A STUDY OF INFORMATION ELEMENTS FOR INCLUSION IN AN INTRODUCTORY COMPUTER GRAPHICS COURSE FOR A DESIGN DRAFTING PROGRAM

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PREFACE

This study was undertaken in order to determine the course content items for a Design Drafting Technology computer graphics course. The results of this study are due directly to the time and consideration given by industrial representatives in Texas and Oklahoma. This co-operation is essential for relevance in technician education.

I would like to express my appreciation to Dr. Cecil W. Dugger for his guidance and interest in this study. I will always be indebted to Dr. Donald S. Phillips for the guidance he has provided and the personal interest he has shown in my career.

The faculty and staff of Cameron University provided invaluable assistance and encouragement during the development of this study. Dr. Terry Spradley's guidance and criticism was most beneficial. I appreciate the interest he showed in the study.

I am especially grateful to Sharon, my wife, for contributing suggestions useful in improving the quality of the thesis. Also, I am greatly indebted to her for the time she spent typing and proof reading the copy. Sharon's encouragement and sacrifices helped to make the completion of the study possible.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

THE PROBLEM

Introduction

The digital computer has developed rapidly within the last thirty years. Industry is purchasing the most current systems and modifying the older systems for new found uses. At first, applications were limited to data retrieval and then to data analysis. Now, these are common tasks assigned to a computer. Engineers and architects have learned the advantage of solving massive, complex, analytical problems on the computer. Simulation can be made of real or proposed systems by changing the input parameters at the whim of the computer programmer. Graphical displays can be used as input or output for computerized systems. Present computer systems have eliminated much of the routine work for engineers and architects, allowing more time for designing and research. Not only is more time available for research and development, but a whole new dimension and flexibility is provided with new computer applications in research.

The technician plays an integral role in the industrial society. Therefore, it is important that the technician be educated in the most current techniques required on the job. Technician educators must monitor industrial needs in order to ensure job opportunities for their graduates and up-to-date technicians for industry.

Statement of the Problem

Development of a more effective computer graphics course has been hindered by lack of information concerning the course content.

This problem is complicated by the following factors:

1. lack of information necessary to determine the type of computer graphics hardware and software available and being used by industry;
2. inability to determine which potential employers will hire graduates;
3. lack of information concerning computer applications employers will assign to be done by the design drafting technician.

While no course could meet the exact requirements for every industrial computer graphics system, identification of the principal information elements should be made.

Purpose of the Study

The purpose of this study was to identify specific information elements which are appropriate for inclusion in an introductory computer graphics course for associate degree design drafting students. This study sought to determine what information elements are necessary as indicated by Oklahoma and Texas industrial firms which use computer graphics systems.

Research Questions

The following research questions were considered:

1. What information elements should be included in an introductory computer graphics course for associate degree design drafting students?
2. What computer graphics facilities are necessary to adquately prepare the design drafting graduate for placement?

Need for the Study

The complexity of today's design problems and the keen competition for immediate solutions demand that the design drafting technician have a broader training program than the conventional drafting room training.[1] However, it is also important that the educational experience provide what industry needs. Many companies purchase unnecessary computer equipment because they were not careful to identify their needs correctly. This problem also exists in technician education. Care should be taken to insure that the correct courses and the priority of courses are properly determined in a technician curriculum. The schools attempting to stay abreast of industrial needs may find themselves burdened down economically trying to change laboratory equipment and curriculum on a continuous basis.[2] It is important that industry and education work together in developing technician education objectives within reasonable limitations.

Because great emphasis has been placed on the use of the computer in technician education, it is important to give careful consideration

to the topics included in the introductory computer course for associate degree design drafting students.

Delimitations

This study is restricted to identifying content appropriate for inclusion in an introductory computer graphics course for associate degree design drafting students.

The participants in this study were limited to industrial representatives whose Texas or Oklahoma based companies use computer graphics systems. These representatives worked either in the computer division or the graphics division of their respective companies.

Assumptions

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

1. The selected industrial representatives possess expertise in the computer graphics field.
2. The selected industrial representatives will complete openly and accurately the Delphi consensus.
3. The six-point continuum used for the calculation of the consensus index is an interval scale.

Definition of Terms

Computer Graphics - the graphical output of analytical data which has been processed by a digital computer.[3]

Computing Power - the amount of computer programmed operations which can be completed within a specified time.

CPU - the main body of the computer, usually consisting of memory sections and a display of internal memory addresses.

CRT - a cathode ray tube used for temporary graphical display of computer generated output.

Graphical Tablets - electronic or acoustic devices which convey to the computer the position of the stylus relative to a reference point on the tablet.[4]

Hardware - the computer, disk drives, tape drives, card reader/punches, drum, or flatbed plotters, CRT, keypunch, and console typewriters.[5]

Image Digitizer - a passive type input electro-mechanical tracking device that inputs coordinates relative to an established reference point.[6]

Industrial Representative - an individual with a specialty in engineering, architecture, technology, or data processing, who is currently working with computer graphics in industry.

Industry - any potential employer of Design Drafting graduates including industrial firms, government agencies, and businesses.

Input - data or commands entered into the computer system.

Joy-stick - an analog device which converts displacement into digital signals.[7]

Mainframe - a computer with large physical storage areas and a CPU, which organizes and monitors multiple input and output devices simultaneously.

Mini-computer - a physically small computer with specialized service capabilities, usually connected to control a minimum of peripheral equipment simultaneously.

Optical Scanner - an input photo-electric device which converts the light and dark areas of a drawing into on/off dots on a grid (matrix).[8]

Output - data, information, or graphical displays typed, printed or drawn on a plotter, or displayed on a CRT by the computer.

Peripheral Device - any hardware which is not structurally connected to the CPU.

Plasma Display Panel - a matrix of gas cells sandwiched between two glass plates. The glass plates contain embedded conductors of selective activation of the gas cells.[9]

Plotter - incremental devices which allow the computer to perform the actual drawing tasks with ink on paper.

Software - consists of data cards, paper tape, magnetic tape, disks, printer paper, plotter paper, and CRT photographs.

Technician Education - a planned sequence of classroom and laboratory experiences designed to prepare persons for a cluster of job opportunities in a specialized field of technology. The program of instruction normally includes the study of the underlying sciences and supporting mathematics inherent in a technology. Technician education prepares for the occupational area between the skilled craftsman and the professional person.[10]

FOOTNOTES

[1]Gary Stamper, "Let's Update Drafting Education," Plan and Print, Vol. N47/No. 9 (November, 1974), p. 19.

[2]Grant Venn, Man, Education and Work (Washington, D.C., 1968), pp. 18-28.

[3]Fred White and Tom Thomas, Computer Graphics Instruction Units (Stillwater, Oklahoma, 1973), pp. 1-4.

[4]Ibid., pp. 1-5.

[5]Dan M. McNeil, "Auto-Trol Automated Graphics System," unpub. speech for American Institute for Design and Drafting, April, 1974.

[6]White and Thomas, pp. 1-5.

[7]Ibid.

[8]Ibid.

[9]Ibid.

[10]Donald S. Phillips, "Personal and Social Background Characteristics of Entering Technician Education Students at Four Post-High School Institutions" (unpub. Ed.D. dissertation, Oklahoma State University, 1968), p. 6.

CHAPTER II

REVIEW OF LITERATURE

There is concern in the drafting and design profession that computer aided drafting (CAD) will displace large numbers of draftsmen. However, the resistance to automation may decrease as the need for the systems is established. John Mauchly and J. Presper Eckert developed a computation system when the Army expressed an urgent need for a fast method of computing accurate ballistics tables.[1] John A. Brown explains the relationship between the development of automated military systems and factory automation. He points out that military systems are fundamentally the same as those required by industry and that many of industry's problems have already been solved before plant automation has even begun.[2] The first successful mainframe computers, the MARK I and the ENIAC, were developed for military use during World War II.[3]

The MARK I was developed at Harvard and the ENIAC at MIT.[4] The funding came from the Federal Government. The expertise necessary for the development was found in the faculty and staff of these universities. While industry and education have been reluctant to fund development of computer systems, John Caffrey and Charles Meesman identified motivations behind the growth of computers in educational programs.[5] This would seem to indicate that college administrations have responded when a need has been established. However, by the time

the need is determined, educational programs are behind; attempting to prepare the student with educational objectives which are two to six years behind industrial requirements. Duane C. Spriesterbach, Vice-President for Research and Dean of the Graduate College for the University of Iowa, considers this point in a speech he presented to the 1970 Conference on Computers in Undergraduate Curricula. He also expressed concern that educators were possibly over emphasizing computer education because of unquestioned acceptance of the benefits cited by the computer industry.[6]

Education has played an active role in the development of interactive computer graphics systems. Ivan Sutherland developed the first man-machine communication system, SKETCHPAD I, at MIT's Lincoln laboratory in 1963.[7] The costs of the equipment at the time prevented wide spread acceptance of the system. SEL CIR (Systems Engineering Laboratory Circuit Analyzer) was developed by James Blinn, at the University of Michigan.[8] With this system, students in electrical engineering can build circuits with standard electronic elements on the CRT and then analyze the circuit through the computer. A problem solution program STRESS (Structural Engineering Systems Solver) was developed with cooperation between MIT and the University of Illinois.[9] Stephen MacDonald and Robert Wehil developed an Architectural Design System during 1966. This system was based on graphics displays generated with a computer.[10]

Electronics components went through some rapid developments in the late sixties. Bell Lab's researchers had invented the magnetic bubble memory system.[11] RCA scientists had worked out an infrared light laser semiconductor device called an "inverter."[12] These improvements have

been adopted for use by the growing mini-computer industry. The mini-computer systems have greatly reduced the cost of computing power.

The mini-computer connected to newly produced peripheral equipment allows for a low cost interactive computer graphics system. No longer is the use of special languages for interaction with the computer required. Management is not restricted to systems requiring a relatively large long term investment of money in computers. Education's response to this era of mini-computer systems will depend heavily upon the type of influence exercised by industry. With all of the options now available, industry must decide how to best apply computer graphics and educators should be anticipating the preparation of graduates to meet industrial needs.

The cost factor of computer systems has been reduced to the extent that some complete mini-systems and software are on the market for $10,000. Many more companies can now readily afford computer systems. At a 1970 meeting of drafting managers in Detroit, Ford Motor Company revealed a cost savings investment of 85 to 1 for the use of the computer in developmental design.[13] At a similar meeting in 1974, Dan McNeill of Auto-Trol Corporation estimated that a computer graphics system doing the work of 14 draftsmen could save a company $311,220 yearly above the equipment cost.[14] It would appear that, at least in the computer graphics area, cost is being offset by savings.

It is difficult to determine any industry trends based on sales where large mainframe systems are compared to the mini-computers. Recent high sales of mini systems and stabilization of large mainframe sales, may not be indicative of the types of systems technicians should be prepared to use. This may indicate only that the less

expensive mini systems are more attainable to smaller companies. The technician may still be using the mainframe systems more than the stand alone mini system.

Engineering managers are still debating how to best utilize computer systems. At a seminar on computer graphics, Richard Lanham, Manager of Marketing Administration for Calma Company of Sunnyvale, California, said:

> . . . most of the industry has persisted in concentrating on the graphics output itself, viewing that as an ultimate objective. That ignores the computer's great potential for organizing and manipulating data.[15]

During a speech to the American Institute for Design and Drafting (AIDD) convention in 1974, William Beck, Manager, Design Automation Services, Control Data Corporation, presented these five applications as primary to design utilization of computers:

> Design Simulation/Graphics Automation
> Semi-automated/Interactive Drafting
> Design Verification
> Computer Aided Documentation
> Centralized Engineering Data Base Management.[16]

These types of systems would include computer systems with some program capability and an interactive computer graphics system. The interactive systems include image digitizers, CRT's, teletypes, and plotters. This interactive system allows the operator to use a rough sketch and digitizer for input. The CRT and the teletype provide direct access to the core for correction of any errors seen on the CRT. This system also allows for the storage of standard images for recall. The storage of completed drawing allows for building a data base that is easily accessible for review. The operator is not required to learn any special programming languages for use of the interactive system.

There is also the question of considering how far automation should go. It is important to determine if CAD should be coupled with Computer Aided Manufacturing (CAM). A. R. Salerno, Drafting Manager, Westinghouse Electric Corporation, stated in a 1974 speech at the AIDD convention that with proper education, drawing communication between engineering and manufacturing would be obsolete by the year 2000.[17] In an article by Robert Wilson, many industrial leaders interviewed are advising that CAD/CAM is the only hope American companies have of remaining competitive with foreign industry in cost and time of production.[18]

There are no apparent indications that CAD will cause less demand for draftsmen and designers. In a speech delivered to the Oklahoma Council of AIDD, N. N. Freling of Phillips Petroleum Company, cited the reason Phillips opted for an automated drafting system was to fill vacant technician slots.

There is evidence to indicate that the CAD systems do not reduce the labor force of designers and draftsmen, but rather deepen their design capabilities and free them for more creative work. Arthur T. Farrell, 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.[19] Phillip P. O'Neill, a Section Supervisor for E. I. du Pont de Nemours and Company, stated that in a Du Pont study they found that only 20 per cent of the draftsman's time is spent at the drawing board producing a drawing.[20] The time saved by the computer graphics usage relieves the designer of redundant work for more creative activities

or more management. Many drawing details can be stored in computer memory and simply plugged into any new design.

G. Neil Harper points out another positive attribute of computer graphics:

> Graphical recall ability could make it possible to transmit detail design experience to the student or young professional in a very short amount of time. Hence certain types of experience which now come only after several years of practice could be much more readily attainable, perhaps even before leaving the educational environment.[21]

There is also the possibility that educators could quickly update their background experience or broaden their technical expertise by having access to an up-to-date computer graphics data base.

With industry adopting computer graphics systems, it is necessary to identify what priority should be given to these systems in development of design drafting programs. Therefore, it is necessary to identify the course content items. Industrial representatives can assist in identifying course items important for inclusion in a design drafting program's computer graphics course. The identified course content items can be evaluated in relation to existing design drafting program objectives and industrial needs.

FOOTNOTES

[1]Jerry M. Rosenberg, The Computer Prophets (London, 1969), p. 145.

[2]John A. Brown, Computers and Automation (New York, 1968), p. 196.

[3]Rosenberg, p. 145.

[4]Ibid.

[5]John Caffrey and Charles J. Meesman, Computers on Campus (Washington, D.C., 1967), p. 69.

[6]Proceedings of a Conference on Computers in the Undergraduate Curricula (Iowa City, Iowa, 1970), p. 0.3.

[7]Jeanne W. Halpern, "Computer Graphics," Research News, V 21n 4 and 5 (October/November, 1970), p. 4.

[8]Ibid, p. 23.

[9]Steven D. Popell, Computer Time-Sharing (Dynamic Information Handling for Business) (New Jersey, 1966), p. 142.

[10]Stephen L. MacDonald and Robert Wehil, "An Architectural Design System Based on Computer Graphics" (a speech presented at the National Research Conference on Architectural Psychology, Park City, Utah, 1966), pp. 31-32.

[11]Computer Yearbook 72 (Detroit, Michigan, 1972), p. 54.

[12]Ibid., p. 53.

[13]"Drafting Managers Speak Their Minds," Engineering Graphics, Vol. 10, No. 12 (December, 1970), p. 18.

[14]George E. Rowbothan, "Computer Graphics Benefits Cited at Drafting Managers' Meeting," Engineering Graphics, Vol. 14, No. 12 (December, 1974), p. 16.

[15]Computer Yearbook 72, p. 52.

[16]"Computer Graphics Chasing Wrong Goals, Says Seminar Speaker," Engineering Graphics, Vol. 14, No. 12 (December, 1974), p. 4.

[17]William E. Beck, "Automated Graphics in a Decentralized Corporation," (unpub. speech presented to the 1974 American Institute for Design and Drafting Conference, Chicago, Illinois, 1974).

[18]Robert A. Wilson, "CAD/CAM Breaks the Holding Pattern," Iron Age, Vol. 215, No. 3 (January 20, 1975), pp. 33-42.

[19]Art T. Farrell, "Design Automation--Make It Work," (unpub. speech presented to the 1974 American Institute for Design and Drafting Conference, Chicago, Illinois, 1974).

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

[21]G. Neil Harper, ed., Computer Applications in Architecture and Engineering (New York, 1968), p. 224.

CHAPTER III

METHODOLOGY

Introduction

The Delphi method was developed by the Rand Corporation to enhance long range forecasting. This method is used to attain a group consensus of experts through correspondence without personal interactions swaying the group through a strong and impelling personality instead of logic.[1]

The Delphi Technique, as originally developed, consists of four steps:

> First, each participant is asked to write his opinion on a specific topic.
>
> Second, each participant is asked to evaluate all of the opinions in terms of a given criteria.
>
> Third, each participant receives the list and a summary of the responses, and, if his view differs from the most frequent response, he is asked either to revise his opinion or to indicate his reason for not doing so.
>
> Finally, each participant receives the list with an updated summary, including minority opinions, and is asked to repeat or revise his own opinion.[2]

A modification of the Delphi Technique, eliminating the fourth mailing, was used for this study. This change is based on the results of research conducted by Frederick Cyphert and Walter Gant. Using the result of a 400 participant Delphi evaluation of a Virginia education program, the following conclusion was drawn:

> Virtually all (99 per cent) of the respondents' changes in opinion occurred on Questionnaire III, which informed them of the first 'consensus' reached by the group. With hindsight, one can seriously question the need for going beyond Questionnaire III.[4]

Participants

Experts employed in this study were selected using the following criteria: (1) they were employed by industries operating in Texas or Oklahoma; (2) employing organizations were currently using computer graphics systems in architectural or engineering applications, and (3) the experts have computer graphics experience through engineering, data processing, or management.

Procedure

The first step in this study was to identify the industrial users of computer graphics systems in Texas or Oklahoma. A manufacturers' Index of Engineering Department Equipment listed in Machine Design, November 24, 1974, was used to develop a list of manufacturers of the following equipment: drafting equipment, computers, and peripheral equipment. There were 238 manufacturers contacted using this list. The letter of transmittal and questionnaires are included in Appendix A. From the original list, 76 manufacturers responded. The responding manufacturers are listed in Appendix B. Fourteen manufacturers provided names of Texas or Oklahoma companies using computer graphics systems.

The first Delphi mailing was sent to 61 companies (listed in Appendix C), who had been identified by the responding systems manufacturers. The first Delphi mailing included a letter of transmittal

and Correspondence Sheet Number One, instructing the participants in use of the form (Appendix D). Each participant was asked to supply five subject items they considered important for inclusion in a computer graphics course. The form was coded to insure that a follow-up could be completed. A self-addressed stamped envelope was provided to enhance the possibility of return of the Delphi form.

In order to improve response to the first Delphi mailing, a follow-up memorandum was sent (Appendix E). A copy of the Delphi Correspondence Sheet Number One was included with the memorandum.

A committee, consisting of three Cameron University Technical Department faculty members, reviewed the replies to the first Delphi mailing. All similarly worded responses were combined and the list was condensed to eliminate redundancy and ambiguity. These items were then placed randomly on Correspondence Sheet Number Two. A six-point continuous scale was provided for rating each item on the form. Zero was used to indicate no importance and five most important. The correspondence sheet, a transmittal letter (Appendix F), and self-addressed stamped envelope were returned to the Delphi participants.

Upon receipt of the questionnaire, the consensus index was computed for each item. The consensus index was determined by calculating the arithmetic mean for each subject content item listed. An example of the calculation is shown in Table I.

The Delphi form was rewritten with the items receiving the highest consensus index being listed first and items receiving the lowest consensus index being listed last. Items having the same index value were listed with the same rank number but a different alphabetic character to show individual items within the same rank order.

TABLE I

COMPUTATION OF THE CONSENSUS INDEX

Example Item Responses	No	1	2	3	4	5
	2	5	3	30	5	5

$$\frac{(2x0) + (5x1) + (3x2) + (30x3) + (5x4) + (5x5)}{50} =$$

$$\frac{146}{50} = 2.92$$

Correspondence Sheet Number Three, a letter of transmittal (Appendix G), and self-addressed stamped envelope were returned to the participants. They were asked to re-evaluate responses considering the consensus priorities. An item was added by one of the participants during the second mailing. The group was asked to rank this item in relation to the priorities already established. The participants were also asked to revise their opinions in line with the group or indicate why they would not revise it.

The third Delphi responses were reviewed. Individual opinions were grouped and listed. A summary of the Delphi results was sent to the participants.

FOOTNOTES

[1]Dale P. Scannell, "The Use of the Delphi Technique to Gain Consensus of the Professional Education Components of Teacher Certification Requirements in Kansas, Final Report" (Kansas University, Lawrence, Kansas, August, 1972), p. 3.

[2]Philip H. Richards, "Analysis of the Delphi Survey," AOTE National Invitational Conference Redesigning Teacher Education Pre-Conference Input, 1972-73, p. 1.

[3]Frederick R. Cyphert and Walter L. Gant, "The Delphi Technique--A Case Study," Phi Delta Kappan (January, 1971), pp. 272-274.

CHAPTER IV

RESULTS AND ANALYSIS

The purpose of this study was to identify appropriate course content items for an introductory computer graphics course. A modified Delphi Technique was used as an instrument in the study. Table II illustrates the responses to each of the Delphi mailings.

TABLE II

SUMMARY OF DELPHI MAILING RESPONSES

	Delphi Correspondence Sheet		
	I	II	III
Number of questionnaires mailed	62	19	17
Number of responses to questionnaires	22	18	12
Per cent of responses to questionnaires mailed	35.48	94.73	70.59

Of the 22 responses to the first Delphi mailing, three participants indicated they were not using the computer graphics equipment for production drafting. Continental Oil Company of Ponca City, Oklahoma, indicated that their graphics usage was ". . . in the area of oil exploration," and felt their own expertise too limited to participate. The Fort Worth, Texas, office of the Army Corps of Engineers, was still analyzing use of a computer graphics system and asked to be eliminated from participation due to lack of expertise. The research division of Halliburton Corporation, Duncan, Oklahoma, stated that a computer graphics ". . . system is too expensive for today's industry to justify." This company did not want to participate in the Delphi correspondence.

Two of the respondents to the first Delphi mailing participated after receiving the follow-up memorandum to the first mailing. Of the 22 respondents to the first mailing, 15 of the original letters were addressed to "Head, Design and Drafting Division." Therefore, 68.18 per cent of those participants responded to an impersonal letter. Six of the participants were from Oklahoma and 16 were from Texas.

A three-week period elapsed between the mailing of the first Delphi letter and the second. The follow-up memorandum was sent two weeks after mailing the first letter.

Delphi Correspondence Sheet Number One provided five places for the participants to identify computer graphics course content items (see Appendix D). A three-member committee reduced the 95 items to 47 items by removing redundancies and ambiguities. None of the participants indicated that any of their responses had been omitted from

the second questionnaire.

After reviewing the second questionnaire, one of the participants added another item. This item, Drawing Annotation, was submitted to the group on the third questionnaire.

Seventeen participants ranked course items listed on the second questionnaire. Some of these participants did not rank all of the items. Table III lists the items not ranked by all of those responding to the second Delphi mailing.

No indication was given by participants for their lack of response to these items other than Item Two. Item Two appeared ambiguous to the participants. Therefore, Item Two, Applications, was rewritten for the third mailing as Computer Graphics Applications. Since all items on the second questionnaire were not ranked, the denominator used in the consensus index was the number of those responding to each item.

TABLE III

ITEMS NOT RANKED BY ALL SECOND DELPHI CORRESPONDENCE PARTICIPANTS

Item	Number Responding	Item	Number Responding
1	16	19	15
2	15	25	16
6	16	31	16
14	16	32	16
15	16	41	16
16	16	42	16

Following calculation of the consensus index, items having the same index value were indicated by identical rank number, but with different alphabetic characters. The rank order of the course content items is listed in Table IV. The third questionnaire was prepared using this rank order.

TABLE IV

INTRODUCTORY COMPUTER GRAPHICS COURSE
CONTENT ITEMS IN RANK ORDER

Rank Order		Course Content Item
1.		Introduction to digitizer applications and use
2.		Use of plotters and interaction of the draftsman with plot output
3.		Laboratory on elementary data entry to allow experience in actual production of plotted output
4.		Study on-line interactive graphics (keyboard entry, cathode ray tube, light pencil entry, computer generated perspective)
5.	A.	Thorough understanding of scale, scale conversion, etc.
	B.	Graphic input methodology (Light pen, Graphic Tablet, Digitizing Scanner, etc.)
6.		Computer Graphics Applications
7.		Engineering Drawing
8.		Study of the capabilities and limitations of plotting equipment (drum, flatbed, cathode ray tube)
9.		Basic knowledge of electronic computer, plotters (drum and flatbed), and cathode ray display devices
10.	A.	Retrieval, update of graphical data
	B.	Operations of computer graphics system

TABLE IV (Continued)

Rank Number		Cource Content Item
11.		Basic understanding of plotting software
12.	A.	Field trip to drafting and design oriented computer graphics installation
	B.	Descriptive Geometry
	C.	Data Processing concepts
13.		Editing of digitized data
14.		Input--intelligent versus digitizing versus scanning
15.		Introduction to 3-D projection
16.		The various methods of storage of graphical data digitally
17.	A.	Computer graphics systems configurations
	B.	Development of automated dimensioning techniques
18.	A.	Basics of FORTRAN programming
	B.	Basic knowledge of plotting subroutines
	C.	Real time interrogation and maintenance of the data base
19.		Containing data base by "levels"
20.		Study digitizing input of Photogrammetric data
21.		Study of output mediums (how to select from ink on mylar, refresh scope, microfilm, etc.)
22.	A.	Introduction to hardcopy graphic devices
	B.	Computer number systems (binary, octal, etc.)
23.		Introduction to operating systems
24.		How computer generates plot tapes
25.		Psychological impact of computer graphics on the individual draftsman
26.		Topographic mapping procedures
27.		Basic introduction to mini computer system design (including peripherals)

TABLE IV (Continued)

Rank Number		Course Content Item
28.	A.	Study of numerical control manufacturing methods
	B.	Computer graphics systems development (history)
	C.	Plotting geological formations
29.		Relate monetary constraints to hardware
30.		Creative writing
31.		Computer programming - PL/1
32.		Mechanics and Strengths of Materials
33.		Plotting of steel structures
34.	A.	Computer programming - analog
	B.	Calculation of earthwork quantities for highway surveys
35.		Introduction to differential and integral calculus
36.		Stress analysis of the computer model

There were two weeks between the mailing of the second and third questionnaires. One company responded to the second mailing after the cut-off period and was omitted from the third mailing. The participants receiving the third correspondence were instructed to review the items listed and indicate why any items should have a different priority. Table V lists the individual opinions of the participants.

TABLE V

INDIVIDUAL OPINIONS OF PARTICIPANTS
IN THIRD DELPHI MAILING

Item Rank Number on Third Correspondence	New Rank Number	Reason for the Change
4 and 5 B	---	Ranked too high. You cannot teach all methods in depth (time restraint), so some methods will have to be learned on the job. Better to cover these items at survey level.
7	25	Engineering drawing should be a prerequisite to this course.
12 A	---	Field trips have never been productive for me. They seem to cover too much in too short a time. Always want to show "gee-whiz" work rather than daily grind.
12 B	15	Items 12 and 15 are virtually the same.
13	5 C	Editing and digitizing is absolutely essential to the digitizer data entry system.
18 A	31	Down to same level with assembly and PL/1.
18 C	4	Real time of interrogation and maintenance of the data base are critical items for us, and where we have highest development.
21	---	Appears too low. This is an important decision which a student should be capable of making.
30	---	The single most neglected subject in American education. Should rank in top 10 per cent of any field.

The item added to the third questionnaire, Drawing Annotation, received a consensus index of 3.5692. This would give the item a rank order between seven and eight. Since rank order items eight and nine are closely related to drawing annotation, this appears to be a reasonable location on the list.

Two weeks elapsed between the third Delphi mailing and the final cut-off date. Twelve participants had responded to the final mailing. A breakdown on the participating industries and their location is given in Table VI.

TABLE VI

IDENTIFICATION OF DELPHI PARTICIPANTS

Number of Participants	Type of Company	Location
2	Aircraft	Texas
2	Consulting Firms	Texas
1	Data Processing Service Firms	Texas
1	Federal Government Agency	Oklahoma
1	Municipal Government	Texas
3	Oil Companies	2 Texas 1 Oklahoma
1	Oil Field Equipment Supplies	Texas
1	State Highway Department	Texas

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to identify specific information elements which are appropriate for inclusion in an introductory computer graphics course for associate degree design drafting students. Specifically, this study sought to answer these research questions:

1. What information elements should be included in an introductory computer graphics course for associate degree design drafting students?
2. What computer graphics facilities are necessary to adequately prepare the design drafting graduate for placement?

Answers to these questions were sought through use of a modified Delphi correspondence technique. Experts cooperating in the study were selected from companies in Texas or Oklahoma known to use computer graphics systems.

Conclusions

In answering the first research question, the course information elements determined necessary for computer graphics by the Delphi experts are listed in Table IV. These items, listed in order of priority, would be included in a computer graphics course based upon available resources. The higher ranked items indicate an emphasis for

"hands-on" educational experience in computer graphics. The lower ranked items indicated educational experiences of engineers, such as calculus and computer languages, and problems peculiar to specific jobs.

The second research question can be answered by examining the high ranked items in Table IV. With few exceptions, the items ranked in the upper 50 per cent would require access to an intensive computer graphics system with a CRT terminal, digitizer, and some form of hard copy media (CRT photographs or plots).

The emphasis on descriptive geometry is an important consideration. Use of the interactive system as a medium for teaching an advanced course in descriptive geometry would be most beneficial to the student.

Also, a number of items referring to drafting and related design courses were ranked relatively high. This indicates concern by industry that the students have a thorough understanding of the fundamentals before entering a computer graphics course.

Recommendations

With the emphasis being placed upon interactive computer graphics systems, it is recommended that these systems be used to prepare design drafting graduates for placement. Necessary computer languages should be integrated into design courses where this technique lends itself to the solution of analytical problems.

Proper consideration should be given to ensuring design drafting programs provide adequate training in the fundamentals of design and drafting. Inclusion of the computer graphics course content items into a design drafting program should be based upon the strength of

the existing program, availability of funds, and relative to determined industrial needs. The computer graphics course content items listed in Table IV do reflect the opinions of the participants in the Delphi correspondence but are not necessarily representative of all industrial applications.

A SELECTED BIBLIOGRAPHY

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

Brown, John A. Computers and Automation. New York: ARCO Publishing Company, 1968.

Caffrey, John and Charles J. Meesman. Computers on Campus. Washing on, D.C.: American Council on Education, 1967.

"Computer Graphics Chasing Wrong Goals, Says Seminar Speaker." Engineering Graphics, Vol. 14, No. 12 (December, 1974), p. 4.

Computer Yearbook 72. Detroit: Computer Yearbook Company, 1972.

Cyphert, Frederick R. and Walter L. Gant. "The Delphi Technique--A Case Study." Phi Delta Kappan (January, 1971), pp. 272-274.

"Drafting Managers Speak Their Minds." Engineering Graphics, Vol. 10, No. 12 (December, 1970), p. 18.

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

Halpern, Jeanne W. "Computer Graphics." Research News, V 21n 4 and 5 (October-November, 1970), p. 4.

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

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

McNeil, Dan M. "Auto-Trol Automated Graphics System." Unpub. speech for the 1974 American Institute for Design and Drafting, Chicago, Illinois, 1974.

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

Phillips, Donald S. "Personal and Social Background Characteristics of Entering Technician Education Students at Four Post-High School Institutions." (Unpub. Ed.D. dissertation, Oklahoma State University, 1968.)

Popell, Steven D. Computer Time-Sharing (Dynamic Information Handling for Business). Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966.

Proceedings of Conference on Computers in the Undergraduate Curricula. University of Iowa, Iowa City, Iowa, 1970.

Richards, Philip H. "Analysis of the Delphi Survey." AOTE National Invitational Conference Redesigning Teacher Education Pre-Conference Input, Washington, D.C., 1972-73.

Rosenberg, Jerry M. The Computer Prophets. London: The Macmillan Company, 1969.

Rowbothan, George E. "Computer Graphics Benefits Cited at Drafting Managers' Meetings." Engineering Graphics, Vol. 14, No. 12 (December, 1974), p. 16.

Scannell, Dale P. "The Use of the Delphi Technique to Gain Consensus of the Professional Education Components of Teacher Certification Requirements in Kansas, Final Report." Lawrence, Kansas: Kansas University, August, 1972.

Stamper, Gary. "Let's Update Drafting Education." Plan and Print, Vol. N47/No. 9 (November, 1968), p. 19.

Venn, Grant. Man, Education, and Work. Washington, D.C.: The American Council of Education, 1968.

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

Wilson, Robert A. "CAD/CAM Breaks the Holding Pattern." Iron Age, Vol. 215, No. 3 (January, 1975), pp. 33-42.

APPENDIX A

TRANSMITTAL LETTER AND QUESTIONNAIRE MAILED TO COMPUTER EQUIPMENT MANUFACTURERS

Lawton, Oklahoma 73501

Cameron University is in the process of reviewing its computer needs in order to determine equipment requirements necessary to better prepare our graduates for employment in Texas and Oklahoma industries. As a part of this effort, I am conducting a survey of companies utilizing computer graphics systems for drafting and design applications. This study will provide information to be used in planning for new courses and additional computer hardware.

I need the names and addresses of companies in Texas and Oklahoma that use the following equipment for engineering or architectural applications:

Optical Scanner
Plasma Display Panel
Plotter (Flatbed or Drum)
Linear Display CRT
Graphical Tablets
Image Digitizer

Would you please complete and forward the enclosed form to me by February 20. This information will be confidential and presented as grouped data only. Your assistance in this survey is greatly appreciated.

Sincerely,

Tom Sutherlin, Coordinator
Design Drafting Curriculum

TO: Tom Sutherlin, Coordinator
Design Drafting Curriculum
Cameron University
Lawton, Oklahoma 73501

Please check Computer Graphics Equipment

Company

___OPTICAL SCANNER
___PLASMA DISPLAY PANEL
___PLOTTER (FLATBED OR DRUM)
___LINEAR DISPLAY CRT
___GRAPHICAL TABLETS
___IMAGE DIGITIZER

NAME ________________________________

____

STREET ADDRESS ________________________

CITY ______________ STATE_____ ZIP____

___OPTICAL SCANNER
___PLASMA DISPLAY PANEL
___PLOTTER (FLATBED OR DRUM)
___LINEAR DISPLAY CRT
___GRAPHICAL TABLETS
___IMAGE DIGITIZER

NAME ________________________________

____

STREET ADDRESS ________________________

CITY ______________ STATE_____ ZIP____

___OPTICAL SCANNER
___PLASMA DISPLAY PANEL
___PLOTTER (FLATBED OR DRUM)
___LINEAR DISPLAY CRT
___GRAPHICAL TABLETS
___IMAGE DIGITIZER

NAME ________________________________

____

STREET ADDRESS ________________________

CITY ______________ STATE_____ ZIP____

___OPTICAL SCANNER
___PLASMA DISPLAY PANEL
___PLOTTER (FLATBED OR DRUM)
___LINEAR DISPLAY CRT
___GRAPHICAL TABLETS
___IMAGE DIGITIZER

NAME ________________________________

____

STREET ADDRESS ________________________

CITY ______________ STATE_____ ZIP____

___OPTICAL SCANNER
___PLASMA DISPLAY PANEL
___PLOTTER (FLATBED OR DRUM)
___LINEAR DISPLAY CRT
___GRAPHICAL TABLETS
___IMAGE DIGITIZER

NAME ________________________________

____

STREET ADDRESS ________________________

CITY ______________ STATE_____ ZIP____

(If more company listings are required, please attach to this form.)

APPENDIX B

COMPUTER EQUIPMENT MANUFACTURERS

REPLYING TO QUESTIONNAIRE

Advanced Scientific Instruments
Div. of Electro-Mechanical Research Inc.
1 Garfield Circle
Burlington, Mass. 01803

Alvin and Company, Inc.
Bloomfield, Conn. 06002

American Used Computer Corp.
Kenmore Station, Box 68
Boston, Mass. 02215

Artronix, Inc.
1314 Hanley Industrial Court
St. Louis, Mo. 63144

AST/Servo Systems, Inc.
930 Broadway
Newark, N. J. 07104

Autonetics, A Div. of North
American Aviation Corp.
9150 E. Imperial Highway
Downey, Calif. 90242

Autorotol Corp.*
5660 North Pecos St.
Denver, Colo. 80221

Boston Digital Corp.
South Street
Hopkinton, Mass. 01748

Broomall Industries*
682 Parkway
Broomall, Pa. 19008

Bunker Corp.
Information Systems Div.
35 Nutmet Drive
Trumbull, Conn. 06609

E.C.D. Representative
Burroughs Corporation
1914 N. Harwood
Dallas, Tex. 75202

Cincinnati Milacron*
Process Controls Div.
Lebanon, Ohio 45036

Collins Radio Company*
Comms. Data Systems Div.
820 E. Arapaho Road
Dallas, Tex. 75207

Courier Terminal Systems, Inc.
2202 E. University Dr.
Phoenix, Ariz. 85034

Control Data Corp.
5545 E. Skelly Dr.
Tulsa, Okla. 74135

Data General Corp.*
Southboro, Mass. 01772

Data 100 Corp.
7725 Washington Ave. S.
Minneapolis, Minn. 55435

Data Technology, Inc.
4 Gill St.
Woburn, Mass. 01801

Datacom, Inc.
Box 278
Ft. Walton Beach, Fla. 32548

Data Machines, Inc.
Engineers International Co.
6409 Maple Ave.
Dallas, Tex. 75235

Datron Equipment
Div. of Data Access Systems, Inc.
100 Route 46
Mountain Lakes, N. J. 07046

Decision Data Computer Corp.
100 Witmer Rd.
Horsham, Pa. 19044

Di-An Controls, Inc.
944 Dorchester Ave.
Boston, Mass. 02125

Digital Equipment Corp.
146 Main St.
Maynard, Mass. 01754

Digitronics Corp.
Albertson Ave.
Albertson, N. Y. 11507

Edmund Scientific Co.
555 Edscorp Bldg.
Barrington, N. J. 08007

General Electric Company ISBS
1341 West Mockingbird Lane
917 East Tower
Dallas, Tex. 75247

General Precision, Inc.
Commercial Computer Div.
100 East Tujunda Ave.
Burbank, Calif. 91502

Gerber Scientific Instrument Co.*
P. O. Box 305
Hartford, Conn. 06101

Hampshire Engineering Co.
2300 Washington St.
Newton Lower Falls, Mass. 02162

Haxeltine Corp.
Little Nexk, L. I.
New York 11363

Hewlett-Packard Co.*
201 East Arapaho Road
Richardson, Tex. 75080

Hogan Laboratories, Inc.
155 Perry St.
New York, N. Y. 10014

Honeywell, Inc.
4400 Lincoln Blvd.
Oklahoma City, Oklahoma 73105

Hughes Aircraft Co.
Industrial Prodicts Div.
6855 El Camino Real
Carlsbad, Calif. 92008

Information Displays, Inc.*
333 N. Bedford Rd.
Mt. Kisco, N. Y. 10549

Information International
12435 W. Olympic Blvd.
Los Angeles, Calif. 90064

International Memory Systems
14609 Scottsdale Rd.
Scottsdale, Ariz. 85260

ITT Data and Information Systems Div.
Box 285
Paramus, N. J. 07652

Jarrell-Ash Div.
Fisher Scientific Co.
590 Lincoln St.
Waltham, Mass. 02154

Laboratory for Electronics, Inc.
1079 Commonwealth Ave.
Boston, Mass. 02115

Litton Systems, Inc.
Data Systems Div. of Litton Ind.
6700 Eton Ave.
Canoga Park, Calif. 91303

3M Co., Computer Division
3M Center
St. Paul, Minn. 55101

MEGATEK Budget Peripherals*
1055 Shafter St.
San Diego, Calif. 92106

National Cash Register Co.
3300 W. Mockingbird Lane
Suite 517, Blanton Towers
Dallas, Tex. 75235

Northrop Corp.
9744 Wilshire Blvd.
Beverly Hills, Calif. 90212

Odec Computer Systems, Inc.
25 Graystone St.
Warwick, R. I. 02886

Olivetti Corp. of America
500 Park Ave.
New York, N. Y. 10022

Optical
Box 11140
Tucson, Ariz. 85734

Pacific Data Systems, Inc.
1058 E. First St.
Santa Ana, Calif. 92701

Packard Bell Computer Corp.
1905 Armacost Ave.
Los Angeles, Calif. 90025

Philco-Ford Corp.
Computer Division
3900 Welsh Rd.
Willow Grove, Pa. 19090

Photobell Co., Inc.
12 E. 22nd St.
New York, N. Y. 10010

Precision Mechanism Corp.
44 Brooklyn Ave.
Westbury, N. Y. 11590

Radio Corp. of America
RCA Electronic Data Processing
30 Rockefeller Plaza
New York, N. Y. 10020

Research, Inc.
Box 24064
Minneapolis, Minn. 55424

Sage Action, Inc.
Box 416
Ithaca, New York 14850

Scientific Control Corp.
14008 Distribution Way
Dallas, Tex. 75234

Scientific Data Systems, Inc.
6434 Maple Ave.
Dallas, Tex. 75235

Simco Co., Inc.
920 Walnut St.
Lansdale, Pa. 19446

The Singer Co.
Business Machines Div.
30 Rockefeller Plaza, 26th Floor
New York, N. Y. 10020

The Singer Co.
Librascope Division
833 Sonora Ave.
Glendale, Calif. 91201

Sperry Univac
Box 500
Blue Bell, Pa. 19422

Summagraphics Corp.*
35 Brentwood Ave.
Fairfield, Conn. 06430

Superior Electric
383 Hiddle St.
Bristol, Conn. 06010

System-Donner Corp.
One Systron Dr.
Concord, Calif. 14518

Tektronix, Inc.*
800 NE 63rd St., Suite 201
Oklahoma City, Okla. 73105

Teletype Corp.
5555 Touhy Ave.
Skokie, Ill. 60076

Terminal Systems, Inc.
11300 Hartland Ave.
North Hollywood, Calif. 91605

Theta Instrument Corp.
24 Dwight Place
Fairfield, N. J. 07006

Time/Data
1050 E. Meadow Circle
Palo Alto, Calif. 94303

Tri-Data Corp.
800 Maude Ave.
Mountain View, Calif. 94043

Wang Laboratories, Inc.*
Wang Computer Services
836 North St.
Tewksbury, Mass. 01876

Westinghouse Electric Corp.
Computer and Instrumentation Div.
200 Beta Dr.
Pittsburgh, Pa. 15238

Wright Line
Div. of Barry Wright Corp.
160 Gold Star Blvd.
Worcester, Mass. 01606

Xynetics, Inc.*
2901 Coronada Dr.
Santa Clara, Calif. 95050

* Manufacturers providing names of Texas or Oklahoma firms using computer graphics systems.

APPENDIX C

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Dresser Tool Group
Dresser Industries, Inc.
10032 Monroe
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E-Systems
12000 Jupiter Road
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Head, Drafting & Design Division
Exploration Survey
6400 North Central Expressway
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Exxon
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Head, Drafting & Design Division
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Waskom, Texas 75692

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Geo-Search
Wall Towers East
201 North Wall
Midland, Texas 79701

Head, Drafting & Design Division*
Halliburton ERD
Drawer 1431
Duncan, Oklahoma 73533

Head, Drafting & Design Division
Holguin-Clark
131 North Campbell
El Paso, Texas 79901

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Honeywell Information Systems, Inc.
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Head, Drafting & Design Division
IBM
11400 FM Road 1325
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6910 Fannin
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Head, Drafting & Design Division
Synercom Technology, Inc.
6300 Hillcroft
Houston, Texas 77036

Head, Drafting & Design Division
Taylor Publishing Co.
1550 West Mockingbird Lane
Dallas, Texas 75235

Head, Drafting & Design Division ***
Texaco, Inc.
Exploration Department (48-001)
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Bellaire, Texas 77401

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Head, Drafting & Design Division
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Head, Drafting & Design Division
Zentron Equipment Corp.
13624 Neutron Road
Dallas, Texas 77018

* Replied to Delphi Correspondence Sheet No. 1 only.

** Replied to Delphi Correspondence Sheets No. 1 and No. 2.

*** Replied to Delphi Correspondence Sheets No. 1, No. 2, and No. 3.

APPENDIX D

TRANSMITTAL LETTER AND DELPHI QUESIONNAIRE

SHEET NUMBER ONE

CAMERON UNIVERSITY
LAWTON OKLAHOMA
1908
Lawton, Oklahoma 73501

March 31, 1975

Head, Drafting & Design Division
Dresser Oil
1120 Overlake Drive
Dallas Texas 75220

The Design Drafting Division of Cameron University's Technical Department is evaluating courses and equipment to keep our program abreast of industrial needs. We feel that it is essential to maintain good communications with industry. Considering this and the current increase in the use of computer graphics by industry, I am conducting a study of industrial use of computer graphics systems in engineering and architectural applications. The results of the study will be used to determine the course content of a computer graphics course for Cameron University's Design Drafting Associate Degree Program. (A brochure on the existing Design Drafting program is enclosed.)

The Delphi Technique has been chosen as the method to be used in obtaining your opinion of the subject items to be included in the computer graphics course. This technique, which is built on informed, sound judgement, is intended to get opinions from persons without bringing the individuals into any kind of face-to-face confrontation. Successive questionnaires and feedback are necessary with each round designed to produce more carefully considered group opinions. Four separate mailings will be used and spaced approximately two weeks apart.

Correspondence
No. 1

List five subject areas which should be included in a computer graphics course for Cameron University Design Drafting Students.

Correspondence No. 2 — A list of course subject areas will be compiled from the participant's responses and mailed back to you. Using this list, each person will evaluate and rank the subject items by importance.

Correspondence No. 3 — The average rankings of each subject item will be compiled from correspondence Number 2 responses. Each participant will be asked to either revise his opinions in line with the priority list developed in Step 2 or specify his reasons for remaining outside consensus.

Correspondence No. 4 — The average rankings of each subject item will be calculated from correspondence Number 3 responses. Each participant will be asked to evaluate for the final time his responses in line with the priority list developed in Step 3 or specify his reasons for remaining outside the consensus.

From response Number 4, a list of subject items will be incorporated for use in the computer graphics course at Cameron University.

We hope that you will agree to participate in this effort to update technician education. This is an excellent opportunity for us to improve communication between industry and education. Thank you for your assistance.

Sincerely,

Tom Sutherlin

Tom Sutherlin, Coordinator
Design Drafting Technology

ddg

CORRESPONDENCE SHEET No. 1

(TO BE ENCLOSED IN RETURN MAIL BY APRIL 8, 1975)

Please list up to five possible items to be included in a Design Drafting Technology computer graphics course. No order of importance is required.

EXAMPLE: A possible item might be: "Study use of digitizer to coordinate rough sketches."

LIST YOUR RESPONSES BELOW

NUMBER ONE:

NUMBER TWO:

NUMBER THREE:

NUMBER FOUR:

NUMBER FIVE:

A self-addressed stamped envelope has been provided for the return of this sheet.

To facilitate the remaining Delphi mailings, please check to see that I have used your correct mailing address. Please make any corrections and write them in the space below.

APPENDIX E

FOLLOW-UP MEMORANDUM TO DELPHI CORRESPONDENCE

SHEET NUMBER ONE

CAMERON UNIVERSITY
LAWTON OKLAHOMA
1908
Lawton, Oklahoma 73501

April 14, 1975

MEMORANDUM TO: Computer Graphics DELPHI Participants

FROM: Tom Sutherlin, Design Drafting Curriculum Coordinator Tom S.

SUBJECT: DELPHI Correspondence Sheet Number One

On March 31, I mailed you correspondence sheet number one for identification of items to be included in a Design Drafting Technology computer graphics course. This memorandum is to remind you that this information is very valuable to us and your participation is important. If you have not already completed correspondence sheet number one, please fill out the enclosed correspondence sheet and return it immediately. This information is needed in order for us to construct correspondence sheet number two and begin the second round of the study.

APPENDIX F

TRANSMITTAL LETTER AND DELPHI

CORRESPONDENCE SHEET

NUMBER TWO

CAMERON UNIVERSITY
LAWTON OKLAHOMA
1908

Lawton, Oklahoma 73501

April 21, 1975

Thank you for completing the first of three correspondence questionnaires. I appreciate your cooperation in helping us identify course items for computer graphics. The initial results are promising. I hope that you will continue to assist by completing correspondence sheet number two.

Correspondence sheet number two contains the items recommended by you and others for inclusion in a computer graphics course. In order that we may determine the most important items, we are asking you to rank them on a six-point continuum. Keep in mind that you are working with course content, not courses to be included in a curriculum.

The highest ranked factors chosen by you and the other DELPHI participants will be given priority in the course structure. Therefore, consider carefully those items you think should be included.

Again, I would like to thank you for your time and attention. A quick response to correspondence sheet two will be appreciated.

Sincerely,

Tom Sutherlin, Coordinator
Design Drafting Curriculum

TS:rm

Enc.

CORRESPONDENCE SHEET NUMBER 2

(TO BE ENCLOSED IN RETURN MAIL BY APRIL 29, 1975)

Below are the items that you and others suggested that we utilize in a Design Drafting Technology computer graphics course. In order that a priority can be assigned to essential course items, we are asking you to rank each factor on a six-point continuum, ranging from the most important (5) to no importance (0).

Please be selective in choosing those items you consider as most important for the computer graphics course.

EXAMPLE:	Place (X) in appropriate section No Importance — Most Important
1. Use digitizer to coordinate rough sketch	/ / / / / X / / 0 1 2 3 4 5
2. Program in FORTRAN IV	/ / X / / / / 0 1 2 3 4 5

	No Importance — Most Important
1. Study of output mediums (how to select from ink on mylar, refresh scope, microfilm, etc.)	/ / / / / / / 0 1 2 3 4 5
2. Applications	/ / / / / / /
3. Laboratory on elementary data entry to allow experience in actual production of plotted output	/ / / / / / /
4. Calculation of earthwork quantities for highway surveys	/ / / / / / /
5. Topographic mapping procedures	/ / / / / / /
6. The various methods of storage of graphical data digitally	/ / / / / / /

		No Importance / Most Important 0 1 2 3 4 5
7.	Plotting geological formations	/ / / / / / /
8.	Introduction to digitizer applications and use	/ / / / / / /
9.	Thorough understanding of scale, scale conversion, etc.	/ / / / / / /
10.	Study digitizing input of Photogrammetric data	/ / / / / / /
11.	Retrieval, update of graphical data	/ / / / / / /
12.	Use of plotters and interaction of the draftsman with plot output	/ / / / / / /
13.	Plotting of steel structures	/ / / / / / /
14.	Basic understanding of plotting software	/ / / / / / /
15.	Relate monetary constraints to hardware	/ / / / / / /
16.	How computer generates plot tapes	/ / / / / / /
17.	Study of the capabilities and limitations of plotting equipment (Drum, Flatbed, Cathode Ray Tube)	/ / / / / / /
18.	Introduction to hardcopy graphic devices	/ / / / / / /
19.	Containing a data base by "levels"	/ / / / / / /
20.	Computer graphics systems configurations	/ / / / / / /
21.	Computer graphics system development (history)	/ / / / / / /
22.	Creative writing	/ / / / / / /
23.	Study of numerical control manufacturing methods	/ / / / / / /
24.	Descriptive Geometry	/ / / / / / /
25.	Stress analysis of the computer model	/ / / / / / /
26.	Introduction to 3-D projection	/ / / / / / /

	No Importance / Most Important
27. Graphic input methodology (Light Pen, Graphic Tablet, Digitizing Scanner, etc)	/ / / / / / / 0 1 2 3 4 5
28. Engineering Drawing	/ / / / / / /
29. Data Processing concepts	/ / / / / / /
30. Psychological impact of computer graphics on the individual draftsman	/ / / / / / /
31. Editing of digitized data	/ / / / / / /
32. Input, intelligent versus digitizing versus scanning	/ / / / / / /
33. Developement of automated dimensioning techniques	/ / / / / / /
34. Field trip to drafting and design oriented computer graphic installation	/ / / / / / /
35. Basics of FORTRAN programming	/ / / / / / /
36. Computer number systems (binary, octal etc.)	/ / / / / / /
37. Study on-line interactive graphics (keyboard entry, Cathode Ray Tube, light pencil entry, computer generated perspective)	/ / / / / / /
38. Basic knowledge of plotting subroutines	/ / / / / / /
39. Real time interrogation and maintenance of the data base	/ / / / / / /
40. Computer programming - analog	/ / / / / / /
41. Computer programming - PL/1	/ / / / / / /
42. Introduction to operating systems	/ / / / / / /
43. Operations of computer graphics systems	/ / / / / / /
44. Basic knowledge of electronic computer, plotters (drum and flat bed), and cathode ray display devices	/ / / / / / /
45. Mechanics and Strengths of Materials	/ / / / / / /

	No Importance / Most Important
46. Basic introduction to mini computer system design (including peripherals)	/ / / / / / / 0 1 2 3 4 5
47. Introduction to differential and integral Calculus	/ / / / / / /

If we have somehow missed a factor that you consider important, please write below the factor, its ranking, and your reasons for considering the factor:

1. / / / / / / / 0 1 2 3 4 5

REASON:

---

2. / / / / / / / 0 1 2 3 4 5

REASON:

COMMENTS:

APPENDIX G

TRANSMITTAL LETTER AND DELPHI

CORRESPONDENCE SHEET

NUMBER THREE

CAMERON UNIVERSITY
LAWTON OKLAHOMA
1908

Lawton, Oklahoma 73501

May 1, 1975

This study, making use of the DELPHI Technique, has been very successful and your cooperation has been instrumental in this success. Originally I had planned to send you four correspondence sheets, however, the results have been definitive enough to complete the study with three mailings. A ranking of the course items is presented as the last step to complete your participation in the study. The third mailing is provided for the purpose of your evaluating the items in relation to their rank order. Please return correspondence sheet number three by May 10.

On behalf of Cameron University, I would like to express our gratitude for your time and assistance in establishing the course items for computer graphics. Your individual comments have been very helpful in determining current industrial needs for computer graphics in Texas and Oklahoma.

Upon completion of the study, I will send you the results along with a list of the types of industries which participated and a summary of your individual comments.

Thank you again for your time and assistance.

Sincerely,

Tom Sutherlin, Coordinator
Design Drafting Curriculum

TS:rm

Enc.

CORRESPONDENCE SHEET NUMBER THREE

(TO BE ENCLOSED IN RETURN MAIL)

Below are the course items you and others ranked with respect to their priority in a Design Drafting Technology computer graphics course. Each item was ranked on a six-point continuum from no-importance to most importance. Those factors with the highest group averages are considered as most important and appear first below. The remaining items are listed in rank order according to importance.

Examine these ranked items and place an 'X' in the blank beside each item that you feel should be placed significantly higher or lower. Use the space provided at the end of this correspondence sheet to indicate each item that you believe should have a revised priority and your justification for the change.

RANK NUMBER	COURSE CONTENT ITEM	GROUP AVERAGE
1.	Introduction to digitizer applications and use	4.1765 _
2.	Use of plotters and interaction of the draftsman with plot output	4.1176 _
3.	Laboratory on elementary data entry to allow experience in actual production of plotted output	4.0588 _
4.	Study on-line interactive graphics (keyboard entry, cathode ray tube, light pencil entry, computer generated perspective)	4.0000 _
5A.	Thorough understanding of scale, scale conversion, etc.	3.8235 _
5B.	Graphic input methodology (Light pen, Graphic Tablet, Digitizing Scanner, etc.)	3.8235 _
6.	Computer Graphics Applications	3.8000 _
7.	Engineering Drawing	3.5882 _
8.	Study of the capabilities and limitations of plotting equipment (drum, flatbed, cathode ray tube)	3.5294 _

9.	Basic knowledge of electronic computer, plotters (drum and flatbed), and cathode ray display devices	3.4118 _
10A.	Retrieval, update of graphical data	3.3529 _
10B.	Operations of computer graphics system	3.3529 _
11.	Basic understanding of plotting software	3.3125 _
12A.	Field trip to drafting and design oriented computer graphics installation	3.2941 _
12B.	Descriptive Geometry	3.2941 _
12C.	Data Processing concepts	3.2941 _
13.	Editing of digitized data	3.1875 _
14.	Input, intelligent versus digitizing versus scanning	3.0625 _
15.	Introduction to 3-D projection	3.0588 _
16.	The various methods of storage of graphical data digitally	3.0000 _
17A.	Computer graphics systems configurations	2.8235 _
17B.	Development of automated dimensioning techniques	2.8235 _
18A.	Basics of FORTRAN programming	2.7059 _
18B.	Basic knowledge of plotting subroutines	2.7059 _
18C.	Real time interrogation and maintenance of the data base	2.7059 _
19.	Containing data base by "levels"	2.6667 _
20.	Study digitizing input of Photogrammetric data	2.5882 _
21.	Study of output mediums (how to select from ink on mylar, refresh scope, microfilm, etc.)	2.4375 _
22A.	Introduction to hardcopy graphic devices	2.2941 _
22B.	Computer number systems (binary, octal, etc.)	2.2941 _
23.	Introduction to operating systems	2.2500 _
24.	How computer generates plot tapes	2.1875 _
25.	Psychological impact of computer graphics on the individual draftsman	2.1176 _

26.	Topographic mapping procedures	2.0000 _
27.	Basic introduction to mini computer system design (including peripherals)	1.8824 _
28A.	Study of numerical control manufacturing methods	1.8235 _
28B.	Computer graphics systems development (history)	1.8235 _
28C.	Plotting geological formations	1.8235 _
29.	Relate monetary constraints to hardware	1.5625 _
30.	Creative writing	1.3529 _
31.	Computer programming - PL/1	1.3125 _
32.	Mechanics and Strengths of Materials	1.2941 _
33.	Plotting of steel structures	1.2352 _
34A.	Computer programming - analog	1.0588 _
34B.	Calculation of earthwork quantities for highway surveys	1.0588 _
35.	Introduction to differential and integral Calculus	1.0000 _
36.	Stress analysis of the computer model	0.9375 _

The following item was added to Correspondence Sheet Number Two by one of the participants who gave it an importance of (5). Please consider this item and assign it a rank in relation to those items listed above.

DRAWING ANNOTATION RANK NUMBER _____

If you agree with the Rank Order of the items above, please sign below.

_____
(Signature)

Write the rank number and the justification as to why you feel this course item should receive a lower or higher ranking.

RANK NUMBER _____
REASON FOR RANKING CHANGE:

RANK NUMBER _____
REASON FOR RANKING CHANGE:

VITA

Thomas Lewis Sutherlin

Candidate for the Degree of

Master of Science

Thesis: A STUDY OF INFORMATION ELEMENTS FOR INCLUSION IN AN INTRODUCTORY COMPUTER GRAPHICS COURSE FOR A DESIGN DRAFTING PROGRAM

Major Field: Technical Education

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, May 4, 1947, the son of Mr. and Mrs. Lewis C. Sutherlin.

Education: Graduated from Capitol Hill High School. Oklahoma City, Oklahoma, in May, 1965; received an Associate degree in Drafting and Design Technology from Oklahoma State University in May, 1967; received Bachelor of Science degree in Technical Education from Oklahoma State University in May, 1969; completed an additional course at Central State University, Edmond, in 1974; completed requirements for the Master of Science degree with a major in Technical Education in July, 1975.

Professional Experience: Draftsman, George Cornman Heating and Air-Conditioning Company, Oklahoma City, Oklahoma, May, 1965-August, 1965; Draftsman, Aero Commander Division of Rockwell Corporation, Bethany, Oklahoma, May-August, 1966; Associate Designer, Aero-Commander Division of Rockwell Corporation, Bethany, Oklahoma, May-August, 1967; Draftsman, Rhodes Corporation, Oklahoma City, Oklahoma, June-December, 1968; Associate Designer, Aero-Commander Division of North American Rockwell Corporation, Norman, Oklahoma, May-August, 1969; Automatic Data Processing Programming Specialist, United States Army, August, 1969-March, 1971; Civil Engineering Technician, Civil Engineering Division, Tinker Air Force Base, Midwest City, Oklahoma, April-June, 1971; Engineering Coordinator, Vindale Corporation, Ada, Oklahoma, June, 1971-August, 1972; Design Drafting Instructor, Cameron University, Lawton, Oklahoma, 1972-1975.

Professional Organizations: Oklahoma Technical Society, American Institute for Design and Drafting, Certified Engineering Technician, Oklahoma High Education Alumni Council.