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A Survey of University Engineering Departments in the State of Washington to Determine Engineering Drawing Requirements for High Schools

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A SURVEY OF UNIVERSITY ENGINEERING DEPARTMENTS IN THE STATE OF WASHINGTON TO DETERMINE ENGINEERING DRAWING REQUIREMENTS FOR HIGH SCHOOLS

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CHAPTER 1

THE PROBLEM AND DEFINITIONS OF TERMS USED

During the past few decades universities and colleges have been increasing the requirements for high school students entering engineering. These requirements include algebra, geometry, physics or chemistry, and English. Up to the present time, universities in the state of Washington have given little attention to engineering drawing as one of these requirements. Engineering schools in other states, however, have established high school mechanical drawing as a specific entrance requirement.

1. THE PROBLEM

Statement of the problem. It was the purpose of this study to determine (1) whether a course in engineering drawing designed to parallel part of the first year engineering college drawing requirement could be taught in the high schools in the state of Washington and (2) how much time should be allocated in each of the various areas of such an engineering drawing course.

Importance of the study. Engineering drawing, a basic tool in the engineering profession, is the principal means by which an engineer expresses his ideas in a technical world. In our changing society, engineers need additional time for courses of a more technical nature. Part of this additional time is acquired by deleting or cutting down the credit hours in engineering drawing and the fundamentals of mechanical drawing in the college. Therefore, high schools must improve their offerings in mechanical drawing to fulfill the responsibilities given them by the engineering schools. These courses could be revised to parallel the introductory drawing course being taught in the universities. The engineering student would have the benefit of extra time for technical courses and still have the necessary instruction in drawing techniques.

II. DEFINITIONS OF TERMS USED

Engineering Drawing. Engineering drawing means a graphic language in the field of engineering. It is the principal means of expressing ideas in a technical world. In this study the term is interchangeable with mechanical drawing and engineering graphics.

Descriptive geometry. This, the grammar of the graphic language, is the three-dimensional geometry forming the back ground for solving problems graphically.

Pre-engineer. A student who plans to enter the engineering course of study in colleges or universities is classified as pre-engineer.

Period. This, a unit of time used in high schools, is the amount of time designated for one class, usually from forty-five to fifty minutes in length.

Representatives. These were the engineering deans and instructors interviewed in the four universities included in this study.

Unit. A unit is referred to as one part of a drawing course which would contain many units.

University. An educational institution for advanced instruction is often used interchangeably with college. In this study only the universities that offered a degree in engineering were interviewed since no colleges in the state of Washington offer the engineering degree.

CHAPTER 11

REVIEW OF THE LITERATURE

A considerable amount has been written about entrance requirements to our colleges and universities, but very few writers have been concerned with the topic discussed in this study.

The reduction of drawing requirements in engineering colleges has been of great concern to many people. The engineer will have difficulty in presenting new ideas in his professional work if he lacks preparation in engineering drawing. He may also find it difficult to present an improvement in a piece of machinery without the use of orthographic projectional view which includes dimensions.

John H. Hernandez of Manhattan College is one of the people vitally concerned with this problem. In a recent engineering journal he reported:

> Another difficulty not at all unique to graphics, but one that is a problem for anyone hoping to do a meaningful job of preparing a student in any field of engineering is the lack of sufficient time. Although this is true of most fields, it is particularly true with respect to graphics. Graphics, for some reasons to be discussed later, is high on the list of subjects whittled down to make room in the engineering program for new courses or for a reduced program load (8:20).

In agreement with Mr. Hernandez is Shriver L. Coover, presently the Director of the Industrial Arts Department, State Teachers College, California, Pennsylvania. Mr. Coover states:

> If the present trend of minimizing drawing in engineering-college curriculums continues, it will only be a few years until high schools will have to assume a major role in the teaching of mechanical drawing. In fact, basic mechanical drawing courses will become prerequisites for admission to engineering courses, the same as mathematics is at the present time. Drawing must be considered a basic educational tool just as the three R's were considered tool subjects in the past (4:24).

Time has certainly made Mr. Coover's statement come true. Basic mechanical drawing courses are now prerequisites for admission to the engineering schools in California. There, several schools of engineering require students to have high school mechanical drawing. California has been a leader in the field of education for many years, and it is probable they have started a trend for other schools to follow.

Mechanical drawing in high school is a prerequisite to entering the school of engineering at the universities at Berkeley, Davis, and Los Angeles. The catalog of the University of California at Los Angeles states:

> It is important for such applicants to include the following subjects in the list of high school courses taken to satisfy the University admission requirements, regardless of which of the plans of admission they choose:

Algebra	2 units
Plane Geometry	1 unit
Trigonmetry.	1/2 unit
Chemistry or Physics	1 unit (both are desirable)
Mechanical Drawing	1 unit (18:35).

All of the state colleges in California recommend that mechanical drawing be taken in high school. At least one year and sometimes two years of mechanical drawing is suggested. Fresno State College has recently made it a requirement in its school of engineering. The section on high school preparation in their catalog states:

> The minimum high school preparation for the courses leading to the B. S. degree in Engineering and the B. S. degree in agricultural engineering consists of plane geometry (1 year), algebra (2 years), trigonmetry (one-half year), physics or chemistry (1 year), and mechanical drawing (1 year). The omission of any part of the minimum amount of high school preparation will almost invariably make it necessary for the student to spend more than four years obtaining the B. S. degree. Solid geometry, both physics and chemistry, and additional mechanical drawing are strongly recommended (6:262).

Universities and colleges in California are aware of the necessity of this pre-college requirement; schools in other states also are aware of this fact. Donald P. Hoagland of New Jersey recently made a survey of 34 colleges and universities, all of which offer a degree in engineering. Colleges and universities in New Jersey, New York, Pennsylvania, and several other states were included. He writes:

Section 1: 8% of the colleges required one year of drawing in high school. The majority of the colleges preferred that all of the entrants have mechanical drawing. Pennsylvania State is at present studying the possibility of creating such a requirement.

Section 2: 76% of the colleges recommended at least one year of mechanical drawing. George Institute of Technology recommends at least two years (9:23).

Schools of engineering are not alone in their concern with this problem. Industry is interested; so is the engineering profession. Professional engineering journals indicate that the profession would like to see more and better engineering drawing courses offered in our high schools. Robert S. Lang said, "If colleges are to teach more and better graphics, the high school drawing program must be improved" (10:38). This is very true. Colleges may begin teaching at a much higher level if students have had a comprehensive drawing course in high school. This saves valuable teaching time in college and allows the engineering program to provide additional courses in place of engineering drawing. A pre-engineering course in high school removes much of the burden from college faculties (17:43).

Engineering educators strongly favor this type of program. An article in one of their journals reads:

> Balloting followed the 1960 conference on Civil Engineering Education at the University of Michigan in Ann Arbor, from 140 schools. They recommended (1) a pre-engineering program and (2) extending the total period of education according to A. S. C. E. (5:86).

Evidence points to the need for a high school engineering drawing course to cover the basic material ordinarily included in the introductory drawing course in universities. This need should be met as quickly as possible in this state. When accomplished, the total educational system will be improved.

CHAPTER 111

METHOD OF GATHERING DATA

Method of gathering data. Deans of the colleges of engineering in the universities were interviewed, and at the time of the interview a check list was filled out. A sample of the check list is shown in the Appendix.

The people being interviewed generally believed that an engineering drawing course to parallel the introductory course in the universities in the state of Washington could be taught in the secondary schools. Based upon the recommendations of the departments of engineering, a guide has been set up showing the amount of time that should be spent in each area of engineering drawing.

Groups interviewed. The people interviewed were the Deans of Engineering at Gonzaga University, Seattle University, Washington State University, and the University of Washington.

The interview check list. This study began in June, 1960, when the writer was teaching mechanical drawing in a high school in the state of Washington. He felt a need for improvement in the drawing courses being offered in high schools. An informal interview with a representative

of Washington State University indicated a need for a drawing course of this type in the near future. During 1961, research was done in the literature and the check list was formulated. In June, 1962, letters were sent to the universities involved to arrange for the interview. The interviews were made the following week during a three day period.

During the interview, the writer discussed each question with each representative. This allowed him (1) to obtain accurate views of the universities, which a check list could not do, and (2) to answer any questions about the check list. The check list served as a guide to follow and as a means of recording information received. The interview check list covered two main points: (1) do the universities believe a pre-engineering drawing course should be offered in the high schools? and (2) how much time should the schools spend on each unit in such a course?

CHAPTER IV

THE INTERVIEW CHECK LIST RESULTS

The results of the personal interviews were satisfying. This chapter will discuss the responses to the check list questions.

The universities were in agreement with the writer concerning the need for a drawing course designed for the pre-engineer. They believed that high schools could and should teach a drawing course paralleling part of the first year engineering college drawing requirements. However, this would be feasible and desirable only if taught by a fully-qualified instructor. Representatives of the four universities believed this person should have a good background in engineering drawing as well as a knowledge of the construction, operation, and function of equipment and machines.

All four representatives responded affirmatively to question four, "Do you believe a one-year course in high school, meeting daily, would be adequate to meet the requirements of the beginning college course?" To question five, "How many semesters should be required?", Seattle University checked one semester. On this same question Washington

State University marked one or two semesters.

The universities believe the elementary aspects of beginning engineering drawing courses are being forced out of the curriculum. In some instances the introductory course is by-passed.

Descriptive geometry is no longer required for the civil engineering student enrolled at Gonzaga University. For many years this course was required for all engineering students. The amount of time in credit hours has been reduced in all drawing courses. Descriptive geometry is now a two-hour course, and the engineering drawing course has also been reduced to two hours. Originally, students were allowed three credit hours for each of the courses at Gonzaga University.

A student may be excused from enrollment in the introductory drawing course. Dr. John G. McGivern, Dean of Engineering, stated:

> An examination is given to the people who feel that they know the basic material in engineering drawing. The work that they have done in high school is studied. If the combination of work and the results of the examination are satisfactory, the student is excused from the introductory course in engineering drawing. If the work is of good quality but deficient in one area, additional work is assigned out of class to satisfy the requirement (13).

Gonzaga is not the only university that has done this. At Seattle University a student may take a test in mechanical drawing, and if he has the ability to pass this test, he is excused from registering for the introductory course in engineering drawing. This allows the student to enroll in an advanced course in his junior or senior year. At this university, students majoring in mechanical engineering are the only ones required to take descriptive geometry.

At Seattle University there are three drawing courses. One is descriptive geometry and the remaining two are engineering drawing. The introductory course in engineering drawing may be omitted from the curriculum in the near future. A representative of the school felt that much of this material could be studied elsewhere. The most likely place for obtaining this basic material would be in the secondary schools.

All of the incoming freshman at the University of Washington are given a test in engineering drawing. This test measures spatial visualization and mechanical aptitudes, and about 20 per cent of the freshmen pass. These students are not required to take the regular introductory courses, General Engineering 101 and 102. Instead, they take special courses, General Engineering 104 and 105.

Washington State University has just revised its introductory drawing course. Any student who does not have the basic fundamentals of engineering drawing will find this course difficult. The School of Engineering feels that students should have a basic understanding of the principles of engineering drawing before they enter college. The course outline states:

> In the fall of 1962, the first course in engineering graphics will commence a gradual upgrading of this course to provide a shift from the essentially representational aspects of engineering drawing to a program that can be titled an introduction to engineering design.
>
> Projects have been devised that stimulate a creative approach, and appropriate morphology has been employed to enhance the engineering orientation aspects of this freshmen program (15:1).

Students needing additional help with the basic concepts of drawing may take night classes. These classes will operate for a short period of time, and there will be no credit. They are primarily to help the individual who does not have an adequate background in drawing. However, evening sessions will be discontinued after one or two years. This indicates that students will have to receive their training prior to entering the university. The easiest and most practical place to obtain such training is in high school.

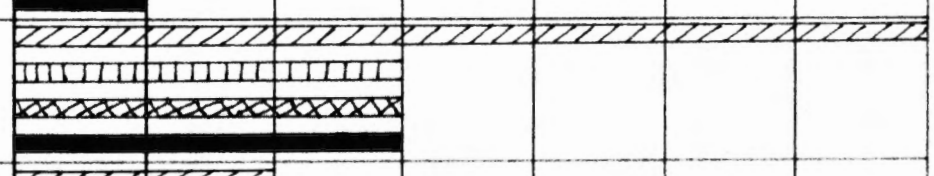
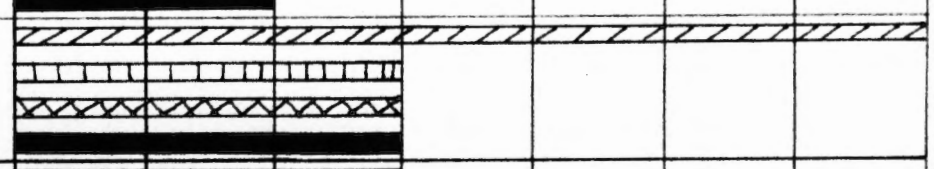
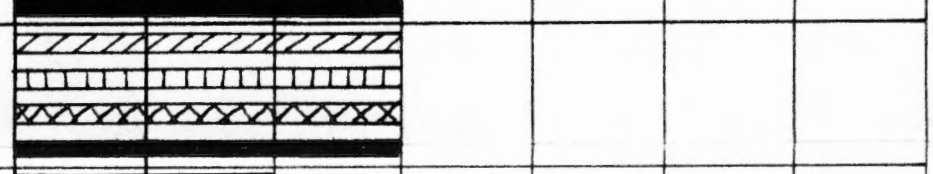
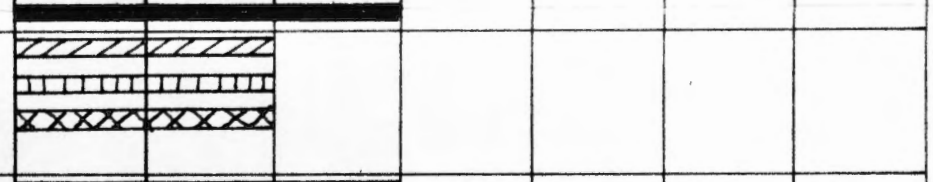
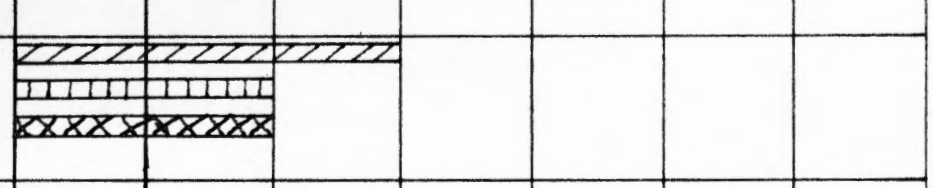
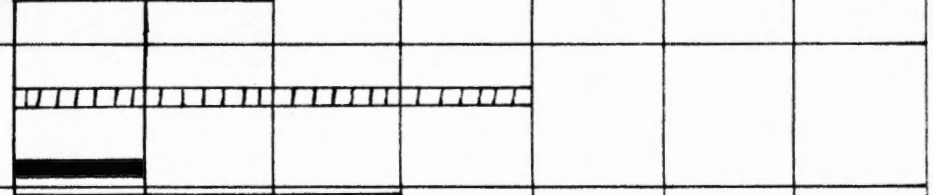
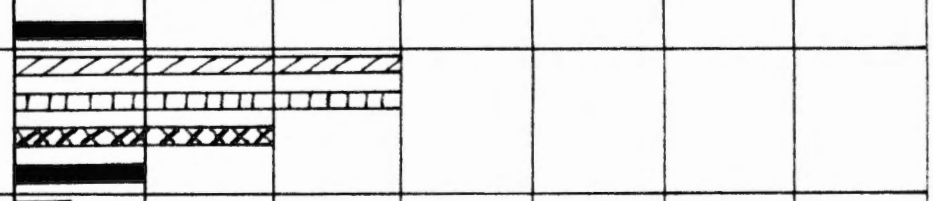
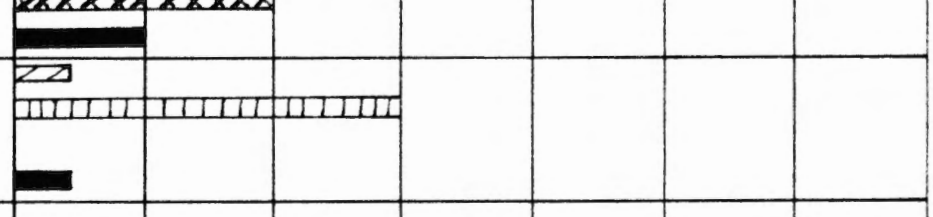
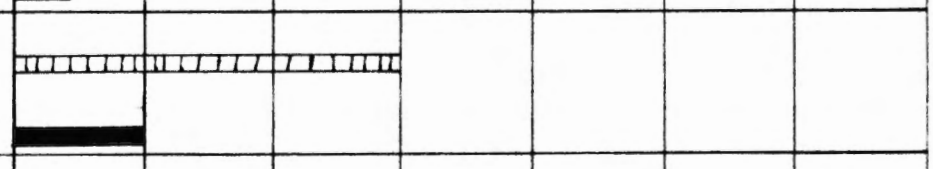
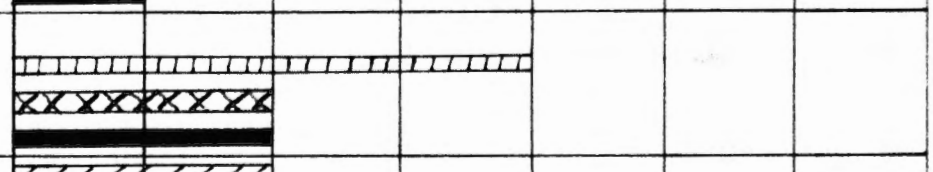
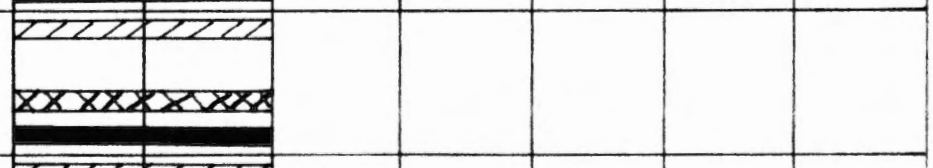
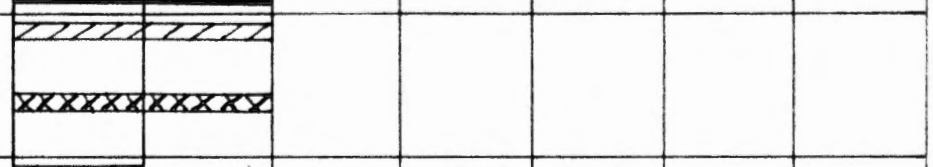
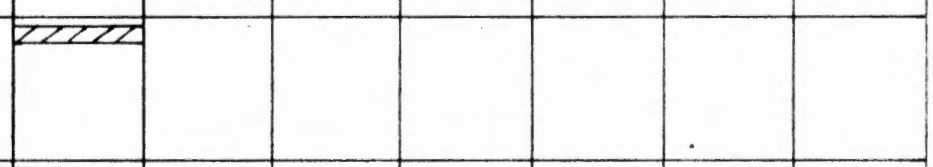
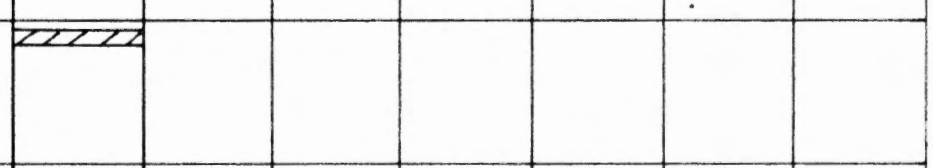
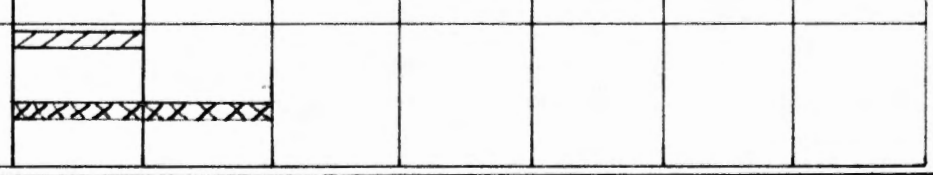
Question six asked whether it was desirable to have a separate room for drawing. The representative from Washington State University saw no need for a separate room for drawing in the high school. He believed that a qualified instructor should be able to instruct students in almost any room. The industrial arts general shop was used as an example. The work benches, with some modifications, would suffice as drawing tables, and it was assumed there would be adequate lighting in this room. The main reason for not recommending a separate drawing room was the cost involved. If such a room were available, he agreed it would be most advantageous.

It could be assumed beforehand that there would be variation in the answers received to question seven, "How much time should be spent in the following unit?" Except for one or two units, there was a very close correlation among the four universities. (See Figure 1). In the language of drawing, which also includes the history of drawing, the representatives believed the material could be covered in two days. The unit, "Learning to Draw" including the description, explanation, and use of instruments, would take approximately three days to cover. Gonzaga University grouped unit one and two together, to be covered in one week.

Washington State University and the University of Washington limited the time allowed for lettering to two days, although this did not include lettering plates to be done during the course. Seattle University and Gonzaga University believed that it would take one week to cover lettering, and that this week would be stretched out over the full year and would include practice lettering each week. Three universities agreed that geometric construction could be covered in one week. Gonzaga University, the exception on this unit, left blank the check list. This representative believed other units were more important.

Shape description or visualization and multiview projection are probably the most important requisites of a successful engineer. Visualization is the ability of a person to study the three views of an object and form a mental picture of it in three-dimensional shape. Multiview projection is the ability to look at an object and then visualize or draw three views of it. To the engineer, planning a new machine for a job means the ability to form a mental picture before the object even exists. This is one of the reasons visualization and multiview projection are so important. Washington State University, Seattle University, and the University of Washington checked three weeks' time for each unit. The Gonzaga University representative found these two units gave the incoming students the most trouble. With this in mind, he combined the two units and recommended fourteen weeks be used to cover this material.

INSTRUCTIONAL UNIT	SCHOOL	WEEKS TO BE DEVOTED TO EACH UNIT 1 2 3 4 5 6 7
Language of Drawing (universal language)	GU SU UW WSU	
Learning to Draw (use of instruments)	GU SU UW WSU	
Lettering (importance of lettering)	GU SU UW WSU	
Geometric Construction (principle of pure geometry)	GU SU UW WSU	
Shape Description (draw objects from three views)	GU SU UW WSU	
Sketching (types, scales, proportions)	GU SU UW WSU	
Multiview Projection (complete the third view)	GU SU UW WSU	
Sections (an internal view)	GU SU UW WSU	
Auxiliary Views (view used to show principal faces)	GU SU UW WSU	
Revolutions (views used to show true length and shape)	GU SU UW WSU	
Shop Processes (manufacturing methods)	GU SU UW WSU	
Dimensioning (to show the size of objects)	GU SU UW WSU	
Tolerancing (maximum and minimum of sizes)	GU SU UW WSU	
Screws, Bolts and Fastenings (type of threads, pitch and kinds)	GU SU UW WSU	
Working Drawings (drawings used in production)	GU SU UW WSU	

Lettering (importance of lettering)	GU SU UW WSU	
Geometric Construction (principle of pure geometry)	GU SU UW WSU	
Shape Description (draw objects from three views)	GU SU UW WSU	
Sketching (types, scales, proportions)	GU SU UW WSU	
Multiview Projection (complete the third view)	GU SU UW WSU	
Sections (an internal view)	GU SU UW WSU	
Auxiliary Views (view used to show principal faces)	GU SU UW WSU	
Revolutions (views used to show true length and shape)	GU SU UW WSU	
Shop Processes (manufacturing methods)	GU SU UW WSU	
Dimensioning (to show the size of objects)	GU SU UW WSU	
Tolerancing (maximum and minimum of sizes)	GU SU UW WSU	
Screws, Bolts and Fastenings (type of threads, pitch and kinds)	GU SU UW WSU	
Working Drawings (drawings used in production)	GU SU UW WSU	
Pictorial Views (several types of pictorial views)	GU SU UW WSU	
Axonometric Drawings (inclined views)	GU SU UW WSU	
Oblique Projection (oblique views of objects)	GU SU UW WSU	
Perspective Views (as a person sees an object)	GU SU UW WSU	
Engineering Graphics (mathematics and drawing)	GU SU UW WSU	

Key: GU-Gonzaga University; SU-Seattle University; UW-University of Washington; WSU-Washington State University

FIGURE 1

COMPARATIVE RESULTS OF CHECK LIST OF UNIVERSITIES INTERVIEWED

The importance of freehand sketching to the engineer cannot be over-estimated. To the person who has a knowledge of drawing as a language, the ability to execute quick, clear, and accurate sketches constitutes a valuable means of expression (7:129). Sketching should include approximately two weeks' time. All of the representatives were in agreement on the question of sketching. This unit should be distributed throughout the course, as a sketch should be made of each new object prior to the actual starting of the drawing.

Many times engineers are confronted with the need for showing the interior of parts that cannot be shown clearly with hidden lines. This is accomplished by slicing through the object with a plane, much as one would cut through an apple. A cutaway view is drawn. This is called a sectional view. It was a unanimous decision by the universities to spend three weeks' time on this unit.

Three representatives believed auxiliary views could be covered in two weeks. Washington State University was the exception, making no allowance for this unit in the check list.

Washington State University did not check any time for the unit on revolutions. Seattle University and the University of Washington

thought two weeks would be enough time to cover the unit, and the representative of Gonzaga University believed three week's time should be used.

The preceding ten units were the most important to the four university representatives as a group. Agreement as to the relative importance of the remaining ten units was not so great.

The University of Washington and Gonzaga University allowed no time for shop processes, which includes information on the shape, size, material, and finish.

Seattle University grouped this unit with the next four (Dimensioning; Tolerancing; Screws, Bolts, and Fastenings; and Working Drawings) into an eighteen week period. This would cover just about one semester and would be primarily machine drafting.

Dimensioning was mentioned by the remaining three universities with varying emphasis: Washington State University checked one week, University of Washington checked two weeks, and Gonzaga University checked three weeks. Tolerancing was checked only by the representatives of Washington State University and Gonzaga University. The emphasis was slight, only two days' time.

Screws, Bolts, and Fastenings was checked for one week by Washington State University, the material to be covered in several drawings and not to be given in a unit by itself.

Working Drawings was omitted by Gonzaga University; the other schools believed two weeks would be enough time to cover the material. Beyond this point no unit was checked by Seattle University.

The remaining three schools judged two weeks would be used to cover the material included in pictorial views.

Axonometric Drawings, which include dimetric and trimetric views, was omitted by Washington State University and Seattle University. Gonzaga University and the University of Washington recommended two weeks for this unit.

Only Gonzaga University suggested that Oblique Projection and Perspective Views be included in such a course. The representative thought two weeks should be enough to cover the material.

The remaining unit, Engineering Graphics, was checked for one week by Gonzaga University and for two weeks by University of Washington. Both considered this an introduction to engineering graphics.

Question eight is more difficult to interpret. Washington State University listed in order of importance the following: Visualization, Multiview Projection, Pictorial Views, and Sections. Gonzaga

University only listed three: Visualization, a second group of four units (Axonometric Drawings, Oblique Projection, Perspective Views, and Pictorial Views) and Auxiliary Views.

Multiview Projection, Engineering Graphics, Sketching and Dimensioning was the order of importance given by the University of Washington. Seattle University listed Lettering, Line Weight, Orthographic Projection, and Dimension as the important units. The four units, Shape Description or Visualization, Multiview Projection, Pictorial Views, and Dimensioning had the highest rating. Each of these units was marked by two representatives.

The only representative the writer interviewed who was willing that his name be used as a reference was Dr. John G. McGivern of Gonzaga University.

Figure 2 compares the mechanical drawing units in the state curriculum guide and the units recommended by the university representatives. There is a definite indication that the university engineering departments would like to see a larger coverage of material than the curriculum guide recommends. Some of the universities would like to see Tolerancing, Axonometric Drawing, Oblique Projection, Perspective Views, and Engineering Graphics included in the pre-engineering drawing course. The units included in

Unit	Curriculum Guide	Universities
Language of Drawing (History)	X	X
Learning to Draw (Description, explanation, and use of instruments)	X	X
Lettering	X	X
Geometric Construction	X	X
Shape Description (Visualization)	X	X
Sketching	X	X
Multiview Projection	X	X
Sections	X	X
Auxiliary Views	X	X
Revolutions	X	X
Shop Processes (Shape, size, material, and finish)	X	X
Dimensioning	X	X
Tolerancing		X
Screws, Bolts, and Fastenings	X	X
Working Drawings	X	X
Pictorial Views	X	X
Axonometric Drawings		X
Oblique Projection		X
Perspective Views		X
Engineering Graphics		X

FIGURE 2

COMPARISON OF MECHANICAL DRAWING UNITS LISTED IN THE WASHINGTON STATE CURRICULUM GUIDE FOR INDUSTRIAL ARTS AND THE UNITS OF DRAWING UNIVERSITIES BELIEVE TO BE OF IMPORTANCE

this chart taken from the curriculum guide are a computation of two drawing courses listed in the guide, introductory drawing and general drawing. General drawing includes machine and industrial drawing, architectural drawing, and aircraft drawing. The information included in this figure should give the reader a more concise picture of this comparison.

CHAPTER V

SUMMARY AND CONCLUSIONS

There is definitely a need for the secondary schools in the state of Washington to provide a basic, comprehensive course for students who plan to enter schools of engineering. There is a definite trend toward shortening the time allotted to engineering drawing in the college curriculum. This time allotment for engineering drawing courses is being completely omitted from some engineering programs. Because these courses are being reduced, there is an urgent need for students to obtain this training prior to entering college. The easiest and most logical place to receive this training would be in high school. The universities agree with this.

Representatives of the four universities believe a course offered in the secondary schools could adequately cover the basic material presently being forced out of the college curriculum.

They are sure that a one-year course would be enough to cover the necessary material. This time allowance might be reduced

to one semester depending upon the instructor and the students involved. One period per day or five periods per week should be allowed for this course.

Until universities in the state of Washington specifically state that engineering drawing is a prerequisite for students entering the school of engineering, it is going to be difficult to convince some of the administrators, school boards, and parents of this need. This job will have to be accomplished by the industrial arts instructor, and it will not be an easy one. One of the better ways to do this is to convince students going into engineering of the need for such a course. Usually if enough students are interested in a course, the administration and the school board will find a place for it in the curriculum. To some parents, seeing this requirement in the catalog for the University of California would be very convincing. California, one of the leaders in education, many times in the past has been followed by Washington.

The counselor may be very helpful in encouraging pre-engineering drawing courses in high school. Most counselors are aware of present trends in the entrance requirements of colleges and universities and will usually support the inclusion of required and recommended courses in the high school curriculum.

If possible, this course should be offered to students of senior standing who have a 3.0 or better grade point average. It may be difficult to offer a drawing course only to pre-engineers because of the size of the school. The qualifications of the instructor would be of prime importance. He should have a good background in engineering drawing as well as a knowledge of the construction, operation, and functions of equipment and machines.

The projected course outline (Figure 3) is two fold in purpose. First, it indicates the units that should be covered to parallel the introductory courses in the universities; it also recommends the time a student should be involved in order to cover the material thoroughly.

The proposed time allotment in the course outline may deviate as will any class in high school, and should be balanced according to the discretion of the instructor.

The course units and time allotment recommended by the four universities should certainly be helpful as a guide for a proposed drawing course of this type.

The instructional units in the projected course outline are presented as guides, not as a rigid course to be followed verbatim by

PROJECTED COURSE OUTLINE FOR WASHINGTON STATE HIGH SCHOOLS		
UNIT	WEEKS	REMARKS
Language of Drawing (history)	1	Universal language, drafting standards, definitions
Learning to Draw (description, explanation and use of instruments)	1	Description, operation and use of instruments, line weight
Lettering	1	Importance of lettering, lettering styles, size of letters, practice throughout the course
Geometric Construction	1	Bisecting lines and angles, principles of pure geometry
Shape Description (visualization)	3-4	Draw objects from three views
Sketching	2-3	Types of sketches, scales, proportions, choice of view
Multiview Projection	4-6	Glass box, folding lines, two view, three view
Sections	3-4	Cutting plane, types of sections
Auxiliary Views	2	Reference planes, auxiliary plane, dihedrial lines, successive auxiliary
Revolutions	2	Successive views, true length, counter revolutions
Shop Processes (information to shape, size, material and finish)	2	Manufacturing methods, patterns, shop tools, equipment, measuring devices
Dimensioning	2	Size, description, lines used, fractional and decimal dimensions
Tolerancing	1/2	Definition of terms, unilateral and bilateral tolerances, types of fits

Lettering	1	Importance of lettering, lettering styles, size of letters, practice throughout the course
Geometric Construction	1	Bisecting lines and angles, principles of pure geometry
Shape Description (visualization)	3-4	Draw objects from three views
Sketching	2-3	Types of sketches, scales, proportions, choice of view
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Auxiliary Views	2	Reference planes, auxiliary plane, dihedrial lines, successive auxiliary
Revolutions	2	Successive views, true length, counter revolutions
Shop Processes (information to shape, size, material and finish)	2	Manufacturing methods, patterns, shop tools, equipment, measuring devices
Dimensioning	2	Size, description, lines used, fractional and decimal dimensions
Tolerancing	1/2	Definition of terms, unilateral and bilateral tolerances, types of fits
Screws, Bolts and Fastenings	1/2	Types of threads, pitch, kinds
Working Drawings	2	Definition and use of details, types, check drawings
Pictorial Views	2	Several faces appearing at one time
Axonometric Drawings (dimetric and trimetric)	1	Isometric projection, dimetric and trimetric views
Oblique Projection	1	Cavalier and cabinet projection
Perspective Views	1	Multiview, one point, two point, and three point perspectives
Engineering Graphics	1	Mathematics and Drawing

FIGURE 3

PROJECTED COURSE OUTLINE FOR WASHINGTON STATE HIGH SCHOOLS

the instructor. The course material is considered to be basic material that will parallel the introductory drawing course in the universities in the state of Washington.

Students should learn to use acceptable drafting techniques in the production of working drawings. They should learn to include reference material (when needed in their drawings) in a logical and readable order and be able to picture accurately complicated drawings of equipment, machines, and details.

Drawing projects have not been included in this outline because the selection and design of projects is never static. Ideas may be obtained from contemporary sources or from various textbooks or magazines. It should be kept in mind, however, that the selection of projects for drawing should progress from the simple to the complex, each drawing involving new concepts and methods of attack.

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APPENDIX

APPENDIX A

THE INTERVIEW CHECK LIST

1. Do you feel that the beginning engineering drawing course is being forced out of the curriculum for one reason or another at your university?

   Yes_____ No_____

2. Do you think that a beginning course in engineering drawing to parallel part of the first-year engineering college drawing requirements could be taught in the high schools of Washington?

   Yes_____ No_____

3. Would your department be in favor of such a program?

   Yes_____ No_____

4. Do you believe a one-year course in high school, meeting daily, would be adequate to meet the requirements of the beginning college course?

   Yes_____ No_____

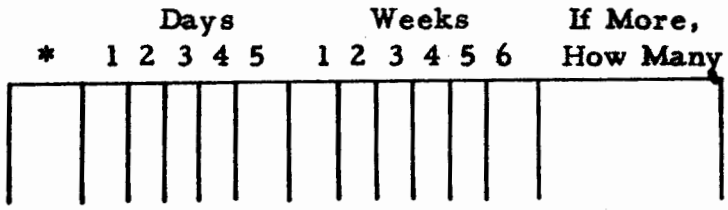
5. If not, how many semesters do you think should be required?

   1. _____ 4. _____
   2. _____ 5. _____
   3. _____ 6. _____

6. Do you think that there should be a separate room for drawing?

   Yes_____ No_____

7. How much time do you think should be spent on the following units?



1. Language of Drawing (History)

	*	Days 1	2	3	4	5	Weeks 1	2	3	4	5	6	If More, How Many
2. Learning to Draw (Description, explanation, and use of instruments)													
3. Lettering													
4. Geometric Construction													
5. Shape Description (Visualization)													
6. Sketching													
7. Multiview Projection													
8. Sections													
9. Auxiliary Views													
10. Revolutions													
11. Shop Processes (Information to shape, size, material and finish)													
12. Dimensioning													
13. Tolerancing													
14. Screws, Bolts, and Fastenings													
15. Working Drawings													
16. Pictorial Views													
17. Axonometric Drawings (Dimetric and Trimetric)													

	*	Days 1	2	3	4	5	Weeks 1	2	3	4	5	6	If More, How Many
18. Oblique Projection													
19. Perspective Views													
20. Intersections and Developments													
21. Aircraft Drafting													
22. Welding Drawings													
23. Electric Drawings													
24. Cams and Gears													
25. Graphs													
26. Engineering Graphics													
27. Structural Drafting													
28. Topographic Drawing													
29. Mapping													
30. Architectural Drafting													
31. Reproduction of Drawings													
32. Others													

8. In the column with the *, would you please mark in order of preference, the minimum units that should be included in such a course?

9. Would you mind if I used your name with reference to this university in my thesis?

Yes_____ No_____