3	4	5
2. Commercial	1	2	3	4	5
3. Energy Conservation	1	2	3	4	5
4. Other ____________________					

	1. Not Important	2. Slightly Important	3. Important	4. Very Important	5. Extremely Important
ELECTRICAL & ELECTRONICS DRAFTING					
1. Graphic Symbol	1	2	3	4	5
2. Connections Diagram	1	2	3	4	5
3. Printed Circuits	1	2	3	4	5
4. Block Diagrams	1	2	3	4	5
5. Schematic Diagrams	1	2	3	4	5
6. Other ________	1	2	3	4	5
MAP DRAFTING					
1. Survey Practice	1	2	3	4	5
2. Topography Maps	1	2	3	4	5
3. Contour Maps	1	2	3	4	5
4. Profile Maps	1	2	3	4	5
PIPE DRAFTING					
1. Flow Diagrams	1	2	3	4	5
2. Vessel Drawing	1	2	3	4	5
3. Exchange Drawing	1	2	3	4	5
DESIGN					
1. Hydraulic & Pneumatic	1	2	3	4	5
2. Mechanism & Kinematics	1	2	3	4	5
3. Jigs & Fixtures	1	2	3	4	5
4. Structural	1	2	3	4	5
5. Machine	1	2	3	4	5
6. Material	1	2	3	4	5
7. Solar	1	2	3	4	5
8. Other ________	1	2	3	4	5
OTHER					
1. Descriptive Geometry	1	2	3	4	5
2. Graphical Integral	1	2	3	4	5
3. Nomograms	1	2	3	4	5
4. Vector Geometry	1	2	3	4	5
5. Graphical Calculus	1	2	3	4	5
6. Computer Graphics	1	2	3	4	5
7. Other ________					

/___/ **Please send a copy of the results of this study to me.**

Name ____________________

Address ____________________

____

RAS/kp

APPENDIX B

TRANSMITTAL LETTER

Oklahoma State University

SCHOOL OF OCCUPATIONAL AND ADULT EDUCATION

STILLWATER, OKLAHOMA 74074
CLASSROOM BUILDING 406
(405) 624-6275

April 11, 1980

It is essential from time to time for educational institutions to compare curriculum content of professional education programs with existing conditions and needs of employing companies and agencies. We are especially concerned at this time with the extent to which various mechanical drafting skills should be developed among student majors in undergraduate engineering programs. We therefore are asking selected individuals who are either practicing engineers or engineering educators to please respond to the enclosed questionnaire.

Your response to the questionnaire will require only about 10-15 minutes and will be a very worthwhile contribution to engineering education. If you wish to receive a copy of the results, please indicate your desire by checking the bottom of the questionnaire.

Thanks in advance for assisting in this effort.

Sincerely,

R. A. Schlemm
Program Assistant

RAS/kp

APPENDIX C

COMMENTS BY GROUPS

NSPE Members

It is not extremely important that a graduate engineer be personally proficient in any of these skills. However, it is absolutely necessary that he understand how his specialist can best perform their tasks and be able to recognize poor quality performance of a surveyor or draftsman in order to eliminate their errors. It is impossible for instance for a civil engineer to design without a knowledge of field surveying.

Glad to see that educators are reconsidering the need for engineering drafting, descriptive geometry, etc., in engineering education. This lack in curriculum in recent years has been a great disservice, not only to the Consulting Enginnering profession, but also the graduates and the Universities as well. Getting right in on the board, without a drafting handicap, is the best and quickest way for a new graduate to learn the consulting profession. No employer wants to teach a graduate how to draw lines and make letters.

There are in practice two very important items that should be stressed. Both are the basics of communication for engineers: to be able to "letter" so that the written communication is clear; to be able to sketch so that the engineer can communicate his thoughts to drafters, clients, other engineers and business associates. Anything else should be confined to "familiarization" only.

I have long been a critic of engineering curricula that acted as if all drafting was a high school subject and cut it out of the curriculum. Drafting is as important to the engineer as grammar is to journalism. Like mathematics, drafting can be at all levels. Advanced drafting is as intellectual demanding as calculus.

I very much appreciate the opportunity to offer an evaluating of your drafting program . . . For the civil engineering field, there are many major areas of drafting that are not included in your curriculum. These are filing plats; utility layouts; plan and profile for design of streets, sanitary sewer, storm drain and water mains; coordination of structural drafting with piping; process piping including routing, standard fittings, flexibility, joints, wall penetrations and supports; and the development of site plans . . .

Each is important only to the engineer who will practice in the field, otherwise not important except to understand what another trade is doing.

We find it essential that an engineer be capable of communicating in several ways, including verbal and written words, and through graphics. Graphic communication would include at least the following:

--Ability to communicate effectively, both telling and reading.

--Ability to organize a graphic presentation.

--Development of organizational abilities with regards to elements of project production, i.e., calculations, drawing and specifications.

We consider these to be conceptual abilities, that could be taught through almost any of the categories listed in your questionnaire, as well as all subjects in the engineering curriculum . . . We want to encourage your efforts to incorporate graphic skills in your engineering program. This is an area in which most new graduates are deficient. It is also an area which is of obvious importance to the efficiency and effectiveness of consulting engineering work.

To understand, be able to read, to sketch but not necessarily have the mechanical ability to put out a finished drawing. Architects must develop drafting skills. Engineers whould be much better off learning how to write, express themselves, etc. Drafting in technical schools can stress drafting but I do not think an engineering curriculum should.

As a practicing Consulting Engineer in the Civil Engineering field, I am very much concerned about the question your questionnaire addresses. I wish to add emphasis to three particular areas: 1) Basic Drawing; 2) Structural Drafting; and 3) Map Drafting. These three areas were not approached during my education to the degree I would have requested had I been aware of the requirements of my field . . . Also, I would take this opportunity to state that the engineering schools I have visited with recently are eliminating surveying from the required course list. This is a mistake. Should this be the case at OSU, please inform the proper people that at least one alumni would like them to reconsider.

I am a Civil/Structural Engineer. My problem is that recent graduates have not been exposed to solutions of practical problems. Same applies to Drafting. I have some ideas but professors won't listen.

ASEE Members

Map drafting should not be taught as a separate course but should be included in a final project as part of a course in surveying and plane table mapping as we do it at El Camino College, Torrance, California, and as it is done at Long Beach State College, Long Beach, California.

In our opinion, the primary objective is to learn to visualize hardware and its function. To think in three dimensions plus time and temperature superimposed is a skill that is hard to find among recent graduates. The recent emphasis on the use of computers as wonderfully useful tools is not sufficient for effective development of the art of engineering. An understanding--a "feel"--for hardware and its function is a very important factor. The recent computer-trained graduates are not notable in this respect. We suggest that you consider as your criteria for judging the usefulness of drafting courses their contribution to teaching the engineering student to clearly visualize hardware and its function, both static and dynamic.

This is an excellent survey form to send to technical education centers throughout the country--not to schools of Engineering. Drafting is not an engineering function. Design is!

Special drafting skills related to these areas (Design) are not too important.

I do not believe any given engineering student will receive instruction in all these skill areas. All should have significant work in the Basic Drawing and Other categories. But beyond that, I believe only one or two specialty areas would be addressed by any given student--those specialty areas appropriate to his particular field of study.

I am unable to decide whether you want what we feel is important, what I expect students to know in advanced courses, or what I feel is essential for engineers in industry to know. Based on my industrial experience, I have chosen the latter.

APPENDIX D

LIST OF ADDITIONAL SKILLS

NSPE Members

Steel Detailing; Water, Sewer and Street Design; Organizing Drawing Presentation; Layout for Power and Lighting; Control Diagrams; Concrete Drawings; Foundation Layout; Construction Detailing; Quality of Line Work; Symbols; Weight of Drawing Lines; Lighting, Switching Schedules.

ASEE Members

Pictorial Representation; Fasteners; Shop Drawings; Graphs; Symbolic Representation; Assembly Drawings.

APPENDIX E

PRINTOUT OF RANKED TOP TEN GRAPHIC SKILLS

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS PAGE 10

06/21/80 FILE - NONAME - CREATED 06/21/80

DIME DIMENSIONING

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	1	0.7	0.7	0.7
SLIGHTLY IMPORTANT	2.	12	7.9	8.1	8.8
IMPORTANT	3.	36	23.7	24.3	33.1
VERY IMPORTANT	4.	42	27.6	28.4	61.5
EXTREMELY IMPORTANT	5.	57	37.5	38.5	100.0
	0.	4	2.6	MISSING	100.0
	TOTAL	152	100.0	100.0	

AMERICAN SOCIETY FOR ENGINEERING EDUCATION PAGE 10

06/21/80 FILE - NONAME - CREATED 06/21/80

DIME DIMENSIONING

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	5	3.6	3.8	3.8
SLIGHTLY IMPORTANT	2.	14	10.1	10.5	14.3
IMPORTANT	3.	39	28.3	29.3	43.6
VERY IMPORTANT	4.	43	31.2	32.3	75.9
EXTREMELY IMPORTANT	5.	32	23.2	24.1	100.0
	0.	5	3.6	MISSING	100.0
	TOTAL	138	100.0	100.0	

MEAN	3.624	MEDIAN	3.698	MODE	4.000
STD DEV	1.077	RANGE	4.000	MINIMUM	1.000
MAXIMUM	5.000				

VALID CASES 133 MISSING CASES 5

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS PAGE 9

06/21/80 FILE - NONAME - CREATED 06/21/80

SECV SECTIONAL VIEWS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	1	0.7	0.7	0.7
SLIGHTLY IMPORTANT	2.	7	4.6	4.7	5.4
IMPORTANT	3.	49	32.2	32.9	38.3
VERY IMPORTANT	4.	63	41.4	42.3	80.5
EXTREMELY IMPORTANT	5.	29	19.1	19.5	100.0
	0.	3	2.0	MISSING	100.0
	TOTAL	152	100.0	100.0	

AMERICAN SOCIETY FOR ENGINEERING EDUCATION PAGE 9

06/21/80 FILE - NONAME - CREATED 06/21/80

SECV SECTIONAL VIEWS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	4	2.9	3.0	3.0
SLIGHTLY IMPORTANT	2.	16	11.6	11.9	14.9
IMPORTANT	3.	44	31.9	32.8	47.8
VERY IMPORTANT	4.	54	39.1	40.3	88.1
EXTREMELY IMPORTANT	5.	16	11.6	11.9	100.0
	0.	4	2.9	MISSING	100.0
	TOTAL	138	100.0	100.0	

MEAN	3.463	MEDIAN	3.556	MODE	4.000
STD DEV	0.955	RANGE	4.000	MINIMUM	1.000
MAXIMUM	5.000				

VALID CASES 134 MISSING CASES 4

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS PAGE 11

06/21/80 FILE - NONAME - CREATED 06/21/80

WKING WORKING DRAWINGS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	3	2.0	2.0	2.0
SLIGHTLY IMPORTANT	2.	4	2.6	2.7	4.7
IMPORTANT	3.	45	29.6	30.2	34.9
VERY IMPORTANT	4.	50	32.9	33.6	68.5
EXTREMELY IMPORTANT	5.	47	30.9	31.5	100.0
	0.	3	2.0	MISSING	100.0
	TOTAL	152	100.0	100.0	

AMERICAN SOCIETY FOR ENGINEERING EDUCATION PAGE 11

06/21/80 FILE - NONAME - CREATED 06/21/80

WKING WORKING DRAWINGS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	12	8.7	9.0	9.0
SLIGHTLY IMPORTANT	2.	16	11.5	12.0	21.1
IMPORTANT	3.	47	34.1	35.3	56.4
VERY IMPORTANT	4.	38	27.5	28.6	85.0
EXTREMELY IMPORTANT	5.	20	14.5	15.0	100.0
	0.	5	3.6	MISSING	100.0
	TOTAL	138	100.0	100.0	

MEAN	3.286	MEDIAN	3.319	MODE	3.000
STD DEV	1.139	RANGE	4.000	MINIMUM	1.000
MAXIMUM	5.000				

VALID CASES 133 MISSING CASES 5

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS PAGE 6

06/21/80 FILE - NONAME - CREATED 06/21/80

SKTCH SKETCHING

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	11	7.2	7.4	7.4
SLIGHTLY IMPORTANT	2.	18	11.8	12.1	19.5
IMPORTANT	3.	50	32.9	33.6	53.0
VERY IMPORTANT	4.	47	30.9	31.5	84.6
EXTREMELY IMPORTANT	5.	23	15.1	15.4	100.0
	0.	3	2.0	MISSING	100.0
	TOTAL	152	100.0	100.0	

AMERICAN SOCIETY FOR ENGINEERING EDUCATION PAGE 6

06/21/80 FILE - NONAME - CREATED 06/21/80

SKTCH SKETCHING

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	2	1.4	1.5	1.5
SLIGHTLY IMPORTANT	2.	14	10.1	10.3	11.8
IMPORTANT	3.	33	23.9	24.3	36.0
VERY IMPORTANT	4.	47	34.1	34.6	70.6
EXTREMELY IMPORTANT	5.	40	29.0	29.4	100.0
	0.	2	1.4	MISSING	100.0
	TOTAL	138	100.0	100.0	

MEAN	3.801	MEDIAN	3.904	MODE	4.000
STD DEV	1.024	RANGE	4.000	MINIMUM	1.000
MAXIMUM	5.000				

VALID CASES 136 MISSING CASES 2

NATICNAL SCCIETY OF PROFESSICNAL ENGINEERS PAGE 23

C6/21/8C FILE - NCNAME - CREATEC 06/21/80

CET CETAIL CRAWING

CATEGCRY LAEEL	CCDE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NCT IMPCRTANT	1.	1	0.7	C.7	C.7
SLIGHTLY IMPORTANT	2.	7	4.6	4.9	5.6
IMPCRTANT	3.	43	28.3	29.9	35.4
VERY IMPCRTANT	4.	50	32.9	34.7	70.1
EXTREMELY IMPORTANT	5.	43	28.3	29.9	100.0
	0.	8	5.3	MISSING	1CC.0
	TOTAL	152	1CC.0	100.0	

AMERICAN SCCIETY FOR ENGINEERING EDUCATICN PAGE 23

C6/21/8C FILE - NONAME - CREATED 06/21/80

CET CETAIL CRAWING

CATEGCRY LAEEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NCT IMPCRTANT	1.	29	21.0	24.0	24.C
SLIGHTLY IMPORTANT	2.	26	18.8	21.5	45.5
IMPCRTANT	3.	33	23.9	27.3	72.7
VERY IMPCRTANT	4.	23	16.7	19.0	91.7
EXTREMELY IMPORTANT	5.	10	7.2	8.3	100.0
	0.	17	12.3	MISSING	1CC.0
	TOTAL	138	1CC.0	1CC.C	

MEAN	2.661	MEDIAN	2.667	MODE	3.000
STC DEV	1.262	RANGE	4.000	MINIMUM	1.COC
MAXIMUM	5.000				

VALIC CASES 121 MISSING CASES 17

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS PAGE 32

06/21/80 FILE - NONAME - CREATED 06/21/80

SKEM SCHEMATIC DIAGRAMS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	7	4.6	5.9	5.9
SLIGHTLY IMPORTANT	2.	10	6.6	8.5	14.4
IMPORTANT	3.	40	26.3	33.9	48.3
VERY IMPORTANT	4.	34	22.4	28.8	77.1
EXTREMELY IMPORTANT	5.	27	17.8	22.9	100.0
	0.	34	22.4	MISSING	100.0
	TOTAL	152	100.0	100.0	

AMERICAN SOCIETY FOR ENGINEERING EDUCATION PAGE 32

06/21/80 FILE - NONAME - CREATED 06/21/80

SKEM SCHEMATIC DIAGRAMS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	17	12.3	14.2	14.2
SLIGHTLY IMPORTANT	2.	21	15.2	17.5	31.7
IMPORTANT	3.	35	25.4	29.2	60.8
VERY IMPORTANT	4.	30	21.7	25.0	85.8
EXTREMELY IMPORTANT	5.	17	12.3	14.2	100.0
	0.	18	13.0	MISSING	100.0
	TOTAL	138	100.0	100.0	

MEAN	3.075	MEDIAN	3.129	MODE	3.000
STD DEV	1.251	RANGE	4.000	MINIMUM	1.000
MAXIMUM	5.000				

VALID CASES 120 MISSING CASES 18

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS PAGE 4

06/21/80 FILE - NONAME - CREATED 06/21/80

LTR LETTERING

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	4	2.6	2.6	2.6
SLIGHTLY IMPORTANT	2.	19	12.5	12.6	15.2
IMPORTANT	3.	49	32.2	32.5	47.7
VERY IMPORTANT	4.	47	30.9	31.1	78.8
EXTREMELY IMPORTANT	5.	32	21.1	21.2	100.0
	0.	1	0.7	MISSING	100.0
	TOTAL	152	100.0	100.0	

AMERICAN SOCIETY FOR ENGINEERING EDUCATION PAGE 4

06/21/80 FILE - NONAME - CREATED 06/21/80

LTR LETTERING

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	8	5.8	5.9	5.9
SLIGHTLY IMPORTANT	2.	31	22.5	22.8	28.7
IMPORTANT	3.	56	40.6	41.2	69.9
VERY IMPORTANT	4.	34	24.6	25.0	94.9
EXTREMELY IMPORTANT	5.	7	5.1	5.1	100.0
	0.	2	1.4	MISSING	100.0
	TOTAL	138	100.0	100.0	

MEAN	3.007	MEDIAN	3.018	MODE	3.000
STD DEV	0.962	RANGE	4.000	MINIMUM	1.000
MAXIMUM	5.000				

VALID CASES 136 MISSING CASES 2

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS PAGE 47

06/21/80 FILE - NONAME - CREATED 06/21/80

DESC DESCRIPTIVE GEOMETRY

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	8	5.3	6.1	6.1
SLIGHTLY IMPORTANT	2.	22	14.5	16.7	22.7
IMPORTANT	3.	45	29.6	34.1	56.8
VERY IMPORTANT	4.	38	25.0	28.8	85.6
EXTREMELY IMPORTANT	5.	19	12.5	14.4	100.0
	0.	20	13.2	MISSING	100.0
	TOTAL	152	100.0	100.0	

AMERICAN SOCIETY FOR ENGINEERING EDUCATION PAGE 47

06/21/80 FILE - NONAME - CREATED 06/21/80

DESC DESCRIPTIVE GEOMETRY

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	13	9.4	10.1	10.1
SLIGHTLY IMPORTANT	2.	19	13.8	14.7	24.8
IMPORTANT	3.	43	31.2	33.3	58.1
VERY IMPORTANT	4.	29	21.0	22.5	80.6
EXTREMELY IMPORTANT	5.	25	18.1	19.4	100.0
	0.	9	6.5	MISSING	100.0
	TOTAL	138	100.0	100.0	

MEAN	3.264	MEDIAN	3.256	MODE	3.000
STD DEV	1.222	RANGE	4.000	MINIMUM	1.000
MAXIMUM	5.000				

VALID CASES 129 MISSING CASES 9

NATICNAL SOCIETY OF PROFESSIONAL ENGINEERS PAGE 5

C6/21/8C FILE - NONAME - CREATED 06/21/80

CRTC CRTOGRAPHIC PROJECTION

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	17	11.2	11.6	11.6
SLIGHTLY IMPORTANT	2.	38	25.0	25.9	37.4
IMPORTANT	3.	53	34.9	36.1	73.5
VERY IMPORTANT	4.	23	15.1	15.6	89.1
EXTREMELY IMPORTANT	5.	16	1C.5	1C.9	1CC.C
	0.	5	3.3	MISSING	1CC.0
	TOTAL	152	10C.0	1CC.0	

AMERICAN SOCIETY FOR ENGINEERING EDUCATION PAGE 5

06/21/80 FILE - NONAME - CREATED C6/21/80

CRTC CRTOGRAPHIC PROJECTION

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	6	4.3	4.5	4.5
SLIGHTLY IMPORTANT	2.	17	12.3	12.7	17.2
IMPORTANT	3.	36	26.1	26.9	44.C
VERY IMPORTANT	4.	36	26.1	26.9	7C.9
EXTREMELY IMPORTANT	5.	39	28.3	29.1	100.0
	0.	4	2.9	MISSING	1CC.0
	TOTAL	138	100.0	100.0	

MEAN	3.634	MEDIAN	3.722	MODE	5.00C
STD DEV	1.160	RANGE	4.000	MINIMUM	1.000
MAXIMUM	5.000				

VALID CASES 134 MISSING CASES 4

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS PAGE 37

06/21/80 FILE - NONAME - CREATED 06/21/80

FLOW FLOW DIAGRAMS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	8	5.3	6.3	6.3
SLIGHTLY IMPORTANT	2.	9	5.9	7.0	13.3
IMPORTANT	3.	41	27.0	32.0	45.3
VERY IMPORTANT	4.	39	25.7	30.5	75.8
EXTREMELY IMPORTANT	5.	31	20.4	24.2	100.0
	0.	24	15.8	MISSING	100.0
	TOTAL	152	100.0	100.0	

AMERICAN SOCIETY FOR ENGINEERING EDUCATION PAGE 37

06/21/80 FILE - NONAME - CREATED 06/21/80

FLOW FLOW DIAGRAMS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NOT IMPORTANT	1.	22	15.9	18.8	18.8
SLIGHTLY IMPORTANT	2.	23	16.7	19.7	38.5
IMPORTANT	3.	34	24.6	29.1	67.5
VERY IMPORTANT	4.	29	21.0	24.8	92.3
EXTREMELY IMPORTANT	5.	9	6.5	7.7	100.0
	0.	21	15.2	MISSING	100.0
	TOTAL	138	100.0	100.0	

MEAN	2.829	MEDIAN	2.897	MODE	3.000
STD DEV	1.220	RANGE	4.000	MINIMUM	1.000
MAXIMUM	5.000				

VALID CASES 117 MISSING CASES 21

APPENDIX F

LISTING OF COMPUTER PROGRAMS

```
//LIST     JCB TYPRUN=CCPY                                                    JOB 2008
/*JOBPARM FORMS=A031
// EXEC SFSS
//GO.SYSIN DD *
RUN NAME         NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS
DATA LIST        FIXED/ 1 LTR ORTC SKTCH INK AUXV SECV DIME WKING ISO OBL PER INT
                 SUR TOL GEN CAS FAB CAM GEAR DET ER RES COM ENCO SYM CONN PRINT
                 BLOCK SKEM SURV TOP CONT PROF FLOW VESS EXCE HYDR MECH JIGS
                 STRAL MACH MAT SOL DESC INTG NGRAM VECT CALC COMP 1-49
INPUT MEDIUM     CARD
N OF CASES       152
VAR LABELS       LTR,LETTERING/
                 ORTO,ORTHOGRAPHIC PROJECTION/
                 SKTCH,SKETCHING/
                 INK,INKING & REPRODUCTION/
                 AUXV,AUXILIARY VIEWS/
                 SECV,SECTIONAL VIEWS/
                 DIME,DIMENSIONING/
                 WKING,WORKING DRAWINGS/
                 ISO,ISOMETRIC PROJECTION/
                 OBL,OBLICUE PROJECTION/
                 PER,PERSPECTIVE DRAWING/
                 INT,ITERSECTION & DEVELOPMENT/
                 SUR,SURFACE TREATMENT OF METALS/
                 TOL,TOLERANCING/
                 GEN,GENERAL MACHINE DRAFTING/
                 CAS,CASTING & FORMING/
                 FAB,FABRICATION/
                 CAM,CAMS/
                 GEAR,GEARS/
                 DET,DETAIL DRAWING/
                 ER,ERECTION DRAWING/
                 RES,RESIDENTIAL/
                 COM,COMMERCIAL/
                 ENCO,ENERGY CONSERVATION/
                 SYM,GRAPHIC SYMBCL/
                 CONN,CONNECTIONS DIAGRAMS/
                 PRINT,PRINTED CIRCUITS/
                 BLOCK,BLOCK DIAGRAMS/
                 SKEM,SCHEMATIC DIAGRAMS/
                 SURV,SURVEY PRACTICE/
                 TOP,TOPOGRAPHY MAPS/
                 CONT,CONTOUR MAPS/
                 PROF,PROFILE MAPS/
                 FLOW,FLOW DIAGRAMS/
                 VESS,VESSEL DRAWING/
                 EXGE,EXCHANGE DRAWING/
                 HYDR,HYDRAULIC & PNEUMATIC DESIGN/
                 MECH,MECHANISM & KINEMATICS DESIGN/
                 JIGS,JIGS &FIXTURES DESIGN/
                 STRAL,STRUCTURAL DESIGN/
                 MACH,MACHINE DESIGN/
                 MAT,MATERIALS/
                 SOL,SOLAR DESIGN/
                 DESC,DESCRIPTIVE GEOMETRY/
                 INTG,GRAPHICAL INTEGRAL/
                 NGRAM,NOMOGRAMS/
                 VECT,VECTOR GEOMETRY/
                 CALC,GRAPHICAL CALCULUS/
                 COMP,COMPUTER GRAPHICS/
VALUE LABELS     LTR TO COMP (5) EXTREMELY IMPORTANT (4) VERY IMPORTANT
                 (3) IMPORTANT (2) SLIGHTLY IMPORTANT (1) NOT IMPORTANT/
MISSING VALUES LTR TO COMP (0)
READ INPUT DATA
```

43332244213200000000320000000003333000000000300000	001
4251243422222222222442225422555554224224323211111	007
4531132321221252233443322323444434353324442322332	008
32422444223300000003234400000344533300000000323224	010
24313433411110000003311022112303322000000000113312	011
4532555433254543432343343435543335334435353323434	012
32322322222223222223333322222444422233333333323332	013
32323324433300000000444442223453334223323222322223	016
3431344422223441411421114310413114223444321201212	020
4343344333333330300333333000033333334323332333433	025
5233445422323533222543355535445434343434345533444	026
4131445522230000000543433433333434333114123211121	029
4232245522342321421533320000034331111415232433442	030
4443444443330000000430000000044344304304030443333	032
5345445422201111111441114444454441114111111223223	036
3221455521233333333553335333355533322252522222222	039
4332334432222433333332333423344434313323332212223	040
4531234322122432333332223333312213223434432311112	043
5332344432233433333544435433554445435535443533333	045
53453443323422222222443324434455555552222222424224	046
33313333333333333333300000000003333333333330300000	047
3124344521211531111420401334344444224214321114111	052
3542555543224543322442224423400004224423432543430	054
3352445533333300000440454505500005505505000533334	055
432323533330000003333400000234300000000000302303	061
32313322311100000003300033233222232200000000300000	062
33423333333300000000334400000333200000000000412215	068
3333333434430034433444433343434333443334433333333	070
42311444222400000005244400000444400000000000533533	071
55445555444434433333333345554555543300000000443333	072
233133332223343434431112232345553334442332232332	073
5445345322230000000443443322244443333334333113213	074
41521343111111111111424421111154441113111111111111	077
4332444444330000000443443333334444422222222222222	079
21434333211224434112222243134343241133333332222222	080
00000000000000000000000004543434444344544544554450	082
11111223111100000003244412113333310000000000311323	084
53454455444355355335555554444555544444444444554445	085
34414444323334334333333343333443333333333333322333	087
2111345511233542533533333322554325333243224322 43	089
42412234322322343233400044334000043200000000000044	091
3552245332224533322433345323353335223323233522524	093
2111443421231122322321223323333332222133212 23212	094
333133243330000000333302333300033333333324333344	095
3345445532230000000433440000045555433343434444455	097
33414433333000000332343444434444335324333333333	098
3244334432224543322544435433354435435433332403333	099
40334554422300000004455444335355400000000000000000	103
433144552111111141155242311133333111111411142 2432	105
4432444422123433433542222322353333222222222322224	112
5511355521200000000523550000044230000050004000000	113
43323444323434444444444423333333333334444434333444	116
34334455333323324225423043333434444443224330433334	118
5244455522250000000554405555500000004545452444444	119
324323332742000000044343422250003334224002303323	121
3542253322113333333520004425544445335224242444425	123
11513333212300000003300033333333330000000000333112	124
53344445223234333334434442234443333333333533223	125
50355555000000000005500000000555500000000000000000	126
35413433545400000004300000000000000000000000000000	127
35525555555553333333444443333333333334444444355555	131
42344454333300000005333334444345544323325244433444	133

53554444332235435334545344345444453344343333333330	134
52210341111000000005134042225422552250000004243000	137
44535555433455533335422244345543353355443333344333	140
21313322221122211112312333333444332122132212222222	142
22342334222000000000000000000033330000000000003032100	144
30410000000000000000000303003300004000000000000000	146
52522355222200000000522250000023335220003000211111	147
13213333331222222222224412222222222222222222222222	150
32521333223111111111322211111134451113123121412313	154
25235543511122233114233333333334444222222222222234	156
43433444434333334334333444333444443333224244443332	157
33413344311134313224313444334333342244144332222235	161
41422444223100000000024234124444200000000000000003	165
42102454322300000000434420000044444324344330000000	169
33323333333322322333323433333222232233222243322234	170
14424455433324223333223434435333333322243333322334	173
33333333333333333333333333333333333333333333333333	175
25433434554355444454544454543433343344344332423350	176
32310304111111111114411122222222223333333333433322	177
53332554311100000000541410000055523112224222313311	183
53422345222111111111333332133332222112213212322332	185
43423455434300000000535504424444444000000000444444	186
32233333333334334334433333344333334334434333343444 4	187
22324443232343334333333444243332443332332222222332	189
33513355334355555555555445333554444544555555533333 4	190
52333344333233334433433334343333333333333334333330	191
32332254222200000000443330000004333000000000222223	193
33323333333333333333333345232343444533332332200000 0	195
42333443111200000000440004312455444304314121000000	196
43334443222222222223333433333522222233323233332323	197
33333333333333313113333244244333333333333333333343	199
43424454333400000000443440000044130000000000443442	202
43524433333333333333333444333333444444444444432233 3	206
23321433311300000000322230000542322240043324422235	207
42242344222211221113233200000000000000000000000000	208
53454555554433445455555544555233433333333333444444	209
32423444222200000000000000000000444400000000000000	210
31111111414223334334434334455333354433333333432433	212
31444343223300000000520000000000000000005040000000	213
44224455323224535335435234445455553334233223232230	215
31423444222500000000530000000055555334225211000000	219
45235545553500000000553554422555555304315344430435	221
54444455434354524445323543555555555545355455334540	226
33434434334323434224334334444000042323243233222220	227
42322234223223322112222333222033222211122123323230	229
32424443222011111111433333223444445225424233402222	234
43123455213435324225324244244444443112224333431134	236
54344555544231424311543555555555555335435343434324	237
44443455434433323225534554235334453550142023112240	239
31111455111100000000330000000033330000000000300030	240
22322334222200000000433340000443343343242343223330	242
22423323324200000000000000000034405204323330403210	244
24443333323434304330033400003333332432333403203	245
33400000000000000000000133454440000000000000000000	246
33423333222700000000334422333433444343334443243333 4	251
52512224111311111111222222222333333325525215333333	253
44523455222245422223324433343344432233233232222220	254
53122554322423435224543500000000000000000000000000	255
33522555211100000000550000000000000000000000000000	256
55535554444522222222442222222222444444444444444444 4	257
22222222222221111111122111111111444433355333333334	258
43513355333300000000421454444455555305505034533555	260

```
53444555403455445555544555555555555555545555455455    264
34434455333544400005500035345544400000000000000000    265
32222333323211212113223433333433333333233323322324    267
34312554332344523223212344344323343233233331534222    268
53534555333455444444553545343355544434444434522235    269
55313335332335433334435054355445553333333333332211    271
41142343212411111114413311111444432142141414 21114    272
23322444371200000003314433133321200033121141232 20    273
21213333221311111113011111111332311141141112 01122    274
42523553222212213225434233333555532221152424 45335    275
44040445000004404004400000000000000000000000000    276
52435545534400000005544555055550050500040040 00000    277
53343455333345334335445500000000000000000000000000    278
44013444322300000004423333334333343354343335 00003    279
31131333111311311113333122222333311131131111 11111    280
53512555313213114114434333113555531155151135 11111    281
44333355444444444444444434443433334434444433 333433    283
32423333222211111111111011111111121111111101 11111    284
42212444212222312223212233334233332230232222 21122    285
55525555443522213225555554335355455553253235 15313    288
23413321444500000003224342224433330042242235 33334    291
53225553422000000000555550000055555505225244 500000    292
44223455333323333434453333433334344433334432 322340    294
40550555555155511115311111111445511111134411 11115    295
53233333333300000000443330000054443004404033 222223    296
44534555322222323225533344345544454343243234 33222    297
43233444322222222222223222222222222343333333 30333    298
24414424444233333333333333333333444444444444 44444    299
FREQUENCIES     GENERAL = ALL
STATISTICS      1,3,4,5,9,10,11
OPTIONS         3
FINISH
//
```

------ JES2 JOB STATISTICS ------

231 CARDS READ

0 SYSOUT PRINT RECORDS

0 SYSOUT PUNCH RECORDS

0.00 MINUTES EXECUTION TIME

```
//LIST     JOB TYPRUN=COPY                                          JOB 2014
/*JOBPARM FORMS=AC21
// EXEC SPSS
//GO.SYSIN DD *
RUN NAME        AMERICAN SOCIETY FOR ENGINEERING EDUCATION
DATA LIST       FIXED/ 1 LTR ORTO SKTCH INK AUXV SECV DIME WKING ISO OBL PER INT
                SUR TOL GEN CAS FAB CAM GEAR DET ER RES COM ENCO SYM CONN PRINT
                BLOCK SKEM SURV TOP CONT PROF FLOW VESS EXGE HYDR MECH JIGS
                STRAL MACH MAT SOL DESC INTG NGRAM VECT CALC COMP 1-49
INPUT MEDIUM    CARD
N OF CASES      138
VAR LABELS      LTR,LETTERING/
                ORTO,ORTHOGRAPHIC PROJECTION/
                SKTCH,SKETCHING/
                INK,INKING & REPRODUCTION/
                AUXV,AUXILIARY VIEWS/
                SECV,SECTIONAL VIEWS/
                DIME,DIMENSIONING/
                WKING,WORKING DRAWINGS/
                ISO,ISOMETRIC PROJECTION/
                OBL,OBLIQUE PROJECTION/
                PER,PERSPECTIVE DRAWING/
                INT,ITERSECTION & DEVELOPMENT/
                SUR,SURFACE TREATMENT OF METALS/
                TOL,TOLERANCING/
                GEN,GENERAL MACHINE DRAFTING/
                CAS,CASTING & FORMING/
                FAB,FABRICATION/
                CAM,CAMS/
                GEAR,GEARS/
                DET,DETAIL DRAWING/
                ER,ERECTION DRAWING/
                RES,RESIDENTIAL/
                COM,COMMERCIAL/
                ENCO,ENERGY CONSERVATION/
                SYM,GRAPHIC SYMBOL/
                CONN,CONNECTIONS DIAGRAMS/
                PRINT,PRINTED CIRCUITS/
                BLOCK,BLOCK DIAGRAMS/
                SKEM,SCHEMATIC DIAGRAMS/
                SURV,SURVEY PRACTICE/
                TOP,TOPOGRAPHY MAPS/
                CONT,CONTOUR MAPS/
                PROF,PROFILE MAPS/
                FLOW,FLOW DIAGRAMS/
                VESS,VESSEL DRAWING/
                EXGE,EXCHANGE DRAWING/
                HYDR,HYDRAULIC & PNEUMATIC DESIGN/
                MECH,MECHANISM & KINEMATICS DESIGN/
                JIGS,JIGS &FIXTURES DESIGN/
                STRAL,STRUCTURAL DESIGN/
                MACH,MACHINE DESIGN/
                MAT,MATERIALS/
                SOL,SOLAR DESIGN/
                DESC,DESCRIPTIVE GEOMETRY/
                INTG,GRAPHICAL INTEGRAL/
                NGRAM,NOMOGRAMS/
                VECT,VECTOR GEOMETRY/
                CALC,GRAPHICAL CALCULUS/
                COMP,COMPUTER GRAPHICS/
VALUE LABELS    LTR TO COMP (5) EXTREMELY IMPORTANT (4) VERY IMPORTANT
                (3) IMPORTANT (2) SLIGHTLY IMPORTANT (1) NOT IMPORTANT/
MISSING VALUES  LTR TO COMP (0)
READ INPUT DATA
```

1551332244144454433334442222234550003443344523423	001
4333443344444354343343444434334333433444333543335	007
4432444332243333333333334333333333333333333222222	008
3551455244131111111111111111111121111111111111111	013
2341303000200000000000000334530000000000000000404	014
4453444443332332322332224434434323332423333222434	015
3553554443330000000330000000000332000000000333333	022
5543344342224344214544445555545540000000000333542	023
3132332111212331311322225435522212112322200552453	025
2441444522220453422000003334400000003444540422320	027
2451444331133453333232324433533334323333342322332	029
5035000000000000000000000455350000000000000000000	031
3541355522233443333002202222222222333433332433433	032
3333240333332222222321222111155553114313211523323	035
4441444423324543333000000000000000003443443322223	037
3231111221111111111111111111111112221111111143221	044
4552334444233543333443355543344445333434543533335	048
2551445442350500055300000000000000000000000503350	052
3232344432432222222434444422433334222113123311112	053
4433433433232332323332334423432233223233323422222	054
2021223111022322112111011122111132123123212222223	056
4442443333323423334344333344555544433151433333224	057
3552555455223333333000000000000003323432333344445	059
1331231131121111111111111112111112111111111322224	060
2441333340101321211111111332331111111121121132332	061
2222222222222222222222222222222222222222222333444	063
1131333311111133111111110000000000000000000000000	064
2341344334223433333322232334333334334333334344344	066
2532424233213543333333333040343403303323333422324	067
2541334221322443422321120000000000002423343322334	069
3542444333133432344000000000000000003432422322325	070
3331333333330033033111113333333333110321302444344	073
3442055533402553355444403344400004403434423423023	074
2541444422232431111111211111111111111111111421224	079
3542353443211321111323334444445553224545544533534	080
2321444554333542422530000000000000443443335253422	081
2431132111211211222111313333311111111111111211210	082
4552444431442443433411111111111111145434443222222	085
2340440030000000000000000030330000300000000000000	086
4432444322223443322321114443344444433444443322 1122	089
2321333423232432322221442222222222222444344342225	092
3541554444143422221212222222322332111212212433332	097
1221222122221111111111111111221111111111111253555	098
4252334122330000000000000454530000000000000452533	102
2222222222222222222222222222555552222222222222222	104
3551544403221321111111111111111111111111111032323	105
1551111144411111111111111111111111111111111111111	107
4332333333223333300440053334400004000000000000000	108
3342333222232233333323333324334332133233243222333	109
4442444342421311111221111112333441111111111113113	113
4532545543423333333344333333335555333333333533543	114
3442343332323433222232223222333221113211212222224	116
2441445432233443333542544344433333222222222311111	117
3253135421223333242233222332222333332222422222225	118
4252234321212332244322245544534434323422434334445	120
4343355532243533544444434434333354345134422222532	121
4432345433332344433444444433445443322333333433323	123
2451335444222543323321235555532114223532224153554	128
3431445344352323211111111112112111111111111411211	132
3332223327332332222333322223333332223233333333444	134
3433324332222322222222224353322223222222222443334	136
3452344322220000000033000000000444400343443242422	137

2222222222222111111111111442551111111131111333331433	139
3541443222233333333330003343355554223522432311525	146
0000000000000000000000000222221111111111111453445	147
2431223311332232322233333333323223222223322211334	148
44424444444442242222444422222244442222224322322223	149
44423354112235444314434434344444454444444433422224	153
4542555531142344444221142222233332224444444522524	155
3442334433332222222232232222222332222222222323223	156
2451445433431422422221103225411333000000000244555	161
2341255531133552222542225522433335405425422223322	162
3353333333332232222220230544444454443333333554555	163
43410444313111111111324430000044440003004000222222	164
23313322222122111110000000000000000000000000111111	167
432133353321000000043344333334333433444444433222224	168
4543344443544442332430004434400004304430000400005	170
342333434322132222222111122222222332122212211332323	171
3242345433330000000335430000044550004334334444524	173
33513333322312211121111111211111111213211333334	175
2141222421422221222221114434411112211111111311223	178
435433343322233122242334323332222202313324322224	181
55533445443434433333333433343333223333323433333	182
00000000000000000000000000000033334000004000000030	184
4453225432113531111221132222223334421113110334343	189
3322333332232332220000033333000000000000000322222	190
5553555555553443333444454444444443444444444433435	191
443244533344333333441115433532324323333331532434	192
3131113211212211111111113323311111111111111111113	193
234244234322222222222222222222244443223223223323223	196
45425555442335533444445455555544445504443400543543	202
3351332222431122312313332233333224233323222533332	204
55545555543535533325443444433543344325544534522414	205
3241233232212221111211115425511211111211111122123	207
2221233332132233332122233233343334230000000403332	212
2331231332311221111111103333312211111111111233324	213
2341232322222232222331113222333332222223221312112	215
3531555431111541155331110000000000000000000000000	216
32312233222222223222200000000000003223333323333335	217
434433443234453333344334343233322433344434333224	218
3530533333050500000000000000000000000000000055500	219
34523433422233323333331112222234443332222222322224	225
2542433333212232211111111111111221110311211542543	226
334233333333322222222443332222244442223333333333333	228
435133331111331331133000222223333330000000301315	230
3343223332221111111212224424432322222222222223324	232
3452343344133433343232334333433334333433322342443	234
3551333333223232222212233342333334324324332411324	235
4543555433330000000554455535555555545534434535544	237
3541444544243554322443335444444444333333333443343	239
4552435433332222222222222222222222222222222543434	241
3244222422221111111111111444441111444111111111111	247
3543444432230000000000000000000000000000000400304	252
3341343111331111111111111444442222111111111554555	253
4351223121113322222111113324321113213322222332444	254
1451335332242542422241223225521114203333333331312	255
3331333211113321111111113113323223113313311322223	257
433244443322334343333333434343333334433433443444	260
3451444443333343322111113223312213112323333322223	266
2542444355441111111111111111111111111111111332433	268
345144434444221121122223222221111222212212322223	270
3231445532253553532535535333544445335535532521212	271
3222445534433333444442344543434433324433344334434	273
3341334411133434433331133333311113334445431313335	275

```
11111111111111111111111111111112555111111111111333          276
14514443442213111211111111222222111112310301111112          278
42323455222233443455554545555555444444444545443322 3          279
33514421434411111111111112222224444222111111434434          281
31413231111111111111111111111111111422111111333343          284
35312332112334335455535435535345353233345245234 34          285
33524443322211111113311111111133332221113111333334          286
34210443444411111111111111111111111111111111211114          288
45534454333335343335444544544345522235434435 22525          289
55514555442335333333000333330300300032333053333 2          291
55143355542100000000000000000555550000000000511111          296
34523333535300C0C000022244444000C00000000000444444          297
25222544522234553333443454443444433333433444543335          298
34423443411111111111111131111111314513211111111111          299
FREQUEACIES     GENEFAL = ALL
STATISTICS      1,3,4,5,9,10,11
CPTIONS         3
FINISH
//

------ JES2 JOB STATISTICS ------

        217 CARCS READ

          0 SYSOUT FFINT RECORDS

          C SYSCUT PUNCH RECORDS

       0.00 MINUTES EXECUTION TIME
```

```
//LIST     JOB TYPRUN=COPY                                                    JOB 1961
/*JOBPARM FORMS=A031
// EXEC SPSS
//GO.SYSIN DD *
RUN NAME        GRAPHIC SKILLS DEVELOPMENT IN UNDERGRADUATE ENGINEERING PROGRAMS
DATA LIST       FIXED/ 1 LTR ORTO SKTCH INK AUXV SECV DIME WKING ISO OBL PER INT
                SUR TOL GEN CAS FAB CAM GEAR DET ER RES COM ENCO SYM CONN PRINT
                BLOCK SKEM SURV TOP CONT PROF FLOW VESS EXGE HYDR MECH JIGS
                STRAL MACH MAT SOL DESC INTG NGRAM VECT CALC COMP 1-49
INPUT MEDIUM    CARD
N OF CASES      290
VAR LABELS      LTR,LETTERING/
                ORTO,ORTHOGRAPHIC PROJECTION/
                SKTCH,SKETCHING/
                INK,INKING & REPRODUCTION/
                AUXV,AUXILIARY VIEWS/
                SECV,SECTIONAL VIEWS/
                DIME,DIMENSIONING/
                WKING,WORKING DRAWINGS/
                ISO,ISOMETRIC PROJECTION/
                OBL,OBLIQUE PROJECTION/
                PER,PERSPECTIVE DRAWING/
                INT,ITERSECTION & DEVELOPMENT/
                SUR,SURFACE TREATMENT OF METALS/
                TOL,TOLERANCING/
                GEN,GENERAL MACHINE DRAFTING/
                CAS,CASTING & FORMING/
                FAB,FABRICATION/
                CAM,CAMS/
                GEAR,GEARS/
                DET,DETAIL DRAWING/
                ER,ERECTION DRAWING/
                RES,RESIDENTIAL/
                COM,COMMERCIAL/
                ENCO,ENERGY CONSERVATION/
                SYM,GRAPHIC SYMBOL/
                CONN,CONNECTIONS DIAGRAMS/
                PRINT,PRINTED CIRCUITS/
                BLOCK,BLOCK DIAGRAMS/
                SKEM,SCHEMATIC DIAGRAMS/
                SURV,SURVEY PRACTICE/
                TOP,TOPOGRAPHY MAPS/
                CONT,CONTOUR MAPS/
                PROF,PROFILE MAPS/
                FLOW,FLOW DIAGRAMS/
                VESS,VESSEL DRAWING/
                EXGE,EXCHANGE DRAWING/
                HYDR,HYDRAULIC & PNEUMATIC DESIGN/
                MECH,MECHANISM & KINEMATICS DESIGN/
                JIGS,JIGS &FIXTURES DESIGN/
                STRAL,STRUCTURAL DESIGN/
                MACH,MACHINE DESIGN/
                MAT,MATERIALS/
                SOL,SOLAR DESIGN/
                DESC,DESCRIPTIVE GEOMETRY/
                INTG,GRAPHICAL INTEGRAL/
                NGRAM,NOMOGRAMS/
                VECT,VECTOR GEOMETRY/
                CALC,GRAPHICAL CALCULUS/
                COMP,COMPUTER GRAPHICS/
VALUE LABELS    LTR TO COMP (5) EXTREMELY IMPORTANT (4) VERY IMPORTANT
                (3) IMPORTANT (2) SLIGHTLY IMPORTANT (1) NOT IMPORTANT/
MISSING VALUES LTR TO COMP (0)
READ INPUT DATA
```

15513322441444544333344422222345500034433445234 23	001
43334433444435434334344443433433343344433335433 35	007
44324443322433333333333343333333333333333332222 22	008
35514552441311111111111111111111211111111111111	013
23413030002000000000000003345300000000000000000404	014
44534444433323323223322244344343233324233332224 34	015
35535544433300000033000000000033200000000003333 33	022
55433443422243442145444455555455400000000003335 42	023
31323321112123313113222254355222121123222005524 53	025
24414445222204534220000033344000000344454042223 2C	027
24514443311334533332323244335333343233333423223 32	029
50350000000000000000000000455350000000000000000000	031
35413555222334433330022022222222233334333324334 33	032
33332403333322222223212221111555531143132115233 23	035
44414444233245433330000000000000000034434433222 23	037
32311112211111111111111111111111122211111111432 21	044
45523344442335433334433555433444453334345435333 35	048
25514454423505000553000000000000000000000005033 50	052
32323444324322222224344444224333342221131233111 12	053
44334334332323323233323344234322332232333234222 22	054
20212231110223221121110111221111321231232122222 23	056
44424433333323423334344333344555544433151433332 24	057
35525554552233333330000000000000332343233334444 5	059
13312311311211111111111111121111121111111113222 24	060
24413333401013212111111133233111111111211211323 32	061
22222222222222222222222222222222222222222223334 44	063
11313333111111331111111100000000000000000000000 00	064
23413443342234333333222323343333343433333434434 43	066
25324242332135433333333330403434033033233334223 24	067
25413342213224434223211200000000000002423343322 334	069
35424443331334323440000000000000000034324223223 25	070
33313333333300330331111133333333331103213024443 44	073
34420555334025533554444033444000014034344234230 23	074
25414444222324311111112111111111111111111114212 24	079
35423534432113211113233344444455532245455445335 34	080
23214445543335424225300000000000044344333525342 22	081
24311321112117112221113133333111111111111112112 10	082
45524444314421434334111111111111111114543443222 222	085
23404400300000000000000000303300003000000000000 00	086
44324443222234433223211144433444443334444332211 22	089
23213334232324323222244422222222222244434434222 25	092
35415544441434222212122222223223321112122124333 32	097
12212221222211111111111111112211111111111111112535 55	098
42523341223300000000000045453000000000000004525 33	102
22222222222222222222222225555522222222222222222 222	104
35515444032213211111111111111111111111111110323 23	105
15511111444111111111111111111111111111111111111 11	107
43323333322233333004400533344000040000000000000 00	108
33423332223322233333233333324334332133233243223 33	109
44424443424213111112211111123334411111111111131 13	113
45325455434233333334433333333555533333333335335 43	114
34423433323234332222322232223332211132112122222 24	116
24414454322334433335425443444333322222222223111 11	117
32531354212233324223322233222333332222422222222 25	118
42522343212123372443222455445344343234224343344 45	120
43433555322435335444444434434333354345434422225 32	121
4432345433332344433444444433-.4544332233333334333 23	123
24513354442225433233212355555321142235322241535 54	128
34314453443523232111111111111211211111111114112 11	132
33322233223323322223333322233333332223233333334 44	134
34333243322223222222222243533222232222222224433 34	136

3452344322220000000033000000000044440003434432442422	137
2222222222222111111111111442551111111311113331433	139
3541443222233333333300033433555542235224323311525	146
000000000000000000000000022222111111111111111453445	147
243122331113222323222333333333232232222332221 1334	148
4442444444442242222444422222244442222224322322223	149
4442335411223544431443443434444445444444433422224	153
4542555531142344444221142222233332224444444522524	155
3442334433332222222322322222233222222222222323223	156
2451445433431422422221103225411333000000000244555	161
2341255531133552222542225522433335405425422223322	162
3353333333333223222222023054444444544433333354555	163
4341044431311111111132443000004444000300400022222 2	164
2331332222122111110000000000000000000000000011111	167
4321333533210000000433443333343334334444433222224	168
4543344443544442332430004434400004304430000400005	170
3423334342221322222211112222222332122212211332323	171
3242345433330000000335430000044550004334334444524	173
3351333332231221111211111111211111111213211333334	175
2141222421422221222221144344111122111111111311223	178
4354333433222331222423343233322222023133243 22224	181
5553344544343443333333334333433333223333323433333	182
0000000000000000000000000000000000333340000400000000300	184
4453225432113531111221132222223334421113110334343	189
3322333332232332222000003333300000000000000322222	190
5553555555553443333444454444444444344444444433435	191
4432445333443333333441115433532324323333331532434	192
3131113211212211111111113323311111111111111111113	193
2342442343222222222222222222224444322322322332 3223	196
4542555544233553344444545555544445504443400543543	202
3351332222431122312313332233333224233323222533332	204
5554555554353553332544344433543344325544534522414	205
3241233232212221111211115425511211111211111122123	207
2221233332132233332122233233343334230000000403332	212
2331231332311221111111103333312211111111111233324	213
2341232322222232222331113222333332222223221312112	215
3531555431111541155331110000000000000000000000000	216
3231223322222222322220000000000000322333332333335	217
4344334432344533333443343432333224333344434333224	218
3530533333050500000000000000000000000000000055500	219
3452343342223332333331112222234443332222222322224	225
2542433333212232211111111111111221110311211542543	226
3342333333333222222244333222224444222333333333333 3	228
4351333311113313311330002222233333300000000301315	230
3343223332221111111212224424432222222222222223324	232
3452343344133433343232334333433334333433322342443	234
3551333333232332222212233342333333432432433241 1324	235
4543555433330000000554455535555555545534434535544	237
3541444544243554322443335444444444333333333443343	239
4552435433332222222222222222222222222222222543434	241
3244222422221111111111111444444111144411111111111 1	247
3543444443223000000000000000000000000000000400304	252
3341343111321111111111111444444222211111111111554555	253
4351223121113322222211111332432111321332222233244 4	254
1451335332242542422241223225521114203333333331312	255
3331333211113321111111113113323223113313311322223	257
4332444433223343433333331343433333334433433443444	260
3451444443333343322111113223312213112323333322223	266
2542444355441111111111111111111111111111111332433	268
3451444344442211211222232222211112222212212322223	270
3231445532253553532535535333544445335535532521212	271
2222445534433333444442344543434433324433344334434	273
3341334411133434433331133333311113334445431313335	275

11111111111111111111111111112555111111111111111333	276
1451444344221311121111111222222111112310301111112	278
42323455222334434555545455555544444444445454433223	279
33514421434411111111111112222244442221111111434434	281
31413231111111111111111111111111142211111111333343	284
35312332112334335455535435535345353233345245234 34	285
33524443322211111113311111111333322211131113333 34	286
34210443444411111111111111111111111111111211114	288
45534454333353433354444544544345522235434435225 25	289
55514555442335333333000333330300300032333053333 2	291
551423555421C0C000CC00000CCCC5555CC0000000051111 1	296
34523333535300000000022244444000000000000000444444	297
25225445222345533334434544434444333334334445433 35	298
34423443411111111111111311111131451321111111111 1	299
43332244213200000003200000000333300000000000300000	001
42512434222222222224422254225555542242243232111 11	007
45311323212212522334433223234444343533244423223 32	008
32422444223300000003234400000344533300000000323224	010
24313433411110000003311022112303322000000000113312	011
45325554332545434323433434355433353344353533234 34	012
32322322222232222233333222224444222333333323333 2	013
32323324433300000000444442222345333422332322232222 3	016
34313444222234414114211143104131142234443212012 12	020
43433443333333030033333330000333333343233323334 33	025
52334454223235332225433555354454343434343455334 44	026
41314455222300000005434334333334343331141232111 21	029
42322455223423214215333 20C000343311114152324334 42	030
44434444433300000000430000000004434430430403044 3333	032
53454454222011111114411144444544411141111112232 23	036
32214555212333333335533352333555333222525222222 2	039
43323344322224333333323334233444343133233322122 23	040
45312343221224323333322233333122132234344323111 12	043
53323444332334333335444354335544454355354435333 33	045
53453443323422222224433244344555555222222224242 24	046
33313333333333333333300000000333333333333303000 00	047
31243445212115311114204013343444442242143211141 11	052
35425555432245433224422244234000042244234325434 30	054
33524455333333000004404545055000055055050005333 34	055
4323235333333CCC00CC33334 00C0C23430CCC000CC00302303	061
32313322311100000000330003323322223220000000030000 0	062
33423333333300000000334400000333200000000000412215	068
33333334344300344334444333434343334433344333333 33	070
42311444222400000005244400000444400000000000533533	071
55445555444434433333333345554555543300000000443333	072
23313333222334343443111223234555333444233223233 2	073
54453453222300000000443443322244143333334333113213	074
41521343111111111114214211111544411131111111111 11	077
43324444443 3CC0000C4434433333344444222222222222 22	079
21434333211224434112222243134343241133333332222 22	080
00000000000000000000000004543431444344544544554450	082
11111223111 1CCC000CC32444121133323331CC0000000311323	084
53454455444355355335555554444455554444444444554445	085
34414444323334334333333433334133333333333333322333	087
21113455112335425335333333225543253333243224322 43	089
42412234322322234323340004433400004320000000000044	091
35522453322245333224333453233533352233232335225 24	093
21114434212311223223212233233333322221332122321 2	094
33313324333300000000333302333300003333333324333344	095
33454455322300000000433440000045555443334343444455	097
3341443333 33CCC00003323434444344443353243333333 33	098
32443344322245433225444354333544135435433332403333	099

40334554422300000000445544433535540000000000000000	103
43314455211111114115524231113333311111141114224 32	105
44324444221234334335422223223533332222222223322224	112
55113555212000000000523550000044230000005000400000	113
43323444333434444444444442333333333333444434333444	116
34334455333323324225423043334344444432243304333 34	118
52444555222500000000554405555500000004545452444444	119
32432333224200000000443434222500003334224002303323	121
35422533222113333333520004425544445335224242444425	123
11513333212300000000330003333333333000000000333112	124
53344445223234333334434443223444333333333333533223	125
50355555000000000055000000005555000000000000000000	126
35413433545400000000430000000000000000000000000000	127
35525555555553333333344444333333333333444444355555 5	131
42344454333300000005333334443455443233252444 33444	133
53554444332235435334545344345444453344434333333330	134
52210341111000000000513404222542255225000000424300	137
44535555423455533335422244345543353355443333334433	140
21313322221122221111231233333334443321221322122222 2	142
22342334222000000000000000000003333000000000303210	144
30410000000000000000000303003300004000000000000000	146
52522355222200000000522250000023335220003000211111	147
13213333331222222222224442222222222222222222222222	150
32521333223111111111322211111113445111312312141 2313	154
25235543511122233114233333333334444222222222222234	156
43433444434333333433433444333444443333224244444333 2	157
33413344311134313224313444334333342244144332222 35	161
41422444223100000000024234124444200000000000000003	165
42102454322300000004344200000444443243443300000 00	169
33323333333322322333323433333222232233222243322 34	170
14424455423332422333322343443533333332224333322334	173
33333333333333333333333333333333333333333333333333	175
25433434554355444454544454543433343344344332423 35	176
32310304111111111114411122222222233333333333433322	177
53332554311100000000541410000055523112224222313311	183
53422345222111111111333332133332221122132123223 32	185
43423455434300000000535504424444444000000000444444	186
32233333333333433433443333344333333433444343334344 44	187
22324443232343334333333444243332443333233222223 32	189
33513355334355555555554453335544445445555555333334	190
52333344333233344334333334343333333333333333433330	191
32332254222200000000443330000043330000000000222223	193
33323333333333333333333345232343444533332332200000 0	195
42333443111200000000440004312455444304314121000000	196
43334443222222222222233333433333522222233232333323 23	197
33333333333333331311333324424433333333333333333343	199
43424454333400000000443440000044430000000000443442	202
43524433333333333333333344433333344444444444443223 33	206
23321433311300000000322230000542322240043324422 35	207
42242344222211221113233200000000000000000000000000	208
53454555554433445455555554455523343333333333444444	209
32423444222200000000000000000004444000000000000000	210
31111111414223334334434334455333354433333333432433	212
31444343223300000000520000000000000000005040000000	213
44224455323224535335435234445455553334233223232 23	215
31423444222500000000530000000055555334225211000000	219
45235545555350000000553554422555555304315344430435	221
54444455434354524445323543555555555454535545533454	226
33434434334323434224334334444000042323243233222 22	227
42322234223223322112222333222033222211122123323 23	229
32424443222011111111433333223444445225424233402222	234
43123455213435324225324244244444431122243334311 34	236
54344555442314243115435555555555555335435343434324	237

```
444434554344333232255345542253344535501420231122 4          239
311114551111000000003300000000033330000000000300030          240
2232233422220000000043334000004433433432423432233 3          242
2242332337 42CCC00CCCC00C0CCCC344052043233304032 1C          244
24443333323434304330033400000333333243 2333403203          245
33400000000000000000013345444000000000000000000000          246
33423333222200000000334422333433444343333443243333 4          251
5251222411131111111122222222223333332552521533333 3          253
44523455222245422223324433343344432233233232222 22          254
53122554322423435224543500000000000000C0000000000 C          255
33522555211100000000550000000000000000000000000000 0          556
555355544445222222244222222222244444444444444444 44          257
22222222222211111112211111111444433355333333333 34          258
43513355333000000004214544444555553055050345335 55          260
534445554034554455555445555555555555455554554 55          264
344344553335444 0CCC550003534554440 0C0000C000C0000          265
32222333323211212113223433333433333332333232232 4          267
3431255433234452322321234434432334323323331534222          268
53534555333455444445535453433555444344444345222 35          269
55313335332335433334435054355445553333333333332211          271
41142343212411111114413311111444432142141414211 14          272
233224443212C0000C331443313332120C03312114123220          273
21213333221311111113011111111332311141141112011 22          274
425235532222122132254342333335555322211524244533 5          275
4404C4450CCCC4404CC4400C0CCC000C0C0C0000000000000          276
52435545534400000005544555055550050500040040000 00          ·277
53343455333345334335445500000000000000000000000 00          278
44013444322300000004423333334333343354343335C0003          279
31131333111311131111333312222233331113113111111 11          280
5351255531321311411443433311355553115515113511111          281
44333355444444444444444344434333344344444333334 33          283
3242333322221111111111110111111111211111111011111 1          284
42212444212222312223212233334233322302322222211 22          285
55525555443522213225555554335355455553253235153 13          288
23413321444500000000322434222443333004224223533334          291
53225553422C000000055555000005555550522524450000 0          292
44223455333323334344533334333434443333443232234 0          294
4055C55555515551111153111111114455111111344111111 5          295
53233333333300000000443330000054443004404033222223          296
44534555322322323225533344345544454343243234332 22          297
43233444322222222222222322222222222223433333330333          298
24414424444233333333333333333334444444444444444 44          299
T-TEST          GROUPS = 13E, 152/ VARIABLES = LTR TO COMF
FINISH
//


------ JES2 JOB STATISTICS ------

       375 CARDS READ

         0 SYSOUT PRINT RECORDS

         C SYSOUT PUNCH RECORDS

      C.0C MINUTES EXECUTION TIME
```

VITA

Roberto Alexandre Schlemm

Candidate for the Degree of

Doctor of Education

Thesis: THE RELATIVE IMPORTANCE OF GRAPHIC SKILLS DEVELOPMENT IN UNDERGRADUATE ENGINEERING PROGRAMS

Major Field: Occupational and Adult Education

Biographical:

Personal Data: Born in Pôrto União, Santa Catarina, Brazil, May 28, 1944, the son of Alexandre and Luiza Schlemm.

Education: Graduated from Colégio Estadual Tulio de França, Brazil, in 1963; received the Bachelor of Science degree in Mechanical Engineering from Universidade Federal do Paraná, Brazil, in 1972; received the Master of Science degree in Technical Education from Oklahoma State University, in 1973; completed requirements for the Doctor of Education degree from Oklahoma State University in December, 1980.

Professional Experience: Assistant Professor, Centro Federal de Educação Tecnológica do Paraná, Brazil, 1970; Staff member (Engineer), Centro Paranaense de Assistência Gerencial (CEAG), Brazil, 1974-1976; Professor and Head, Drafting Department, Centro Federal de Educação Tecnológica do Paraná, 1975; Associate Professor, Universidade Católica do Paraná, Brazil, since 1975; Assistant Professor, Universidade Federal do Paraná, Brazil, since 1976.

Professional Organizations: American Institute for Design and Drafting, American Society for Engineering Education, American Vocational Association, Instituto de Engenharia do Paraná.