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A study of the status of mechanical drawing in the secondary schools of Indiana together with a suggested course of study

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A STUDY OF THE STATUS OF MECHANICAL DRAWING IN THE SECONDARY SCHOOLS OF INDIANA TOGETHER WITH A SUGGESTED COURSE OF STUDY

by

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A. The Problem

Little has been done toward the standardization of the teaching of mechanical drawing in the secondary schools of Indiana. Although a state course of study has been written on the subject of mechanical drawing, many instructors teach this subject in their own ways and use their own courses of study. It was believed that a study of the work of mechanical drawing instructors throughout the state would make available comparative data on the practices, objectives, and courses of study most commonly used in the state. It was believed that from these data a suggested course of study could be compiled. Although every instructor would not be required to follow a rigid course of study, these data would, nevertheless, guide him in the teaching of the fundamental facts of the subjects found common throughout the state.

The purpose of this study is to learn the objectives, content of courses, and presentation of the work in mechanical drawing as now prevailing in Indiana, and from these data to compile a suggested course of study.

B. The Scope

This study has been made with the purpose of determining the teaching of mechanical drawing in Indiana with respect to:

1. Objectives
2. Content of courses
3. Methods of presentation
4. The compilation of a suggested course of study

C. The Method

Since it was impossible to contact the instructors of the state personally, it was necessary to use a questionnaire as a means of securing information for this study.

In preparing the questionnaire, twelve objectives of mechanical drawing were listed. To determine these objectives, a number of leading authorities[1] were consulted and those objectives most commonly mentioned by them were used. A space was left where other objectives could be listed by instructors who wished to add to the list.

Instructors of mechanical drawing were asked to check the objectives used in their classes and also to rank the objectives in what they thought to be the order of their importance.

To determine the content of courses a number of instructional topics were listed, as found in the previously mentioned references and from personal experience. Each instructor was asked to check the topics taught and the grade in which they were offered.

To get some conception of the method of presentation and preparation of courses by the instructors of the state, a number of questions were made out to be checked. Care was taken to make the questions as short as possible and to word them so they might

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[1] See Page 8 for authorities used.

be answered either by a short statement or a check mark.

D. The Procedure

First a preliminary questionnaire was made and handed to a number of mechanical drawing teachers in Gary, Indiana, where the writer was teaching. These teachers made suggestions for improving the questionnaire. It was revised as shown in appendix, page 51.

Enclosed with each questionnaire sent out was a form letter (see appendix, page 55).

E. The Extent of the Study and the Replies Received

An attempt was made to find the names of all the teachers of mechanical drawing in the state. Due to the fact that there was no available list of mechanical drawing teachers, the names were selected from the State Directory for 1934-35. In a number of cases teachers were listed as industrial arts teachers instead of mechanical drawing teachers. Even when this was true a questionnaire was sent, and in several instances, when it happened to reach a shop teacher, it was passed on to the drawing teacher. There were 175 questionnaires sent out to all parts of the state. Of the 175 sent out 122 were returned, 15 of which were unanswered. Those that were returned unanswered were from instructors who did not teach mechanical drawing. The total number of questionnaires used in this study was 107 or 61% of those sent out. Since these returns are from all parts of the state and from leading instructors in the field of mechanical

drawing, a rather definite cross section of the work can be ascertained.

Table I shows by counties the distribution of questionnaires sent out and the replies received.

TABLE I

DISTRIBUTION OF QUESTIONNAIRES SENT OUT AND REPLIES RECEIVED BY COUNTIES

County	Questionnaires sent out	Replies received
Adams	1	1
Allan	8	5
Bartholomew	2	2
Benton	1	1
Blackford	1	1
Boone	1	1
Barrol	1	1
Cass	2	1
Clark	1	1
Clay	1	0
Clinton	1	1
Daviess	2	1
Dearborn	1	1
Decatur	1	1
DeKalb	1	1
Delaware	3	2
Dubois	1	1
Elkhart	5	4
Fayette	2	1

TABLE I (Continued)

Floyd	2	1
Fulton	1	1
Gibson	2	1
Grant	2	0
Greene	2	1
Harrison	1	1
Henry	1	0
Howard	3	2
Huntington	3	2
Jackson	1	0
Jasper	1	0
Jay	1	0
Jefferson	1	0
Johnson	2	2
Knox	1	1
Lake	20	16
La Porte	4	4
Lawrence	2	1
Madison	4	2
Marion	21	14
Marshall	2	2
Miami	2	0
Monroe	2	1
Montgomery	3	3
Newton	1	1
Noble	1	1

TABLE I(Continued)

Orange	1	0
Parke	1	1
Pike	1	0
Porter	1	1
Posey	2	1
Putnam	2	2
Rush	1	1
St. Joseph	8	8
Shelby	2	1
Sullivan	1	1
Tippecanoe	5	4
Tipton	1	0
Union	1	0
Vanderburg	6	4
Vermillion	1	1
Vigo	11	9
Wabash	2	1
Warrick	1	1
Washington	1	0
Wayne	2	2
Wells	1	0
Whitely	1	0
Total	175	122

II. OBJECTIVES, CONTENT OF COURSES, AND OTHER ITEMS CONSIDERED IN MECHANICAL DRAWING AS REVEALED BY THE QUESTIONNAIRE

A. How the Objectives Used in the Questionnaire Were Obtained

Before making the questionnaire, the writer made a study of the objectives of mechanical drawing. Stating the objectives for any line of educational work is, to a certain extent, a matter of personal opinion. Lack of agreement as to objectives is one of the reasons for industrial arts being shifted from one position to another in the educational system. Perhaps more uniformity and agreement, than exist at present, are needed in industrial arts. An instructor may have a wrong objective, but in time he can discover his error for himself. The teacher who has nothing definite to achieve will not reach his goal or discover his error.

"In the formulation of objectives for mechanical drawing in the school curriculum many of the terms used are similar to those employed in connection with the industrial arts program as a whole. There is, however, some indefiniteness in much of the actual work.

Some teachers formulate certain objectives and support their claims by visible evidence. Other teachers state their objectives --objectives which seem to exist as beliefs in their minds and can be proved only with difficulty.

Two claims can now be substantiated: (1) drawing permits the development, expression, and understanding of an idea without

the preliminary use of material; and (2) drawing reduces the waste of material and time, by enabling the worker to work from a definite picture.

Some of the more indefinite claims for drawing are that it will develop visualization; develop logical thinking; provide an additional avenue for the reception for information; strengthen the imagination; help to form desirable habits of observation and perception; and, in fact, contribute to the development of all the desirable moral and mental characteristics attributed to industrial arts. All these objectives are desirable, but the degree of success attained can be determined only to the extent in which more specific purposes are enumerated."[2]

A number of distinct purposes have been attributed to the teaching of mechanical drawing, such as those listed in the following section.

Statements quoted in the following paragraphs are selected from statements made by leading educators on the objectives of mechanical drawing. Objectives listed in the questionnaire were partly selected from the following list.

1. "Ability to Read Drawings. The act of interpreting a blueprint is described by the term "blueprint reading." The reading embodies the comprehension of the lines, figures, and symbols, and an intelligent interpretation of their meaning. Every line in a drawing must mean something. It is important that pupils interpret drawings in order to fulfill an immediate

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[2] Dean M. Schweickhard, Industrial Arts in Education, Chapter XI, p. 219.

need."

2. "Better Understanding of Shopwork. One of the best examples of applied correlation is that possible between drawing and shopwork. The preliminary work of the drawing room serves to facilitate the work of the shop by establishing a background."

3. "Development of Technical Skill. It is a wide-spread belief that the main purpose of drawing is technical manipulative skill. There is a place for drawing in which this is the chief purpose, but it is not in the intermediate stage of education. It belongs in advanced education where drawing is chosen for specialization. In school, technical skill is the incentive for the later training which it provides."

4. "Consumer's Use in Later Life. The consumer is the person who may have occasional need for some knowledge of drawing. He can copy intelligently with the varied applications of drawing in life outside of school."

5. "Discovery of Individual Ability. Courses in drawing offer great possibilities along the line of discovering special abilities in the individual student. The discovery of special ability in drawing is often due to the fact that particular interest in the work stimulated special effort in it."[3]

"To teach the fundamentals of mechanical drawing; to develop the power of visualization and constructive imagination; to teach how to read and write the graphic language of industries. To give him modern industrial practice in drafting in

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[3] Dean M. Schweickhard, op. cit., p. 219.

order that he may have an understanding of his trade for the purpose of selecting his future vocation."[4]

"1. To develop the ability to interpret the conventional mechanical drawing.

2. To develop the ability to make neat freehand mechanical drawings.

3. To develop a small amount of skill in the use of tools and instruments used in mechanical drawing."[5]

"1. To teach the reading of any simple drawing.

2. To develop the power of visualization.

3. To teach the making of freehand sketches of machine parts.

4. To teach the making of neat, intelligible, instrumental drawings, to scale, to within 1/64 of an inch.

5. To teach the making of tracings and reproduction of drawings by the blueprinting process.

6. To develop the ability to make clean, neat, legible letters and figures."[6]

"1. To develop the power of visualization.

2. To strengthen the constructive imagination.

3. To train in exactness of thought.

4. To teach how to read and write the language of the industries.

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4 Towne R. Abercrombi, "Objectives for Drafting Courses," Industrial Arts Magazine, 17:361, October, 1928.

5 Drew W. Castle, "Mechanical Drawing in General Education," Industrial Education Magazine, 29:397-398, May, 1928.

6 John F. Faber, "Mechanical Drafting for the First Year High School Classes," Industrial Arts Magazine, 12:20-5, January, 1923.

5. To give modern commercial practice in making working drawings."[7]

"Educational:

1. To develop in the pupil the power to visualize.

2. To broaden his imagination.

3. To train for accuracy of thought and expression."

"Practical:

1. To enable the pupil to read and make simple working drawings.

2. To develop his skill in lettering and drafting.

3. To familiarize him with correct drafting-room practice."[8]

"1. To provide exploratory contacts with and information about a wide variety of drafting occupations depending on drafting.

2. To teach a variety of interesting and useful facts about a variety of drafting occupations depending on drafting.

3. To teach a variety of interesting and useful facts about industrial organization, methods, machines, and materials.

4. To teach certain generally usable skills in the making of simple mechanical drawings and in free-hand lettering.

5. To develop the ability to interpret working drawings.

6. To develop an appreciation of the relationships among industries through drawing, the universal language thereof.

7. To develop the ability and the habit of using drawing as a tool in working out and planning matters of a mechanical

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[7] Thomas E. French and Carl L. Svenson, Mechanical Drawing for High Schools (New York: McGraw Hill Book Company) 1927, p. VII.

[8] F. J. McAuliffe, "A Mechanical Drawing Course," Industrial Arts and Vocational Education Magazine, 22:159-160, April, 1933.

nature."[9]

"1. A training in creative imagination.

2. An ability to think in three dimensions.

3. Ability to visualize quickly and accurately.

4. A forming of clear mental images.

5. A thorough acquaintance with the great industrial language of the world.

6. A technical skill to express one's self in that great language.

7. A sound elementary preparation for the needs of the manufacturing or structural industries.

8. The laying of a sound and well-defined foundation upon which our engineering and technical schools may build.

9. The forming of a great stock of ideas conducive to a better understanding of the industrial world."[10]

B. Objectives for Mechanical Drawing as Checked by the Instructors

In the questionnaire 12 objectives in the teaching of mechanical drawing were listed. Each teacher was asked to check the objectives of his course. Table II[11] shows the number of teachers checking each objective. Beginning at the top of the

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9 R. A. McGee and W. W. Sturtevant, General Mechanical Drawing; "A Course Based on the Junior High School Movement," (The Bruce Publishing Company, Milwaukee, 1930) p. VI.

10. John M. Shadra, "Standards for Mechanical Drawing in High Schools," Industrial Arts Magazine, 12:108-9, March, 1923.

11 In the case of some items of information asked for the questionnaires were not completely filled out. It will be found throughout this study that the number of teachers or replies used will vary from the total number of questionnaires actually given.

column, Table II should be read that 71 teachers consider General Education an objective in the teaching of mechanical drawing, and so on down the list.

TABLE II

TEACHER REPLIES CONCERNING OBJECTIVES

Objective	Number of times checked
General education	71
Reading and executing working drawings	73
To discover individual ability	55
Skill in manipulative processes	56
Principles of drawing	64
Guidance	60
Aid to other subjects	52
Consumer's use in later life	64
Training in creative imagination	57
To develop the power of visualization	76
To train in exactness of thought	60
To teach how to read and write the graphic language of the industries	77

Table III shows the final combined ranking of the objectives in the order of their importance according to the opinion of the instructors. In arranging Table III twelve objectives were listed. The top row of numbers, from 1 to 12 inclusive, indicates the ranking of the objectives. The objective "General education" was ranked first by 43 instructors, second by 4 instructors,

third by 5 instructors, and so on.

The objective "General education" ranked first in the entire group of twelve objectives listed.

Fifty-seven per cent of those ranking this objective ranked it first, which is, by far, higher than any other. The objective receiving next highest ranking was "To teach how to read and write the graphic language of the industries." This objective received 19 per cent in both first and second rankings. Since this objective comes second to the objective "General education", it seems that the instructors have kept in mind two broad objectives: general education and vocational preparation.

The objective "Reading and executing working drawings" is ranked comparatively high. Of those ranking it, 12 per cent rank it first, 18 per cent second, and 22 per cent third. This objective overlaps the objective "To teach how to read and write the graphic language of the industries." Another objective ranking rather consistently is the objective "To develop the power of visualization." Sixteen per cent rank it first, 12 per cent second, and 12 per cent third.

The only other objective ranking with any degree of consistency is the objective "To teach the principles of drawing." Seven per cent rank it first, 15 per cent second, and 16 per cent third.

The ranking of all other objectives is quite varied. Instructors differed widely in their opinions concerning them.

This leads the writer to use or suggest as objectives for mechanical drawing only those most commonly accepted.

TABLE III

RANKING OF THE OBJECTIVES BY THE INSTRUCTORS

Objectives	Ranking											
	1	2	3	4	5	6	7	8	9	10	11	12
General education	43	4	5	3	2	3	3	2	1	3	1	5
To teach how to read and write the graphic language of the industries	15	15	9	9	8	5	2	3	5	4	1	3
Reading and executing working drawings	11	17	20	8	8	8	9	5	3	0	1	0
To discover individual ability	1	5	11	7	10	6	9	4	6	4	2	2
To develop the power of visualization	14	10	10	8	11	9	6	3	8	3	1	1
Principles of drawing	7	12	13	7	8	13	5	3	3	2	7	0
To train in exactness of thought	4	5	7	7	10	9	8	5	6	1	5	3
Training in creative imagination	1	7	7	10	4	6	5	7	3	5	5	7
Guidance	1	6	5	8	7	6	9	7	5	5	6	3
Consumer's use in later life	1	9	3	14	8	7	5	12	6	6	3	1
Skill in manipulative processes	1	4	5	8	10	9	5	8	3	8	5	4
Aid to other subjects	0	6	4	4	6	2	5	5	7	10	6	7

OTHER OBJECTIVES MENTIONED

To develop the ability to concentrate
Training in neatness and accuracy
To develop correct habits of thought and work
The fullest development of the boy
To give modern commercial practice in drafting

For enrichment the following can be used as desired:

To develop the power of visualization.

Principles of drawing.

To train in exactness of thought.

To train in creative imagination.

To aid in guidance.

To aid in the development of a consumer's use in later life.

To develop skill in manipulative processes.

To aid in the teaching of other subjects.

C. Content of Courses as Checked by the Instructors

Table IV shows the results of the checking of the various instructional topics. In arranging this table the grade numbers from 8 to 12 inclusive were placed on the top line. Under each grade level the table was divided into two columns representing the first semester and the second semester of that grade.

Beginning with the first instructional topic, "Lettering," Table IV reads that in the eighth grade 31 teachers teach "Lettering" in the first semester; 15 teachers teach "Lettering" during the second semester; 26 teachers teach "Lettering" during the first semester of the ninth grade, and so on.

Thirty-two items were listed originally, and five were added by other instructors. Each instructor checked those topics which applied to his own classes, in so far as it was possible for him to do so. He also indicated the grade and semester in which each

topic was presented. In looking at Table IV it appears that almost every instructional topic is taught in each semester of each grade from eighth grade to twelfth, inclusive. This shows a surprising amount of variation, particularly since the instructional topics vary from those ordinarily found in beginning work to those of a rather advanced nature. The problem, which at once seems to suggest itself, is that a more uniform development and acceptance of standardized practice would be quite desirable.

In spite of the fact that a wide variation in the grade placement of various topics is apparent, there does seem to be a rather definite grouping of instructional topics by grades as determined by the grade placement of those topics receiving the highest frequency of mention.

In the eighth grade there is not as much checking as in the grades from 9 to 12, because several of the four year high schools do not offer drawing in the eighth grade. Of the topics checked, those that seem to be most suitable are the following: lettering, use of instruments, three view projection, simple working drawings, dimensioning, free-hand sketching, and the use of shop terms.

In the grades from nine to twelve a better opportunity to note the grouping of various topics is afforded, since they are checked by a greater number of instructors. They are checked as follows: ninth grade--lettering, use of instruments, three view projection, simple working drawings, geometrical construction, dimensioning, inking, orthographic projection, free-hand sketching, use of shop terms, pictorial drawings; tenth grade

--lettering, sections, tracing, revolution of objects, development, intersections, screw threads, bolts and nuts, machine fastening, assembly drawings, and graphs and diagrams; eleventh grade --sheet metal drafting, architectural drawing, construction details and working construction, gears, cams, and topographical drawing; twelfth grade--orders of architecture, rendering, perspective, and structural drawing.

In my opinion, some of the reasons for variation in the placement of the different topics are: (1) In most schools mechanical drawing courses are elective. (2) Courses are begun during all the different years of high school. (3) Pupils from different grade levels are enrolled in the same class. Instructors are confronted with vital problems of adjusting the content and arranging the instructional material to accommodate the unusually wide range of individual differences which occur.

TABLE IV

THE INSTRUCTIONAL TOPICS CHECKED BY THE INSTRUCTORS

Instructional topic	8		9		10		11		12	
	1	2	1	2	1	2	1	2	1	2
Lettering	31	15	36	28	38	23	31	16	28	20
Use of instruments	23	16	50	17	23	7	12	5	11	6
Three view projection	27	11	53	20	17	10	11	3	11	5
Simple working drawings	28	18	48	16	25	8	11	4	10	4
Geometrical construction	8	5	33	19	18	7	12	2	9	2
Sections	8	3	24	21	29	18	18	7	11	6
Dimensioning	28	16	50	24	27	14	16	7	11	5
Inking	5	5	34	26	26	17	19	11	14	8
Tracing	3	4	17	19	30	20	17	15	12	12

TABLE IV (Continued)

Graphs or diagrams	0	0	6	8	8	9	7	9	6	4
Orthographic projections	19	9	33	19	22	15	15	10	14	8
Revolution of objects	0	2	9	16	20	14	7	8	11	6
Development	8	7	15	22	23	24	16	16	10	10
Intersections	0	1	6	14	15	20	15	14	12	8
Sheet metal drafting	4	4	6	9	16	14	16	17	8	7
Screw threads	2	3	8	12	26	16	19	13	12	6
Bolts and nuts	1	2	10	11	24	21	20	13	10	10
Machine fastenings	1	1	10	10	15	15	16	12	9	7
Free-hand sketching	14	9	24	19	20	18	12	12	7	8
Assembly drawings	5	3	12	13	24	23	21	22	15	17
Use of shop terms	15	9	26	21	22	23	20	16	14	12
Pictorial drawings	6	4	18	16	20	12	9	13	10	9
Architectural drawings										
a. Construction details	2	1	7	4	20	17	27	20	20	13
b. Working construction	1	1	6	4	15	15	19	22	17	13
c. Orders					2	3	11	10	16	13
d. Rendering					3	5	9	8	9	13
Perspective		1		8	8	10	15	15	20	17
Gears				2	1	8	14	14	11	13
Cams			1	2	1	4	12	17	15	11
Structural				1		5	6	11	17	14
Aviation				1	1	4	5	3	4	5
Topographical					1	6	5	4	3	5
Other topics										
Electrical						5	1	1	1	1
Designing										2
Plumbing								1		1
Heating and estimating								1		1
Show card and poster work								2		2

To show how the instructional topics were emphasized by the instructors of the state, each grade was ranked separately. Tables V to IX inclusive show these rankings. In Table V, which deals with the eighth grade, we find that "Lettering" ranks first, having been checked by 46 instructors. "Simple working drawings" also was checked by 46 instructors, which puts it on an equal basis with "Lettering." "Dimensioning" ranks second, since it was checked by 44 instructors. In like manner, the rest of the instructional topics were ranked.

Each grade, from 8 to 12 inclusive, was ranked by the same method.

TABLE V

THE RANKING OF INSTRUCTIONAL TOPICS FOR THE EIGHTH GRADE BY THE INSTRUCTORS

Rank	Instructional topic	Frequency
1.5	Lettering	46
1.5	Simple working drawings	46
3	Dimensioning	44
4	Use of instruments	39
5	Three view projection	38
6	Orthographic projections	28
7	Use of shop terms	24
8	Free-hand sketching	23
9	Development	15
10	Geometrical construction	13
11	Sections	11
12.5	Inking	10
12.5	Pictorial drawings	10
14.5	Assembly drawings	8
14.5	Sheet metal drafting	8
16	Tracing	7
17.5	Architectural drawing	5
17.5	Screw threads	5
19	Bolts and nuts	3
20.5	Machine fastenings	2
20.5	Revolution of objects	2
22.5	Intersections	1
22.5	Perspective	1

TABLE VI

THE RANKING OF INSTRUCTIONAL TOPICS FOR THE NINTH GRADE BY INSTRUCTORS

Rank	Instructional topic	Frequency
1	Dimensioning	74
2	Three view projection	73
3	Use of instruments	67
4.5	Lettering	64
4.5	Simple working drawings	64
6	Inking	60
7.5	Geometrical construction	52
7.5	Orthographic projection	52
9.5	Development	47
9.5	Use of shop terms	47
11	Sections	45
12	Free-hand sketching	43
13	Tracing	36
14	Pictorial drawing	34
15.5	Assembly drawings	25
15.5	Revolution of objects	25
17	Bolts and nuts	21
19	Intersections	20
19	Machine fastenings	20
19	Screw threads	20
21	Sheet metal drafting	15
22	Graphs or diagrams	14
23	Architectural construction details	11

TABLE VI (Continued)

24	Architectural working construction	10
25	Perspective	8
26	Cams	3
27	Gears	2
28.5	Structural	1
28.5	Aviation	1

TABLE VII

THE RANKING OF INSTRUCTIONAL TOPICS FOR THE TENTH GRADE BY THE INSTRUCTORS

Rank	Instructional topic	Frequency
1	Lettering	61
2	Tracing	50
3.5	Sections	47
3.5	Development	47
4	Assembly drawings	47
5.5	Bolts and nuts	45
5.5	Use of shop terms	45
7	Inking	43
8	Screw threads	42
9	Dimensioning	41
10	Free-hand sketching	38
11.5	Orthographic projection	37
11.5	Architectural construction details	37
13	Intersections	35

TABLE VII (Continued)

14	Revolution of objects	34
15	Simple working drawings	33
16	Pictorial drawings	32
18.5	Use of instruments	30
18.5	Sheet metal drafting	30
18.5	Machine fastenings	30
18.5	Architectural working construction	30
21	Three view projection	27
22	Geometrical construction	25
23	Perspective	18
24	Graphs or diagrams	17
25	Gears	9
26	Architectural rendering	8
27	Topographical	7
30	Architectural orders	5
30	Aviation	5
30	Cams	5
30	Structural	5
30	Electrical	5

TABLE VIII

THE RANKING OF INSTRUCTIONAL TOPICS FOR THE ELEVENTH GRADE BY THE INSTRUCTORS

Rank	Instructional topic	Frequency
1.5	Lettering	47
1.5	Architectural construction details	47
3	Assembly drawings	43
4	Architectural working construction	41
5	Use of shop terms	36
6.5	Sheet metal drafting	33
6.5	Bolts and nuts	33
9	Screw threads	32
9	Development	32
9	Tracing	32
11.5	Inking	30
11.5	Perspective	30
13.5	Cams	29
13.5	Intersections	29
15.5	Gears	28
15.5	Machine fastenings	28
17.5	Sections	25
17.5	Orthographic projection	25
19	Free-hand sketching	24
20	Dimensioning	23
21	Pictorial drawings	22
22	Architectural orders	21

TABLE VIII (Continued)

24	Structural	17
24	Use of instruments	17
24	Architectural rendering	17
26	Graphs or diagrams	16
27.5	Simple working drawings	15
27.5	Revolution of objects	15
29.5	Three view projection	14
29.5	Geometrical construction	14
31	Topographical	9
32	Aviation	8
33.5	Electrical	2
33.5	Show card and poster work	2
35.5	Plumbing	1
35.5	Estimating	1

TABLE IX

THE RANKING OF INSTRUCTIONAL TOPICS FOR THE TWELFTH GRADE BY THE INSTRUCTORS

Rank	Instructional topic	Frequency
1	Lettering	48
2	Perspective	37
3	Architectural construction details	33
4	Assembly drawings	32
5	Structural	31
6	Architectural working construction	30
7	Architectural orders	29
8.5	Use of shop terms	26
8.5	Cams	26
10.5	Tracing	24
10.5	Gears	24
13	Inking	22
13	Orthographic projection	22
13	Architectural rendering	22
16	Development	20
16	Intersections	20
16	Bolts and nuts	20
18	Pictorial drawings	19
19	Screw threads	18
21	Use of instruments	17
21	Sections	17
21	Revolution of objects	17

TABLE IX (Continued)

24	Three view projection	16
24	Dimensioning	16
24	Machine fastenings	16
26	Sheet metal drafting	15
27	Simple working drawings	14
28	Geometrical construction	11
29	Graphs or diagrams	10
30	Aviation	9
31	Topographical	8
33	Electrical	2
33	Designing	2
33	Show card work	2
35.5	Plumbing	1
35.5	Heating	1

D. Various Methods of Preparation and Presentation of the Topics in Mechancial Drawing Checked by the Instructors

The writer was interested in learning some of the general practices and methods used in preparing teaching materials to be used in mechanical drawing classes by the instructors of the state. Questions in Table X were asked to obtain these facts.

TABLE X

A SUMMARY OF THE ANSWERS ON QUESTIONS RELATING TO PREPARATION AND PRESENTATION OF THE WORK IN MECHANICAL DRAWING

Who prepares your course of study?

Instructor - 71 Supervisor - 4
Instructor and Supervisor - 15 State - 5

Are your courses taught separately from other subjects?

Yes - 81 No - 20

If correlated, with what subjects?

Shopwork - 18

Length of period.

40 minutes - 13 60 minutes - 25
45 minutes - 8 65 minutes - 1
50 minutes - 9 80 minutes - 11
55 minutes - 24 90 minutes - 8

Number of periods per week.

2 periods - 1 7 periods - 2
5 periods - 82 10 periods - 9

Number of semesters of mechanical drawing offered in your school.

1 semester - 7 6 semesters - 9
2 semesters- 20 8 semesters - 10
3 semesters- 6 12 semesters - 1
4 semesters- 22 14 semesters - 2
5 semesters- 2 37 semesters - 1
44 semesters - 1

TABLE X (Continued)

Do you use a text book?

Yes - 62 No - 28

Titles of books used and the frequency of their use are listed below.

Mechanical Drawing for High School by French and Svenson	29
Basic Units in Mechanical Drawing by Hoelscher and Mays	5
Engineering Drawing by T. E. French	8
Mechanical Drawing by Ermling, Fischer and Greene	13
Mechanical Drawing by Woods	1
General Mechanical Drawing by McGee and Sturtevant	2
Architectural Drawing by Elwood	3
Architectural Drawing by Svenson and Shelton	1
Mechanical Drawing by H. E. Boggy	2
Problems in Mechanical Drawing by Bennett	1
Simplified Mechanical Drawing by T. C. Crooks	3
Essentials of Mechanical Drawing by Turner	1
Architectural Drawing by Bush and Townsley	1
Mechanical Drawing Problems by Berg and Kronquest	4

Table X shows the results of the answers to a number of questions on preparation and presentation. In answer to the question "Who prepares your course of study?" it is found that 74 per cent of the instructors prepare their own courses, 15 per cent prepare their courses in cooperation with their supervisors, 4 per cent have their courses prepared by the supervisor alone, and 7 per cent use the state course of study.

The fact that most of the instructors make their own courses is another reason for such a variation in the work throughout the state, and suggests a need for improvement in the organization of this phase of industrial educational work in the schools of Indiana.

There is some correlation of mechanical drawing with other subjects, but 80 per cent of the instructors teach the subject independently of other work. Where the work is correlated, it is chiefly correlated with shop work.

The length of period used in different schools varies greatly. The 60 minute and 55 minute periods are most commonly used. In some schools two 40 minute or 45 minute periods are combined into one, making 80 and 90 minute periods respectively. The periods vary in the following manner: 25 per cent use 60 minute periods; 24 per cent use 55 minutes; 14 per cent use 40 minutes; 11 per cent use 80 minutes; 9 per cent use 50 minutes; 8 per cent use 45 minutes; 8 per cent use 90 minutes; 1 per cent use 65 minutes.

This shows a need for further study leading to greater unification of time element recognized over the state for a

given amount of work.

The number of periods per week does not vary as much as the length of the period. From all of the instructors reporting, 87 per cent of them use five periods a week, indicating that in most cases drawing is taught every day for the five school days of the week.

The number of semesters of mechanical drawing offered in the schools varies more than any other item checked. The semesters range from one semester up to forty-four semesters. The semesters having the greatest frequency were two and four, with eight and six ranking next. Twenty-seven per cent of the schools offer 4 semesters; 24 per cent offer two semesters; 12 per cent offer 8 semesters; 11 per cent offer 6 semesters.

It is difficult to see the status of the number of courses in industrial arts as differentiated from vocational education in mechanical drawing. This shows a need for further study.

The use of a text book in mechanical drawing is quite prevalent over the state. Sixty-eight per cent of the instructors are using a text book, while 32 per cent are not. Of those that are not, several use drawing books for reference work. This indicates that a high per cent of the drawing work of the state is assigned from text books.

The text book that is used far more than any other one mentioned is entitled Mechanical Drawing for High Schools, written by French and Svenson. This book is used by 39 per cent of the instructors. This signifies that there is some agreement on the part of the instructors of the state as to the subject matter taught. Several other texts are mentioned,

but with no regularity of frequency.

Table XI shows the various methods used in presenting the various topics in mechanical drawing, as they were checked by the instructors. In reading Table XI it will be seen that in answer to the question "Do you require home work in drawing?" one instructor requires this work regularly, 28 instructors require this work occasionally, and 60 instructors never make this requirement at all. Other topics listed should be read in a similar manner.

When we examine Table XI we find that very little home work is required, for 67 per cent of the answers received were "No", 31 per cent "Occasionally", and 2 per cent "Regularly."

Typical recitations are not generally used by instructors. In 76 per cent of the cases the instructor used the typical recitation "Occasionally." Only 6 per cent of the instructors used the recitation method "Regularly" and 18 per cent did not use recitations at all. These data indicate that most of the presentations and explanations are given to the students individually or to small groups.

In answer to the question "Do you use lesson or job sheets?" 37 per cent of the teachers answered "Regularly," 39 per cent answered "Occasionally" and 24 per cent answered "None." Approximately 75 per cent of the teachers are using the lesson sheet as a method of instruction.

Some form of blackboard demonstration is practiced by every teacher. In general this method is used more regularly than occasionally for in answer to the question as to its use,

TABLE XI

VARIOUS METHODS OF PRESENTATION OF THE TOPICS IN MECHANICAL DRAWING CHECKED BY THE INSTRUCTORS

	Regularly	Occasionally	None
Do you require home work in drawing?	1	28	60
Do you have typical academic recitation periods?	4	70	17
Do you use lesson or job sheets?	33	35	20
Do you give demonstrations at the blackboard?	54	45	0
Do you give class tests?	36	48	12
Are problems assigned?			
a. Directly from a text book?	43	36	9
b. By blueprints prepared by instructor?	24	36	12
c. By mimeographed sheets?	12	25	18
d. By blackboard sketches?	18	58	3
e. By dictation?	10	40	13
f. By some other method?	4	24	6

What is your practice regarding inking?

Ink all drawings - 20

After 1st semester - 26

A part of all drawings - 24

Very little - 18

None - 10

54 per cent answered "Regularly" and 46 per cent answered "Occasionally." Not one teacher answered in the negative.

Answers to the question "Do you give class tests?" indicate a wide variance in this practice. Out of 96 answers received, 37 per cent of the teachers gave tests "Regularly", 50 per cent "Occasionally," and 13 per cent "None."

The prevalent method of problem assignment is directly from the text book. The per cent of teachers using that method is greater than any other two methods (used in this study) combined. Assignments from blueprints rank second. Other methods, including mimeographed sheets, blackboard sketches, and dictation, are with approximately the same degree of frequency.

About one-fifth of the teachers require all drawings to be inked, while one-tenth require no inking at all. The other teachers' answers varied from the requirement of very little inking of drawings to the inking of all drawings after the first semester's work. The data received on the practice of inking drawings indicate that 27 per cent of the teachers require little or no inking, while 50 per cent require a part of all drawings inked, and the remaining 23 per cent require all drawings inked.

III. SUGGESTED COURSES OF STUDY IN MECHANICAL DRAWING BASED ON THE FINDINGS OF THIS STUDY

These suggested courses of study were prepared from the information collected in the questionnaire. The opinions of the instructors who answered the questionnaire govern the choice of the work outlined in these courses.

Instead of setting up a definite course for each semester or grade, the work has been divided into four groups. Each instructor may choose the work to meet his individual school needs. The order of presentation of the instructional topics as listed in the different groups need not be definitely followed. The time given to these courses should be a minimum of 55 minutes per day, five days a week.

A Suggested Course Outline for Mechanical Drawing.

The objectives of this course:

1. Primary objectives
    a. General education
    b. To teach how to read and write the graphic language of the industries.
    c. To teach how to read and execute working drawings.
    d. To develop the power of visualization.
    e. To teach the principles of drawing.
2. Secondary objectives (for enrichment)
    a. To discover individual ability.
    b. To create skill in manipulative processes.
    c. To aid in guidance.
    d. To aid in other subjects.

e. To aid in the development of a consumer's use in later life.

f. To train in creative imagination.

g. To train in exactness of thought.

Mechanical Drawing

Group I

Scope

Mechanical drawing in this group shall include:

1. Lettering
2. Simple working drawings
3. Dimensioning
4. Use of instruments
5. Three view projection
6. Geometrical construction
7. Inking
8. Orthographic projection
9. Free-hand sketching
10. Use of shop terms

Time

Five periods a week of 55 minutes each. Recitations when deemed necessary by instructor.

Methods of Presentation

1. Blackboard demonstration

In teaching lettering, for example, the instructor should show on the blackboard the method of making the letters. The exact number and order of strokes in forming a letter should be explained, and the proportionate width, height, and spacing of

the letter clearly demonstrated. This can be done for the entire class as a group, thereby saving time.

2. Blueprint assignments

Blueprints make a convenient method of assignment. In three view projection drawings, two views may be shown on the blueprint and handed to the student, with the requirement that he complete the assignment by drawing all three views. The blueprint should include all of the necessary dimensions, information, and requirements relative to the completion of the drawing. This plan enables the instructor to give individual instruction without much re-teaching.

3. Class recitation

Instructors find it necessary to conduct some class recitations. In the explanation of the use of instruments by this method all of the members of the class may get the explanation at one time. The use of each instrument should be carefully explained, and the members of the class permitted to ask questions.

Group II

Scope

Mechanical drawing II includes:

1. Lettering
2. Sections
3. Development
4. Intersections
5. Revolution of objects
6. Machine drawing

a. Assembly

b. Details

7. Screw threads

8. Bolts and nuts

9. Machine fastenings

10. Pictorial drawings

Time

Five periods per week of 55 minutes each. Recitations at least once a week.

Methods of Presentation

1. Reference book assignments

It is often thought advisable to use a reference book to make assignments. For example, in the teaching of the topic "Screw Threads," it will be found that almost any reference book on machine drawing makes a clear explanation of the use, application, and drawing of screw threads. The instructor may designate the chapter and page where the information can be found. The practice of looking up information in references should be valuable to the students.

2. Blackboard demonstration

3. Lesson or assignment sheets

Lesson or assignment sheets are useful aids to the mechanical drawing teacher. This method may be used in the teaching of architectural drawing successfully. Take, for example, an assignment on the designing of a floor plan for a house. The lesson sheet may have printed on it the specifications in regard to the number of rooms, the over-all dimensions, the number of windows and doors, and all other necessary information.

These sheets should be prepared in advance so that they may be handed to the student when he comes to class. If the sheets are properly prepared the instructor should have little further explanation to make.

4. Blueprint assignments

Group III

Scope

Mechanical drawing in Group III includes:

1. Architectural
   a. Construction details
   b. Working construction
2. Architectural orders
3. Architectural rendering
4. Perspective
5. Topographical drawing
6. Graphs and diagrams
7. Tracing and blue printing

Time

Same as Group II.

Methods of Presentation

1. Blackboard demonstration
2. Recitation
3. Lesson or assignment sheets
4. Reference book assignments
5. Blueprint assignments

Group IV

Scope

Mechanical drawing in the fourth group shall include:

1. Gears
2. Cams
3. Structural drawing
4. Sheet metal drafting
5. Aviation drafting

Time

Same as in Group II.

Methods of Presentation

1. Blackboard demonstration
2. Recitation
3. Reference book assignment
4. Blueprint assignment
5. Assignment by dictation

The dictation method probably will be used less frequently than the other methods mentioned. However, at times it will be found helpful. For example, in the teaching of the instructional topic "Graphs and Diagrams", occasionally an instructor will want to present to his class a list of numbers to be put into a graph form. It is often easier to read the numbers and let the students copy them than to use any other method. This method of presentation also saves time for the instructor. This presents a more complete problem to the student for solution.

In using the suggested course of study outlined above, the writer believes that in conjunction with it the standards set

up by the A. V. A. for mechanical drawing should be used. Lists of learning units for mechanical drawing have been placed in two groups: "The Things You Should Be Able to Do," and "The Things You Should Know." The following lists were taken from the 1934 A. V. A. Bulletin.

The Roman numeral preceding each learning unit refers to the group in the suggested outline to which this unit relates. The star indicates that this particular unit should be emphasized in each group.

The Things You Should Be Able to Do.

I--1. Fasten the drawing-paper on the drawing-board.

I--2. Sharpen a drawing-pencil.

I--3. Measure with a scale.

I--4. Mark points with a pencil.

I--5. Choose the necessary views of an object.

I--6. Plan a drawing and make a layout of the sheet.

I--7. Sketch lines and make a working-sketch.

I--8. Use the T-square and pencils in drawing horizontal lines.

I--9. Use the T-square and triangles in drawing vertical lines and lines making common angles with the horizontal.

I-10. Use the triangles to draw lines parallel to other lines.

I-11. Clean and care for drawing instruments.

I-12. Keep the drawing and drawing table neat and orderly.

I-13. Draw, and know when to use, the different kinds of lines required in drafting.

I-14. Erase pencil lines.

I-15. Block out views.

I-16. Make a front-view and top-view, and know the relationship of these views.

I-17. Make a front-view and side-view, and know the relationship of these views.

I-18. Make three views, and know the relationship of these views.

I-19. Pencil a drawing in correct order.

I-20. Draw views with hidden edges.

I-21. Dimension a drawing.

I-22. Sharpen and adjust a compass-lead.

I-23. Use the pencil compass.

I-24. Make arrow-heads.

I-25. Make numerals.

I-26. Lay out a title.

I-27. Letter upper-case letters.

I-28. Make a drawing to scale.

I-29. Check a drawing.

II-30. Draw sectional views of an object, and know when they are required.

II-31. Make an auxiliary view.

*II-32. Letter notes and specifications.

I-33. Transfer measurements with the dividers.

I-34. Divide a line a given number of equal parts with the dividers.

I-35. Draw an irregular curve with the French curve.

III-36. Draw a floor plan.

I-37. Draw an octagon when the diameter or one side is given.

I-38. Draw a hexagon when the long diameter is given.

I-39. Draw a hexagon when the short diameter is given.

III-40. Make and read wiring-diagrams.

I-41. Fill the ruling-pen and compass-pen.

I-42. Ink a line with the ruling pen.

*I-43. Ink a drawing in proper order.

I-44. Use the compass-pen.

I-45. Erase an ink-line or an ink-spot.

III-46. Make a blue print.

II-47. Measure with inside and outside calipers.

II-48. Draw bolts with convential threads.

II-49. Draw machine parts showing finish, drilled, reamed, and topped holes.

II-50. Draw machine parts showing keys and keyways.

I-51. Bisect an angle.

I-52. Bisect an arc.

I-53. Draw an arc tangent to two lines not parallel.

I-54. Transfer an angle.

I-55. Draw an ellipse. (two methods)

II-56. Draw the development of a square, prism shaped object.

II-57. Draw the development of a cone-shaped object.

II-58. Draw the development of a hexagonal prism cut by an oblique plane.

II-59. Draw the development of a pyramid shaped object.

II-60. Draw the development of a cylinder cut by an oblique plane.

I-61. Sharpen dividers.

*I-62. Sharpen a ruling-pen and compass-pen.

II-63. Make a detailed drawing.

II-64. Make an assembly drawing.

*III-65. Make a tracing on paper.

*III-66. Make a tracing on cloth.

I-67. Determine the true length of a line.

II-68. Determine the line of intersection between two intersecting prisms and develop the surfaces.

II-69. Determine the line of intersection between two intersecting and develop the surfaces.

II-70. Make an isometric drawing.

II-71. Make an oblique drawing.

The Things You Should Know

1. The kinds of scales used in measuring, and for what classes of work each is used.
2. The names and uses of drafting instruments, and how to care for them.
3. The sizes of triangles and T-squares, and how designated.
4. How to select and care for a drawing-board.
5. How to arrange the lighting in order to protect the eyes.
6. Kinds and qualities of drawing-papers.
7. The various kinds and grades of pens and their uses.
8. How to select and test T-squares and triangles.
9. The qualities and uses of tracing-paper and tracing-cloth.
10. How to select and care for blue print paper.
11. The kind of ink used in drafting.
12. Kinds of pens best suited for lettering.
13. The conventional ways of representing breaks in materials.

14. Occupational information, including success factors, income, and opportunities.
15. How to read contour maps.

IV. SUMMARY AND CONCLUSIONS

The information found in this study is almost wholly of a factual nature, and consequently it is believed that the results may be accepted with a reasonable degree of confidence. Data gathered from a questionnaire are sometimes questionable, but there seemed no other available way to get the information needed in this study.

In this study four major items have been stressed: the objectives of mechanical drawing in the state of Indiana, the content of courses now taught in the state, methods of preparation and presentation of this work, and a suggested course of study based upon the questionnaire.

It has been found that teachers vary greatly in their opinions on the objectives but that they have really grouped them under two main headings, general education and vocational preparation. In ranking the objectives, general education is ranked as objective number (1) one more often than any other objective.

In regard to the content of courses there is very little uniformity, although there is some agreement on certain instructional topics and some agreement on the grade in which the topics are offered. However, these data show that practically all the topics are offered in all grades. With this fact in mind, it seems that there should be some standardization and classification of the work over the state, hence the suggested course of study compiled by the writer as revealed in this study.

Data received on methods of preparation and presentation

of courses indicate great variation. One of the greatest reasons for this variation in courses is due to the fact that a high per cent of the instructors make out their own course of study. Until we can obtain an appropriate state course, this variation is unavoidable. The suggestions included in this study are offered for any assistance they might offer for the compilation of such a state course of study.

Irregularity in the number of semesters offered in mechanical drawing is revealed. The time ranges from one semester up to forty-four. This affords some students greater opportunities in drawing than others, and is evidence of the need for more uniformity in industrial arts education.

Since there is lack of uniformity in all of the items checked in this study, it is evident that an excellent opportunity affords itself to those interested to organize and standardize the teaching of mechanical drawing in the state of Indiana.

V. APPENDIX

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B. Questionnaire

Listed below are some of the objectives or aims of mechanical drawing. Put a check mark (✓) after the objective of your course. If none of these apply to your courses, list below what your objectives or aims are in the courses that you teach. Rank these objectives by number, in the order of their importance, according to your opinion.

	Check	Rank
General education		
Reading and executing working drawings		
To discover individual ability		
Skill in manipulative processes		
Principles of drawing		
Guidance		
Aid to other subjects		
Consumer's use in later life		
Training in creative imagination		
To develop the power of visualization		
To train in exactness of thought		
To teach how to read and write the graphic language of the industries		

Other Objectives

_____ _____

_____

_____

_____

Who prepares your course of study? _____

Are your courses taught separately from other subjects? ____

If correlated, with what subjects? _____

Length of period _____ Number of periods per week ____

Number of semesters of mechanical drawing offered in your school _____

Do you use a text book? _____ Title _____

Listed below are a number of instructional topics. If additional topics are taught in your school, please list them. Place a check (✓) after each topic that is taught in your school. Place it in the space indicating the semester and grade in which it is taught.

	Grade									
	8		9		10		11		12	
	1Sem.	2Sem.	1	2	1	2	1	2	1	2
Lettering										
Use of instruments										
Three view projection										
Simple working drawings										
Geometrical construction										
Sections										
Dimensioning										
Inking										
Tracing										
Graphs or diagrams										
Orthographic Projections										
Revolution of objects										
Development										
Intersections										

	Grade									
	8		9		10		11		12	
	1Sem.	2Sem.	1	2	1	2	1	2	1	2
Sheet metal drafting										
Screw threads										
Bolts and nuts										
Machine fastenings										
Free-hand sketching										
Assembly drawings										
Use of shop terms										
Pictorial drawings										
Architectural drawings										
a. Construction details										
b. Working construction										
c. Orders										
d. Rendering										
Perspective										
Gears										
Cams										
Structural										
Aviation										
Topographical										

Other topics

_____

_____

_____

Please check in appropriate column (✓)

	Regularly	Occasionally	None
Do you require home work in drawing?			
Do you have typical recitations?			
Do you use lesson or job sheets?			
Do you give demonstrations at the blackboard?			
Do you give class tests?			
Are problems assigned			
a. Directly from a text book?			
b. By blueprints prepared by instructor?			
c. By mimeographed sheets?			
d. By blackboard sketches?			
e. By dictation?			
f. By some other method?			

What is your practice regarding inking? _____

_____

_____

Name _____ School _____

City _____ Position _____

Grades taught _____

C. Copy of Letter Sent with Questionnaire

Dear Mr.

I am endeavoring to make a study of instruction in mechanical drawing in Indiana High Schools. It is my desire to show as fully as possible, just what the status of this subject is, regarding the points listed in the questionnaire.

The questionnaire has been prepared for the purpose of securing information which otherwise would not be available. Your cooperation by filling in this form as completely as possible, is earnestly requested.

Although I am doing this as thesis work, I believe that the results obtained will be of value to all teachers of mechanical drawing, in that it may lead to some form of standardization, of which we are much in need.

Your cooperation and early reply will be greatly appreciated.

Yours very truly,

Finley French

FF:RM

D. Follow-Up Letter

Horace Mann School
Gary, Indiana
February 26, 1935

Dear Mr.

A short time ago I mailed you a questionnaire blank, the filling out of which would have given me some much desired information relating to the teaching of mechanical drawing in your school. I want, very much, to have as many typical high schools as possible represented in this study and am therefore desirous that your school be included.

The number of replies already received has been very gratifying. I know that you are busy with your regular work, but I hope at an early date I may have the privilege of adding your reply to those already at hand.

Let me assure you that this favor will be greatly appreciated and thank you in advance for your cooperation.

Very truly yours,

Finley French