A STUDY TO DEVELOP A CURRICULUM GUIDE
FOR USE IN TEACHING NUMERICALLY
CONTROLLED DRAFTING COURSES

APPROVED:

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Driskell, Hollis E., A Study To Develop A Curriculum Guide For Use In Teaching Numerically Controlled Drafting Courses. Master of Science (Industrial Arts), December, 1970, 39 pp., 4 tables, bibliography, 2 titles.

The problem with which this study is concerned is that of developing a curriculum guide educators can use in planning and organizing a course of study involving computer drafting at the junior college and technical vocational school levels. This study is also concerned with the impact of computer drafting on the present drafting curriculum.

The information and data for the study were obtained from questionnaires completed by engineers and industrial personnel who have experience in, or are currently involved in operating and programming numerically controlled drafting computers. The study was confined to the Dallas and Fort Worth metropolitan area.

Chapter I of the study contains an introduction, statement of the problem, the need of the study, the limitations, definition of terms, source of data, procedures of the study, and the organization of the study. A study of the development of tools used by the draftsman is presented in Chapter II with special emphasis placed on the drafting computer as an additional tool and some of its uses. Chapter III presents the information and data secured from questionnaires sent to industrial concerns in the Dallas and Fort Worth
metropolitan area. The summary, findings, and recommendations are presented in Chapter IV.

In the opinion of industrial concerns using numerically controlled drafting computers, engineering drawing I and II and descriptive geometry should be the required drafting courses in a curriculum guide for numerically controlled drafting computers. Laboratory courses in pattern-making and foundry work and general sheet metal should be required in a drafting computer curriculum. Algebra, plane trigonometry, analytical geometry, differential calculus, and integral calculus were recommended by the participating industrial concerns as required mathematical courses in a drafting computer curriculum. General data processing systems, programming I and II were the three data processing courses recommended as being required in a curriculum guide for drafting computers. This study supports the courses recommended by the participating industrial concerns.
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CHAPTER I

INTRODUCTION

Man has always sought to make his work easier. In drafting technology, man has not only made work easier, he has made work faster and more accurate through a new tool called the numerically controlled drafting computer. Just as the T-square and triangles, the drafting computer must fit into the curriculum.

A curriculum must be developed to enable the student to program and operate the computer efficiently. The junior college and technical vocational schools have an obligation to develop a curriculum that will provide students in the future with opportunities to determine their potentials as technicians.

Statement of the Problem

This study was designed to develop a curriculum guide to be used by educators in planning and organizing a course of study involving computer drafting at the junior college and technical vocational school levels.
Need of Study

The need of this study was two-fold. First, the study sought to develop a curriculum that educators can follow when organizing a plan of study including computer drafting.

Second, to see if a new plan of study including computer drafting will affect the present drafting curriculum.

Limitations

The limitations of the study were as follows:

1. The study was confined to the Dallas and Fort Worth metropolitan area and to those industrial concerns having numerically controlled drafting computers.

2. The study did not attempt to develop a specific curriculum, but one that may be followed in organizing a computer drafting program of instruction.

3. The curriculum was developed for the junior colleges and technical vocational schools.

Definition of Terms

For the purpose of the study, the following terms have been defined:

1. Computer drafting is a term applied when numerically controlled drafting computers are used to produce accurate and speedy drawings of geometrical surfaces.

2. Numerically controlled drafting computers are computers that use a punched or magnetic tape to supply numerical
data to an electronic drafting machine, or X-Y plotter, which in turn produces a complete drawing with all required lines, letters, arrowheads, etc.

3. N/C drafting computer is the abbreviation form for numerically controlled drafting computers.

4. X-Y plotter is an electronically controlled pen or stylus that moves with respect to horizontal (X-axis) and vertical (Y-axis) references according to commands from punched or magnetic tapes.

5. Automatic drafting computer is another name for an N/C drafting computer.

6. Curriculum is a set of related courses offered by an educational institution.

7. Program is a sequence of coded instructions or operations to be performed by any computer.

8. Programmer is one who programs and prepares problem solving procedures for a computer.

9. Software is the internal programs prepared to simplify programming and computer operations. These programs permit the programmer to use his own language (English) or mathematics (algebra) in communicating with the computer.

10. Engineering Drawing I is a study made of the proper use and care of instruments and tools, the technique of mechanical drawing; orthographic projection, auxiliary projection, sections, and pictorial drawing. Good lettering is stressed and practiced in print production.
11. **Engineering Drawing II** covers the elements of machine drafting, design of machine parts, perspective, and lettering are studied. A study is made of machine parts.

12. **Descriptive Geometry** is a study made of the problems relating to points, lines, planes, solids, and surfaces. The graphic solutions of the problems are worked out on the drawing board.

13. **Map Drafting** is a skill that is obtained in graphic translation of land descriptions, and survey field notes. Training is given in general base maps, construction maps, topographic maps and surveying.

14. **Architectural Drafting I** is a study made of various types of building and room design, specifications, estimates, contracts, and lettering. A survey of the history of architecture is also made. A complete set of plans for a one-story home is required of each student.

15. **Architectural Drafting II** is a study made of the planning, designing, and production of plans, details, and estimates for industrial buildings.

16. **Pipe Drafting** covers a brief introduction to connections for pump stations, manifolds, and pressure vessels. Emphasis is given to pipe line systems.

17. **Structural Drafting** is a study made of framing and assembly of structural steel shapes for all types of construction. Reinforced concrete, detailing, and estimating are also explored.
18. **Electronic Drafting** is a course designed to teach modern methods of drawing diagrams and schematics. Design of electronic systems is emphasized.

19. **Technical Illustration** is a study in which emphasis is placed upon the development of isometric, dimetric, trimetric and perspective pictorials of objects. Other areas which are covered include inking, shading, air brush rendering, vu-graphs, freehand sketching, electronic schematics, and preparing illustrations for offset reproduction.

20. **Power Mechanics** is a study of the sources and transmission of power. Emphasis is given to the design, theory, and principles of operation of small internal combustion engines, diesel, jet, and turbine engines, and fluid and pneumatic power systems.

21. **Basic Metalwork** is a study of the basic tools, machines, processes and procedures used in laying out, cutting, shaping, forging, heat-treating, and finishing metals.

22. **Pattern-making and Foundry Work** is a course designed to teach the student a working knowledge of pattern-making and foundry work and its relationship and practical application to the metal industry.

23. **General Sheet Metal** is a study involving blueprint reading, layout work, and the fabrication of sheet metal objects.
24. **General Welding** is a study of the equipment, materials, and process used for brazing, welding, and cutting of metals with emphasis on metallurgy, testing, inspection of welds, and heat treating by the oxyacetylene process.

25. **College Algebra** is a study of fundamentals, graphs, linear and quadratic equations, ration, proportion, variation, progressions and combinations, partial fractions and infinite series.

26. **Plane Trigonometry** includes the trigonometric functions, use of tables, solution of triangles, radian measure, fundamental identities, logarithms, graphic representation of trigonometric functions, and inverse trigonometric functions.

27. **Analytical Geometry** is a study of coordinates, the point, the straight line, the circle, properties of the conic sections, transformations of coordinates, and tangents.

28. **Differential Calculus** is a study of the theory of limits, differentiation of algebraic and transcendental functions, applications of the derivative, maxima and minima, successive differentiation, differentials, and the mean value theorem.

29. **Integral Calculus** is a study of the integration of simple forms, constant of integration, reduction formulas, application, the fundamental theorem, the definite integral, formal integration.
30. General Physics is a course designed for liberal arts, pro-medical, and industrial students. The course includes mechanics and heat and covers vectors, force, momentum, work, velocity, acceleration and calorimetry and change of state.

The second semester is a continuation of the first semester and includes a study of electricity, magnetism, sound and light.

31. General Data Processing Systems provides a basic knowledge of the purpose and use of punched card equipment and computers in business, science, and industry. This course is designed for those students who need only a general knowledge of data processing to assist them in their chosen field.

32. Programming I is a study of the basic fundamentals of programming computers in several languages available to the programmer for solving data processing problems.

33. Programming II is a continuation of Programming I, going into more advanced programming problems.

34. Programming III is a study of assembly language used in programming.

Source of Data
The information and data for the study were obtained from questionnaires completed by engineers and industrial personnel who have experience in, or are currently involved
in operating and programming numerically controlled drafting computers (Appendix D).

Procedures of the Study

In collecting the informational data for the study, a letter explaining the purpose of the study, Appendix A, was prepared and sent to 156 industrial concerns in the Dallas and Fort Worth metropolitan area, inquiring whether or not they used a N/C drafting computer and if they would participate in the study. The industrial concerns selected were described as being a manufacturer or processor in the 1970 Business Guides of the Dallas and Fort Worth metropolitan area. The Business Guides also includes the surrounding cities of Arlington, Euless, Grand Prairie, Garland, Terrell, Greenville, Irving, Richardson, Carrollton, Plano and Grapevine, Texas. A self-addressed card, Appendix B, was enclosed to record if the industrial concerns had a drafting computer, if they would participate in the study, and if they wanted a copy of the results.

Ninety-four industrial concerns responded to the letter. Of these, five industrial concerns indicated they used a drafting computer and would participate in the study. Ten industrial concerns replied they would participate even though they did not use drafting computers in their work. There was no followup request sent to industrial concerns.
who did not respond. A questionnaire, Appendix D, was prepared and sent to the fifteen participating industrial concerns. All five industrial concerns employing drafting computers completed and returned the questionnaire, and only two of the ten industrial concerns not using drafting computers completed and returned their questionnaires. These two industrial concerns' recommendations were not included in this study as it was felt that returns from only two would not represent all the industrial concerns in this area where drafting was being done without the aid of drafting computers. However, it may be noted that these two industrial concerns' recommendations paralleled those of the five industrial concerns that employ a drafting computer.

The questionnaire was designed to include all courses of study offered in junior colleges and technical-vocational schools along with a description of each course. The questionnaire further sought the addition of any course that the industrial concern felt should be added to the curriculum and the changing of any course that was previously described. Each course of study was ranked by the participating industrial concern according to its value as being required, desirable, or unnecessary. From these rankings a recommended curriculum guide for N/C drafting computers was organized.

Of the personnel who completed the questionnaire for each of the five industrial concerns, four were engineers heading the computer graphics department, and one was manager
of drafting services in which the drafting computer was located. These five persons represent the most experienced personnel in the different fields of computer drafting in the Dallas and Fort Worth metropolitan area.

Organization of the Study

Chapter I of the study contains an introduction, a statement of the problem and need of the study, the limitations, definition of terms, source of data, procedures of the study and the organization of the study.

A study of the development of tools used by the draftsman is presented in Chapter II. Special emphasis is placed on the drafting computer as an additional tool and some of its uses.

Chapter III presents the information and data secured from questionnaires sent to industrial concerns in the Dallas and Fort Worth metropolitan area.

The summary, findings, and recommendations are presented in Chapter IV.
CHAPTER II

THE HISTORY OF DRAFTING TOOLS AND THE EFFECTS OF NUMERICALLY CONTROlLED DRAFTING COMPUTERS ON OUR SOCIETY

Man has been trying for many years to develop a world language of words and sentences. Contrary to this, there has actually been a universal language in use since the earliest times—the graphic language. The earliest cave-dwellers came up with the idea of communicating thoughts from one person to another by means of pictures. If they wished to record an idea, they made pictures upon skins, stones, walls of caves, or whatever materials they could find.¹

A drawing may be defined as "a graphic representation of a real thing, an idea, or a proposed design for construction later."² Drawings take many forms, but man has classified drawings along two definite lines: (1) artistic and (2) technical.

Artists have used drawings to express beauty, sadness, trouble, and other abstract ideas. In ancient times there was no printing as we know it today. The few books that

²Ibid., pp. 1-2.
were available were hand-lettered on papyrus or parchment and the general public was not able to use these books. This was a contributing factor to the fact that many people were illiterate. Since almost everyone understood pictures, the people learned, not only by listening to their superiors, but by looking at drawings, pictures, and sculptures in public places.³

Technical drawing is the second form in which drawings have been developed. Man has used drawings to represent objects that are to be constructed from the beginning of recorded history. In fact, we can see today the remains of magnificent old buildings, bridges, and other structures which could not have possibly been erected without carefully made drawings to guide the builders. Many of these magnificent structures are regarded as "wonders of the world." One example is the Temple of Amon, at Karnak, in Egypt, which was completed around 980 B. C.⁴ This building was constructed from sheer masses of stone and its roof structure exceeds any ever built.

During the centuries, man has accomplished four objectives in technical drawing. (Technical drawing will be called drafting henceforth.) The four objectives are:

1. Accuracy: No drawing is of maximum usefulness if it is not accurate.
2. Speed: An unsought by-product of intelligent and continuous work.

³Ibid., p.2.        ⁴Ibid., p. 3.
3. Legibility: The drawing is a means of communicating with others, therefore it must be clear and legible in order to serve its purpose well.

4. Neatness: If a drawing is to be accurate and legible, it must also be clean.

For man to achieve these objectives, he must be continuously looking for ways to improve his instruments and equipment. This he has done. He has traded his compass for a circle template, his ruling pen for a rapidograph pen, his T-square for a drafting machine, and more recently all of these improvements are being traded for the drafting computer.

Within the last ten years, drafting has become a technology in its own right. Not only has drafting engulfed the field of simple paste-on symbols, but it is utilizing the complex, sophisticated computer. The demands of less cost, increasing complexity and improved quality require that the finished product or part be produced as efficiently as possible. As a result, the manner in which "shop information" is produced is no longer sacred. Not long ago a chief draftsman would be horrified if a man on the drawing board shortcut an accepted procedure in the interest of efficiency. There was only one way to do it and everyone accepted it. But, today, if someone has an idea for a change he will probably get a bonus instead of a reprimand. This might be

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due to engineering organizations that are looking for any concepts that will net time.

The key word in today's drafting technology is automation. While the need for engineering drawings increases, the availability of draftsmen has decreased. It is becoming harder to find people to do tedious, repetitive kind of detail drafting necessary to satisfy today's production requirements.\(^7\)

Several systems have been developed to harness the versatility of the drafting computer into a useful engineering, drafting, and design tool. The capabilities of the numerically-controlled and the digital computers have been brought to bear on drafting requirements. The latest of electronic, electromechanical, and optical techniques have had increasing impact on a field in which the manually controlled pencil and pen have been a traditionally dominant force.

Interactive computer graphics permits the designer to work directly with a graphic console. The graphic console not only implements a generation of drawings as output, it also produces tapes to machine the part. There is almost a complete elimination of "manual" functions to produce required production information. The draftsman can be upgraded to either a designer or move into areas of either programming or software when a previous drafting function becomes obsolete.

\(^{7}\)ibid., p. 39.
Developments in software have resulted in computer reproduction of engineering drawings, especially in electrical/electronic, aircraft, and automotive areas. Punched cards and magnetic tapes, produced by programming rough sketches, feed drafting computers to produce precise, complex wiring diagrams, printed-circuit boards, and detailed drawings. While the automatic drawing heads of the drafting computer speeds along at many hundreds of inches per minute, the draftsman's pencil lies idle. But these machines perform tasks of precision and detail that would be difficult, if not impossible to perform manually. The ambitious draftsman will be relieved of drudgery and increase his creativity if he can constructively adjust his thinking toward the automatic drafting machine. In many cases, the production drawings are entirely eliminated. The drawings are made possible from mathematical designs where no drawings exists. The computer and automatic drafting machine functions together to create and produce the illustration. As computer software technology and numerical-control capabilities grow, parts will increasingly be made from computer-generated tapes, with only a tape verification drawing required.

While it is true that more draftsmen are learning to use the drafting computer as an additional tool, there is an air

Ibid., p. 39.
of more alertness in the whole field of drafting because of the many pressures upon it. The many manual and automatic procedures available today are combined and this certainly has made the field of drafting a rather "swinging" technology.
CHAPTER III

DATA AND INFORMATION CONCERNING COURSES THAT COULD BE USED IN A CURRICULUM GUIDE FOR NUMERICALLY CONTROLLED DRAFTING COMPUTERS

In keeping with the purpose of the study, a questionnaire, listing courses that could be used in a curriculum guide for N/C drafting computers in the junior college and technical-vocational school levels, was sent to the five industrial concerns using drafting computers in the Dallas and Fort Worth metropolitan area. The five industrial concerns were engaged in manufacturing the following:

1. Oil refinery and special machinery
2. Electronic devices, systems, and materials
3. Fixed-wing aircraft
4. Helicopters
5. Petrochemical pressure vessels and tanks

The data and information obtained from the questionnaire are presented in table form. All the industrial concerns that completed the questionnaire were asked to indicate if each course should be required, would be desirable, or is unnecessary in a curriculum guide for N/C drafting computers. All the participating industrial concerns completed the questionnaire, but some did not check the courses as being required, desirable, or unnecessary. The unchecked courses are listed in Table I under the heading of "no
response". Their opinions concerning the value of each course in a drafting curriculum provided the following results.

The industrial concerns were asked to indicate if engineering drawing I, engineering drawing II, descriptive geometry, map drafting, architectural drafting I, architectural drafting II, pipe drafting, structural drafting, electronic drafting, and technical illustration should be included in the curriculum guide for N/C drafting computers. As shown in Table I, all five industrial concerns recommended engineering

**TABLE I**

**DRAFTING COURSES THAT ARE REQUIRED, DESIRABLE, OR UNNECESSARY IN A CURRICULUM GUIDE FOR N/C DRAFTING COMPUTERS AS REPORTED BY FIVE INDUSTRIAL CONCERNS**

<table>
<thead>
<tr>
<th>Course of Study</th>
<th>Required</th>
<th>Desirable</th>
<th>Unnecessary</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Engineering Drawing I</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2. Engineering Drawing II</td>
<td>4</td>
<td></td>
<td>1</td>
<td></td>
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<tr>
<td>3. Descriptive Geometry</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Map Drafting</td>
<td></td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5. Architectural Drafting I</td>
<td></td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6. Architectural Drafting II</td>
<td></td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7. Pipe Drafting</td>
<td></td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8. Structural Drafting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Electronic Drafting</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Technical Illustration</td>
<td>1</td>
<td>3</td>
<td>1</td>
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</table>
drawing I and descriptive geometry to be required in the curriculum guide. Industrial concerns manufacturing oil refinery and special machinery, electronic devices, fixed-wing aircraft, and helicopters recommended engineering drawing II be required while the industrial concern manufacturing petrochemical pressure vessels and tanks indicated that it was only desirable. Map drafting, architectural drafting I, and architectural drafting II were rated as desirable by industrial concerns manufacturing oil refinery and special machinery, helicopters, and petrochemical pressure vessels and tanks while industrial concern manufacturing electronic devices indicated them unnecessary. The industrial concern manufacturing fixed-wing aircraft made no response. The industrial concern manufacturing fixed-wing aircraft indicated pipe drafting should be required, while industrial concerns manufacturing oil refinery and special machinery, helicopters, and petrochemical pressure vessels and tanks rated it desirable and the industrial concern manufacturing electronic devices deemed it unnecessary. Industrial concerns manufacturing oil refinery and special machinery, electronic devices, helicopters, and petrochemical pressure vessels and tanks indicated that structural drafting was desirable, while the industrial concern manufacturing fixed-wing aircraft gave no response. The industrial concern manufacturing electronic devices recommended electronic drafting be required, but industrial
concerns manufacturing oil refinery and special machinery, fixed-wing aircraft, helicopters, and petrochemical pressure vessels and tanks indicated that it was desirable. Technical illustration was recommended to be required by the industrial concerns manufacturing oil refinery and special machinery, electronic devices, and fixed-wing aircraft and unnecessary by the industrial concern manufacturing petrochemical pressure vessels and tanks.

As shown in Table I, engineering drawing I, engineering drawing II, and descriptive geometry was deemed important as drafting courses in a curriculum guide for N/C drafting computers by all five participating industrial concerns. The importance of knowing the techniques of mechanical drawing which is expressed through the knowledge of orthographic projection, auxiliary projection, sections, pictorial drawing, lettering and machine parts cannot be stressed enough. Essential skills were recommended to be mastered in graphic solutions of problems relating to points, lines, planes, solids, and surfaces. The knowledge of such problems was recommended as necessary to program the drafting computer effectively.

Table II presents five laboratory courses that could be used in a drafting computer curriculum. Industrial concerns manufacturing oil refinery and special machinery, electronic devices, and fixed-wing aircraft viewed power mechanics as being desirable, while industrial concerns manufacturing
TABLE II

LABORATORY COURSES THAT ARE REQUIRED, DESIRABLE, OR UNNECESSARY IN A CURRICULUM GUIDE FOR N/C DRAFTING COMPUTERS AS REPORTED BY FIVE INDUSTRIAL CONCERNS

<table>
<thead>
<tr>
<th>Courses of Study</th>
<th>Required</th>
<th>Desirable</th>
<th>Unnecessary</th>
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<tbody>
<tr>
<td>1. Power Mechanics</td>
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<tr>
<td>2. Basic Metalwork</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3. Pattern-making and Foundry Work</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. General Sheet Metal</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5. General Welding</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
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</table>

helicopters and petrochemical pressure vessels and tanks deemed it unnecessary. Basic metalwork was important enough to be required by the industrial concern manufacturing electronic devices, and desirable by industrial concerns manufacturing oil refinery and special machinery, fixed-wing aircraft, helicopters, and petrochemical pressure vessels and tanks. Pattern-making and foundry work were recommended as being required by industrial concerns manufacturing electronic devices and fixed-wing aircraft, desirable by industrial concerns manufacturing oil refinery and special machinery and petrochemical pressure vessels and tanks, and unnecessary by the industrial concern manufacturing helicopters. Industrial concerns manufacturing electronic devices,
fixed-wing aircraft, and helicopters indicated general sheet metal should be required, but the industrial concern manufacturing oil refinery and special machinery only deemed it desirable, while the industrial concern manufacturing petrochemical pressure vessels and tanks deemed it unnecessary. General welding was recommended as being required by the industrial concern manufacturing electronic devices, desirable by industrial concerns manufacturing oil refinery and special machinery and fixed-wing aircraft, and unnecessary by industrial concerns manufacturing helicopters and petrochemical pressure vessels and tanks.

Table II shows that a majority of the respondents felt that pattern-making and foundry work and general sheet metal should be included in a N/C drafting computer curriculum. It is evident that these laboratory courses are necessary to teach the students a working knowledge of pattern-making, foundry work, fabrication of sheet metal objects, and layout work along with their relationships and practical applications to the metal industry.

In an effort to determine the mathematical and physics courses to be included in a curriculum guide for N/C drafting computers, a list of six such courses was included in the questionnaire. Table III shows the results of the respondents' opinions concerning each course.

The results showed industrial concerns manufacturing oil refinery and special machinery, fixed-wing aircraft,
helicopters, and petrochemical pressure vessels and tanks recommended college algebra, plane trigonometry, and analytical geometry be required. The industrial concern manufacturing electronic devices checked these three courses as being desirable. Differential calculus was deemed required by industrial concerns manufacturing oil refinery and special machinery, helicopters, and petrochemical pressure vessels and tanks, desirable by the industrial concern manufacturing fixed-wing aircraft, and unnecessary by the industrial concern manufacturing electronic devices. Industrial concerns manufacturing oil refinery and special machinery and helicopters viewed integral calculus as being required, while

### TABLE III

Mathematical and Physics Courses That Are Required, Desirable, or Unnecessary in a Curriculum Guide for N/C Drafting Computers as Reported by Five Industrial Concerns

<table>
<thead>
<tr>
<th>Courses of Study</th>
<th>Required</th>
<th>Desirable</th>
<th>Unnecessary</th>
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<tr>
<td>1. College Algebra</td>
<td>4</td>
<td>1</td>
<td></td>
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<tr>
<td>2. Plane Trigonometry</td>
<td>4</td>
<td>1</td>
<td></td>
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<tr>
<td>3. Analytical Geometry</td>
<td>4</td>
<td>1</td>
<td></td>
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<tr>
<td>4. Differential Calculus</td>
<td>3</td>
<td>1</td>
<td>1</td>
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<tr>
<td>5. Integral Calculus</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. General Physics</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
industrial concerns manufacturing fixed-wing aircraft, and petrochemical pressure vessels and tanks considered it desirable and the industrial concern manufacturing electronic devices thought it to be unnecessary. General physics was recommended by the industrial concern manufacturing helicopters as being required and industrial concerns manufacturing oil refinery and special machinery, fixed-wing aircraft, electronic devices, and petrochemical pressure vessels and tanks indicated it to be desirable.

As shown in Table III, the majority of the industrial concerns were of the opinion that college algebra, plane trigonometry, analytical geometry, differential calculus, and integral calculus should be included in a curriculum guide for N/C drafting computers. To communicate effectively with the drafting computer, a programmer must have working knowledge of mathematical fundamentals, transformations of coordinates and tangents, graphics, linear and quadratic equations, and trigonometric functions.

Table IV presents the opinions of the five industrial concerns regarding the value of general data processing systems and programming courses in a curriculum designed for N/C drafting computers. As shown in Table IV, industrial concerns manufacturing electronic devices, helicopters, and petrochemical pressure vessels and tanks indicated general data processing systems should be required, and industrial concerns manufacturing oil refinery and special machinery
and fixed-wing aircraft deemed it desirable. Industrial concerns manufacturing electronic devices, fixed-wing aircraft, helicopters, and petrochemical pressure vessels and tanks recommended that programming I and programming II should be required, while the industrial concern manufacturing oil refinery and special machinery viewed them as unnecessary. Programming III was indicated by the industrial concern manufacturing helicopters as being required, desirable by industrial concerns manufacturing fixed-wing aircraft and petrochemical pressure vessels and tanks, and unnecessary by industrial concerns manufacturing oil refinery and special machinery and electronic devices.

### TABLE IV

DATA PROCESSING AND PROGRAMMING COURSES THAT ARE REQUIRED, DESIRABLE, OR UNNECESSARY IN A CURRICULUM GUIDE FOR N/C DRAFTING COMPUTERS AS REPORTED BY FIVE INDUSTRIAL CONCERNS

<table>
<thead>
<tr>
<th>Courses of Study</th>
<th>Required</th>
<th>Desirable</th>
<th>Unnecessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. General Data Processing Systems</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2. Programming I</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3. Programming II</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4. Programming III</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Resulting from the analysis of Table IV, the opinions showed general data processing systems, programming I, and programming II were preferred by the five industrial concerns to be included in the drafting computer curriculum. These courses provide a basic knowledge of the purpose and use of punched card equipment and the basic fundamentals of programming computers in several languages which are vital to the programmer for solving numerically controlled problems.

In addition to the courses on the questionnaire to be checked, the industrial concerns were asked to add opinions and recommendations to parts II and III of the questionnaire. Part II asked the industrial concerns to write down any course not already listed on the questionnaire which they felt should be added to the curriculum, an explanation of its contents, and why they believed it necessary. There was no response to this part of the questionnaire. Part III gave the industrial concerns an opportunity to suggest material they wished be added to the courses presented in part I. The industrial concern manufacturing fixed-wing aircraft recommended that graphic reproduction of solids be added to programming II.
CHAPTER IV

SUMMARY, FINDINGS, AND RECOMMENDATIONS

This study was made to (1) develop a curriculum guide educators can follow when organizing a course of study involving computer drafting; (2) see if a new plan of study including computer drafting would affect the present drafting curriculum. Further, and more specific, the study sought to answer the following questions regarding a course of study that could be used in a curriculum guide for N/C drafting computers.

1. In the opinion of industrial concerns using N/C drafting computers, should engineering drawing I, engineering drawing II, descriptive geometry, map drafting, architectural drafting I, architectural drafting II, pipe drafting, structural drafting, electronic drafting, technical illustration, power mechanics, basic metalwork, pattern-making and foundry work, general sheet metal, general welding, college algebra, plane trigonometry, analytical geometry, differential calculus, integral calculus, general physics, general data processing systems, programming I, programming II, and programming III be required, desirable, or unnecessary in a curriculum guide for N/C drafting computers?
2. In the opinion of industrial concerns using N/C drafting computers, what other courses (any course not described in question one) should be added to the curriculum? They were also asked to describe the content of each, and tell why it was deemed necessary.

3. In the opinion of industrial concerns using N/C drafting computers, what should be added, if anything, to the content of each course described in question one?

The data and information used in the study were obtained from the following sources:

1. Research into the history of drafting tools from the Roman stylus to the automatic drafting computer.

2. Responses to questionnaires returned by industrial concerns in the Dallas and Fort Worth metropolitan area.

One hundred and fifty-six industrial concerns, either a manufacturer or processor in the Dallas and Fort Worth metropolitan area, were selected for the study. A letter explaining the purpose of the study and a request to participate in the survey was sent to each industrial concern. Included with the letter was a self-addressed card on which the respondents were requested to indicate if they (1) did or did not use a drafting computer, (2) would or would not participate in the study, and (3) would or would not like a copy of the study. Of these ninety-four industrial concerns responded to the letter, only fifteen indicated that they would participate in the study. Of these fifteen, five indicated they had
drafting computers. There was no follow-up request sent to the industrial concerns which did not respond. Questionnaires were then prepared and sent to the fifteen, seven of which completed and returned the questionnaires. Five of these industrial concerns had previously indicated they used drafting computers.

Findings

Data obtained from the industrial concerns in the Dallas and Fort Worth metropolitan area using drafting computers revealed the following:

1. Engineering drawing I, engineering drawing II, and descriptive geometry should be the required drafting courses in a curriculum guide for N/C drafting computers.

2. Laboratory courses in pattern-making and foundry work and general sheet metal should be required in a N/C drafting computer curriculum.

3. Algebra, plane trigonometry, analytical geometry, differential calculus, and integral calculus were recommended by the participating industrial concerns as required mathematical courses in a N/C drafting computer curriculum.

4. General data processing systems, programming I, and programming II were the three data processing courses recommended by the participating industrial concerns which should be required in a curriculum guide for N/C drafting computers.
5. The study showed no additional courses of study, other than those presented in part I of the questionnaire, needed to be added to the curriculum for N/C drafting computers. Due to this fact, addition of a computer drafting curriculum should not affect the present drafting curriculum in junior colleges and technical-vocational schools today.

6. One industrial concern deemed it necessary to add graphic reproduction of solids to the curriculum of programming II.

Recommendations

The following recommendations are made based on the data presented in the study:

1. Engineering drawing I, engineering drawing II, and descriptive geometry should be required drafting courses in a curriculum guide for N/C drafting computers.

2. Pattern-making and foundry work and general sheet metal should be required laboratory courses in an automatic drafting computer curriculum.

3. The following mathematical courses be required in the curriculum guide: college algebra, plane trigonometry, analytical geometry, differential calculus, and integral calculus.

4. Courses in general data processing systems, programming I, and programming II should be data processing and programming courses required in the curriculum guide.
5. It is recommended that supplementary drafting courses in pipe drafting, electronic drafting, and technical illustration be used in an automatic drafting computer curriculum.

6. It is recommended that supplementary laboratory courses in basic metalwork and general welding be used in a drafting computer curriculum.

7. It is recommended that general physics be used as a supplementary science course in a drafting computer curriculum.

8. It is recommended that programming III be used as a supplementary programming course in an automatic drafting computer curriculum.
Dear Company:

I am conducting a research study to develop a curriculum guide to be used in planning and organizing courses of study involving drafting computers in the Junior Colleges and Technical-Vocational Schools. This course of study will lead to an associate degree in the field of computer graphics. This study will include industries in the Dallas-Fort Worth metropolitan areas utilizing uses in computer drafting.

Enclosed is a stamped, self-addressed card inquiring whether your company uses a drafting computer and if so, whether you would participate in this study by completing and returning a questionnaire that would be mailed to you on a later date.

Your cooperation in this study will be appreciated. Data used in this study will be treated confidential and no individual or company name will be presented in the data. A summary of this study will be sent to any participant if so indicated on the enclosed card.

Thank you for your cooperation.

Sincerely,

Hollis E. Driskell, Chairman
Drafting Technology Department

Enclosure
APPENDIX B

Please check the following:

1. I do __, do not __ use a drafting computer.
2. I will __, will not __ participate in this study.
3. I would __, would not __ like a copy of this study.

Enclosure
September, 1970

Dear Company:

Several weeks ago, I sent you a survey questionnaire asking whether you had a drafting computer and if you would participate in a study for the purpose of developing a curriculum guide for numerically controlled drafting computers. This study is being prepared for students of the Junior College and Vocational-Technical School levels. You replied that you would participate.

I am enclosing the questionnaire with a self-addressed, stamped envelope. Thank you for your courtesy and cooperation.

Sincerely,

Hollis E. Driskell, Chairman
Drafting Technology Department

Enclosure
APPENDIX D

A STUDY TO DETERMINE A CURRICULUM GUIDE FOR NUMERICALLY CONTROLLED DRAFTING COMPUTERS

Name ___________________________ Position ___________________________

Name of Company ___________________________

Address ___________________________

I.

Directions: Listed below are courses that could make up a course of study involving a drafting computer. Please check (✓) the appropriate square as to whether the course should be required, desirable, or unnecessary.

<table>
<thead>
<tr>
<th>Course</th>
<th>Required</th>
<th>Desirable</th>
<th>Unnecessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Engineering Drawing I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A study is made of the proper use and care of instruments and tools, the technique of mechanical drawing; orthographic projection, auxiliary projection, sections, and pictorial drawing. Good lettering is stressed and practiced in print production.</td>
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<tr>
<td>2. Engineering Drawing II</td>
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<td></td>
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<tr>
<td>The elements of machine drafting, design of machine parts, perspective, and lettering are studied. A study is made of machine parts.</td>
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<tr>
<td>3. Descriptive Geometry</td>
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<tr>
<td>A study is made of the problems relating to points, lines, planes, solids, and surfaces. The graphic solutions of the problems are worked out on the drawing board.</td>
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<tr>
<td>4. Map Drafting</td>
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<tr>
<td>Skill is obtained in graphic translation of land descriptions, and survey field notes. Training is given in general base maps, construction maps, topographic maps and surveying.</td>
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</tr>
<tr>
<td>5. Architectural Drafting I</td>
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</tr>
<tr>
<td>A study is made of various types of building and room design, specifications, estimates, contracts, and lettering. A survey of the history of architecture is also made. A complete set of plans for a one-story home is required of each student.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

35
6. Architectural Drafting II
   A study is made of the planning, designing, and production of plans, details, and estimates for industrial buildings.

7. Pipe Drafting
   Application to drafting as applied to pipe line systems is emphasized. A brief introduction is given to connections for pump stations, manifolds, and pressure vessels.

8. Structural Drafting
   A study is made of framing and assembly of structural steel shapes for all types of construction. Reinforced concrete, detailing, and estimating are also explored.

9. Electronic Drafting
   Modern methods of drawing diagrams and schematics are studied. Design of electronic systems is emphasized.

10. Technical Illustration
    Emphasis is placed upon the development of isometric, dimetric, trimetric and perspective pictorials of objectives. Other areas which are covered include inking, shading, air brush rendering, vu-graphs, freehand sketching, electronic schematics, and preparing illustrations for offset reproduction.

11. Power Mechanics
    A study of the sources and transmission of power. Emphasis is given to the design, theory, and principles of operation of small internal combustion engines, diesel, jet, and turbine engines, and fluid and pneumatic power systems.

12. Basic Metalwork
    A study of the basic tools, machines, processes and procedures used in laying out, cutting, shaping, forging, heat-treating, and finishing metals.

13. Pattern-making and Foundry Work
    A course designed to teach the student a working knowledge of pattern-making and foundry work and its relationship and practical application to the metal industry.

14. General Sheet Metal
    A study involving blueprint reading, layout work, and the fabrication of sheet metal objects.
15. General Welding
A study of the equipment, materials, and process used for brazing, welding, and cutting of metals with emphasis on metallurgy, testing, inspection of welds, and heat treating by the oxyacetylene process.

16. College Algebra
A study of fundamentals, graphs, linear and quadratic equations, ration, proportion, variation, progressions and combinations, partial fractions and infinite series.

17. Plane Trigonometry
The trigonometric functions, use of tables, solution of triangle, radian measure, fundamental identities, logarithms, graphic representation of trigonometric functions, and inverse trigonometric functions.

18. Analytical Geometry
Coordinates, the point, the straight line, the circle, properties of the conic sections, transformations of coordinates, and tangents.

19. Differential Calculus
Theory of limits, differentiation of algebraic and transcendental functions, applications of the derivative, maxima and minima, successive differentiation, differentials, mean value theorem.

20. Integral Calculus
Integration of simple forms, constant of integration, reduction formulas, application, the fundamental theorem, the definite integral, formal integration.

21. General Physics
This course is designed for liberal arts, pre-medical, and industrial students. The course includes mechanics and heat and covers vectors, force, momentum, work, velocity, acceleration and calorimetry and change of state.

The second semester is a continuation of the first semester and includes a study of electricity, magnetism, sound and light.

22. General Data Processing Systems
Provides a basic knowledge of the purpose and use of punched card equipment and computers in business, science, and industry. This course is designed for those students who need only a general knowledge of data processing to assist them in their chosen field.
23. Programming I
A study of the basic fundamentals of programming computers in several languages available to the programmer for solving data processing problems.

24. Programming II
Continuation of Programming I, going into more advanced programming problems.

25. Programming III
A study of assembly language used in programming.

II

Please write down any course that you feel should be added to the curriculum and explain its contents and why you believe it is necessary. If you need more space, please use the back.
If you wish to add to the curriculum of any of the above courses, please state the course and the information you are adding.

Thank you for participating in this survey.

Return to

Hollis E. Driskell
Drafting Technology Department
Navarro Junior College
Corsicana, Texas
BIBLIOGRAPHY

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Reports