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ENGINEERING GRAPHICS COURSES FROM THE VIEWPOINT OF MECHANICAL ENGINEERING EDUCATORS

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CHAPTER I

INTRODUCTION

Graphical representation has evolved from the prehistoric carvings on cave walls to a major form of communication in today's industrialized society. The beginnings of graphics as a means of communication have been lost in the dim past of history, but references to their use by architects have been found in early Grecian writings. Although perspective projection was the first organized and scientific approach to drawing, its descriptive limitations were recognized early and evidence of the use of orthogonal projection has been found which dates back to the fifteenth century.[1]

It is not known whether Leonardo da Vinci used any form of projection besides his highly developed perspective method, but his place in the development of engineering

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[1]Frederic G. Higbee, "The Development of Graphical Representation," Journal of Engineering Drawing, XXII (May, 1958), p. 14.

graphics is important because of his teaching and extensive use of graphics for the purpose of recording and communicating ideas on mechanical subjects.[1]

Even though graphics as a means of communication had been in use for centuries, it was not until Gaspard Monge developed his descriptive geometry during the concluding years of the eighteenth century[2] that it became a subject area with a full body of organized knowledge and literature of its own.

During this same period engineering education had its early beginnings. From the start graphics, in one form or another, has been an intrinsic part of the engineering curriculum. Crozet introduced descriptive geometry at United States Military Academy, West Point, at the very beginning of engineering education in the United States. As new fields of engineering developed, so did the need for specialized graphical representation so that by the time of the twentieth century the art of draughting became the science of drafting.[3]

Thus, engineering graphics courses of today are the products of a gradual evolution spanning a one hundred year period of engineering education.[4]

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[1] Ibid., p. 15.

[2] James S. Rising, "Integration of Engineering Drawing and Descriptive Geometry," Journal of Engineering Drawing, XII (November, 1948), p. 16.

[3] Ibid., p. 17.

[4] B. Leighton Wellman, "Drawing for Tomorrow," Journal of Engineering Education, XLVII (December, 1956), p. 343.

Just as engineering graphics has evolved from an art to a science, engineering has also developed from the art of engineering to the science of engineering. The engineer has developed from a master mechanic of a century ago to the professional applied scientist of today.[1] This change in the role of the engineer is reflected in the evolution of the engineering curriculum. The emphasis has shifted from "learning how to do specific things to learning how to learn how. Acquiring the ability to solve new problems has become more important than acquiring valuable solutions to important problems."[2]

Background of the Problem

Because of the dynamic nature of engineering[3] the American Society of Engineering Education has made a number of studies to determine the course of engineering education in relation to the changes in the profession.[4] Among the

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[1]Carl L. Svensen, "The Graphic Language and the Professional Engineer," Journal of Engineering Drawing, XVII (November, 1953), p. 16.

[2]John T. Rule, "Opportunities and Responsibilities of Graphics in an Engineering Educational Program," Journal of Engineering Drawing, XVII (May, 1953), p. 71.

[3]"Report of the Committee on Evaluation of Engineering Education," Journal of Engineering Education, XLVI (September, 1955), p. 39.

[4]H. C. Spencer, "The New Look in Engineering Education," Journal of Engineering Education, XIX (May, 1955), p. 8.

more significant reports are the Mann report[1] which led to Wickenden report of 1923 to 1929, the Hammond report of 1944, and the Grinter report of 1955.[2] The Grinter report is currently having its effect on engineering curricula. The purpose of this report was as follows:

> . . . to recommend the pattern or patterns that engineering education should take in order to keep pace with the rapid developments in science and technology, and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession for the next quarter century.
> . . . The Committee on Evaluation was asked particularly to clarify the curriculum content that differentiates engineering education from that in science on the one hand or in subprofessional technology on the other.[3]

In general, the report recommended a continuation of the emphasis on social humanistic studies and an increase of emphasis on the sciences. The recommendations for this science oriented curriculum were based, in part, on the revolutionary technological developments of recent years. Grinter[4] states that "the Colleges of Engineering are located momentarily in the 'eye' of a hurricane. No matter which direction

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[1]Randolph Hoelscher, "The Contribution of Engineering Drawing in an Engineering Educational Program," Journal of Engineering Education, XVI (November, 1952), pp. 8-9.

[2]Charles J. Vierck, "Basic Principles for the Design of Drawing Courses to Comply with the 1955 Evaluation Report," Journal of Engineering Drawing, XXII (February, 1958), p. 18.

[3]"Report of the Committee on Evaluation of Engineering Education," op. cit., p. 26.

[4]L. E. Grinter, "Graphical Communications--An Aid to Creativity," Journal of Engineering Drawing, XVIII (February, 1954), p. 24.

the storm moves we are certain to have to rebuild a considerable part of the structure of engineering education as we have long known it."

One of the areas in engineering education to be affected by these changes is engineering graphics. Grinter[1] indicates that in order to remain useful in the engineering curriculum the "objectives and ideals of engineering drawing" must gradually be adjusted "into conforming with the changing activities and responsibilities of engineers."

The role that engineering graphics will play in the future of engineering education is indicated by the Evaluation Committee:

> Graphical expression is both a form of communication and a means for analysis and synthesis. The extent to which it is successful for these purposes is a measure of its professional usefulness. Its value as a skill alone does not justify its inclusion in a curriculum. The emphasis should be on spatial visualization, experience in creative thinking, and the ability to convey ideas, especially by free-hand sketching, which is the normal mode of expression in the initial stages of creative work. Though the engineer may only supervise the preparation of the drawings required to execute his designs, he can hardly be expected to do this effectively unless he himself is thoroughly familiar with graphical communication.[2]

Thus, in the past one hundred years both engineering and engineering graphics have evolved from arts to sciences

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[1]L. E. Grinter, "Foreshadowing of Events in Engineering as Related to Graphics Instruction," Journal of Engineering Education, XLVIII (December, 1957), p. 210.

[2]"Report of the Committee on Evaluation of Engineering Education," op. cit., p. 39.

because of rapid technological advances. Although engineering graphics remains important in the engineering curriculum, the changing role and professional status of the engineer has brought about new relationships and different emphasis on graphical needs in the engineering curriculum.

Need for the Study

Because engineering education is a dynamic profession, constant research should be carried out to develop a professionally sound program at both the undergraduate and graduate levels.

The need for curriculum development in the field of engineering graphics at this time is apparent because of the wide variety of practices concerning this area. At many institutions engineering graphics areas are being de-emphasized by decreasing the number of course offerings, decreasing the time and credit allotted for each course, or both of these practices. At other institutions, the course offerings are remaining unchanged, or in some cases, graphical offerings are increasing.

There is also a wide variety of practices in the matter of emphasis on objectives and content within the field of engineering graphics. Many schools offer the traditional courses of engineering drawing and descriptive geometry with a wide range of topics emphasized in varying degree. Other schools include the area of graphical mathematics by crowding them into basic engineering graphics courses, by replacing

traditional topics in basic engineering graphics courses, or by adding advanced engineering graphics courses.

Engineering graphics is a service area in the engineering curriculum and many engineering educators believe that the degree granting departments should be consulted concerning the objectives and content of engineering graphics courses. The opinions of the engineering educators of the degree-granting departments should be valuable in this respect, inasmuch as they are aware of the technological and philosophical changes in the over-all engineering curriculum.

Many engineering graphics courses now are based, in part, on the opinions of mechanical engineering educators at the local level. There has not been, however, a large scale study made of the opinions of mechanical engineering educators concerning the objectives and content of engineering graphics courses in the undergraduate curriculum. This investigation should furnish some needed data for the basis of judgment in the evaluation and improvement of engineering graphics courses and the mechanical engineering curriculum. This study, however, is but one part of the total research that is necessary for a complete analysis of engineering graphics courses. Other investigations needed include the data of the opinions of engineering educators of all the degree-granting departments, engineering graphics educators, practicing engineers, and industries which employ engineering graduates. There are, therefore, many facets to the problem

of determining an appropriate undergraduate engineering graphics program for engineers. This research is an attempt to isolate one of these facets, the opinions of mechanical engineering educators.

This study also should be of interest to other service areas of the mechanical engineering curriculum, since some graphical areas are pointed up as being important in mechanical engineering education but may not be included in their own local engineering graphics courses for various reasons.

Statement of the Problem

The problem considered in this study was: What are the opinions of mechanical engineering educators concerning the purposes and content of engineering graphics courses appropriate to the undergraduate mechanical engineering curriculum?

Specifically, this study was concerned with the implications of these opinions and certain factors associated with these opinions for the development and improvement of undergraduate engineering graphics courses and the undergraduate mechanical engineering curriculum.

Definition of Terms

For the purpose of this study the term engineering graphics courses was used to designate undergraduate required courses in the mechanical engineering curriculum as usually

taught by drawing departments and commonly termed engineering graphics or engineering drawing and descriptive geometry.

Methods and Procedures

The survey method was used for this study and the following procedures were used to gather the data and analyze it for implications which may be used in evaluating and improving engineering graphics courses and the mechanical engineering curriculum.

An instrument was constructed to obtain the opinions of mechanical engineering educators concerning the objectives and content of engineering graphics courses appropriate to the undergraduate mechanical engineering curriculum. This questionnaire was developed through a search of the literature in the field which included engineering graphics textbooks, available courses of study, catalog descriptions and professional writings. The questionnaire is shown in Appendix D.

The questionnaire was pretested by the interview method and revised accordingly. The schools included in this study were limited to those accredited by the North Central Association having Mechanical Engineering Departments accredited by the Engineers' Council for Professional Development. Letters were sent out to the chairmen of the Mechanical Engineering Departments of these forty-six accredited schools, asking them to participate in the study and to

recommend faculty representatives from the major areas in their Mechanical Engineering Department, such as thermodynamics, heat transfer, machine design, and materials and processes, who would also participate in this investigation. It was requested that the chairmen limit their recommendations to faculty representatives who had at least five years teaching experience in the field of mechanical engineering and who did not teach engineering graphics subjects. A copy of this letter appears in Appendix E.

A list of participants was compiled from the returns of the letter which was sent to the chairmen of the Mechanical Engineering Departments. A cover letter and questionnaire were sent to the recommended faculty, and a separate letter and questionnaire were sent to the chairmen who agreed to participate in this study. Copies of these two letters will be found in Appendix E.

A follow-up letter, along with another questionnaire, was sent to those who failed to respond to the original letter. This letter is shown in Appendix E.

The questionnaire consisted of three parts: (1) objectives of engineering graphics, (2) course content, and (3) personal data. In the first section dealing with the objectives of engineering graphics courses in the undergraduate mechanical engineering curriculum, the respondents were asked to indicate the order of importance they believed should be placed on a list of objectives. If they felt one of the

objectives listed should not be included, they were asked to so indicate. If they felt there were objectives other than those listed on the questionnaire, they were to add them in the space provided.

In the second section, the graphical areas in a mechanical engineering curriculum which should be appropriately included in engineering graphics courses, the participants were asked to rate a number of topics as to the degree of emphasis which they felt should be placed upon each.

If the educators believed that a topic was important in the mechanical engineering curriculum but should not be taught in engineering graphics courses, they were asked to so indicate.

The third section requested personal data. The respondents were asked to give name, rank, position, and name of college or university.

The returns of the questionnaire were tabulated and distributions were made according to the various categories indicated in the personal data section in order to determine if these had an influence on the expressed opinions.

In the first section, which dealt with the order of importance of objectives, the percentage of responses and the average responses were computed. For descriptive purposes, the rank order of eight was given to a response that indicated an objective listed on the questionnaire should not be included. The objectives were arranged according to

the average response and rank orders were assigned to the total group and the categories indicated in the personal data section.

In the second section, which dealt with course content, the percentage of responses was calculated for each item and weights were applied. The weight of four was applied to responses which indicated major emphasis, the weight of three was applied to responses which indicated moderate emphasis, the weight of two was applied to responses which indicated limited emphasis, and the weight of one was applied to responses indicating that the topic should not be included in engineering graphics courses or should be taught in courses other than engineering graphics courses.

The percentage of response to each item was multiplied by the assigned weight in order to determine the average weighted response. This average weighted response was used to determine the rank order for the items of course content according to the total response and the categories indicated in the personal data section.

The data compiled from the questionnaire were analyzed for implications which may be used in evaluating and improving engineering graphics courses and the mechanical engineering curriculum.

CHAPTER II

REVIEW OF RELATED LITERATURE

The literature related to the objectives and content of engineering graphics courses was reviewed. There was little recent related research located, but a number of periodical articles were found discussing various phases of the topics related to this study.

Related Research

Several studies made a number of years ago were reviewed but were not included because the rapidly changing nature of engineering education has affected the objectives and content of undergraduate engineering graphics courses in the mechanical engineering curriculum. This review of literature is limited to studies reported in recent years.

A status study of engineering drawing in the engineering curriculum was conducted by Luzadder.[1] A questionnaire was sent to engineering graphics faculty, and returns represented the conditions existing in fifty-four schools.

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[1]Warren J. Luzadder, "Status of Engineering Drawing --1957 Survey for Drawing Division of American Society for Engineering Education," Journal of Engineering Drawing, XXII (February, 1958), pp. 14-17.

The survey indicated that basic drawing courses have been drastically changed during the past five years in almost two-thirds of these schools. One-third of the group surveyed stated that the number of semesters or credit hours devoted to required courses in engineering graphics have been reduced.

Forty of the fifty-four respondents indicated there had been a change in emphasis in the subject matter in the basic engineering graphics courses. The changes in emphasis most frequently indicated included additional work in multi-view drawings, freehand sketching, pictorials, graphical mathematics, and the creative aspects of engineering drawings. In response to the question of whether more time was devoted to freehand sketching, thirty-nine of the respondents indicated that more time was being devoted to making freehand sketches.

In the area of graphical mathematics, nineteen per cent of the total number of institutions represented indicated that graphical calculus was included in the basic engineering graphics courses and twenty-four per cent indicated that the construction of parallel scale alignment charts was included in these basic courses.

A study was undertaken by Potter[1] to determine the importance of engineering graphics to the practicing engineer in industry and its relationship to the study of engineering

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[1]Orrin W. Potter, "Graphics in Engineering Practice," Journal of Engineering Drawing, XIX (May, 1955), pp. 36-37.

graphics in the undergraduate engineering curriculum. This study was conducted by the survey and interview methods and included opinions of the heads of drawing departments in colleges, teachers of drawing, heads of drafting-design departments of industry, draftsmen, and graduate engineers, excluding teachers.

This study indicated some current drawing procedures in industry, the importance of engineering graphics training to graduate engineers, and suggestions for the improvement of undergraduate engineering graphics courses for engineers. The graduate engineers suggested more emphasis should be placed on the following topics, listed in order of importance:

1. Freehand sketching
2. Descriptive geometry and applications
3. Pictorial drawings
4. Reading problems and exercises in visualization
5. Dimensioning, including tolerances, limits, etc.
6. Layout and design sketches
7. Graphs, charts, nomograms, and graphical calculations
8. Mechanical drafting and detailing
9. Lettering
10. Neatness, accuracy, and clarity
11. More attention to simplified forms, symbols, etc.
12. Fundamentals and basic principles and drafting standards
13. More machine design, creative design, and applications
14. Piping, wiring, flow-sheets, etc.
15. Relation of drawings to processing, casting, forging, machining, welding, etc.
16. More specialization in the different fields
17. More practical application and less theory
18. The use and purpose of drawings
19. Intersections and developments

The phases of drawing which the engineers felt should be stressed less, in the order of emphasis, are as follows:

1. Inking and tracing
2. Lettering
3. Technique and line work
4. Descriptive geometry
5. Too much detailing
6. Pictorial drawing (Production illustration, perspective, etc.)
7. Charts, graphs, nomography, etc.
8. Machine drawings
9. Threads, gears, cams, etc.
10. Freehand sketching

A workshop conducted at the 1958 mid-winter meeting of the Engineering Drawing Division of the American Society of Engineering Education[1] polled the opinions of seventy engineering graphics educators relative to the contents of basic engineering graphics courses. The items of content were discussed individually and a vote was taken which indicated that the topic should either be omitted, receive limited treatment, or receive major treatment in basic engineering graphics courses. The topics which were voted to receive major treatment are as follows:

1. Sketching
2. Orthographic projection
3. Sectional views
4. Primary auxiliary views
5. Dimensioning
6. Lines
7. Planes
8. Successive auxiliary views
9. Piercing points
10. Intersection of planes
11. Angle between planes
12. Parallelism
13. Perpendicularity
14. Angle between line and oblique plane

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[1]The Division of Engineering Drawing of the American Society for Engineering Education, Course Development in Relation to an Engineering Drawing Curriculum and Future Needs of the Young Engineer, A Report of the 1958 Mid-Winter Meeting, Flint, Michigan, pp. 2-3.

The topics which were voted to receive limited treatment are as follows:

1. Lettering
2. Instruments and materials
3. Applied geometry
4. Charts and graphs
5. Isometric drawing
6. Oblique drawing
7. Shop processes
8. Detail drawing
9. Ink work and tracing
10. Threads and fasteners
11. Assembly drawing
12. Reproduction processes
13. Revolution
14. Intersection of solids
15. Developments
16. Intersection of curved surfaces
17. Perspective representation
18. Perspective representation
19. Cone focus problems
20. Applied descriptive geometry problems
21. Warped surfaces
22. Classification and generation of all surfaces

On the question of including graphical mathematics in a basic engineering graphics course, thirty indicated that a limited treatment should be offered and twenty-seven agreed that it should not be included. Of those who thought graphical mathematics should be contained to a limited degree, twelve voted for inclusion of empirical curves, ten for functional scales, fifteen for nomographs, fifteen for graphical calculus, and twenty-eight for three dimensional vectors.

Thirty members responded that such graphics mathematics courses be taught to all engineering students, but in some course other than basic engineering graphics courses.

Related Literature

A number of articles discussing various points of view concerning the objectives of engineering graphics courses and suggested content were reviewed. The articles presented in this report were selected in order to illustrate areas of agreement and disagreement.

A set of objectives for engineering graphics courses based on the needs of engineers was developed by Young. He indicated that a balance of content is of major importance and improvement should come about through consultation with other departments, men of industry, and careful consideration of other evidence. The engineer's graphical needs developed by Young[1] are listed as follows:

1. The ability to read and make drawings of engineering mechanisms and structures. This includes an understanding of standard practices, conventions and symbols, training in drafting technique, and ability in visualization.
2. The ability of and habit of making neat, clear and complete sketches as an aid in the analysis of problems, as a means of expressing his ideas, and as a stimulus to creative thinking.
3. The ability to use graphical solutions when well adapted to engineering problems.
4. The formation of good habits of analysis as developed in the solution of descriptive geometry problems.
5. A better understanding of mathematics through the use of analagous graphical representations. Nomography, curve fitting, logarithmic scales, have countless application to engineering problems.
6. The ability to present data in appropriate graphs, charts, and diagrams.

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[1]Lyle E. Young, "A Balanced Course in Engineering Graphics," Journal of Engineering Drawing, XX (November, 1956), pp. 60-62.

A list of objectives based upon the needs of engineers and engineering students was presented by Buck:[1]

1. Need for a basic knowledge of the various methods of representation. This implies an ability to read drawings that he may encounter. Fundamentally it means a working knowledge of orthographic projection, though this is only the necessary core of knowledge of representation. Other methods of representation would include pictorial, charts, diagrams, etc.
2. Ability to solve problems graphically.
   a) Knowledge of the use of orthographic projection and principles of descriptive geometry in solving spatial problems.
   b) Knowledge of fundamental graphical mathematics, basic types of graphs, nomography, alignment charts, etc., and an appreciation of their uses in the solution of problems.
   c) Experience in creative engineering in the solution of problems involving original design or redesign.
   d) In the solution of problems, an appreciation for a logical approach in reasoning out the solution.
   e) An appreciation, as needed, of accuracy, and thereby neatness, in the solution of problems.
3. Ability to present his ideas to management or to laymen through the use of the above.
4. The engineer is not likely to be a draftsman, but he may be called upon to supervise draftsmen, and he should be able to translate ideas to paper in the form of sketches or more carefully executed layouts. He will therefore need:
   a) An ability to sketch.
   b) An ability to use drafting instruments.
5. He will be expected to clearly annotate his work and should therefore have an appreciation for a neat, clearly legible, form of lettering.

The purposes of engineering graphics courses were outlined by Rule[2] to consist of the following areas:

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[1]Carson P. Buck, "An Outline for an Integrated Course," Journal of Engineering Drawing, XXII (February, 1958), p. 46.

[2]Rule, op. cit., p. 10.

1. Our present major work of teaching engineering drawing and descriptive geometry for the direct purpose of developing competent draftsmen, and giving the engineer a basic tool of his profession.
2. The teaching of analytical graphics as a power tool of intellectual attack on physical problems.
3. The teaching of the ability to observe and a sense of form and design,--the development of creative ability in the whole field of visual representation.

Since the publication of the Grinter Report in 1955, there have been a number of articles published which have developed and listed objectives of engineering graphics courses based upon and complying with the recommendations of the evaluating committee.

Objectives which meet the requirements of the Evaluation Report were discussed by Worsencroft,[1] along with some suggestions on how to attain these goals. The objectives offered by Worsencroft are as follows:

> . . . our first, and most important objective in the basic courses should be to develop the student's ability to (a) visualize spatially, and (b) apply this process in analyzing problems of engineering design.
>
> . . . . . .
>
> Our second objective, a corollary of the first and of equal importance, is to teach the student to translate his analysis of problems into the graphical terms of orthographic projection.
>
> . . . . . .
>
> . . . third objective . . . to teach him the fundamental elements of conventions, standards, and methods of dimensioning used in preparing drawings, so that he may present his ideas in acceptable form, or interpret ideas presented by others.
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> . . . . . .
>
> Our fourth objective and also fourth in order of importance in training engineers, is to train the student

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[1]R. R. Worsencroft, "Objectives of Engineering Drawing in Engineering Education," Journal of Engineering Drawing, XXI (February, 1957), pp. 32-33.

> in drawing techniques (including habits of neatness, thoroughness, and accuracy in both freehand and mechanical media) so that he can make engineering drawings of acceptable quality, or recognize such quality in drawings made under his supervision or his use.

Worsencroft[1] maintained that these objectives may not be new, but are changed perhaps in the order of importance and wording. Nonetheless, he believed they are still sound and legitimate objectives for a present day engineering graphics course.

Objectives and suggestions for means of attainment in relation to descriptive geometry courses complying with the Evaluation Report were discussed by Kliphardt.[2] They are enumerated as follows:

1. Emphasize spatial visualization
2. Provide experience in creative thinking
3. Increase ability to convey ideas by freehand sketching
4. Develop students' powers of analysis and synthesis
5. Promote competence in graphical recording and communication

The suggestions of the Evaluation Report were also expanded into more specific objectives by Hoelscher:[3]

1. Drawing must be a means of communication.
2. It must be a tool for analysis.
3. It must develop spatial visualization.
4. It should develop creativity.
5. It should develop skill in freehand sketching.

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[1] Ibid.

[2] Raymond A. Kliphardt, "Descriptive Geometry Courses Which Comply with the Evaluation Report," Journal of Engineering Drawing, XXI (February, 1957), p. 22.

[3] R. P. Hoelscher, "A Reappraisal of Engineering Drawing," Journal of Engineering Drawing, XIII (May, 1954), p. 12.

Other objectives, although not mentioned in the Evaluation Report, were deemed important by Hoelscher.[1] He felt the following items should also be included:

1. Developments of methods and habits of procedure which are essential to any engineer or executive . . .
2. Development of a technical or engineering vocabulary . . .
3. A rudimentary knowledge of what can and what cannot be economically done in the shop . . .

It may be seen from the foregoing list of objectives that there are many areas of agreement, although terminology may vary. There are some practices and objectives, however, where there is not complete agreement. One of these is the frequently cited objective of creativity. Rule,[2] for example, believed that engineering graphics is one of the most important areas for developing creative thought. Spencer,[3] on the other hand, believed that engineering graphics students, who are in the most part freshmen, cannot be expected to be creative in a strict sense, in that he does not have the basic tools necessary for creativity. He asserted, however, that engineering graphics may contribute toward developing creativity by developing the student's ability to express himself graphically and think in three dimensions. Grinter[4] agreed

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[1] Ibid.

[2] Rule, op. cit., p. 9.

[3] H. C. Spencer, "Basic Principles First," Journal of Engineering Education, XLVII (May, 1957), pp. 771-772.

[4] Grinter, op. cit., p. 25.

that engineering graphics courses are important in developing the tools which are necessary for creativity. He suggested that technical sketching develops hand-mind relationships necessary to engineering creativity.

Freehand sketching is not only important as a tool for creativity, but, according to Wellman,[1] it is a valuable tool used in the solution of problems, and in communicating ideas.

Another major area in which there is considerable disagreement is the area of graphical mathematics. Levens,[2] Paffenbarger,[3] Buck,[4] Heacock,[5] and others were of the opinion that the graphical mathematics area is of such importance as an analytical tool for the engineer that it should be included in the objectives and content of engineering graphics courses. Many others, including Spencer,[6] felt that the basic

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[1]Wellman, op. cit., p. 344.

[2]A. S. Levens, "Building Blocks of Engineering Education," Journal of Engineering Education, XLV (October, 1954), p. 155.

[3]Ralph S. Paffenbarger, "Course Development in Engineering Drawing to Meet the Needs of Present Day Engineering Education," Journal of Engineering Drawing, XVII (February, 1953), p. 28.

[4]Buck, op. cit., p. 46.

[5]Frank A. Heacock, "The Role of Graphics in Engineering Education," Journal of Engineering Education, XLIV (June, 1954), pp. 634-35.

[6]Spencer, "The New Look in Engineering Education," op. cit., p. 11.

engineering graphics courses contain a minimum of essentials and that the inclusion of the graphical mathematics area in these courses would mean either a watering down or an incomplete coverage of basic fundamentals. Spencer held that if the graphical areas are important, more time must be provided for them in the engineering curriculum by the addition of advanced courses.

Summary

The literature related to this study was reviewed and a limited amount of research was located. However, no study was found concerning the opinions of mechanical engineering educators as to the objectives and content of engineering graphics courses for undergraduate mechanical engineers. On the other hand, a number of articles were reviewed which expressed opinions concerning the objectives and content of engineering graphics courses. These articles revealed common areas of agreement with respect to objectives related to graphics as a means of communication, as a means of developing visualization, and as a means of translating problem analyses into terms of orthographic projection.

Areas of disagreement included the objective of creativity in engineering graphics courses. Disagreement in this area, however, centered upon whether creativity, as such, should be developed in the engineering graphics courses or whether the tools for creativity, such as freehand sketching

and visualization, should be developed.

Another area of disagreement concerned the inclusion of graphical mathematics in basic engineering graphics courses. Many felt that this graphical area was of major importance and should be included in basic engineering graphics courses. Those who disagreed felt that the graphical mathematics area was important, but that it should not displace other basic areas. If graphical mathematics, although not mentioned in the Grinter report, is of enough importance to be included in the engineering curriculum, they felt that additional time should be given for it in way of advanced courses.

CHAPTER III

ANALYSIS AND INTERPRETATION OF THE DATA

The mechanical engineering educators participating in this investigation expressed opinions on two aspects of required engineering graphics courses considered in the questionnaire. The first consisted of ranking in order of importance a list of objectives for required engineering graphics courses in the mechanical engineering curriculum. Objectives contained in the list which were felt to be unimportant for required courses were so indicated, and objectives which were felt important but not included on the list were added.

The opinions expressed concerning these objectives are shown in a series of tables. The number of responses to each objective, the percentage distribution of the rank orders, and the computed rank order are given in these tables for the total group and the classifications of this group. (See Appendix A.)

The second element to which the mechanical engineering educators responded concerned the content thought appropriate to engineering graphics courses in the mechanical engineering curriculum. The respondents expressed their

opinions on the content by checking a box which indicated the degree of emphasis which it was felt should be placed on each item of content. The respondents also could indicate items felt important to the mechanical engineering curriculum but which, in their opinion, should not be taught in the required engineering graphics courses. Space was provided for adding topics to the list, if an item was considered important but not included. A series of tables contains the opinions expressed concerning content of engineering graphics courses. These tables show the number of responses to each item of content, the percentage distribution of the opinions expressed concerning the emphasis to be placed on each item, the weighted average response, and the rank order with respect to the other items of content. (See Appendix B.)

A total population study was not practical or desirable for the purposes of this investigation. The participants in this study were selected mechanical engineering educators who had at least five years mechanical engineering teaching experience and who did not teach engineering graphics courses.

The chairmen of the mechanical engineering departments of the forty-six institutions accredited by the North Central Association and the Engineers' Council for Professional Development were asked to participate in the study and to recommend faculty representatives from the major areas in their Mechanical Engineering Department, such as thermo-

dynamics, heat transfer, machine design, and materials and processes, who would also participate in this investigation. Educators from forty-two of the institutions were recommended for participation in this study. (See Appendix C.)

In addition to this group, the chairman of the mechanical engineering department at the University of Denver indicated his institution would participate, but the mechanical engineering faculty also teaches the engineering graphics courses and, therefore, were not qualified to participate in this study.

A total of 186, including the chairmen of the mechanical engineering departments, were recommended to participate in the study and were sent questionnaires. Of these, 164 completed and returned the survey forms. Ten questionnaires were not usable because of the lack of qualifications of the respondent, return after the cut-off date, or unacceptable form in the checking of responses. The 154 usable returns represented 82.8 per cent of the total sent out.

The questionnaire contained a section on personal data which included the items of position, highest degree held, academic rank, teaching fields, teaching experience, and experience in industry. These classifications were studied in relation to the responses in order to determine the relationship between these factors and the opinions expressed on the questionnaire.

Table 1 indicated the number of participants and the

TABLE 1

PERCENTAGE DISTRIBUTION OF THE VARIOUS CLASSIFICATIONS OF RESPONDENTS

Classification	Number of Responses	Percentage
Total Educators	154	100
Position		
Head of Department	30	19
Teacher	124	81
Degree		
Bachelor	17	11
Master	99	64
Doctor	38	25
Rank		
Professor	65	42
Associate Professor	56	36
Assistant Professor	27	18
Instructor	6	4
Teaching fields		
Thermodynamics	59	38
Other M. E. fields	95	62
Teaching experience		
5-9 years	37	24
10-14 years	53	34
15-19 years	20	13
20 plus years	44	29
Experience in industry		
0 years	6	4
1 year	6	4
2-5 years	82	53
6 plus years	60	39

percentage in each of the categories studied. The population of this study included thirty department heads, which made up 19 per cent of the total, and one hundred twenty-four classroom teachers, which amounted to 81 per cent of the total. The highest degree held by 11 per cent of the participants was the bachelor's degree, whereas 64 per cent held the master's degree and 25 per cent, the doctor's degree.

The academic rank most frequently indicated was that of professor, consisting of 42 per cent of the total responses. The second most frequent was associate professor, which included 36 per cent of the responses, while assistant professors made up 18 per cent of the participants. The rank of instructor was indicated by only 4 per cent of the respondents, and this can be attributed to the fact that the participants were required to have at least five years teaching experience.

The teaching fields were classified for the purposes of this study into thermodynamics and a combination of the other mechanical engineering fields. This was done in order to determine whether the educators who teach thermodynamics, which is classified as an engineering science, had opinions significantly different from the other mechanical engineering educators in regard to the purposes and content of engineering graphics courses. The differences or lack of differences may be important because of the increasing emphasis on the engineering sciences in the engineering curricula.

It was revealed that 24 per cent of the participants had between five and nine years experience in teaching mechanical engineering subjects, 34 per cent had between ten and fourteen years experience, 13 per cent had between fifteen and nineteen years experience, and 29 per cent had twenty or more years experience in teaching.

The mechanical engineering experience in industry of the participants indicated that 4 per cent had no industrial experience, 4 per cent had one year of experience, 53 per cent had between two and five years of industrial experience, and 39 per cent indicated they had six or more years mechanical engineering experience in industry.

Responses Concerning the Relative Importance of Objectives

The opinions indicated on the objective of graphical solutions and computations for the development of skill in analyzing, solving and presenting problems involving engineering charts, graphs, and graphical mathematics, are shown in Table 2. (See Appendix A.)

A total of 150 of the participants responded to this objective. The average rank order was 3.74 which resulted in the computed rank order of 4. Although the responses were approximately the same from the total and individual groups, it may be noted that 17 per cent of the heads of the departments indicated that it should not be included as an objective. A higher percentage of those with the most teaching

experience and those with the most engineering experience in industry indicated that the objective should not be included than the respondents with fewer years of experience.

Table 3 (Appendix A) reveals the opinions on the objective of conventional practices for the development of ability in communicating and interpreting ideas by the use of standards and conventions as applied to working drawings.

The average rank order of 3.31 for the 149 opinions expressed on this objective resulted in the computed rank order of 2. There is very little variation between the responses of the classified groups and the total group.

The opinions expressed in Table 4 (Appendix A) on the objective of spatial visualization for the development of ability to visualize in three dimensions and to apply this process to engineering problems indicated a computed rank order of 1 with an average rank order of 2.42. A total of 148 responded to this objective. It may be noted that there is no variation in the computed rank order for any of the classifications listed or the total group. It may also be noted that no participant in this study indicated that this objective should not be included.

The opinions indicated on the objective of creativity for the development of creative ability in design and solution of graphical problems are shown in Table 5. (See Appendix A.) An average rank order of 4.74 resulted in a computed rank order of 6 for this objective. There was very

little variation of the average rank order indicated by the 148 responses of the total group or the separate classifications. It may be noted that a relatively high percentage indicated that this objective should not be included for the required engineering graphics courses. The exception to this was the small group with one or less years of experience in industry.

The objective of developing skill in drawing techniques in order to make or supervise the making of engineering drawings of acceptable form and quality was ranked number 5 by the 147 participants who responded to this objective. As shown in Table 6 (Appendix A), the average rank order was 4.50.

Table 7 (Appendix A) discloses the opinions on the objective of orthographic (orthogonal) projection for the development of ability to translate the analysis of engineering problems into terms of multiview drawing. The average rank order of 3.42 from the 147 opinions expressed by the participants resulted in a computed rank order of 3. There was very little variation between the opinions of the classfied groups and the total group.

There were very few objectives added to the list contained in the questionnaire. Of the additional objectives listed, one included the organization and supervision of drafting and design departments. Another added an objective of introduction to shop terms and processes, and three added

the development of skill in freehand sketching as an objective.

As may be noted in the tables, there was little variation of average weighted responses and rank order between the classified groups and the total group. It may be seen, however, that for most of the objectives there was a considerable variation within each classified group. The classifications used in this investigation did not seem to be associated with these differences of opinions.

Responses Concerning the Emphasis to be Placed on Items of Content

The data of the opinions expressed on the emphasis which should be placed on the items of content in engineering graphics courses appropriate to the mechanical engineering curriculum were given in tables eight through forty-one. (See Appendix B.) A computed rank order was calculated from the average weighted responses of the participants.

Table 8 presented the opinions expressed by mechanical engineering educators concerning the item of course content, lettering--pencil, technical lettering, single stroke Gothic, emphasizing legibility and rapidity. The weighted average of the 154 responses was 2.63 which would indicate the degree of emphasis to be placed upon lettering in engineering graphics courses between limited and moderate. The computed rank order showed this item of content was thirteenth in importance. Although there was little difference

in the average weighted responses, it is noted that the heads of departments, respondents with the higher degrees and greater experience, rated lettering slightly higher than most of the other classifications.

A limited amount of emphasis to be placed on the item of content, instruments and materials--selection, care, and use of common drafting instruments and materials, including pencil linework--was indicated in the opinions revealed in Table 9 (Appendix B). The weighted average response of 2.33 for the 154 participants resulted in the computed rank order of 21 for this objective of the 34 items of content included in this list.

The opinions of mechanical engineering educators on the emphasis to be placed upon applied geometry--geometrical construction as commonly used in the preparation of technical drawing--were given in Table 10 (Appendix B). The average rank order of 9 was computed from the weighted average response of 2.79 indicated by the 154 respondents. The degree of emphasis which these mechanical engineering educators felt should be placed on this item was between limited and moderate emphasis. It may be noted, however, that 13 per cent of the heads of the departments felt this item should not be included in the engineering graphics courses.

Table 11 (Appendix B) presented the opinions on orthographic projection--theory and methods of multiview projection. This item of content was ranked in number one position

of the 34 items of content included in the questionnaire. The 154 responses resulted in a weighted average response of 3.45 which indicated a degree of emphasis between moderate and major.

The rank order of 2 was computed for sketching--technical sketching by freehand representational drawings in orthographic, axonometric, oblique, or perspective projections--as noted in Table 12 (Appendix B). A weighted average response of 3.42 was computed from the opinions of the 154 participants. The degree of emphasis which they felt should be placed upon sketching in the engineering graphics courses was between moderate and major emphasis. It may be noted that several groups have a computed rank order of 1. The mechanical engineering educators from the field of thermodynamics were included among these.

In the opinions of the participants in this study axonometric projection--pictorial drawing by axonometric method including isometric drawing and projection--received between limited and moderate emphasis in an engineering graphics course. The weighted average response of the 153 educators indicated their opinions on this item of content which produced a calculated rank order of 16. This was shown in Table 13. (See Appendix B.)

Table 14 (Appendix B) disclosed the opinions expressed on oblique projection--pictorial drawing by oblique projection, including cavalier projection and cabinet

drawing. The weighted average of 2.15 was calculated from the 153 responses. This indicated a rank order of 26, with a limited amount of emphasis suggested for this topic.

The weighted average of 3.04 indicated a moderate amount of emphasis should be placed upon sectional views--conventional representations, full, half, broken, removed, revolved, and partial sections--in the opinions of the engineering educators as indicated in Table 15 (Appendix B). The average rank order computed from the 154 responses listed this item of content as being the sixth most important of the 34 items.

With the exception of the few participants with one year or no experience in industry and the classification of instructor, there was little variation in rank order between the total group and the classified groups.

Table 16 (Appendix B) presented the opinions of the 122 mechanical engineering educators who responded to the item of content, screw threads and fasteners--A.S.A. detailing symbols and noting of threads, threaded fasteners, keys and rivets. With the exception of the classification of instructor, there is little variation between the rank orders of the classified groups and the rank order of 25 computed for the total. The weighted average response of 2.20 indicated a limited emphasis should be placed upon this item of content in the engineering graphics courses. It may be noted, however, that 11 per cent of the total group indicated

that the topic should not be included in the engineering graphics courses and 2 per cent felt the topic should be included in courses other than engineering graphics.

The opinions of mechanical engineering educators on piping drawing--diagrammatic piping symbols, orthographic, developed and pictorial drawings--indicated that this topic should received limited emphasis, as revealed in Table 17. (See Appendix B.) The weighted average of the 154 responses was 1.78 which resulted in a rank order of 30 of a total of 34 rank orders assigned in this section. Over one-fourth of the respondents indicated that this item should not be included in the engineering graphics courses, and none of the classified groups ranked this item much higher than the total group.

Table 18 (Appendix B) disclosed the opinions concerning electrical diagrams--electrical symbols and circuity representation. A limited amount of emphasis was indicated with a weighted average of 1.65. The computed rank order for this topic was 32, and 43 per cent of the educators participating in this study felt that electrical diagrams should not be included in engineering graphics courses, or should be in courses other than engineering graphics.

The topic of reproduction processes--methods, materials, and advantages and disadvantages of common industrial drawing reproduction methods--with a rank order of 29 should receive a limited emphasis according to the weighted average

response of the opinions of the 154 mechanical engineering educators responding to this item. As presented in Table 19 (Appendix B), 30 per cent indicated that this topic should not be included. There was but slight variation in the rank orders computed for the classified groups and the total group.

The rank order of 31 was computed from the average weighted response of 1.73 for the item of welding drawing--types of weldments, A.S.A. symbols, applications to working drawings--as given in Table 20 (Appendix B). Of the 154 participants, 29 per cent indicated that this topic should not be included and 6 per cent felt it should be included in courses other than engineering graphics. The average emphasis indicated, however, was limited emphasis. There was little variation in the rank order of the classified groups with the rank order of 31 computed for the total group.

Table 21 (Appendix B) disclosed the opinions on the item of shop processes--methods of manufacture and their effect on drawing and dimensioning. The weighted average of the 154 responses resulted in a computed rank order of 27. Although the rank orders of the various classifications did not vary a great deal from the rank order of the total group, there was a wide variance of opinion within the groups. The heads of the departments, for example, indicated with a weighted average of 2.03 that a limited degree of emphasis should be placed on this topic. However, 10 per cent of

this group indicated major emphasis, 20 per cent indicated moderate emphasis, 20 per cent indicated it should not be included, and 17 per cent indicated it should be included in courses other than engineering graphics. The classifications used did not indicate any explanation for the wide distribution of opinions.

A moderate degree of emphasis was indicated for the topic of working drawings--drawings with complete instructional information as used in manufacture, construction, processing, etc. As shown in Table 22 (Appendix B), the weighted response of 154 participants was 2.78, with a computed rank order of 10. There was a considerable degree of variation between the rank orders computed for the classifications and the total. The participants holding a doctor's degree ranked this item as nineteenth, indicating a limited emphasis, whereas those holding bachelor's degrees ranked this item ninth, indicating moderate emphasis. Also, it may be noted that the participants with no engineering experience in industry ranked this item well below those who have engineering experience. It may be that because of the high utilitarian value of this item, the educators who gave low ranking to this topic probably teach the more theoretical subjects as indicated by the doctor's degree or had no practical experience in industry.

A rank order of 28 was computed from the average weighted response of 1.88 for the item, production illustra-

tion--application of pictorial drawing to industrial usage (as in exploded views, installation drawings, etc.). As indicated in Table 23 (Appendix B), many of the 154 respondents felt that this topic should not be included but that the average emphasis indicated was limited emphasis. The rank orders between the classified groups and the total group showed but slight variations.

Table 24 (Appendix B) revealed the opinions expressed concerning the item of content, original design--three-dimensional problems involving original solution and analysis. A rank order of 22 was computed from the weighted average of 2.32 which indicated that a limited emphasis should be placed upon this item. Over one-fifth of the engineering educators participating in this study felt that original design should not be included in engineering graphics courses or should be in courses other than engineering graphics. The rank orders computed did not show a great deal of variation between the classified groups and the total group with exception of those who had one year of experience in industry. Because of the small number in this category and the computed rank order of others in this classified group, it does not seem that experience in industry can be associated with this item of content.

The opinions of the mechanical engineering educators concerning inking--lettering and linework in ink tracing--indicate that it should not be included or receive limited

emphasis. As revealed in Table 25 (Appendix B), almost one-half the group felt that inking should not be included in engineering graphics courses in the mechanical engineering curriculum. A weighted average response of the opinions of the 154 participants was 1.61 which resulted in the computed rank order of 33 of the total of 34 items listed.

The opinions disclosed in Table 26 (Appendix B) concerned with charts and graphs--purposes, selection and drawing of charts and graphs in common engineering usage--indicate a degree of emphasis between limited and moderate should be placed upon this item of content. A rank order of 14.5 was computed from the weighted average response of 2.54 for the 154 participants. The moderate range of rank orders resulted for the various classifications, but no classification could be considered associated with the opinions.

Table 27 (Appendix B) disclosed the opinions of mechanical engineering educators concerning primary auxiliary views--projection methods for finding true size and shape of a slanting surface. A weighted average of 2.72 was determined from the 154 responses, which indicated that between a limited and moderate degree of emphasis should be placed on this topic. The rank order computed was 11 for the total group, with slight variation shown for the classifications. There did not seem to be an association between these factors and the opinions expressed.

The rank order of 5 was computed for the topic of

dimensioning--dimensioning, limit dimensioning, and noting detail drawings. As shown in Table 28 (Appendix B), the weighted average response of 306 for the 153 opinions expressed on this topic indicated a moderate degree of emphasis should be placed on dimensioning in engineering graphics courses for mechanical engineers. With few exceptions, there was little difference between the computed rank orders of the classifications and that of the total group. No specific association could be made between the classifications and the opinions expressed on this topic.

The opinions disclosed in Table 29 (Appendix B) indicated that cams and gears--detailing and layout of cams and gears--ranked last out of 34 items. A weighted average response of 1.57 was computed from the 154 responses. There was very little variation between the rank order computed for the individual classifications and the total group. It may be noted that 55 per cent of the total group believed that this topic should not be included in engineering graphics courses or is important in the mechanical engineering curriculum but should be taught in other courses.

Table 30 (Appendix B) indicated the opinions on simplified drafting procedures--new materials, processes, and methods of simplifying industrial drawings (as use of templates, overlays, simplification of views, etc.). With a computed rank order of 24, and a weighted average response of 2.25, the degree of emphasis which chould be placed upon

this item, according to the average response of the 154 engineering educators, is a limited emphasis. The opinions of 19 per cent of the total group were in the category of not including this item in engineering graphics courses.

Successive auxiliary views--edge views, true sizes and shapes of oblique planes--received a weighted average response of 3.20 which indicated a moderate degree of emphasis should be placed upon this topic. A total of 151 responded to this item. The computed rank order, as given in Table 31 (Appendix B), was 4. There did not appear to be an association between the classifications and the opinions expressed on this item.

The opinions of mechanical engineering educators concerning the emphasis to be placed on perspective drawing--pictorial drawing by perspective projection--is given in Table 32 (Appendix B). The weighted average response of 2.29 calculated from the 151 responses resulted in a computed rank order of 23. There did not seem to be an association between the expressed opinions and classifications. The amount of emphasis indicated by all the groups and the total group was between limited and moderate emphasis.

Table 33 (Appendix B) revealed the opinions on the amount of emphasis to be placed on point, line and plane relationships--spatial relationships of points, lines and planes, including parallelism, perpendicularity, intersection, true length, size, shape, and angles by change of

position method. A rank order of 3 was computed from the weighted average response of the 151 opinions expressed on this item. The amount of emphasis indicated was between moderate and major, with 59 per cent of the total group indicating major emphasis. There was little variation between the rank orders computed for the classifications and the total group.

A moderate emphasis should be placed on revolution --solution of point, line and plane problems by method of revolution about an axis--according to the opinions displayed in Table 34 (Appendix B). The rank order of 7 was computed from the average weighted response of 2.97 for the 151 expressed opinions. No association was indicated between the classified groups and the total group.

The opinions expressed in Table 35 (Appendix B), concerning the emphasis to be placed on curved lines and surfaces--classification and development of surfaces and tangents--resulted in a weighted average response of 2.65 for 151 responses. The opinions indicated an emphasis between limited and moderate, with a rank order of 12 computed for this topic. Although there is some variation in the rank orders computed for the classifications and that of the total, there did not appear to be a strong association between the classifications and the expressed opinions.

A moderate emphasis on the topic of intersection of surfaces--methods of plotting the intersections of surfaces--

is indicated by the opinions found in Table 36. (See Appendix B.) A weighted average response of 2.94 for the 151 expressed opinions determined a computed rank order of 8 for this item. The variation of computed rank orders were not large enough or did not exist in a pattern which suggested association between the classifications and the expressed opinions.

Table 37 revealed the opinions of mechanical engineering educators on the emphasis which should be placed on empirical curves--determining constants by graphical means, in engineering graphics courses in the mechanical engineering curriculum. The weighted average response calculated from the 152 opinions was 2.46. This indicated that the emphasis on this topic should be between limited and moderate. The rank order of 18 was computed for this topic. An examination of the data revealed that 13 per cent believed empirical curves should not be included.

The opinions expressed as to the amount of emphasis which should be placed on functional scales--theory and development of functional graphic scales--is shown in Table 38 (Appendix B). The weighted average computed from the 151 responses resulted in the calculated rank order of 20. Although 13 per cent indicated this topic should not be included in engineering graphics courses and another 9 per cent indicated that functional scales are important in the mechanical engineering curriculum but should be taught in courses other than engineering graphics courses, 78 per cent

indicated functional scales should be included in these courses. Of those who expressed the opinion that functional scales should be included, most felt a moderate degree of emphasis should be placed upon this item. For the entire group, the weighted average response of 2.41 suggested a limited to moderate emphasis.

Table 39 (Appendix B) disclosed the opinions on the emphasis which the mechanical engineering educators participating in this study felt should be placed on nomographs--theory and development of alignment charts for solution of recurring equation of three or more variables. The rank order of 19 was computed from the weighted average of 2.43. Of the total, 74 per cent indicated that nomographs should be included in engineering graphics courses. The computed rank order of the classifications indicated that some of these classifications may have an association with the expressed opinions, although to a very slight degree. It may be noted that the heads of the departments, those with the highest degrees, those with the highest rank, those with the most teaching experience, and those with the most engineering experience in industry had lower computed rank orders for this item than others in their classification. On the other hand, educators from the field of thermodynamics had a computed rank order for nomographs higher than those of the other mechanical engineering fields and of the total group.

Table 40 (Appendix B) indicated the opinions expressed concerning the emphasis to be placed upon graphical calculus--determination of rates or changes from empirical data by graphical means--in engineering graphics courses in the mechanical engineering curriculum. The weighted average response calculated from the 152 expressed opinions resulted in the computed rank order of 14.5. The degree of emphasis indicated by the responses was limited or moderate emphasis, as reflected by the weighted average response of 2.54. From the total responses, 77 per cent indicated that graphical calculus should be included in engineering graphics courses for mechanical engineers, whereas 13 per cent felt that it should not be included, and 11 per cent believed that it was important and should be taught in courses other than engineering graphics courses. There was some variation in computed rank orders, but there did not appear to be an association between the expressed opinions and the various classifications.

The opinions of mechanical engineering educators concerning the emphasis to be placed on vectors--basic fundamentals of coplanar and non-coplanar vector systems--were indicated in Table 41. (See Appendix B.) The weighted average response of 2.48 indicated a moderate to limited degree of emphasis should be placed upon this topic in engineering graphics courses. The rank order for this item was computed to be 17. From the total of 152 participating

educators, 71 per cent indicated that vectors should be taught in engineering graphics courses, 16 per cent felt it should not be included, and 13 per cent indicated it was important but should be taught in courses other than engineering graphics. There were a number of deviations from the computed rank order of the total group, but with the exception of the category of rank, these variations were either not very large or did not follow an observable pattern. The computed rank orders for the classifications of academic rank indicated that the higher the rank of the educators, the lower the computed rank order.

Summary

The data of this study were presented in the preceding tables which indicate the opinions of the 154 participating mechanical engineering educators. These participants were asked to rank six objectives in order of importance, and to rate thirty-four items of content as to the amount of emphasis they felt should be placed upon these items in an engineering graphics course appropriate to the mechanical engineering curriculum.

The opinions were classified according to the position, highest degree held, academic rank, teaching fields, years of teaching experience, and years of mechanical engineering experience in industry of the participants in order to determine if there was a relationship between the expressed opinions and any of these factors.

The differences of opinion between the classified groups were so slight or inconsistent that a conclusive relationship between the classifications of the participants and the opinions expressed could not be made.

A summary of the results of the total group responding concerning the objectives of engineering graphics courses is shown in Table 42. The objectives are listed in the computed rank order. The average rank order is also indicated in this table.

TABLE 42

SUMMARY OF OPINIONS CONCERNING THE OBJECTIVES

Computed Rank Order	Objective	Average Rank Order
1	Spatial visualization	2.36
2	Conventional practices	3.31
3	Orthographic projection	3.42
4	Graphical solutions and computations	3.75
5	Drawing techniques	4.50
6	Creativity	4.74

The objectives listed in the computed rank order are as follows:

1. Spatial visualization--To develop ability to visualize in three dimensions and to apply this process to engineering problems.

2. Conventional practices--To develop ability in the use of standards and conventions as applied to working drawings for the purpose of communicating and interpreting ideas.

3. Orthographic (orthogonal) projection--To develop ability to translate the analysis of engineering problems into terms of multiview drawing.

4. Graphical solution and computations--To develop skill in analyzing, solving and presenting problems involving engineering charts, graphs, and graphical mathematics.

5. Drawing techniques--To develop skill in drawing techniques in order to make or supervise the making of engineering drawings of acceptable form and quality.

6. Creativity--To develop creative ability in design and solution of graphical problems.

A summary of the results of the total participating group concerned with the emphasis to be placed upon the items of content in engineering graphics courses for mechanical engineers is given in Table 43. The items of content are listed in the computed rank order. The weighted average response for each of the items of content is also indicated on this table.

The items of content listed in the computed rank order are as follows:

1. Orthographic projection--Theory and methods of multiview projection.

2. Sketching--Technical sketching by freehand representational drawings in orthographic, axonometric, oblique, or perspective projection.

3. Point, line and plane relationships--Spatial relationships of points, lines, and planes, including parallelism, perpendicularity, intersection, true length, size, shape, and angles by change of position method.

4. Successive auxiliary views--Edge views, true sizes and shapes of oblique planes.

TABLE 43

SUMMARY OF THE OPINIONS CONCERNING ITEMS OF CONTENT

Rank Order	Item of Content	Weighted Average
1	Orthographic projection	3.45
2	Sketching	3.42
3	Point, line and plane relationships	3.40
4	Successive auxiliary views	3.20
5	Dimensioning	3.06
6	Sectional views	3.04
7	Revolution	2.97
8	Intersection of surfaces	2.94
9	Applied geometry	2.79
10	Working drawings	2.78
11	Primary auxiliary views	2.72
12	Curved lines and surfaces	2.65
13	Lettering	2.63
14.5	Graphical calculus	2.54
14.5	Charts and graphs	2.54
16	Axonometric projection	2.50
17	Vectors	2.48
18	Empirical curves	2.46
19	Nomographs	2.43
20	Functional scales	2.41
21	Instruments and materials	2.33
22	Original design	2.32
23	Perspective drawing	2.29
24	Simplified drafting procedures	2.25
25	Screw threads and fasteners	2.20
26	Oblique projection	2.15
27	Shop processes	1.97
28	Production illustration	1.88
29	Reproduction processes	1.80
30	Piping drawing	1.78
31	Welding drawing	1.73
32	Electrical diagrams	1.65
33	Inking	1.61
34	Cams and gears	1.57

5. Dimensioning--Dimensioning, limit dimensioning, and noting detail drawings.

6. Sectional views--Conventional representations, full, half, broken, removed, revolved, and partial sections.

7. Revolution--Solution of point, line and plane problems by method of revolution about an axis.

8. Intersection of surfaces--Methods of plotting the intersections of surfaces.

9. Applied geometry--Geometrical construction as commonly used in the preparation of technical drawing.

10. Working drawings--Drawings with complete instructional information as used in manufacture, construction, processing, etc.

11. Primary auxiliary views--Projection methods for finding true size and shape of a slanting surface.

12. Curved lines and surfaces--Classification and development of surfaces and tangents.

13. Lettering--Pencil, technical lettering, single stroke Gothic, emphasizing legibility and rapidity.

14.5 Graphical calculus--Determination of rates or changes from empirical data by graphical means.

14.5 Charts and graphs--Purposes, selection, and drawing of charts and graphs in common engineering usage.

16. Axonometric projection--Pictorial drawing by axonometric method including isometric drawing and projection.

17. Vectors--Basic fundamentals of coplanar and non-coplanar vector systems.

18. Empirical curves--Determining constants by graphical means.

19. Nomographs--Theory and development of alignment charts for solution of recurring equation of three or more variables.

20. Functional scales--Theory and Development of functional graphic scales.

21. Instruments and materials--Selection, care, and use of common drafting instruments and materials, including pencil linework.

22. Original design--Three-dimensional problems involving original solution and analysis.

23. Perspective drawing--Pictorial drawing by perspective projection.

24. Simplified drafting procedures--New materials, processes, and methods of simplifying industrial drawings (as use of templates, overlays, simplification of views, etc.)

25. Screw threads and fasteners--A.S.A. detailing symbols and noting of threads, threaded fasteners, keys and rivets.

26. Oblique projection--Pictorial drawing by oblique projection, including cavalier projection and cabinet drawing.

27. Shop processes--Methods of manufacture and their effect on drawing and dimensioning.

28. Production illustration--Application of pictorial drawing to industrial usage (as in exploded views, installation drawings, etc.).

29. Reproduction processes--Methods, materials, and advantages and disadvantages of common industrial drawing reproduction methods.

30. Piping drawing--Diagrammatic piping symbols, orthographic, developed and pictorial drawings.

31. Welding drawing--Types of weldments, A.S.A. symbols, applications to working drawings.

32. Electrical diagrams--Electrical symbols and circuity representation.

33. Inking--Lettering and linework in ink tracing.

34. Cams and gears--Detailing and layout of cams and gears.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The problem considered in this study was: What are the opinions of mechanical engineering educators concerning the purposes and content of engineering graphics courses appropriate to the undergraduate mechanical engineering curriculum?

Specifically, this study was concerned with the implications of these opinions and certain factors associated with these opinions for the development and improvement of undergraduate engineering graphics courses and the undergraduate engineering curriculum.

The survey method was used for this study and the following procedures were used to gather the data and analyze it for implications. The heads of the mechanical engineering departments of the forty-six institutions accredited by the North Central Association which have mechanical engineering departments accredited by the Engineers' Council for Professional Development were asked to participate in this study and recommend faculty representatives from the major areas

in their mechanical engineering departments. The qualifications established were at least five years teaching experience and not teach engineering graphics subjects. The heads of the departments from forty-two institutions cooperating with this study recommended 187 mechanical engineering educators. A questionnaire was sent to this group which resulted in 122 usable returns. A percentage distribution of the opinions was made and the average weighted response was calculated after weights were applied. The average computed rank order was determined for the objectives and the items of content.

The major findings disclosed by the data in this study were as follows:

1. The objectives of spatial visualization, conventional practices, and orthographic (orthogonal) projection ranked higher than the objectives of graphical solutions and computations, drawing techniques and creativity.

2. There was a considerable range of opinions concerning the objectives.

3. There were but slight differences between the opinions of the classified groups and the total group.

4. The opinions concerning course content showed a high degree of consistency with the opinions on the objectives.

5. With the exception of freehand drawing, the skills listed in the content were rated lower than the

contents on the theory of orthographic projection.

6. The objective of creativity and the content item of original design were ranked very low by these engineering educators.

7. The opinions indicated that the area of graphical mathematics including empirical curves, functional scales, nomographs, graphical calculus, and vectors warranted inclusion in the engineering graphics courses, although with a degree of emphasis between limited and moderate.

8. The opinions indicated that a moderate degree of emphasis should be placed upon conventional practices as found in sectional views, working drawings, and dimensioning.

9. It was indicated that the topics of charts and graphs should have between a moderate and limited emphasis.

10. The topics covered in the area of descriptive geometry were ranked relatively high, with the opinion that a moderate degree of emphasis should be placed upon them.

Conclusions

The implications for the development and improvement of required undergraduate engineering graphics courses and the undergraduate engineering curriculum are based upon the data supplied by the mechanical engineering educators participating in this study. The data and findings may be limited to a group similarly selected, but opinions of these experi-

enced mechanical engineering educators should prove to be of value as one of the facets for determining appropriate engineering graphics courses. The conclusions were as follows:

1. The opinions expressed by the participants in this investigation indicate that the fundamental concepts in engineering graphics courses should not be changed. The emphasis should remain on the development of spatial visualization and the ability to translate the analysis of engineering problems into terms of multiview drawing.

2. In the opinions of the participants, engineering graphics courses should develop ability, also, in the use of graphical representation for the purpose of communicating ideas. This was indicated by the emphasis placed upon conventional practices and freehand sketching.

3. The mechanical engineering educators revealed that creativity had a relatively small place in the required engineering graphics courses. It may be, as pointed out earlier in this investigation, that the role played by engineering graphics courses in the development of creativity in engineering students is to furnish basic skills necessary for creativity.

4. Although creativity, as such, was rated very low, one of the skills necessary to creativity was indicated to be important in engineering graphics courses. This was the development of ability in freehand sketching, which was emphasized over all other skills by the participants of this

investigation.

5. An important implication in the development of the mechanical engineering curriculum and engineering graphics courses is that in the opinion of over three-fourths of the participants the area of graphical mathematics should be included in the required engineering graphics courses. Although it was clear from the computed rank orders that these educators felt this material should not replace any of the fundamental concepts in engineering graphics courses, it was indicated that empirical curves, functional scales, nomographs, graphical calculus, and vectors should be included with at least a limited to moderate emphasis.

6. The items of content which were devoted to the development of drafting skills were not rated as being of primary importance but were indicated as being worthy of limited to moderate emphasis.

7. From the limited range of weighted average responses it may be that one of the more important aspects of engineering graphics courses appropriate to mechanical engineering students is the matter of balance, inasmuch as a number of the items of content were indicated as being of moderate importance.

8. Of importance in the curriculum planning of engineering graphics departments may be the fact that few of the topics which were rated high by the mechanical engineering educators were limited to use in mechanical engineering

but are probably of importance to all engineers.

9. According to the opinions of the selected mechanical engineering educators, engineering graphics courses appropriate to the mechanical engineering curriculum should emphasize the fundamentals of visualization, communication, and orthographic projection, emphasize skill in freehand sketching over the skills with instruments, include the area of graphical mathematics, provide the skills necessary for creativity, and maintain a balance between the items of content in the courses.

Recommendations

The results of this study should be of value to mechanical engineering and graphics departments contemplating curriculum revision. It is recommended that consideration of the findings of this investigation be used as one of the major factors for consideration in the revision of the mechanical engineering curriculum. A balanced program containing selected items from the technical drawing, descriptive geometry, and graphical mathematics areas is recommended as follows:

1. Descriptive geometry, whether organized as a separate course, or as part of an integrated program, should be given major consideration. The most important of the graphics objectives, the development of spatial visualization, can best be developed in this curriculum area. The

topics which should receive major treatment are orthographic projection, point, line and plane relationships, auxiliary views, revolution, and intersection of surfaces. Curved lines and surfaces may also be treated, but perspective drawing should be included only if time permits.

2. In the technical drawing area it is recommended that major emphasis be placed on the development of graphical communication skills. Items which develop ability in the use of standards and conventions should be included. The major topics are the study of working drawings, dimensioning, sectional views, and charts and graphs. The items of orthographic projection and auxiliary views may be included in technical drawing, descriptive geometry, or both, depending upon organization and sequence of the courses.

Manual skills should be developed, also, in technical drawing, with the major emphasis on freehand drawing. Technical sketching which includes both orthographic and pictorial drawing is an important tool in the development of spatial visualization, creative engineering, and industrial communication. The topic of lettering should be included, but not emphasized to as great a degree as technical sketching.

The development of drafting skills should come about incidentally with the development of other topics, rather than being emphasized for its own merit. Applied geometry is a major topic which also develops skill in the use of instru-

ments.

Pictorial representation should be limited to isometric drawings and should not include other axonometric projections.

The study of screw threads and shop processes should be limited to information necessary for the understanding of dimensioning and working drawings.

Reproduction processes and other minor topics which are not time consuming may be included, also.

3. It is recommended that the area of graphical mathematics be included in required engineering graphics courses. Graphical mathematics should not replace or diminish the emphasis placed on basic content in the technical drawing or descriptive geometry areas. However, graphical mathematics should take precedence over many of the items frequently included in the drawing curriculum. If course content has already been reduced to the minimum essentials, it is recommended that time be provided for this area.

Two of the items, graphical calculus and vectors, should be considered essential to a balanced program, and empirical curves, functional scales, and nomographs would be useful tools for the engineer.

It was not within the province of this study to determine the most appropriate organizational arrangement for the provision of engineering graphics experiences. Rather, the responsibility was to develop recommendations concerning

the most appropriate engineering graphics content for the preparation of mechanical engineers. Whether these experiences shall be provided within the framework of several separate courses or whether they should be provided within integrated arrangements is a matter for the individual engineering programs to determine.

It is therefore recommended that a balanced program of engineering graphics for mechanical engineers provide, as a minimum, the following items of content:

Descriptive Geometry Area

- Orthographic projection
- Auxiliary views
- Point, line and plane relationships
- Intersection of surfaces
- Revolution

Technical Drawing Area

- Freehand sketching
- Sectional views
- Working drawings
- Applied geometry
- Lettering
- Isometric drawing
- Charts and graphs

Graphical Mathematics Area

- Graphical calculus
- Vectors

Further recommendations are made concerning research needed for a more complete analysis of engineering graphics courses in the engineering curricula:

1. A further study of the opinions of a similar group of mechanical engineering educators using the interview method. A study of this type would be valuable in verifying

the data of this study.

2. A study of the opinions of engineering educators from all of the degree granting departments. The similarities and differences of opinions would be important in the planning of engineering graphics courses common to the curricula of these fields.

3. A study of the opinions of engineering graphics educators. The differences and similarities of the opinions of the engineering graphics educators and the engineering educators of the degree granting departments would be of value in curriculum planning.

4. A study to determine the time necessary to accomplish the objectives and include the content suggested in this study. The time allotted to engineering graphics courses in the engineering curriculum has, in many cases, been reduced in recent years. A study of this nature would provide information necessary to make judgments concerning the content that can be included in a given time or the amount of time needed for a given content and emphasis.

5. A study of the opinions of engineers and employers of engineers in order to determine objectives and content based on engineering needs.

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APPENDIX A

TABLES CONCERNING THE RELATIVE IMPORTANCE OF OBJECTIVES

TABLE 2

OPINIONS CONCERNING IMPORTANCE OF GRAPHICAL SOLUTIONS AND COMPUTATIONS

Classification	No. of Responses	Percentage Distribution of Rank Order								Average	Rank Order
		1	2	3	4	5	6	7	8		
Total Educators	150	13	15	17	24	18	4	1	8	3.75	4
Position											
Head of Department	30	14	13	20	23	13	0	0	17	3.93	4
Teacher	120	12	15	17	24	19	5	2	6	3.76	4
Degree											
Bachelor's	17	11	24	24	11	18	6	6	0	3.43	2
Master's	95	10	13	18	26	19	3	1	10	3.94	4
Doctor's	38	18	15	13	26	16	6	0	6	3.55	3
Rank											
Professor	63	11	13	14	25	19	3	2	13	4.10	4
Assoc. Professor	54	17	15	20	22	13	7	0	6	3.50	4
Asst. Professor	27	10	19	22	22	19	0	4	4	3.57	3
Instructor	6	0	17	0	33	50	0	0	0	4.16	5
Teaching fields											
Thermodynamics	57	11	23	21	21	18	3	0	3	3.36	2
Other M. E. fields	93	14	10	15	26	18	4	2	11	3.99	4
Teaching experience											
5-9 years	36	16	14	16	28	14	6	3	3	3.55	4
10-14 years	53	15	15	19	23	17	4	0	7	3.59	4
15-19 years	19	11	16	26	26	16	0	0	5	3.45	2
20 plus years	42	7	15	12	21	24	4	2	15	4.35	4
Experience in industry											
0 years	6	17	50	0	0	33	0	0	0	2.82	2
1 year	6	17	0	33	0	50	0	0	0	3.66	4
2-5 years	81	17	14	17	23	18	6	0	5	3.54	4
6 plus years	57	4	14	18	30	14	2	4	14	4.28	4

TABLE 3

OPINIONS CONCERNING IMPORTANCE
OF CONVENTIONAL PRACTICES

Classification	No. of Responses	Percentage Distribution of Rank Order								Average	Rank Order
		1	2	3	4	5	6	7	8		
Total Educators	149	23	13	19	17	17	8	0	3	3.31	2
Position											
Head of Department	30	37	10	23	10	13	7	0	0	2.73	2
Teacher	119	20	14	19	18	17	8	0	4	3.42	2
Degree											
Bachelor's	17	30	0	18	29	6	11	0	6	3.44	3
Master's	94	22	15	19	18	18	5	0	3	3.25	2
Doctor's	38	26	15	22	6	15	13	0	3	3.23	2
Rank											
Professor	63	28	14	17	14	14	10	0	3	3.17	2
Assoc. Professor	53	23	11	19	16	19	8	0	4	3.41	3
Asst. Professor	27	15	15	22	22	19	3	0	4	3.44	2
Instructor	6	33	17	33	0	0	17	0	0	2.68	2
Teaching fields											
Thermodynamics	57	26	11	18	16	12	12	0	5	3.38	3
Other M. E. fields	92	23	15	21	16	18	5	0	2	3.16	2
Teaching experience											
5-9 years	36	25	14	19	8	25	9	0	0	3.21	3
10-14 years	52	17	15	23	21	12	8	0	4	3.40	2
15-19 years	19	16	11	11	21	21	15	0	5	3.90	3
20 plus years	42	34	12	19	15	12	4	0	4	2.91	2
Experience in industry											
0 years	6	33	0	33	0	17	17	0	0	3.19	3
1 year	6	17	17	0	33	0	33	0	0	3.81	5
2-5 years	80	25	13	25	11	16	5	0	5	3.20	2
6 plus years	57	21	16	12	23	18	8	0	2	3.35	2

TABLE 4

OPINIONS CONCERNING IMPORTANCE
OF SPATIAL VISUALIZATION

Classification	No. of Responses	Percentage Distribution of Rank Order								Average	Rank Order
		1	2	3	4	5	6	7	8		
Total Educators	148	30	29	22	14	4	1	0	0	2.36	1
Position											
Head of Department	30	23	40	17	20	0	0	0	0	2.34	1
Teacher	118	32	27	23	12	5	1	0	0	2.34	1
Degree											
Bachelor's	16	25	25	19	19	12	0	0	0	2.68	1
Master's	94	33	31	20	14	1	1	0	0	2.22	1
Doctor's	38	26	29	26	12	7	0	0	0	2.45	1
Rank											
Professor	62	31	31	21	15	2	0	0	0	2.26	1
Assoc. Professor	53	30	32	23	9	4	2	0	0	2.31	1
Asst. Professor	27	30	22	26	14	8	0	0	0	2.48	1
Instructor	6	34	33	0	33	0	0	0	0	2.32	1
Teaching fields											
Thermodynamics	57	36	30	19	12	3	0	0	0	2.16	1
Other M. E. fields	91	27	30	23	15	4	1	0	0	2.42	1
Teaching experience											
5-9 years	36	22	30	22	14	9	3	0	0	2.67	1
10-14 years	52	29	30	26	13	2	0	0	0	2.29	1
15-19 years	19	53	42	0	0	5	0	0	0	1.62	1
20 plus years	41	29	22	27	20	2	0	0	0	2.44	1
Experience in industry											
0 years	6	50	17	33	0	0	0	0	0	1.83	1
1 year	6	33	17	17	33	0	0	0	0	2.50	1
2-5 years	80	26	37	19	14	4	0	0	0	2.33	1
6 plus years	56	34	21	25	13	5	2	0	0	2.40	1

TABLE 5

OPINIONS CONCERNING IMPORTANCE OF CREATIVITY

Classification	No. of Responses	Percentage Distribution of Rank Order								Average	Rank Order
		1	2	3	4	5	6	7	8		
Total Educators	148	9	9	13	12	15	25	1	16	4.74	6
Position											
Head of Department	30	7	10	13	13	17	20	0	20	4.83	5
Teacher	118	9	8	13	12	14	27	1	16	4.79	6
Degree											
Bachelor's	16	12	12	20	12	12	20	0	12	4.20	5
Master's	94	7	9	13	9	15	29	1	17	4.92	6
Doctor's	38	11	7	12	18	15	22	0	15	4.60	5
Rank											
Professor	62	11	11	15	11	16	19	0	17	4.52	5
Assoc. Professor	53	6	4	9	17	17	30	2	15	5.08	6
Asst. Professor	27	7	10	22	7	10	22	0	22	4.79	6
Instructor	6	17	17	0	0	0	66	0	0	4.47	6
Teaching fields											
Thermodynamics	57	14	11	7	14	19	21	0	14	4.46	5
Other M. E. fields	91	6	8	16	10	12	29	1	18	4.95	6
Teaching experience											
5-9 years	36	3	9	17	14	13	22	0	22	5.01	6
10-14 years	52	16	2	12	13	13	29	2	13	4.65	6
15-19 years	19	11	16	16	11	25	16	0	5	3.96	4
20 plus years	41	4	15	10	10	12	29	0	20	4.88	6
Experience in industry											
0 years	6	0	17	0	33	17	33	0	0	4.49	5
1 year	6	0	0	17	17	0	66	0	0	5.15	6
2-5 years	80	8	6	13	10	17	28	1	17	4.95	6
6 plus years	56	12	12	16	12	12	18	0	18	4.44	5

TABLE 6

OPINIONS CONCERNING IMPORTANCE OF DRAWING TECHNIQUES

Classification	No. of Responses	Percentage Distribution of Rank Order								Average	Rank Order
		1	2	3	4	5	6	7	8		
Total Educators	147	10	10	11	13	24	20	1	11	4.50	5
Position											
Head of Department	30	7	3	13	7	30	30	0	10	4.90	6
Teacher	117	9	12	10	15	22	18	2	12	4.51	5
Degree											
Bachelor's	16	12	13	12	12	25	13	0	13	4.29	6
Master's	93	9	9	12	14	23	22	0	11	4.54	5
Doctor's	38	5	11	7	11	29	22	5	10	4.84	6
Rank											
Professor	62	8	5	13	11	26	24	2	11	4.77	6
Assoc. Professor	52	12	8	8	19	27	19	2	5	4.31	5
Asst. Professor	27	7	26	7	4	19	15	0	22	4.57	5
Instructor	6	0	17	32	17	17	17	0	0	3.85	4
Teaching fields											
Thermodynamics	56	9	11	9	12	23	27	2	7	4.53	6
Other M. E. fields	91	9	10	12	13	25	17	1	13	4.55	5
Teaching experience											
5-9 years	36	8	14	8	9	19	25	0	17	4.77	5
10-14 years	51	8	14	6	14	33	20	2	3	4.33	5
15-19 years	19	0	0	26	21	26	16	0	11	4.76	6
20 plus years	41	15	7	12	12	17	20	2	15	4.52	5
Experience in industry											
0 years	6	0	0	0	33	17	50	0	0	5.17	6
1 year	6	33	17	0	17	33	0	0	0	3.00	3
2-5 years	79	9	9	11	16	25	19	0	11	4.51	5
6 plus years	56	8	12	16	5	23	21	4	11	4.57	6

TABLE 7

OPINIONS CONCERNING IMPORTANCE
OF ORTHOGRAPHIC PROJECTION

Classification	No. of Responses	Percentage Distribution of Rank Order								Average	Rank Order
		1	2	3	4	5	6	7	8		
Total Educators	147	16	22	18	18	10	11	0	5	3.42	3
Position											
Head of Department	30	20	17	13	23	7	13	0	7	3.54	3
Teacher	117	15	22	20	17	9	12	0	5	3.44	3
Degree											
Bachelor's	16	13	25	12	13	12	25	0	0	3.61	4
Master's	93	17	23	18	18	10	9	0	5	3.33	3
Doctor's	38	13	18	22	22	5	13	0	7	3.62	4
Rank											
Professor	62	16	26	18	16	3	15	0	6	3.39	3
Assoc. Professor	52	10	27	23	15	12	10	0	3	3.37	2
Asst. Professor	27	27	7	7	30	11	11	0	7	3.59	4
Instructor	6	17	0	33	17	33	0	0	0	3.49	3
Teaching fields											
Thermodynamics	56	5	16	27	20	13	14	0	5	3.87	4
Other M. E. fields	91	22	25	13	18	7	10	0	5	3.18	3
Teaching experience											
5-9 years	36	25	14	19	28	8	3	0	3	3.04	2
10-14 years	51	15	20	15	18	14	14	0	4	3.58	3
15-19 years	19	11	16	21	20	0	21	0	11	4.00	5
20 plus years	41	10	34	20	10	7	12	0	7	3.41	3
Experience in industry											
0 years	6	0	17	33	33	17	0	0	0	3.50	4
1 year	6	17	33	33	0	17	0	0	0	2.67	2
2-5 years	79	15	20	16	22	10	13	0	4	3.51	3
6 plus years	56	18	23	18	16	5	11	0	9	3.45	3

APPENDIX B

TABLES CONCERNING THE EMPHASIS TO BE PLACED ON ITEMS OF COURSE CONTENT

TABLE 8

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON LETTERING

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	0	3	40	48	9	2.63	13
Position								
Head of Department	30	0	0	43	47	10	2.67	9
Teacher	124	0	4	40	48	8	2.60	13
Degree								
Bachelor's	17	0	0	35	47	18	2.83	13
Master's	99	0	5	40	47	8	2.58	13
Doctor's	38	0	0	42	50	8	2.66	11.5
Rank								
Professor	65	0	0	43	49	8	2.65	11
Assoc. Professor	56	0	5	34	52	9	2.65	12.5
Asst. Professor	27	0	4	48	37	11	2.55	20
Instructor	6	0	17	33	33	17	2.50	24.5
Teaching fields								
Thermodynamics	59	0	7	41	42	10	2.55	15.5
Other M. E. fields	95	0	1	40	51	8	2.66	13
Teaching experience								
5-9 years	37	0	8	46	32	14	2.52	21
10-14 years	53	0	4	32	55	9	2.69	11
15-19 years	20	0	0	50	50	0	2.50	15
20 plus years	44	0	0	41	50	9	2.68	10.5
Experience in industry								
0 years	6	0	0	50	50	0	2.50	19
1 year	6	0	0	17	66	17	3.00	12
2-5 years	82	0	3	38	49	10	2.66	11
6 plus years	60	0	3	45	44	8	2.57	13

TABLE 9

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON INSTRUMENTS AND MATERIALS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics Should not be Included (0)	(1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	0	6	59	31	4	2.33	21
Position								
Head of Department	30	0	6	57	37	0	2.31	20
Teacher	124	0	6	60	29	5	2.33	22
Degree								
Bachelor's	17	0	6	76	18	0	2.12	27
Master's	99	0	7	58	31	4	2.32	21
Doctor's	38	0	3	55	34	8	2.47	18
Rank								
Professor	65	0	6	52	37	5	2.41	16.5
Assoc. Professor	56	0	5	66	25	4	2.28	21
Asst. Professor	27	0	4	66	26	4	2.30	23
Instructor	6	0	17	33	33	17	2.50	24.5
Teaching fields								
Thermodynamics	59	0	8	63	26	3	2.24	23.5
Other M. E. fields	95	0	4	57	34	5	2.40	19
Teaching experience								
5-9 years	37	0	11	62	22	5	2.21	26
10-14 years	53	0	4	60	34	2	2.34	21
15-19 years	20	0	5	70	20	5	2.25	21
20 plus years	44	0	5	50	39	6	2.46	15
Experience in industry								
0 years	6	0	0	67	33	0	2.33	22.5
1 year	6	0	0	50	33	17	2.67	17
2-5 years	82	0	6	59	32	3	2.32	21
6 plus years	60	0	7	60	28	5	2.31	19

TABLE 10

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON APPLIED GEOMETRY

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	1	4	29	48	18	2.79	9
Position								
Head of Department	30	0	13	23	50	14	2.65	10
Teacher	124	1	2	30	48	19	2.83	9.5
Degree								
Bachelor's	17	6	6	29	53	6	2.53	21
Master's	99	0	5	29	47	19	2.90	8
Doctor's	38	0	0	26	50	24	2.98	5
Rank								
Professor	65	0	6	25	52	17	2.80	9
Assoc. Professor	56	0	4	27	50	19	2.84	9
Asst. Professor	27	4	0	44	41	11	2.59	19
Instructor	6	0	0	17	17	66	3.49	8
Teaching fields								
Thermodynamics	59	1	5	29	41	24	2.83	9
Other M. E. fields	95	0	3	28	53	16	2.82	10
Teaching experience								
5-9 years	37	3	0	24	41	32	3.02	9
10-14 years	53	0	4	38	45	13	2.67	12
15-19 years	20	0	0	20	55	25	3.05	6
20 plus years	44	0	9	25	55	11	2.68	10.5
Experience in industry								
0 years	6	0	0	33	33	34	3.01	7
1 years	6	0	0	33	17	50	3.17	8
2-5 years	82	1	4	29	49	17	2.78	9
6 plus years	60	0	5	27	52	16	2.79	10

TABLE 11

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON ORTHOGRAPHIC PROJECTION

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	0	0	12	31	57	3.45	1
Position								
Head of Department	30	0	0	17	33	50	3.33	2
Teacher	124	0	0	11	31	58	3.47	1.5
Degree								
Bachelor's	17	0	0	12	17	71	3.59	3
Master's	99	0	0	12	31	57	3.45	1
Doctor's	38	0	0	13	37	50	3.37	1
Rank								
Professor	65	0	0	11	35	54	3.43	1
Assoc Professor	56	0	0	18	29	53	3.35	2
Asst. Professor	27	0	0	7	33	60	3.53	2
Instructor	6	0	0	0	0	100	4.00	1
Teaching fields								
Thermodynamics	59	0	0	24	34	42	3.18	3
Other M. E. fields	95	0	0	5	29	66	3.61	1
Teaching experience								
5-9 years	37	0	0	5	30	65	3.60	1
10-14 years	53	0	0	23	28	49	3.26	3
15-19 years	20	0	0	5	35	60	3.55	2
20 plus years	44	0	0	9	34	57	3.48	1
Experience in industry								
0 years	6	0	0	17	33	50	3.33	2
1 year	6	0	0	0	33	67	3.67	2
2-5 years	82	0	0	11	34	55	3.44	1
6 plus years	60	0	0	15	27	58	3.43	3

TABLE 12

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON SKETCHING

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	0	1	11	33	55	3.42	2
Position								
Head of Department	30	0	0	17	30	53	3.36	1
Teacher	124	0	2	10	33	55	3.41	3
Degree								
Bachelor's	17	0	6	6	23	65	3.47	4
Master's	99	0	1	10	34	55	3.43	2
Doctor's	38	0	0	18	32	50	3.32	2
Rank								
Professor	65	0	0	12	35	53	3.41	2
Assoc. Professor	56	0	0	11	30	59	3.48	1
Asst. Professor	27	0	7	15	30	48	3.19	5
Instructor	6	0	0	0	33	67	3.67	5
Teaching fields								
Thermodynamics	59	0	2	13	32	53	3.36	1
Other M. E. fields	95	0	1	10	33	56	3.44	3
Teaching experience								
5-9 years	37	0	3	10	27	60	3.44	3
10-14 years	53	0	2	9	36	53	3.40	1
15-19 years	20	0	0	5	30	65	3.60	1
20 plus years	44	0	0	18	34	48	3.30	2
Experience in industry								
0 years	6	0	0	17	50	33	3.16	4.5
1 year	6	0	0	0	50	50	3.50	4
2-5 years	82	0	2	13	31	54	3.37	2
6 plus years	60	0	0	10	32	58	3.48	1

TABLE 13

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON AXONOMETRIC PROJECTION

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	153	0	8	44	38	10	2.50	16
Position								
Head of Department	30	0	10	40	47	3	2.43	13
Teacher	123	0	8	45	35	12	2.51	17
Degree								
Bachelor's	16	0	6	38	25	31	2.81	14.5
Master's	99	0	9	44	40	7	2.45	15
Doctor's	38	0	8	45	37	10	2.49	17
Rank								
Professor	65	0	9	43	40	8	2.47	14
Assoc. Professor	55	0	11	49	35	5	2.34	20
Asst. Professor	27	0	0	41	37	22	2.81	14.5
Instructor	6	0	17	17	33	33	2.82	18.5
Teaching fields								
Thermodynamics	58	0	14	40	33	13	2.45	21
Other M. E. fields	95	0	5	46	40	9	2.53	14.5
Teaching experience								
5-9 years	37	0	3	43	38	16	2.67	16
10-14 years	53	0	13	43	35	9	2.40	20
15-19 years	19	0	5	32	58	5	2.63	13
20 plus years	44	0	9	50	32	9	2.41	16
Experience in industry								
0 years	6	0	0	50	33	17	2.67	14.5
1 year	6	0	0	33	50	17	2.84	15
2-5 years	81	0	7	52	31	10	2.44	20
6 plus years	60	0	12	33	45	10	2.53	14

TABLE 14

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON OBLIQUE PROJECTION

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	153	0	21	48	26	5	2.15	26
Position								
Head of Department	30	0	27	40	33	0	2.06	25
Teacher	123	0	19	50	24	7	2.19	26
Degree								
Bachelor's	16	0	25	38	25	12	2.24	23.5
Master's	99	0	22	49	24	5	2.12	26
Doctor's	38	0	16	47	34	3	2.24	24
Rank								
Professor	65	0	23	43	29	5	2.16	24
Assoc. Professor	55	0	22	52	24	2	2.06	26
Asst. Professor	27	0	15	52	26	7	2.25	24
Instructor	6	0	17	33	17	33	2.66	20.5
Teaching fields								
Thermodynamics	58	0	27	43	21	9	2.12	25
Other M. E. fields	95	0	17	51	29	3	2.18	26
Teaching experience								
5-9 years	37	0	16	49	27	8	2.27	24
10-14 years	53	0	20	51	25	4	2.13	26
15-19 years	19	0	26	37	32	5	2.16	25
20 plus years	44	0	23	48	25	4	2.10	27
Experience in industry								
0 years	6	0	17	66	17	0	2.00	29.5
1 year	6	0	0	33	67	0	2.67	17
2-5 years	81	0	22	51	20	7	2.12	26
6 plus years	60	0	22	43	32	3	2.16	26

TABLE 15

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON SECTIONAL VIEWS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	0	1	25	43	31	3.04	6
Position								
Head of Department	30	0	0	23	47	30	3.07	4
Teacher	124	0	1	26	43	30	3.02	6
Degree								
Bachelor's	17	0	6	12	41	41	3.17	8
Master's	99	0	0	27	44	29	3.02	6
Doctor's	38	0	0	26	45	29	3.03	4
Rank								
Professor	65	0	0	22	44	34	3.12	4
Assoc. Professor	56	0	2	30	43	25	2.91	8
Asst. Professor	27	0	0	26	45	29	3.03	8
Instructor	6	0	0	17	33	50	3.33	11
Teaching fields								
Thermodynamics	59	0	0	34	44	22	2.88	6
Other M. E. fields	95	0	1	20	43	36	3.14	6
Teaching experience								
5-9 years	37	0	0	24	46	30	3.06	7.5
10-14 years	53	0	2	36	37	25	2.85	7
15-19 years	20	0	0	10	70	20	3.10	5
20 plus years	44	0	0	21	36	43	3.22	4
Experience in industry								
0 years	6	0	0	33	50	17	2.84	10
1 year	6	0	0	0	17	83	3.83	1
2-5 years	82	0	0	32	43	25	2.93	6
6 plus years	60	0	2	18	47	33	3.11	6

TABLE 16

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON SCREW THREADS AND FASTENERS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	2	11	60	21	6	2.20	25
Position								
Head of Department	30	4	13	70	13	0	1.96	27
Teacher	125	2	11	57	23	7	2.24	25
Degree								
Bachelor's	17	0	18	59	6	17	2.22	25
Master's	99	3	12	57	22	6	2.19	24
Doctor's	38	3	7	66	24	0	2.14	25.5
Rank								
Professor	65	5	9	63	23	0	2.09	26
Assoc. Professor	56	2	13	61	16	8	2.17	24
Asst. Professor	27	0	15	56	19	10	2.24	25
Instructor	6	0	0	33	50	17	2.84	17
Teaching fields								
Thermodynamics	59	5	12	61	17	5	2.10	26
Other M. E. fields	95	1	11	59	23	6	2.23	25
Teaching experience								
5-9 years	37	0	14	59	16	11	2.24	25
10-14 years	53	2	13	58	21	6	2.18	24
15-19 years	20	0	0	80	20	0	2.20	23.5
20 plus years	44	7	11	52	25	5	2.17	24
Experience in industry								
0 years	6	0	0	67	33	0	2.33	22.5
1 year	6	0	0	67	33	0	2.33	21.5
2-5 years	82	2	15	54	24	5	2.17	25
6 plus years	60	4	8	67	13	8	2.17	25

TABLE 17

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON PIPING DRAWING

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	5	29	55	10	1	1.78	30
Position								
Head of Department	30	3	30	57	10	0	1.77	30
Teacher	124	5	30	54	10	1	1.77	30
Degree								
Bachelor's	17	6	35	41	18	0	1.77	30.5
Master's	99	4	28	58	9	1	1.79	29
Doctor's	38	8	31	50	11	0	1.72	32
Rank								
Professor	65	4	34	54	8	0	1.70	30.5
Assoc. Professor	56	5	23	63	7	2	1.83	29
Asst. Professor	27	7	33	45	15	0	1.75	29
Instructor	6	0	33	34	33	0	2.00	29.5
Teaching fields								
Thermodynamics	59	7	29	47	15	2	1.83	29.5
Other M. E. fields	95	4	31	59	6	0	1.71	31
Teaching experience								
5-9 years	37	5	24	57	14	0	1.85	29.5
10-14 years	53	6	28	49	15	2	1.85	28
15-19 years	20	0	25	65	10	0	1.85	28
20 plus years	44	6	39	55	0	0	1.55	33
Experience in industry								
0 years	6	0	17	66	17	0	2.00	29.5
1 year	6	0	17	83	0	0	1.83	31.5
2-5 years	82	5	39	46	10	0	1.66	31
6 plus years	60	7	20	61	10	2	1.87	29

TABLE 18

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON ELECTRICAL DIAGRAMS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	8	35	50	6	1	1.65	32
Position								
Head of Department	30	7	29	57	7	0	1.71	32
Teacher	124	8	36	48	6	2	1.66	32
Degree								
Bachelor's	17	12	47	18	23	0	1.64	33
Master's	99	7	33	55	4	1	1.66	32
Doctor's	38	7	34	53	3	3	1.68	33
Rank								
Professor	65	4	40	51	3	2	1.63	33
Assoc. Professor	56	9	28	57	4	2	1.71	32
Asst. Professor	27	15	33	41	11	0	1.63	33
Instructor	6	0	50	17	33	0	1.83	32.5
Teaching fields								
Thermodynamics	59	5	32	51	9	3	1.78	32
Other M. E. fields	95	9	37	49	5	0	1.59	33
Teaching experience								
5-9 years	37	11	27	46	16	0	1.78	32
10-14 years	53	6	32	58	2	2	1.68	32
15-19 years	20	15	30	45	10	0	1.65	32
20 plus years	44	5	48	45	0	2	1.51	34
Experience in industry								
0 years	6	0	17	66	17	0	2.00	29.5
1 year	6	0	17	83	0	0	1.83	31.5
2-5 years	82	6	41	49	4	0	1.57	33
6 plus years	60	12	30	47	8	3	1.72	32

TABLE 19

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON REPRODUCTION PROCESSES

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	0	30	60	10	0	1.80	29
Position								
Head of Department	30	0	17	77	6	0	1.89	28
Teacher	124	0	33	56	11	0	1.78	29
Degree								
Bachelor's	17	0	23	59	18	0	1.95	28.5
Master's	99	0	34	57	9	0	1.75	30
Doctor's	38	0	21	71	8	0	1.87	28
Rank								
Professor	65	0	23	65	12	0	1.89	28
Assoc. Professor	56	0	32	61	7	0	1.75	31
Asst. Professor	27	0	44	48	8	0	1.64	32
Instructor	6	0	17	66	17	0	2.00	29.5
Teaching fields								
Thermodynamics	59	0	22	68	10	0	1.88	28
Other M. E. fields	95	0	35	56	9	0	1.74	29
Teaching experience								
5-9 years	37	0	35	59	6	0	1.71	33
10-14 years	53	0	34	55	11	0	1.77	30.5
15-19 years	20	0	20	80	0	0	1.80	29.5
20 plus years	44	0	25	59	16	0	1.91	29
Experience in industry								
0 years	6	0	17	83	0	0	1.83	32
1 year	6	0	17	83	0	0	1.83	31.5
2-5 years	82	0	28	60	12	0	1.84	28
6 plus years	60	0	35	57	8	0	1.73	31

TABLE 20

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON WELDING DRAWING

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	6	29	57	8	0	1.73	31
Position								
Head of Department	30	10	27	53	10	0	1.73	31
Teacher	124	5	29	58	8	0	1.74	31
Degree								
Bachelor's	17	6	35	41	18	0	1.77	30.5
Master's	99	6	28	58	8	0	1.74	31
Doctor's	38	5	26	61	8	0	1.77	30
Rank								
Professor	65	6	34	52	8	0	1.68	32
Assoc. Professor	56	7	22	64	7	0	1.78	30
Asst. Professor	27	4	30	59	7	0	1.73	30
Instructor	6	0	33	34	33	0	2.00	29.5
Teaching fields								
Thermodynamics	59	6	29	51	14	0	1.79	31
Other M. E. fields	95	5	28	61	6	0	1.73	30
Teaching experience								
5-9 years	37	2	27	57	14	0	1.85	29.5
10-14 years	53	6	21	67	6	0	1.79	29
15-19 years	20	10	35	50	5	0	1.60	33
20 plus years	44	7	36	48	9	0	1.66	31
Experience in industry								
0 years	6	0	17	66	17	0	2.00	29.5
1 year	6	0	17	83	0	0	1.83	31.5
2-5 years	82	6	33	52	9	0	1.70	30
6 plus years	60	7	25	60	8	0	1.76	30

TABLE 21

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON SHOP PROCESSES

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	18	20	33	23	6	1.97	27
Position								
Head of Department	30	17	20	33	20	10	2.03	26
Teacher	124	19	20	31	24	6	1.97	27
Degree								
Bachelor's	17	5	41	12	18	24	2.20	26
Master's	99	19	13	37	26	5	2.04	27
Doctor's	38	21	29	29	18	3	1.74	31
Rank								
Professor	65	17	22	31	25	5	1.96	27
Assoc. Professor	56	15	16	39	25	5	2.04	27
Asst. Professor	27	22	26	22	15	15	1.97	28
Instructor	6	33	17	17	33	0	1.83	32.5
Teaching fields								
Thermodynamics	59	26	15	31	25	3	1.90	27
Other M. E. fields	95	14	23	33	22	8	2.10	27
Teaching experience								
5-9 years	37	16	24	33	19	8	1.95	28
10-14 years	53	25	19	28	20	8	1.92	27
15-19 years	20	5	25	50	20	0	1.90	27
20 plus years	44	18	16	27	32	7	2.12	25.5
Experience in industry								
0 years	6	50	0	33	17	0	1.67	33
1 year	6	0	33	50	0	17	2.01	29
2-5 years	82	18	16	34	27	5	2.03	27
6 plus years	60	17	27	27	22	7	1.92	27

TABLE 22

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON WORKING DRAWINGS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	2	10	23	40	25	2.78	10
Position								
Head of Department	30	0	17	20	50	13	2.59	12
Teacher	124	3	8	23	38	28	2.83	9.5
Degree								
Bachelor's	17	0	0	29	29	42	3.13	9
Master's	99	3	11	16	41	29	2.85	10
Doctor's	38	3	10	37	42	8	2.45	19
Rank								
Professor	65	3	15	25	45	12	2.51	12.5
Assoc. Professor	56	2	7	16	43	32	2.98	6
Asst. Professor	27	4	4	32	19	41	2.93	10.5
Instructor	6	0	0	17	66	17	3.00	14.5
Teaching fields								
Thermodynamics	59	3	14	24	45	14	2.56	14
Other M. E. fields	95	2	7	22	37	32	2.92	9
Teaching experience								
5-9 years	37	0	3	27	41	29	2.96	10
10-14 years	53	6	7	23	40	24	2.75	9
15-19 years	20	0	10	25	45	20	2.75	11
20 plus years	44	2	18	18	39	23	2.65	12
Experience in industry								
0 years	6	0	33	33	17	17	2.18	24
1 year	6	0	0	17	50	33	3.16	9.5
2-5 years	82	4	11	17	44	24	2.77	10
6 plus years	60	1	7	30	37	25	2.79	10

TABLE 23

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON PRODUCTION ILLUSTRATION

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics Should not be Included (0)	(1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	3	29	49	18	1	1.88	28
Position								
Head of Department	30	0	27	57	16	0	1.87	29
Teacher	124	3	29	48	19	1	1.89	28
Degree								
Bachelor's	17	5	24	47	24	0	1.95	28.5
Master's	99	2	33	46	18	1	1.85	28
Doctor's	38	3	20	61	16	0	1.93	27
Rank								
Professor	65	3	29	54	12	2	1.84	29
Assoc. Professor	56	2	34	43	21	0	1.85	28
Asst. Professor	27	4	22	48	26	0	2.00	27
Instructor	6	0	17	66	17	0	2.00	29.5
Teaching fields								
Thermodynamics	59	3	30	53	12	2	1.83	29.5
Other M. E. fields	95	2	28	47	23	0	1.93	28
Teaching experience								
5-9 years	37	0	27	46	27	0	2.00	27
10-14 years	53	4	30	55	11	0	1.77	30.5
15-19 years	20	0	35	50	15	0	1.80	29.5
20 plus years	44	5	27	46	20	2	1.92	28
Experience in industry								
0 years	6	0	17	50	33	0	2.16	26
1 year	6	0	17	33	50	0	2.33	21.5
2-5 years	82	2	33	49	15	1	1.82	29
6 plus years	60	3	27	52	18	0	1.88	28

TABLE 24

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON ORIGINAL DESIGN

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	10	23	21	27	19	2.32	22
Position								
Head of Department	30	7	37	17	27	12	2.07	24
Teacher	124	10	19	23	28	20	2.39	21
Degree								
Bachelor's	17	24	24	4	24	24	2.24	23.5
Master's	99	10	22	20	33	15	2.31	22
Doctor's	38	3	24	32	16	25	2.39	23
Rank								
Professor	65	8	29	15	28	20	2.31	20
Assoc. Professor	56	9	21	30	26	14	2.24	22.5
Asst. Professor	27	19	11	15	33	22	2.47	22
Instructor	6	0	17	33	17	33	2.66	20.5
Teaching fields								
Thermodynamics	59	8	22	19	26	25	2.46	20
Other M. E. fields	95	11	23	23	28	15	2.24	24
Teaching experience								
5-9 years	37	5	16	24	31	24	2.58	20
10-14 years	53	17	19	24	25	15	2.19	23
15-19 years	20	10	25	15	40	10	2.25	21
20 plus years	44	4	32	18	23	23	2.33	18
Experience in industry								
0 years	6	0	33	17	17	33	2.50	19
1 year	6	0	0	17	50	33	3.16	9.5
2-5 years	82	10	26	22	24	18	2.24	22
6 plus years	60	12	20	22	30	16	2.30	20

TABLE 25

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON INKING

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	2	44	49	3	2	1.61	33
Position								
Head of Department	30	3	40	54	3	0	1.60	34
Teacher	124	1	45	49	3	2	1.61	33
Degree								
Bachelor's	17	0	35	65	0	0	1.65	32
Master's	99	0	50	46	3	1	1.55	34
Doctor's	38	5	31	53	5	6	1.81	29
Rank								
Professor	65	3	34	58	3	2	1.70	30.5
Assoc. Professor	56	0	48	45	5	2	1.61	33
Asst. Professor	27	0	59	37	0	4	1.49	34
Instructor	6	0	50	50	0	0	1.50	34
Teaching fields								
Thermodynamics	59	3	46	44	5	2	1.60	34
Other M. E. fields	95	0	43	53	2	2	1.63	32
Teaching experience								
5-9 years	37	0	62	32	3	3	1.47	34
10-14 years	53	0	45	57	4	0	1.59	33
15-19 years	20	0	35	60	5	0	1.70	31
20 plus years	44	4	32	57	3	4	1.75	30
Experience in industry								
0 years	6	0	50	50	0	0	1.50	34
1 year	6	0	0	83	17	0	2.17	25
2-5 years	82	1	46	48	4	1	1.59	32
6 plus years	60	2	45	48	2	3	1.61	33

TABLE 26

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON CHARTS AND GRAPHS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	7	8	31	39	15	2.54	14.5
Position								
Head of Department	30	13	17	17	40	13	2.36	18.5
Teacher	124	6	5	35	39	15	2.58	14
Degree								
Bachelor's	17	0	11	24	41	24	2.78	16
Master's	99	9	10	32	37	12	2.42	16
Doctor's	38	5	0	32	45	18	2.76	10
Rank								
Professor	65	8	11	35	32	14	2.41	16.5
Assoc. Professor	56	9	5	27	43	16	2.61	14
Asst. Professor	27	4	0	30	48	18	2.80	16.5
Instructor	6	0	33	33	34	0	2.01	27
Teaching fields								
Thermodynamics	59	13	3	25	37	22	2.65	11
Other M. E. fields	95	4	10	35	40	11	2.48	16
Teaching experience								
5-9 years	37	8	5	30	38	19	2.63	18.5
10-14 years	53	8	6	24	51	11	2.59	14
15-19 years	20	10	10	35	35	10	2.35	18
20 plus years	44	5	11	39	27	18	2.47	14
Experience in industry								
0 years	6	17	0	17	50	16	2.65	16
1 year	6	17	17	33	17	16	2.15	28
2-5 years	82	5	9	27	41	18	2.63	15
6 plus years	60	8	7	38	37	10	2.42	16

TABLE 27

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON PRIMARY AUXILIARY VIEWS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	1	4	36	41	18	2.72	11
Position								
Head of Department	30	0	3	43	4	10	2.61	11
Teacher	124	1	5	34	40	20	2.74	11
Degree								
Bachelor's	17	6	0	18	47	29	2.99	12
Master's	99	0	4	40	39	17	2.69	11
Doctor's	38	0	8	34	42	16	2.66	11.5
Rank								
Professor	65	0	6	37	42	15	2.66	10
Assoc. Professor	56	0	5	38	39	18	2.70	11
Asst. Professor	27	4	0	30	41	25	2.87	12
Instructor	6	0	0	20	60	20	2.80	19
Teaching fields								
Thermodynamics	59	0	3	41	42	14	2.67	10
Other M. E. fields	95	1	5	33	40	21	2.76	11
Teaching experience								
5-9 years	37	3	0	32	49	16	2.78	13.5
10-14 years	53	0	9	36	36	19	2.65	13
15-19 years	20	0	0	35	40	25	2.90	10
20 plus years	44	0	4	39	41	16	2.69	9
Experience in industry								
0 years	6	0	0	50	33	17	2.67	14.5
1 year	6	0	0	17	33	50	3.33	6.5
2-5 years	82	1	7	35	42	15	2.64	13.5
6 plus years	60	0	2	37	41	20	2.79	10

TABLE 28

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON DIMENSIONING

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	153	2	1	21	43	33	3.06	5
Position								
Head of Department	30	0	0	33	47	20	2.87	6
Teacher	123	2	0	19	42	37	3.14	5
Degree								
Bachelor's	17	0	0	18	23	59	3.41	5
Master's	98	1	1	23	39	36	3.09	5
Doctor's	38	3	0	20	63	13	2.86	9
Rank								
Professor	63	3	0	29	46	22	2.87	7
Assoc. Professor	56	0	0	23	45	32	3.09	5
Asst. Professor	26	0	3	8	31	58	3.44	4
Instructor	6	0	0	0	50	50	3.50	7
Teaching fields								
Thermodynamics	58	2	0	30	47	21	2.87	7.5
Other M. E. fields	95	1	1	17	41	40	3.19	5
Teaching experience								
5-9 years	37	0	3	19	43	35	3.10	6
10-14 years	53	2	0	22	40	36	3.10	5
15-19 years	19	0	0	26	47	27	3.01	7
20 plus years	44	2	0	23	45	30	3.03	7
Experience in industry								
0 years	5	0	0	20	80	0	2.80	11
1 year	6	0	0	17	66	17	3.00	12
2-5 years	82	0	0	26	45	29	3.03	5
6 plus years	60	4	2	18	34	42	3.12	5

TABLE 29

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON CAMS AND GEARS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	18	37	34	10	0	1.57	34
Position								
Head of Department	30	23	24	40	13	0	1.66	33
Teacher	124	16	40	33	10	1	1.56	34
Degree								
Bachelor's	17	18	59	5	18	0	1.41	34
Master's	99	18	36	35	10	1	1.58	33
Doctor's	38	16	32	45	7	0	1.59	34
Rank								
Professor	65	22	34	32	11	1	1.57	34
Assoc. Professor	56	12	46	38	4	0	1.46	34
Asst. Professor	27	22	30	30	18	0	1.66	31
Instructor	6	0	17	50	33	0	2.16	26
Teaching fields								
Thermodynamics	59	17	29	42	12	0	1.66	33
Other M. E. fields	95	18	42	29	10	1	1.52	34
Teaching experience								
5-9 years	37	10	30	38	22	0	1.82	31
10-14 years	53	18	40	38	4	0	1.46	34
15-19 years	20	25	45	30	0	0	1.30	34
20 plus years	44	18	36	30	14	2	1.64	32
Experience in industry								
0 years	6	17	17	16	15	0	2.16	26
1 year	6	0	33	67	0	0	1.67	34
2-5 years	82	17	39	33	10	1	1.56	34
6 plus years	60	20	37	35	8	0	1.51	34

TABLE 30

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON SIMPLIFIED DRAFTING PROCEDURES

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	154	1	19	44	27	9	2.25	24
Position								
Head of Department	30	3	17	50	27	2	2.13	23
Teacher	124	1	20	42	27	10	2.26	24
Degree								
Bachelor's	17	4	24	24	24	24	2.44	22
Master's	99	0	19	46	27	8	2.24	23
Doctor's	38	3	19	47	26	5	2.14	25.5
Rank								
Professor	65	2	15	51	26	6	2.21	22
Assoc. Professor	56	0	21	43	27	9	2.24	22.5
Asst. Professor	27	3	30	30	26	11	2.15	26
Instructor	6	0	0	34	33	33	2.99	16
Teaching fields								
Thermodynamics	59	3	17	41	34	5	2.24	23.5
Other M. E. fields	95	0	21	45	22	12	2.25	23
Teaching experience								
5-9 years	37	3	16	38	27	16	2.40	23
10-14 years	53	0	26	38	32	4	2.14	25
15-19 years	20	0	10	65	25	0	2.15	26
20 plus years	44	3	18	45	21	14	2.29	20
Experience in industry								
0 years	6	0	17	50	33	0	2.16	26
1 year	6	0	0	34	33	33	2.99	14
2-5 years	82	2	23	37	29	9	2.22	24
6 plus years	60	0	17	53	22	8	2.21	24

TABLE 31

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON SUCCESSIVE AUXILIARY VIEWS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	151	0	2	17	40	41	3.20	4
Position								
Head of Department	29	0	7	24	45	24	2.86	7
Teacher	122	0	1	16	38	45	3.27	4
Degree								
Bachelor's	17	0	0	0	24	76	3.76	2
Master's	97	0	2	18	39	41	3.19	4
Doctor's	37	0	3	24	49	24	2.94	6.5
Rank								
Professor	63	0	3	17	47	33	3.10	5
Assoc. Professor	56	0	2	21	34	43	3.18	4
Asst. Professor	27	0	0	11	33	56	3.45	3
Instructor	5	0	0	0	60	40	3.40	9.5
Teaching fields								
Thermodynamics	58	0	0	22	45	33	3.11	4
Other M. E. fields	93	0	3	14	37	46	3.26	4
Teaching experience								
5-9 years	36	0	0	6	58	36	3.30	4
10-14 years	52	0	2	27	21	50	3.19	4
15-19 years	20	0	0	15	45	40	3.25	4
20 plus years	43	0	5	16	44	35	3.09	5
Experience in industry								
0 years	6	0	0	17	50	33	3.16	4.5
1 year	6	0	0	0	50	50	3.50	4
2-5 years	79	0	4	19	33	44	3.17	4
6 plus years	60	0	0	16	47	37	3.21	4

TABLE 32

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON PERSPECTIVE DRAWING

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	151	1	15	46	31	7	2.29	23
Position								
Head of Department	29	0	17	34	42	7	2.39	15.5
Teacher	122	1	15	48	29	7	2.27	23
Degree								
Bachelor's	17	0	6	35	41	18	2.71	18
Master's	97	1	18	47	32	2	2.17	25
Doctor's	37	0	14	46	24	16	2.42	20
Rank								
Professor	63	1	16	40	37	6	2.32	19
Assoc. Professor	56	0	18	54	25	3	2.13	25
Asst. Professor	27	0	11	44	26	19	2.53	21
Instructor	5	0	0	40	60	0	2.60	22.5
Teaching fields								
Thermodynamics	58	1	16	45	29	9	2.30	22
Other M. E. fields	93	0	15	46	32	7	2.31	22
Teaching experience								
5-9 years	36	0	11	44	31	14	2.48	22
10-14 years	52	0	19	44	33	6	2.24	22
15-19 years	20	0	5	60	35	0	2.30	19
20 plus years	43	2	19	42	30	7	2.23	21
Experience in industry								
0 years	6	0	16	50	17	17	2.35	21
1 year	6	0	17	33	33	17	2.50	19
2-5 years	79	1	18	45	30	6	2.23	23
6 plus years	60	0	12	48	33	7	2.35	17

TABLE 33

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON POINT, LINE AND PLANE RELATIONSHIPS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	151	0	4	11	26	59	3.40	3
Position								
Head of Department	29	0	7	17	31	45	3.14	3
Teacher	122	0	3	9	26	62	3.47	1.5
Degree								
Bachelor's	17	0	0	0	18	82	3.82	1
Master's	97	0	4	10	26	60	3.42	3
Doctor's	37	0	5	17	32	46	3.19	3
Rank								
Professor	63	0	3	13	29	55	3.36	3
Assoc. Professor	56	0	7	11	23	59	3.34	3
Asst. Professor	27	0	0	7	30	63	3.56	1
Instructor	5	0	0	0	20	80	3.80	3
Teaching fields								
Thermodynamics	58	0	5	12	38	45	3.23	2
Other M. E. fields	93	0	3	10	19	68	3.52	2
Teaching experience								
5-9 years	36	0	3	8	28	61	3.47	2
10-14 years	52	0	6	10	23	61	3.39	2
15-19 years	20	0	0	10	30	60	3.50	3
20 plus years	43	0	5	14	28	53	3.29	3
Experience in industry								
0 years	6	0	0	17	17	66	3.49	1
1 year	6	0	0	0	50	50	3.50	4
2-5 years	79	0	6	13	22	59	3.34	3
6 plus years	60	0	2	8	32	58	3.46	2

TABLE 34

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON REVOLUTION

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	151	0	3	23	48	26	2.97	7
Position								
Head of Department	29	0	3	17	66	14	2.91	5
Teacher	122	0	2	25	43	30	3.01	7
Degree								
Bachelor's	17	0	0	12	47	41	3.29	6.5
Master's	97	0	3	24	48	25	2.95	7
Doctor's	37	0	3	27	46	24	2.91	8
Rank								
Professor	63	0	3	17	51	29	3.06	6
Assoc. Professor	56	0	4	38	39	19	2.73	10
Asst. Professor	27	0	0	11	63	26	3.15	6
Instructor	5	0	0	0	20	80	3.80	3
Teaching fields								
Thermodynamics	58	0	5	22	40	33	3.01	5
Other M. E. fields	93	0	1	24	53	22	2.96	8
Teaching experience								
5-9 years	36	0	0	22	50	28	3.06	7.5
10-14 years	52	0	2	31	44	23	2.88	6
15-19 years	20	0	5	20	50	25	2.95	8.5
20 plus years	43	0	5	16	49	30	3.04	6
Experience in industry								
0 years	6	0	17	0	33	50	3.16	4.5
1 year	6	0	0	0	67	33	3.33	6.5
2-5 years	79	0	4	29	43	24	2.87	7
6 plus years	60	0	0	20	53	27	3.07	7

TABLE 35

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON CURVED LINES AND SURFACES

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	151	0	5	40	40	15	2.65	12
Position								
Head of Department	29	0	14	41	38	7	2.38	17
Teacher	122	0	3	39	41	17	2.72	12
Degree								
Bachelor's	17	0	0	29	42	29	3.00	11
Master's	97	0	7	40	39	14	2.60	12
Doctor's	37	0	0	43	46	11	2.68	13
Rank								
Professor	63	0	10	41	37	12	2.51	12.5
Assoc. Professor	56	0	2	43	43	12	2.65	12.5
Asst. Professor	27	0	0	33	41	26	2.93	10.5
Instructor	5	0	0	20	60	20	3.00	14.5
Teaching fields								
Thermodynamics	58	0	5	49	29	17	2.58	12
Other M. E. fields	93	0	4	34	48	14	2.72	12
Teaching experience								
5-9 years	36	0	3	33	42	22	2.83	12
10-14 years	52	0	0	44	39	17	2.73	10
15-19 years	20	0	5	45	40	10	2.55	14
20 plus years	43	0	12	37	42	9	2.48	13
Experience in industry								
0 years	6	0	16	17	50	17	2.68	12.5
1 year	6	0	0	33	67	0	2.67	17
2-5 years	79	0	6	37	43	14	2.65	12
6 plus years	60	0	2	47	33	18	2.67	12

TABLE 36

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON INTERSECTION OF SURFACES

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	151	0	1	30	43	26	2.94	8
Position								
Head of Department	29	0	3	28	52	17	2.83	8
Teacher	122	0	0	31	41	28	2.97	8
Degree								
Bachelor's	17	0	0	12	47	41	3.29	6.5
Master's	97	0	1	34	41	24	2.88	9
Doctor's	37	0	0	30	46	24	2.94	6.5
Rank								
Professor	63	0	2	33	46	19	2.82	8
Assoc. Professor	56	0	0	32	39	29	2.97	7
Asst. Professor	27	0	0	26	41	33	3.07	7
Instructor	5	0	0	0	60	40	3.40	9.5
Teaching fields								
Thermodynamics	58	0	0	33	47	20	2.87	7.5
Other M. E. fields	93	0	1	29	41	29	2.98	7
Teaching experience								
5-9 years	36	0	0	19	42	39	3.20	5
10-14 years	52	0	0	39	42	19	2.80	8
15-19 years	20	0	0	25	55	20	2.95	8.5
20 plus years	43	0	2	33	40	25	2.88	8
Experience in industry								
0 years	6	0	0	17	50	33	3.16	4.5
1 year	6	0	0	33	34	33	3.00	12
2-5 years	79	0	1	33	47	19	2.84	8
6 plus years	60	0	0	29	38	33	3.04	8

TABLE 37

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON EMPIRICAL CURVES

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	152	10	13	22	41	14	2.46	18
Position								
Head of Department	30	13	17	17	37	16	2.39	15.5
Teacher	122	9	12	24	41	14	2.48	18
Degree								
Bachelor's	17	6	6	35	29	24	2.65	20
Master's	97	9	17	21	43	10	2.37	17.5
Doctor's	38	13	8	21	37	21	2.58	15
Rank								
Professor	65	15	15	17	39	14	2.37	18
Assoc. Professor	55	7	14	29	35	15	2.44	19
Asst. Professor	27	4	7	22	56	11	2.67	18
Instructor	5	0	0	20	40	40	3.20	12.5
Teaching fields								
Thermodynamics	59	17	10	10	44	19	2.55	15.5
Other M. E. fields	93	5	15	30	38	12	2.42	18
Teaching experience								
5-9 years	36	6	11	19	45	19	2.66	17
10-14 years	52	9	12	21	46	12	2.49	18
15-19 years	20	20	10	35	20	15	2.20	23.5
20 plus years	44	9	18	20	39	14	2.40	17
Experience in industry								
0 years	6	0	17	0	50	33	2.99	8.5
1 year	6	17	17	0	66	0	2.32	23
2-5 years	80	5	10	29	43	13	2.54	17
6 plus years	60	17	17	18	33	15	2.29	21.5

TABLE 38

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON FUNCTIONAL SCALES

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	151	9	13	27	39	12	2.41	20
Position								
Head of Department	30	10	17	33	30	10	2.23	21
Teacher	121	9	12	26	41	12	2.44	20
Degree								
Bachelor's	17	6	6	24	47	17	2.69	19
Master's	96	8	17	26	41	9	2.35	19.5
Doctor's	38	13	8	32	32	15	2.41	21.5
Rank								
Professor	64	14	14	36	28	8	2.16	24
Assoc. Professor	55	5	16	24	39	16	2.50	15
Asst. Professor	27	7	4	11	63	15	2.82	13
Instructor	5	0	0	40	60	0	2.60	22.5
Teaching fields								
Thermodynamics	58	15	7	19	47	12	2.49	19
Other M. E. fields	93	5	16	32	35	12	2.38	20
Teaching experience								
5-9 years	36	6	8	28	39	19	2.63	18.5
10-14 years	52	9	8	19	55	9	2.56	16
15-19 years	20	20	10	30	25	15	2.25	21
20 plus years	43	7	23	35	28	7	2.12	25.5
Experience in industry								
0 years	6	0	16	17	50	17	2.68	12.5
1 year	6	17	17	32	17	17	2.17	25
2-5 years	79	6	9	32	40	13	2.51	18.5
6 plus years	60	13	17	22	38	10	2.28	23

TABLE 39

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON NOMOGRAPHS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	152	11	15	20	39	15	2.43	19
Position								
Head of Department	30	17	20	10	33	20	2.36	18.5
Teacher	122	10	14	21	41	14	2.45	19
Degree								
Bachelor's	17	6	11	24	24	35	2.77	17
Master's	97	10	18	18	43	11	2.37	17.5
Doctor's	38	15	11	22	37	15	2.41	21.5
Rank								
Professor	65	17	20	19	35	9	2.16	24
Assoc. Professor	55	9	13	22	42	14	2.48	17
Asst. Professor	27	4	11	15	44	26	2.81	14.5
Instructor	5	0	0	20	40	40	3.20	12.5
Teaching fields								
Thermodynamics	59	17	5	17	46	15	2.54	17.5
Other M. E. fields	93	8	22	20	35	15	2.35	21
Teaching experience								
5-9 years	36	6	8	19	42	25	2.78	13.5
10-14 years	52	12	13	22	40	13	2.41	19
15-19 years	20	20	5	20	45	10	2.40	16.5
20 plus years	44	11	27	16	35	11	2.19	22.5
Experience in industry								
0 years	6	0	17	0	50	33	2.99	8.5
1 year	6	17	16	17	50	0	2.17	25
2-5 years	80	6	14	23	43	14	2.51	18.5
6 plus years	60	18	17	17	32	16	2.29	21.5

TABLE 40

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON GRAPHICAL CALCULUS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	152	10	13	20	37	20	2.54	14.5
Position								
Head of Department	30	10	17	23	33	17	2.40	14
Teacher	122	11	12	18	38	21	2.57	15
Degree								
Bachelor's	17	6	18	6	35	35	2.81	14.5
Master's	97	8	16	20	37	19	2.51	14
Doctor's	38	18	3	24	37	18	2.52	16
Rank								
Professor	65	14	14	20	34	18	2.42	15
Assoc. Professor	55	7	15	25	38	15	2.46	18
Asst. Professor	27	11	10	8	41	30	2.80	16.5
Instructor	5	0	0	0	40	60	3.60	6
Teaching fields								
Thermodynamics	59	15	5	22	29	19	2.57	13
Other M. E. fields	93	8	18	17	35	22	2.53	14.5
Teaching experience								
5-9 years	36	8	11	17	36	28	2.73	15
10-14 years	52	10	13	15	43	19	2.58	15
15-19 years	20	20	5	10	40	25	2.65	12
20 plus years	44	9	17	30	30	14	2.32	19
Experience in industry								
0 years	6	0	17	33	33	17	2.50	19
1 year	6	17	0	50	33	0	2.16	27
2-5 years	80	9	11	20	39	21	2.61	16
6 plus years	60	13	17	13	35	22	2.49	15

TABLE 41

OPINIONS CONCERNING EMPHASIS TO BE PLACED ON VECTORS

Classification	Number of Responses	Percentage Distribution of Opinions					Weighted Average	Rank Order
		Should be in Courses other than Eng. Graphics (0)	Should not be Included (1)	Limited Emphasis (2)	Moderate Emphasis (3)	Major Emphasis (4)		
Total Educators	152	13	16	16	33	22	2.48	17
Position								
Head of Department	30	17	20	20	33	10	2.16	22
Teacher	122	12	15	15	33	25	2.56	16
Degree								
Bachelor's	17	6	11	11	24	48	3.03	10
Master's	97	13	19	18	33	17	2.35	19.5
Doctor's	38	15	11	13	37	24	2.59	14
Rank								
Professor	65	18	20	15	33	14	2.23	21
Assoc. Professor	55	7	14	24	40	15	2.49	16
Asst. Professor	27	15	10	4	22	49	2.95	9
Instructor	5	0	0	0	20	80	3.80	3
Teaching fields								
Thermodynamics	59	15	10	15	41	19	2.54	17.5
Other M. E. fields	93	12	19	16	28	25	2.47	17
Teaching experience								
5-9 years	36	11	11	12	22	44	2.88	11
10-14 years	52	10	15	19	37	19	2.50	17
15-19 years	20	25	5	10	50	10	2.40	16.5
20 plus years	44	14	25	17	30	14	2.19	22.5
Experience in industry								
0 years	6	0	33	0	50	17	2.51	17
1 year	6	17	16	17	33	17	2.34	20
2-5 years	80	6	13	23	33	25	2.64	13.5
6 plus years	60	22	18	8	32	20	2.32	18

APPENDIX C

LIST OF PARTICIPATING INSTITUTIONS

PARTICIPATING INSTITUTIONS

University of Akron

University of Arizona

University of Arkansas

Bradley University

Case Institute of Technology

University of Cincinnati

Colorado State University

University of Colorado

University of Dayton

University of Detroit

Fenn College

Illinois Institute of Technology

University of Illinois

Iowa State College of A and M Arts

Kansas State College of Agriculture and Applied Science

University of Kansas

Marquette University

Michigan College of Mining and Technology

Michigan State University of Agriculture and Applied Science

University cf Minnesota

University of Missouri

University of Nebraska

New Mexico College of A and M Arts

University of New Mexico

North Dakota Agricultural College

University of North Dakota

Northwestern University

University of Notre Dame

Ohio University

Ohio State University

Oklahoma State University

University of Oklahoma

Purdue University

Rose Polytechnic Institute

South Dakota School of Mines and Technology

South Dakota State College of A and M Arts

University of Toledo

Washington University

Wayne State University

West Virginia University

University of Wisconsin

University of Wyoming

APPENDIX D

QUESTIONNAIRE ON THE OPINIONS OF MECHANICAL ENGINEERING EDUCATORS CONCERNING THE PURPOSES AND CONTENT OF ENGINEERING GRAPHICS COURSES

A STUDY
on
THE OPINIONS OF MECHANICAL ENGINEERING EDUCATORS CONCERNING THE PURPOSES AND CONTENT OF ENGINEERING GRAPHICS COURSES

A Research Study Being
Conducted Under the Direction
of the Staff at the

University of Oklahoma

by

SHERMAN F. DREYER

MECHANICAL ENGINEERING DEPARTMENT

TRI-STATE COLLEGE
Angola, Indiana

QUESTIONNAIRE

on

THE OPINIONS OF MECHANICAL ENGINEERING EDUCATORS CONCERNING THE PURPOSES AND CONTENT OF ENGINEERING GRAPHICS COURSES

Definition: The term **Engineering Graphics Courses** is used in this study to designate undergraduate required courses as usually taught by drawing departments and commonly termed engineering graphics or engineering drawing and descriptive geometry.

I. OBJECTIVES OF ENGINEERING GRAPHICS COURSES IN THE UNDERGRADUATE MECHANICAL ENGINEERING CURRICULUM.

Instructions: Indicate the order of importance you believe **should** be placed on the objectives listed below by inserting the number 1 in front of the most important objective, the number 2 for the second most important, etc. If you feel one of the objectives should not be included, place an X in front of it. If you feel that major objectives other than those listed are of importance, please add them in the spaces marked "Others" and include in the rank order designation.

__A. **Graphical Solution and Computations**—To develop skill in analyzing, solving and presenting problems involving engineering charts, graphs, and graphical mathematics.

__B. **Conventional Practices**—To develop ability in the use of standards and conventions as applied to working drawings for the purpose of communicating and interpreting ideas.

__C. **Spatial Visualization**—To develop ability to visualize in three dimensions and to apply this process to engineering problems.

__D. **Creativity**—To develop creative ability in design and solution of graphical problems.

___E. **Drawing Techniques**—To develop skill in drawing techniques in order to make or supervise the making of engineering drawings of acceptable form and quality.

___F. **Orthographic (Orthogonal) Projection**—To develop ability to translate the analysis of engineering problems into terms of multiview drawing.

___G. Others: _____

_____

_____

_____

II. THE GRAPHICAL AREAS IN A MECHANICAL ENGINEERING CURRICULUM WHICH SHOULD BE APPROPRIATELY INCLUDED IN ENGINEERING GRAPHICS COURSES.

Instructions: Place a check (√) in the box which represents your opinion of the degree of emphasis which you feel **should** be made on the following topics as taught in the Engineering graphics courses: The key:

1. **Not Included:** The topic should not be included in Engineering Graphics courses.
2. **Limited Emphasis:** The topic should be introduced but does not warrant intensive study in the Engineering Graphics courses.
3. **Moderate Emphasis:** The topic should be studied in Engineering Graphics courses, and the student should have some proficiency in this area.
4. **Major Emphasis:** The topic is of major importance in Engineering Graphics courses, and concentration should be placed in this area.

(If, in your judgment, the topic is important in the Mechanical Engineering curriculum, but definitely should **not** be taught in Engineering Graphics courses, please circle the item number.)

Should not be included 1	Limited Emphasis 2	Moderate Emphasis 3	Major Emphasis 4	
				A. Engineering Graphics (Technical Drawing Area)
☐	☐	☐	☐	1. Lettering — Pencil, technical lettering, single stroke Gothic, emphasizing legibility and rapidity.
☐	☐	☐	☐	2. Instruments and Materials — Selection, care, and use of common drafting instruments and materials, including pencil linework.
☐	☐	☐	☐	3. Applied Geometry — Geometrical construction as commonly used in the preparation of technical drawing.
☐	☐	☐	☐	4. Orthographic Projection — Theory and methods of multiview projection.
☐	☐	☐	☐	5. Sketching — Technical sketching by **freehand** representational drawings in orthographic, axonometric, oblique, or perspective projections.
☐	☐	☐	☐	6. Axonometric Projection — Pictorial drawing by axonometric method including isometric drawing and projection.
☐	☐	☐	☐	7. Oblique Projection — Pictorial drawing by oblique projection, including cavalier projection and cabinet drawing.
☐	☐	☐	☐	8. Sectional Views — Conventional representations, full, half, broken, removed, revolved, and partial sections.
☐	☐	☐	☐	9. Screw Threads and Fasteners — A.S.A. detailing symbols and noting of threads, threaded fasteners, keys and rivets.

Should not be included	Limited Emphasis	Moderate Emphasis	Major Emphasis	
1	2	3	4	
☐	☐	☐	☐	10. Piping Drawing — Diagrammatic piping symbols, orthographic, developed and pictorial drawings.
☐	☐	☐	☐	11. Electrical Diagrams — Electrical symbols and circuity representation.
☐	☐	☐	☐	12. Reproduction Processes — Methods, materials, and advantages and disadvantages of common industrial drawing reproduction methods.
☐	☐	☐	☐	13. Welding Drawing — Types of weldments, A.S.A. symbols, applications to working drawings.
☐	☐	☐	☐	14. Shop Processes — Methods of manufacture and their effect on drawing and dimensioning.
☐	☐	☐	☐	15. Working Drawings — Drawings with complete instructional information as used in manufacture, construction, processing, etc.
☐	☐	☐	☐	16. Production Illustration — Application of pictorial drawing to industrial usage (as in exploded views, installation drawings, etc.).
☐	☐	☐	☐	17. Original Design — 3-Dimensional problems involving original solution and analysis.
☐	☐	☐	☐	18. Inking — Lettering and linework in ink tracing.
☐	☐	☐	☐	19. Charts and Graphs — Purposes, selection, and drawing of charts and graphs in common engineering usage.

1 Should not be included	2 Limited Emphasis	3 Moderate Emphasis	4 Major Emphasis	
☐	☐	☐	☐	20. Primary Auxiliary Views — Projection methods for finding true size and shape of a slanting surface.
☐	☐	☐	☐	21. Dimensioning — Dimensioning, limit dimensioning, and noting detail drawings.
☐	☐	☐	☐	22. Cams and Gears — Detailing and layout of cams and gears.
☐	☐	☐	☐	23. Simplified Drafting Procedures — New materials, processes, and methods of simplifying industrial drawings (as use of templates, overlays, simplification of views, etc.).

Others:_____

_____

_____

_____

B. Engineering Graphics (Descriptive Geometry Area)

☐	☐	☐	☐	24. Successive Auxiliary Views — Edge views, true sizes and shapes of oblique planes.
☐	☐	☐	☐	25. Perspective Drawing — Pictorial drawing by perspective projection.
☐	☐	☐	☐	26. Point, Line and Plane Relationships — Spatial relationships of points, lines, and planes, including parallelism, perpendicularity, intersection, true length, size, shape, and angles by change of position method.

Should not be included	Limited Emphasis	Moderate Emphasis	Major Emphasis	
1	2	3	4	
☐	☐	☐	☐	27. Revolution — Solution of point, line and plane problems by method of revolution about an axis.
☐	☐	☐	☐	28. Curved Lines and Surfaces — Classification and development of surfaces and tangents.
☐	☐	☐	☐	29. Intersection of Surfaces — Methods of plotting the intersections of surfaces.

Others:_____

_____

_____

_____

C. **Engineering Graphics (Graphical Mathematics Area)**

☐	☐	☐	☐	30. Empirical Curves — Determining constants by graphical means.
☐	☐	☐	☐	31. Functional Scales — Theory and development of functional graphic scales.
☐	☐	☐	☐	32. Nomographs — Theory and development of alignment charts for solution of recurring equation of three or more variables.
☐	☐	☐	☐	33. Graphical Calculus — Determination of rates or changes from empirical data by graphical means.

Should not be included	Limited Emphasis	Moderate Emphasis	Major Emphasis
1	2	3	4

☐ ☐ ☐ ☐ 34. Vectors — Basic fundamentals of coplanar and non-coplanar vector systems.

Others: _____

_____

_____

_____

III. PERSONAL DATA.

*1. Name _____
(Last, First, Middle Initial)

2. College or University _____

3. Position: Dean ☐ Head of Dept. ☐ Classroom Teacher ☐ Lab. Instructor ☐

4. Rank: Prof. ☐ Assoc. Prof. ☐ Assist. Prof. ☐ Instructor ☐ Other ☐ _____

5. **Highest** degree held: Bachelor ☐ Master ☐ Doctor ☐

6. Major Mechanical Engineering teaching field (s) _____

_____
(As thermodynamics, machine design, heat transfer, etc.)

7. Years of engineering teaching experience _____

8. Years of engineering experience in industry _____

*No mention of names of respondents will be made in the report on this questionnaire.

APPENDIX E

LETTERS TO MECHANICAL ENGINEERING EDUCATORS CONCERNING PARTICIPATION IN THIS STUDY

April 18, 1958
Tri-State College
Angola, Indiana

(Chairman, Mechanical Engineering Dept.)
. . .
. . .

Dear Sir:

The University of (. . .) has been selected as one of the universities to participate in a graduate study being conducted at the University of Oklahoma.

This study is concerned with determining the opinions of selected mechanical engineering educators toward the purposes and content of Engineering Graphics courses. We would like to send a check list questionnaire to a selected group from your department who would be representative of the various mechanical engineering subjects taught at your university (as thermodynamics, heat transfer, machine design, and material and processes). The recommended faculty should have at least five years teaching experience and should not be engaged in teaching engineering drawing or descriptive geometry. If you could participate, also, it would make a real contribution toward the validity of this study in engineering education and it will only take a few minutes time to complete the questionnaire check list.

An early reply from you will permit this study to proceed without delay. A stamped envelope is enclosed for your convenience in returning this list. Let me take this opportunity to express my appreciation for your cooperation in this study.

Yours very truly,

Sherman F. Dreyer,
Associate Professor
Mechanical Engineering Dept.
Tri-State College

Sherman F. Dreyer
Tri-State College
Angola, Indiana

The following members of my department are recommended to participate in this study:

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

(If more space is needed, use reverse side of this sheet.)

_____
Chairman, Mechanical Eng. Dept.
University of (. . .)

TRI-STATE COLLEGE

Engineering · Commerce

Angola, Indiana

May 10, 1958

Dear Sir:

You have been recommended by the chairman of your department to be a representative of your subject area for your school in a study being conducted as a part of my doctoral research at the University of Oklahoma. This study is designed to determine the opinions of selected mechanical engineering educators concerning the purposes and content of undergraduate Engineering Graphics courses.

The enclosed questionnaire check list will take only a short time to complete and will make a significant contribution toward this study.

An early reply from you will permit this study to proceed without delay. A stamped envelope is enclosed for your convenience in returning this list. Let me take this opportunity to express my appreciation to you for your co-operation in this research effort.

Yours very truly,

Sherman F. Dreyer
Mechanical Engineering Dept.
Tri-State College

TRI-STATE COLLEGE

Engineering · Commerce

Angola, Indiana

May 15, 1958

(Chairman of the Mechanical Engineering Dept.)

Dear Sir:

It was very kind of you to recommend selected representatives from the Mechanical Engineering Department of your school to participate in the study being conducted as a part of my doctoral research at the University of Oklahoma. A copy of the questionnaire has been sent to these men and I am sure their opinions of the purposes and content of Engineering Graphics courses will be significant in this study.

A questionnaire check list is also enclosed for your opinions and will take only a short time to complete. I would appreciate it if you will return this completed questionnaire in the enclosed stamped envelope as soon as possible. Your opinions, as chairman of the department, will help in establishing the validity of this research project. Thank you again for your cooperation.

Yours very truly,

Sherman F. Dreyer
Mechanical Engineering Dept.
Tri-State College

TRI-STATE COLLEGE

Engineering . Commerce

Angola, Indiana

May 27, 1958

Dear Sir:

In the event you have mislaid our questionnaire check list, we are enclosing another, and also another stamped envelope for your convenience in returning the list. This research project being conducted as a part of my doctoral program at the University of Oklahoma has been sent to such a select group of mechanical engineering educators that your opinion concerning the purposes and content of undergraduate Engineering Graphics courses is of great value to us.

I am sure the enclosed questionnaire check list will take only a few minutes of your time to complete, and your efforts will certainly be appreciated.

Yours very truly,

Sherman F. Dreyer
Mechanical Engineering Dept.
Tri-State College

P.S. If you have already returned the questionnaire, please disregard this letter.