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ORDER OF PRESENTING ORTHOGRAPHIC PROJECTION AND ISOMETRIC PROJECTION AND ITS EFFECT ON ACHIEVEMENT IN MECHANICAL DRAWING

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A Thesis Submitted to the Graduate Division in Partial Fulfillment of the Requirements for the Degree of Master of Science

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CHAPTER I

INTRODUCTION

Each year thousands of students enroll in the mechanical drawing classes of our country's high schools. At Turner High School, Kansas City, Kansas, there are about one hundred students taking the course, Mechanical Drawing One. As one examines the projected student population of the school district, he realizes that the trend is for more students, and therefore more drafting students in the future. Especially when many students are involved the teacher asks himself, "Is everything being done that is possible to help his pupils gain as much useful information as they can? Are the present methods and techniques successful enough?"

Most of the students taking the mechanical drawing course have had no drafting or drawing experience and therefore the instructor must begin with basic fundamentals and elementary principles and practices of the subject. It is common to begin the course with plate layout, basic lettering, use of instruments, and geometric constructions. Upon completion of the introductory phase the student progresses into actually making drawings.

There are two general plans of procedure followed in teaching the student the theory of shape description. The

procedure used most often is teaching orthographic first and then progressing to isometric projection. The results of a questionnaire[1] (given to students attending Kansas State College of Pittsburg--Summer 1962) seem to verify the previous statement. Table 1 indicates the results of a questionnaire used to check the procedure thought to be in common practice among drafting instructors.

TABLE I

RESULTS OF QUESTIONNAIRE TO A SELECT GROUP OF PROFESSIONAL DRAFTING TEACHERS

Question	"Yes"	"No"
Do you present orthographic projection before you present isometric projection?	28*	4

*87.5 per cent of those responding.

Orthographic projection is a completely new and sometimes confusing experience for the student, as it does not resemble the natural way he normally observes an object. Orthographic projection involves breaking a three-dimensional object into two or more views at right angles to each other and showing them on a two-dimensional sheet of paper. The

[1]See Appendix A

alternate procedure teaches isometric projection first and is then followed by orthographic projection. In drawings of this type a three-dimensional-object is drawn showing three sides in the one view and appearing very much as it normally would to any observer. Some instructors use the one procedure in teaching while some use the other.

Statement of the Problem

The purpose of this problem was to compare two orders of presentation in the Mechanical Drawing One classes of Turner High School in order to determine the relative effectiveness or superiority of each. More specifically, was it more effective to teach orthographic projection first, followed by isometric projection; or was it a better practice to teach isometric projection first, followed by orthographic projection?

The aim of this study was to ascertain the effect on achievement in mechanical drawing resulting from these two methods of procedure. It was assumed that if any differences should be forthcoming in achievement, they would be noticed in the following ways: drawing skill developed, better ability to visualize, more speed in completing assigned problems, and in informational achievement. It was also assumed that these qualities could be measured.

Sources of Data and Method of Study

Data for the study were obtained by experimentation and observation of four classes in Mechanical Drawing One at Turner High School during the 1961-1962 school year. The experimental technique, according to Good, Barr, and Scates, is "probably the most important method of research from a strictly scientific point of view."[2] Further data were obtained by experimental comparison of equated groups of students enrolled in four classes of Mechanical Drawing One at Turner High School, during the 1962-1963 school year.

The control group was designated as group "C," and received instruction in orthographic projection first, followed by instruction in isometric projection. The other group of students used in the present study were called the experimental group, designated as group "E," and received instruction in isometric projection first, followed by instruction in orthographic projection. All other experiences and factors relating to these test groups in the mechanical drawing classes were kept as similar as possible.

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[2] C. V. Good, A. S. Barr and D. E. Scates, The Methodology of Educational Research (New York: Appleton-Century-Crofts, 1941), p. 482.

Importance of the Study

"One of the criticisms often aimed at education is its apparent unwillingness to change with our changing society. It has been said that education is always at least ten years behind the trends of society."[3] To assume that a procedure is best just because it has always been done, or is generally done a certain way, is open to contention. Surely in this scientific and technologically fast-moving era in which we find ourselves we owe it to our students to give them the advantage of the best methods and techniques of teaching possible. Under conditions similar to those of the present study many students might benefit from a change in the order of presenting orthographic and isometric projection in the mechanical drawing classes of high school.

Limitations of the Study

This study was limited to students in Turner High School, Kansas City, Kansas, who were enrolled in Mechanical Drawing One during the two semesters of the 1962-1963 school year who had completed the testing program required

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[3]Glenn L. Stevenson, "A Comparative Study on Two Ways of Presenting Geometrical Construction in an Elementary Mechanical Drawing Course," (Unpublished Master's thesis, Kansas State Teachers College, Pittsburg, Kansas, 1945), p. 5.

for the study. Of those tested only those students who could be matched with comparable students were included. Individuals who failed to remain in the course the first two six-weeks were excluded.

Definition of Terms

The following terms used throughout this study are herein defined.

"Orthographic projection" is the method of representing the exact form of an object in two or more views, placed on a two-dimensional plane using parallel lines of sight at right angles to the plane of projection.

"Isometric projection" refers to a pictorial method of representation in which all three faces of an object are seen in one view. In this type of projection the principle lines can be measured directly and the base lines are generally drawn at an angle of thirty degrees from a horizontal showing the object very much as it would actually appear to an observer.

"Achievement in mechanical drawing" is acquiring and developing drafting skill which is manifested in the student's ability to make accurate, graphic representations embodying a good quality of line, correct measurements, and lettering technique so that a trained person may read and understand the drawing. Also included in achievement is the

ability to execute the drawing with facility, the acquiring of necessary technical information in the area of terminology, and learning various drawing principles and techniques.

"Mechanical Drawing One" is a fundamentally basic course in drawing employing the use of tools and machines necessary to gain facility in the graphic representation of a single object, machine, or structure.

Survey of Related Literature

An article in School Shop magazine entitled "A Streamlined Approach to Drafting"[4] inspired the current study of experimenting in the order of presenting subject matter to the students. In his article Flam expressed the opinion that perhaps the idea of presenting orthographic projection first and then progressing to isometric projection is more traditional than logical. There seemed to be an impelling need to test this hypothesis.

Many studies have been made in the field of drafting, attempting to determine how best to transfer, or cause the student to gain as much useful information as possible. However, few researchers consider the topic of the present study with the same age-level student.

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[4]August Flam, "A Streamlined Approach to Drafting," School Shop, Vol. 1 (Jan. 1942), pp. 6-7.

Hepler,[5] in a doctoral dissertation, attempted to ascertain the relative effectiveness or superiority of teaching orthographic projection first, followed by pictorial representation as compared with teaching pictorial representation first, followed by orthographic projection. The study was conducted with engineering drawing students in college.

As a result of his findings, he concluded that teaching orthographic projection followed by pictorial representation was superior to, or was a more effective approach in the development of informational achievement, drawing skill, and ability to visualize. There was no significant difference found between the two methods with respect to speed developed and attitude of the student toward his work.

Norman[6] made a study to determine the relative effectiveness of teaching engineering drawing by first teaching freehand drawing and then progressing to instrument drawing, as compared to the reverse procedure. His findings revealed there was no significant difference in the groups tested in the students' ability to construct instrument drawings.

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[5]Earl R. Hepler, "Order of Presenting Orthographic Projection and Pictorial Representation and its Effect on Achievement in Engineering Drawing" (Unpublished Doctoral dissertation, University of Missouri, Columbia, Missouri, 1957).

[6]Ralph P. Norman, "An Experimental Investigation to Determine the Relative Effectiveness of Two Different Types of Teaching Methods in Engineering Drawing," (Unpublished Doctoral Dissertation, University of Minnesota, 1955).

In a study by Richards[7] in which he experimented with the factor of emphasizing time (drawing under time pressure) with engineering students at the University level, he found:

1. The experimental factor seemed to have no effect on the technical information or drawing skill gained by the students.

2. There seemed to be an effect that was favorable in the attitude of the student toward the work, regard for classroom discipline, and teacher ability.

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[7]Maurice F. Richards, "Effect of Emphasizing Time in the Teaching of Engineering Drawing" (Unpublished Doctoral Dissertation, University of Missouri, 1950).

CHAPTER II

DEVELOPING SUITABLE GROUPS AND CONDUCTING THE EXPERIMENT

In the preceding chapter the problem was stated, its importance was outlined, various terms were defined and related studies were briefly reviewed. This chapter describes the methods employed in obtaining the testing population and completing the experiment.

General Features of the Experiment

This investigation was conducted as a controlled experiment. The procedure varied the order of presenting orthographic projection and isometric projection to four classes of mechanical drawing students. Two classes received instruction in orthographic projection before receiving instruction in isometric projection. Two classes received instruction in isometric projection before receiving instruction in orthographic projection. All other instruction and presentation of material was handled the same for all classes.

The Null Hypothesis

To aid in the analysis and interpretation of data collected during the term of the experiment, it was considered advisable to establish and test the hypothesis that

there would be no difference in learning resulting from the varied orders of presentation.

Class Organization for Experimentation

Mechanical Drawing One classes were held during the first, third, sixth, and seventh hours of each school day. Enrollment was determined during the annual pre-enrollment period at Turner High School. Each student completed an enrollment sheet with the help and guidance of homeroom teachers and school counselors. During the summer months the school administration planned the fall schedule of classes in the light of the courses students had enrolled for in the spring pre-enrollment. Therefore, classes were made up of students placed in a certain hour because of the student's schedule and, of course, because he had a desire for the subject. It is very difficult, and almost impossible, to change a student from one period to another period. All changes are limited to the first three weeks of the school year.

Periods one and six were designated as the control group and periods three and seven as the experimental group. These were chosen because of the number of students per class and the time of day as related to the student's desire to learn. All four classes were of similar size, namely twenty-two to twenty-five students. Therefore, all classes were suitable for experimentation from a size standpoint.

The Population

Control Factors. It is desirable in any ideal experiment to control all factors except one and allow that factor every opportunity to operate. Controlled factors for this experiment were:

1. Informational content and classroom presentation[1]
2. Informational material assignments
3. Drafting problem assignments
4. Subject matter tests
5. Drawing tests
6. Duration of the course

Every effort was made to control the above factors equally for both the experimental and control groups.

Experimental Factor. Attempting to control all factors except one was the plan for this study. The order of presenting orthographic projection and isometric projection was reversed with the control group and the experimental group. The control group received instruction in orthographic projection before they received instruction in isometric projection. The experimental group received instruction in isometric projection before they received instruction in orthographic projection.

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[1] See Appendix B. "Teacher Planning Form" pp. 40-46.

Forming Equated Groups

To conduct this experiment it was necessary to form two groups that would be as equal in aptitude and native ability as possible. Scores from the following three tests were recorded as an indication of the student's aptitude and potential ability.

1 -- Otis Mental Test (form Gamma) This was used to determine the comparative I. Q. scores for all subjects of the population. This test is used regularly by the school's guidance staff, therefore the scores were obtained from them.

2 -- Space Relations Test[2] a segment of the Differential Aptitude Test given annually at the school. These scores were also obtained from the guidance staff.

3 -- Drawing Aptitude Test by Weston W. Mitchell (two parts: skill and visualization)

Quoting Mitchell,

> The purpose of this test is to measure visualizing ability, three-dimensional thinking, and the skills of using a drawing pencil. The test is unique in that it can be given to any person who has had no previous training in mechanical drawing.

Period one was given the designation "A"; period three "B"; period six "C'"; and period seven "D" as a prefix in identifying students for charting and tabulating purposes.

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[2]See Appendix A., p. 46.

After All Mechanical Drawing One students were given the tests, their scores were recorded on sheets listing each student by a code number. The average composite score was obtained for each student and placed on small shuffle cards with only the code number. The cards of classes "A & C'" were compared with the cards of classes "B & D" in an attempt to find students that matched.

Twenty-two subjects of classes "A & C'" were found to have nearly the same average composite score as a like number of subjects of classes "B & D". Table II on the following page lists all test scores and the average composite scores for subjects in periods "A & C'" which made the control group. Table III, page 16, indicates the test scores and average composite score for subjects in periods "B & D" which made the experimental group. Table IV, page 17, shows a comparison of the average composite scores of the control and experimental groups. Subjects in Table IV are equal to a tolerance of no more than two points. Comparing group-for-group the experimental group had a total of eighty hundredths of a point higher score than the control group.

Data of Table IV, "Comparison of Average Composite Scores for Obtaining Equated Groups" were examined statistically. The method used was the comparison of two randomized

TABLE II

SCORES ON TESTS USED TO OBTAIN EQUATED GROUPS

Control Group

Code No.	I.Q.	Space Relations	Mech. Dwg. Apt. Test Skill Sec.--Visualiz.		Average Composite Score
A - 20	107	90	60	218	118.75
C'-7	111	70	54	229	116.
A - 21	99	55	60	230	111.
C' - 13	125	55	36	223	109.75
C' - 15	98	55	60	216	107.25
A - 16	119	75	36	197	106.7
A - 7	99	85	48	194	106.5
A - 10	101	45	48	207	102.5
C' - 21	99	55	48	206	102.
C' - 23	120	50	60	162	99.5
C' - 2	96	30	54	202	95.5
C' - 10	111	5	48	215	94.5
A - 9	109	50	30	181	92.5
C' - 17	102	60	48	154	91.
C' - 3	91	40	54	165	87.5
A - 4	92	45	24	185	86.5
A - 8	93	60	36	129	79.5
C' - 6	73	5	54	170	75.5
C' - 18	94	25	24	155	74.5
C' - 11	89	40	24	118	67.75
C' - 14	75	40	36	85	59.
C' - 5	99	15	36	82	58.

Total 22 pupils

TABLE III

SCORES ON TESTS USED TO OBTAIN EQUATED GROUPS

Experimental Group

Code No.	I.Q.	Space Relations	Mech. Skill	Dwg. Sec.--Visualiz. Apt. Test	Average Composite Score
D - 16	109	95	60	203	116.75
D - 10	103	75	60	228	116.
D - 19	102	80	60	198	110.
B - 10	99	45	60	235	109.75
B - 12	96	80	36	216	107.
D - 11	89	90	60	183	105.5
B-22	121	75	36	188	105.
D - 12	123	95	60	136	103.5
B - 2	99	35	60	219	103.25
B - 17	92	55	48	198	98.25
D - 4	103	10	54	214	95.25
B - 3	93	70	36	176	93.75
B - 6	100	30	36	208	93.5
D - 6	120	35	24	185	91.
B - 20	92	45	54	129	88.25
D - 7	116	45	48	145	88.5
D - 9	85	35	48	154	80.5
D - 20	92	45	54	111	75.5
B - 11	97	25	30	145	74.25
D - 8	93	40	30	113	69.
D - 21	107	1	36	96	59.75
B - 14	89	1	36	107	58.25

Total 22 pupils

TABLE IV

COMPARISON OF AVERAGE COMPOSITE SCORES FOR OBTAINING EQUATED GROUPS

Experimental		Control	
Code No.	Average Composite Score	Code No.	Average Composite Score
D - 16	116.75	A - 20	118.75
D - 10	116.	C' - 7	116.
D - 19	110.	A - 21	111.
B - 10	109.75	C' - 13	109.75
B - 12	107.	C' - 15	107.25
D - 11	105.5	A - 16	106.7
B - 22	105.	A - 7	106.5
D - 12	103.5	A - 10	102.5
B - 2	103.25	C' - 21	102.
B - 17	98.25	C' - 23	99.5
D - 4	95.25	C' - 2	95.5
B - 3	93.75	C' - 10	94.5
B - 6	93.5	A - 9	92.5
D - 6	91.	C' - 17	91.
B - 20	88.25	C' - 3	87.5
D - 7	88.5	A - 4	86.5
D - 9	80.5	A - 8	79.5
D - 20	75.5	C' - 6	75.5
B - 11	74.25	C' - 18	74.5
D - 8	69.	C' - 11	67.75
D - 21	59.75	C' - 14	59.
B - 14	58.25	C' - 5	58.

Note: Average composite scores of compared subjects are within a tolerance of two points of each other. Comparing groups the experimental group has eighty hundredths higher score.

groups of equal size as presented by Snedecor, in his book Statistical Methods.[3]

The calculations are summarized in Table V, "Statistics for Comparison of Equated Groups of Equal Size." The corrected sums of squares are added or polled and the sum divided by the total degrees of freedom. The formula $2 = \frac{2}{2\,(n-1)}$ was used as indicated below, then the value of "t" was found to ascertain whether any

TABLE V

STATISTICS FOR COMPARISON OF EQUATED GROUPS OF EQUAL SIZE

Group	No. of Subjects	Degrees of Freedom	Mean Score	Sum of Squares
Control	22	21	92.81	195,747.008
Experimental	22	21	92.84	195,784.588
		42	.03	391,531.596

$$2 = \frac{391,531.596}{42} = 9322.181$$

$$\bar{x}_1 - \bar{x}_2 = \frac{18644.362}{22} = 847.471 = 29.11$$

$$t = \frac{.03}{29.11} = .00103$$

[3]George W. Snedecor, Statistical Methods (Ames, Iowa: Iowa State University Press, 1956), p. 87.

difference is attributable to a population difference or if it is random variation from a single population mean. (This line of statistical reasoning was chosen as fitting for the test of equated groups.) The equality of variance in the two populations could be taken for granted as a glance at the mean scores and sums of squares would tend to indicate.

The "t" value as found in the foregoing computation is the deviation of the estimated mean from that of the population. Checking a "Distribution of "t" Table" as found in Snedecar's text, the researcher could not locate the amount .00103 for a degrees of freedom value of forty-two indicating the difference in means of the control group and experimental group as very insignificant.

The Instruction Schedule

All classes convened for fifty-five minutes per day in the same classroom. The class session was made up of a presentation and lecture period and a work period. About every three weeks a quiz was given. The students were given reading and study assignments for their homework. All students were instructed to read and study specific pages of material from the textbook just before a lecture session on that unit or part thereof. After an instructional lecture, appropriate plate problems from the textbook were assigned to the students.

Assignments for all students were the same until the last half of the second six-weeks period when types of projection were studied. At that time, periods one and six received instruction in orthographic projection while periods three and seven received instruction in isometric projection. All other instruction was the same for all Mechanical Drawing One Classes.[4]

Procedure Used in Grading Drawings

Criteria considered in evaluating students' drawing projects were as follows:

1. Selection and arrangement of views - 2 points
2. Quality of lines and lettering technique - 2 "
3. Accuracy in the drawing and dimensioning - 2 "
4. General appearance and neatness - 2 "
5. Correct, timely completion of the project - 2 "

The instructor attempted to be as objective as possible in grading drawings, always considering the student's work against a standard established by the instructor through experience. The point system mentioned above caused a student's plate to be graded as follows: 10 points = A, 9 points = A-, 8 points = B+, 7 points = B, etc. This grade as recorded on the student's plate in the title box was also recorded on the instructor's sheet kept for this purpose for each class.

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[4]See Appendix B, "Teacher Planning Form," p. 50.

Record Keeping System for Study

For purposes of this study records needed to be kept on the following items: The date the student began each plate; the date the student finished each plate; the grade received on each plate; the total number of plates turned in by each student. A form called "Student Drafting Time Record"[5] was designed to log this data. From this form a record was maintained of the time required to complete drawing plates by each participant in the study.

Students also kept a record of the date they started and the date they finished each plate. This record was lettered on the plate itself in a place allotted for it in the title box. Each student recorded these facts on each plate as they began and completed their work. It was emphasized in all classes that there was a need for completing all drawings as accurately and correctly as possible in the least amount of time.

The record of grades on plates was kept in the instructor's grade book on sheets designed for that purpose. From this record a cross check was maintained of the number of plates completed.

Time Required for the Experiment

It was anticipated that the first semester of the

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[5]See Appendix A, "Student Drafting Time Record," p. 46.

school year would be sufficient time to collect the necessary data for this study. This was a false assumption as the students comprising the control and experimental groups were too far behind schedule in both areas of projection to make a complete study. Therefore, the writer decided to continue the study through the second semester. This allowed the control and experimental groups to turn in more drawing plates and thereby give the experimental factor more time to operate.

Testing of Informational Material

Courses are divided into time segments of six weeks each. It is normal to have a testing period at or near the conclusion of each six weeks period. Although this was done it was not deemed pertinant to this study to include the records of each of these tests. The semester test at the conclusion of the second semester was used as a final test in this study. This test included material that was designed to ascertain how well the students learned the informational and drawing material to which they were exposed. General school conditions were good during the final testing period as all students were being tested in all classes. This caused the testing period to be of specific duration and completely free of interruptions. Students had ninety minutes to complete the test.

Seniors in the school were dismissed a few days early at the close of the school year (if the student's grade average was sufficiently high.) There were three senior students in the control group and also three seniors in the experimental group. Since there was a like number of students from both groups concerned in the study, the results of the study were possibly equally effected.

Environmental Conditions During Study

It was attempted to keep conditions as nearly normal as possible during the study. The writer had previously used recorded music in the classroom during the drawing period and this practice was continued. There seemed to be a higher concentration on the assigned work while the music was playing. The numbers played were selected with care and taped for use on a tape recorder in the classroom.

Attention was given to the temperature and ventilation in the classroom during the study. For the period of the experiment the room temperature was maintained at sixty-eight to seventy degrees. All other environmental conditions which could be controlled were kept as constant as possible.

Summary

This experiment involved two groups of students, from the four mechanical drawing classes, with sufficient likenesses to form equated groups. The high school classes were

established prior to the beginning of the school year by the administration acting upon the student's choices in pre-enrollment.

Two groups of twenty-two students each became the "control" and "experimental" groups for this study. Scores made on three qualifying tests plus their I.Q. score determined the choice of students. Students from periods one and six formed the control group and from periods three and seven the experimental section was derived. It was found by using the "t" formula that the difference in means of the control group and experimental group was of no significance, and the groups should be considered equated.

Progress of the experimentation of this study was programed to follow the normal class outline of instruction. No changes of timing or material were necessary. This study was not designed to measure the accumulated growth of the subjects in the mechanical drawing course, but to attempt to determine if any significant difference might be noticed in four areas of possible achievement. The only factor in question was what increased achievement might be made by the pupils if isometric projection were presented and taught before orthographic projection. A system of records were established to log various factors pertinent to the study.

Normal environmental conditions were maintained during the course of the study.

CHAPTER III

FINDINGS RELEVENT TO THE STUDY

The previous chapters have shown the various aspects of the experiment -- the assumption of the null hypothesis, selection of students, equating of test groups, controlled factors, experimental factor, and teaching the classes. It was assumed that if any differences should result from a comparison of two orders of presentation in mechanical drawing classes, they would be noticed in the following ways: drawing skill developed, better ability to visualize, more speed in completing assigned problems, and informational achievement.

Drawing Skill Developed

For purposes of this experiment it was decided that a reliable measure of the subjects' drawing skill might be obtained by observing the scores earned on drawing plates completed. Table VI, found on the following page, "Distribution of Grade Scores on Daily Plates Completed by Control and Experimental Groups," lists the scores and gives the average score for each subject that participated in the study. The twenty-two subjects of the control group accumulated 161.64 points, with an average grade of 7.347 points per pupil. Table VI also indicates the distribution of

TABLE VI

DISTRIBUTION OF GRADE SCORES ON DAILY PLATES COMPLETED

by Control Group			by Experimental Group		
Code No.	Ave. Grade (x)	Grade Squared (x^2)	Code No.	Ave. Grade (x)	Grade Squared (x^2)
A-20	9.6	92.16	D-16	9.48	89.8704
C'-7	8.8	77.44	D-10	9.07	82.2649
A-21	9.65	93.1225	D-19	9.08	82.4464
C'-13	9.84	96.8256	B-10	7.8	60.8400
C'-15	9.4	88.36	B-12	7.15	51.1225
A-16	8.2	67.24	D-11	8.6	73.9600
A-7	8.5	68.89	B-22	4.93	24.3049
A-10	8.0	64.	D-12	9.5	90.2500
C'-21	6.7	44.89	B-2	10.	100.
C'-23	9.6	92.16	B-17	7.25	52.5625
C'-2	5.0	25.	D-4	6.32	39.9424
C'-10	8.3	68.89	B-3	8.28	68.5584
A-9	8.8	77.44	B-6	5.78	33.4084
C'-17	9.8	96.04	D-6	9.1	82.81
C'-3	6.8	46.24	B-20	8.7	75.69
A-4	3.8	14.44	D-9	5.7	32.49
A-8	5.8	33.64	D-20	5.84	34.1056
C'-6	6.5	42.25	B-11	6.43	41.3449
C'-18	3.0	9.	D-8	4.7	22.09
C'-11	3.6	12.96	D-21	5.6	31.36
C'-14	5.25	27.5625	B-14	5.6	31.36
C'-5	6.9	47.61	D-7	8.9	79.21
22	161.64	1286.1606	22	163.81	1279.9913

grade scores on daily plates completed for the experimental group. The twenty-two subjects of the experimental group accumulated 163.81 points, with an average grade of 7.446 points per pupil. The experimental group registered .099 points higher average score than did the control group. Whether the experimental group's average or mean score is significant was tested by the 't' test. The calculation appears in Table VII "Comparison of Daily Plate Scores for Equated Groups."

TABLE VII

COMPARISON OF DAILY PLATE SCORES FOR EQUATED GROUPS

Group	No. of Subjects	Degrees of Freedom	Mean Score	Sum of Squares
Control	22	21	7.35	1286.1606
Experimental	22	21	7.45	1279.9113
		42	.10	2566.1519

$$s^2 = \frac{2566.1519}{42} = 61.0989$$

$$s_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{122.1978}{22}} = 2.36$$

$$t = \frac{.1}{2.36} = .042 \qquad H_o : u_1 - u_2 = 0$$

Therefore, the probability is greater than .05 that the difference in population means will be greater than "0" for a forty-two degree of freedom. The located "t" value does not appear on the "t" distribution scale therefore the value calculated was not significant.

Ability to Visualize

It is difficult to know the most reliable method of ascertaining how well a student visualizes his work. In the textbook, Mechanical Drawing by French and Svenson, provided for the course, there were various drawing problems related to the instructional chapters. As mentioned earlier in the report the control group was doing problems in orthographic projection while the experimental group was doing the same problems in isometric projection.

The number of drawing problems completed by the students was thought to be meaningful as an indicator of the student's ability to visualize the work assigned. If a pupil found it difficult to understand a problem, he therefore took longer to complete the problem and consequently turned in fewer plates to be graded.

Table VIII on the next page, "The Number of Drawing Plates Completed," is a record of the number of plates finished for grading by the control and experimental groups participating in this study. The results show the control

TABLE VIII

NUMBER OF DRAWING PLATES COMPLETED

by Control Group			by Experimental Group		
Code No.	Ave. Plates (x)	Plates Squared (x^2)	Code No.	Ave. Plates	Plates Squared
A-20	19	361.	D-16	27	729.
C'-7	29	841.	D-10	28	784.
A-21	20	400.	D-19	26	676.
C'-13	25	625.	B-10	18	324.
C'-15	27	729.	B-12	20	400.
A-16	21	441.	D-11	22	484.
A-7	18	324.	B-22	16	256.
A-10	19	361.	D-12	30	900.
C'-21	23	529.	B-2	21	441
C'-23	30	900.	B-17	24	576.
C'-2	8	64.	D-4	25	625.
C'-10	22	484.	B-3	24	576.
A-9	25	625.	B-6	14	196.
C'-17	21	441.	D-6	18	324.
C'-3	24	576.	B-20	19	361.
A-4	17	289.	D-7	25	625.
A-8	16	256.	D-9	21	441.
C'-6	24	576.	D-20	19	361.
C'-18	17	289.	B-11	23	529.
C'-11	12	144.	D-8	21	441.
C'-14	20	400.	D-21	22	484.
C'-5	29	841.	B-14	22	484.
22	466	10496.	22	485	11017.

group completed 466 drawing plates and the experimental group completed 485 plates. The experimental group completed 19 plates more than the control group. Since there were twenty-two subjects in each group the experimental group completed .863 more plates per pupil than did the control group. Inasmuch as all students had the same amount of time in which to complete their plates, the experimental group must have worked somewhat more quickly.

The findings reported above were checked for significance using the 't' formula and distribution table.

Table IX "Comparison of Number of Plates Completed by Equated Groups" is a treatment of the data of Table VIII with the purpose of checking for significance in the noted variance.

TABLE IX

COMPARISON OF NUMBER OF PLATES COMPLETED BY EQUATED GROUPS

Group	No. of Subjects	Degrees of Freedom	Plates (Mean)	Sum of Squares
Control	22	21	21.18	10,496.
Experimental	22	21	22.05	11,017.
		42	.87	21,513.

$$s^2 = \frac{21,513}{42} = 512.214$$

$$s_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{1024.428}{22}} = 6.82$$

$$t = \frac{.87}{6.82} = .127 \qquad H_o : u_1 - u_2 = 0$$

In checking the t-distribution scale, it was found that a small quantity of .127 was too low to appear on the scale for forty-two degrees of freedom. Therefore, it was concluded that statistically there was no significant difference in the students' ability to visualize due to changing the order of presenting orthographic and isometric projection.

Speed in Completing the Problems

Throughout the time of this study speed was not emphasized so much that the students felt rushed to get the work completed. The amount of time required to successfully complete a drawing project is always of importance to an employer who is paying to have work done. However, while the student is in the instructional stage it would be unfair to consider the time used to complete the drawing plates in judging the student's work unless progress was unduly slow.

Table X on the following page, "Record of Time Used to Complete Daily Plates," lists the control and experimental groups and itemizes the average time in days required by each

TABLE X

RECORD OF TIME USED TO COMPLETE DAILY PLATES

by Control Group			by Experimental Group		
Code No.	Ave. Time (x)	Time Squared (x^2)	Code No.	Ave. Time (x)	Time Squared (x^2)
A-20	9.5	90.25	D-16	5.	25.
C'-7	5.14	26.4196	D-10	3.34	11.1556
A-21	6.7	44.89	D-19	6.38	40.7044
C'-13	7.3	53.29	B-10	7.58	57.4564
C'-15	5.8	33.64	B-12	6.46	41.7316
A-16	7.66	58.6756	D-11	6.42	41.2164
A-7	9.6	92.16	B-22	12.08	145.9264
A-10	8.7	75.69	D-12	4.9	24.01
C'-21	6.3	39.69	B-2	8.9	79.21
C'-23	4.95	24.5025	B-17	7.6	57.76
C'-2	13.2	174.24	D-4	6.33	40.0689
C'-10	7.78	60.4284	B-3	9.5	90.25
A-9	6.1	37.21	B-6	11.5	132.25
C'-17	9.78	95.6484	D-6	7.2	51.84
C'-3	6.5	42.25	B-20	4.14	17.1396
A-4	8.44	71.2336	D-7	6.9	47.61
A-8	9.33	87.0489	D-9	7.18	51.5524
C'-6	5.81	33.7561	D-20	5.6	31.36
C'-18	7.57	57.3049	B-11	5.06	25.6036
C'-11	11.5	132.25	D-8	9.06	82.0836
C'-14	10.06	101.2036	D-21	4.44	19.7136
C'-5	6.15	37.8225	B-14	6.5	42.90
22	173.87	1469.7041	22	152.07	1156.5425

subject to complete one plate. This was obtained by recording the time necessary to complete each plate by each student and by obtaining the sum and then dividing by the number of subjects in the group.

According to Table X, the control group of twenty-two subjects used a total average time of 173.87 days to complete all drawing plates, or 7.9 days per drawing plate per pupil. The experimental group used a total average time of 152.07 days to complete all drawing plates, or 6.9 days per drawing plate per pupil. This indicates that in average time, it took the experimental group members one day less per plate to get the drawing problems done.

At the outset one might think this result to be of significance, but statistically using the t-distribution scale on the findings calculated it was not significant.

Table XI, on the following page, "Comparison of Average Time Used Per Plate by Equated Groups," indicates the calculation used to locate the value of 't' for the means and sum of squares as indicated in the following table.

TABLE XI

COMPARISON OF AVERAGE TIME USED PER PLATE BY EQUATED GROUPS

Group	No. of Subjects	Degrees of Freedom	Days (Mean)	Sum of Squares
Control	22	21	7.90	1,469.7041
Experimental	22	21	6.91	1,156.5425
		42	.99	2,626.2466

$$s^2 = \frac{2626.249}{42} = 62.53$$

$$s_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{125.06}{22}} = 2.377$$

$$t = \frac{.99}{2.3777} = .4165$$

For forty-two degrees of freedom as we have in this study, it is impossible to locate .4165 on the table of t-distribution; therefore, it can be concluded statistically that there was no significant difference in speed in drawing problems because of the varied orders of presenting orthographic and isometric projection.

Testing for Informational Achievement

In testing for informational achievement the instructor decided that the most reliable method would be to check

the results of the final test taken by the students at the close of the school year. This was done as is indicated in Table XII, found on the following page. This test included material studied at various times during the school year and with which all students should have been familiar.

Table XII, "Scores of Mechanical Drawing Final Test," is a record of the results of this test. This table indicates the grade points of each subject taking the test, the points squared, and the totals. The scores of both the control and experimental groups are represented on the same table.

The findings indicate that the control group accumulated an average total of 116 points or a student average of 6.105 points. The experimental group had a total average of 104 points, or a student average of 5.473 points. The control group had the better point score by .623 of a point. The fact that seniors were excused from final tests caused a variation in the test as compared with the other phases of the experiment. This variation was in balance, however, as there were three seniors excused from each of the two groups under study.

In each of the above areas mentioned where there might have been significant variance, no measurable variance was indicated statistically. The same thing was true in the case of informational achievement as is shown in Table XIII.

TABLE XII

SCORES OF MECHANICAL DRAWING FINAL TEST

by Control Group			by Experimental Group		
Code No.	Grade Pts. (x)	Points Squared (x^2)	Code No.	Grade Pts. (x)	Points Squared (x^2)
A-20	11	121.	D-16	*	---
C'-7	10	100.	D-10	*	---
A-21	9	81.	D-19	10	100.
C'-13	11	121.	B-10	6	36.
C'-15	7	49.	B-12	6	36.
A-16	6	36.	D-11	7	49.
A-7	5	25.	B-22	3	9.
A-10	5	25.	D-12	11	121.
C'-21	*	---	B-2	11	121.
C'-23	11	121.	B-17	6	36.
C'-2	3	9.	D-4	2	4.
C'-10	6	36.	B-3	5	25.
A-9	9	81.	B-6	2	4.
C'-17	8	64.	D-6	6	36.
C'-3	5	25.	B-20	3	9.
A-4	5	25.	D-7	7	49.
A-8	3	9.	D-9	1	1.
C'-6	*	---	D-20	6	36.
C'-18	0	---	B-11	*	---
C'-11	1	1.	D-8	3	9.
C'-14	1	1.	D-21	8	64.
C'-5	*	---	B-14	1	1.
22	116	930.	22	104	746.

*Seniors who finished school and did not take the final test.

Table XIII, "Comparison of Final Test Scores by Equated Groups" indicates the calculation used in determining the t-value from the means and sum of squares as derived from Table XII on the previous page.

TABLE XIII

COMPARISON OF FINAL TEST SCORES BY EQUATED GROUPS

Group	No. of Subjects	Degrees of Freedom	Scores (Mean)	Sum of Squares
Control	22	21	5.27	930.
Experimental	22	21	4.72	746.
		42	.55	1676.

$$s^2 = \frac{1676}{42} = 39.904$$

$$s_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{79.808}{22}} = 1.9904$$

$$t = \frac{.55}{1.99} = .276$$

The above t-value of .276 did not appear on the t-distribution scale, in the text by Snedecor, for forty-two degrees of freedom. Therefore there was no significant difference in the informational material achieved due to varying the order of presenting orthographic and isometric projection in the Mechanical Drawing One classes.

Summary

As stated earlier in this study, if the order of presenting isometric and orthographic projection were reversed there might be some advantage to the pupil. It was also stated if there were significant differences, they would be noticed in the following ways: drawing skill developed, better ability to visualize, more speed in completing problems, and informational achievement.

Each of these avenues of possible evidence of achievement was checked for all members of the participating groups. Records were kept on the control and experimental groups and results were expressed in Tables VI, VIII, X, and XII. In three of the areas checked; namely, skill developed, ability to visualize, and speed in doing daily plates, the experimental group had the best score. However when a statistical treatment was applied to the results there was found to be no significant difference. In the other area of informational achievement the reverse was true. It appeared that the control group had better results but when checked statistically there was again no significance indicated.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Two orders of presentation of material pertinent to the learning of drafting have been examined in the light of their relative effectiveness when one is presented before the other. An attempt was made to examine the superiority of teaching orthographic projection first followed by isometric projection as compared with teaching isometric projection first followed by orthographic projection. Four high school mechanical drawing one classes took part in the experiment which lasted for one school year. After comparing the results of students on various qualifying tests, an experimental and a control group were designated. Care was taken to obtain students of like ability in each group. The control group received instruction in orthographic projection before being instructed in isometric projection. The experimental group received instruction in isometric projection before receiving instruction in orthographic projection.

The premise of this study was that if any significant difference in superiority of one method over the other was to be noted, it would manifest itself in some of the following ways: drawing skill developed, better ability to

visualize, more speed in completing drawing problems, and better informational achievement.

Records were kept of the pupils' work during the year to see if any difference in achievement in any of the areas might be noted. The experimental group made a slightly higher average grade on the drawing plates completed and also did somewhat better on the test of informational achievement in the final examination. The experimental group seemed to have more speed in completing drawing problems as they were able to complete the plates in 1.000 fewer days per plate. The experimental group also turned in .863 more plates per pupil than the control group.

Analysis of Study Findings

The experimental group, which was presented isometric projection followed by orthographic projection made higher scores on the drawing problems completed and turned in. The control group did better on the test of informational achievement. Results tend to indicate that the experimental group developed better drawing skill. The control group seemed to learn the informational facts related to the course better, or more completely, as they did better on the test of informational material.

Speed in completing the assigned problems was considered an area in which results might be noticeable in this

study. The experimental group actually completed more drawing plates and in less time.

In viewing the results of this study it seems significant to note that neither the control nor experimental group did more superior work than the other. Both groups actually performed very much the same in each of the areas where results were expected. Some differences were shown, but the differences were not pronounced as the statistical examination proved.

The researcher found that although a slight advantage appeared in the findings as the results were examined by themselves alone, when statistics were applied it was learned that no significant advantage was gained by either the control or experimental group.

Conclusions

Evidence collected in this study warrent the following conclusions:

1. Insofar as drawing skill developed by pupils in the Mechanical Drawing One class is concerned, it seems that teaching of orthographic projection first, followed by isometric projection is as effective as teaching isometric projection first followed by orthographic projection.

2. The teaching of orthographic projection followed by isometric projection is as effective as teaching isometric projection followed by orthographic projection in terms of informational achievement by the pupils.
3. With respect to speed in completing the drawing problems assigned, the teaching of isometric projection followed by orthographic projection is as effective as teaching orthographic projection first, followed by isometric projection.
4. Presenting isometric projection followed by orthographic projection was as effective as presenting orthographic projection followed by isometric projection in relation to the students' ability to visualize drawing problems.

Although this study did not find one method of presentation to be superior to the other, enough evidence has been presented to cause the writer to conclude that to vary the order of presentation of instructional material in the classroom might be of value to the students. It was noticed during the course of the experimentation that the students being taught isometric projection first seemed to show greater interest in their work and tended to apprehend the drawing problems easily.

Recommendations

This experimental study, to ascertain whether there might be any significant effect on achievement in mechanical drawing classes by changing the order of presenting orthographic projection and isometric projection, has been limited to the mechanical drawing classes of one high school. The writer feels that value could be derived from repeating this study with larger test groups.

Other studies could also be rewarding to mechanical drawing teaching. Examples are: checking to see at which time it is best to present freehand sketching to mechanical drawing students, ascertaining whether students do better lettering if they have had some principles of drawing presented first.

Research done by Hepler[2] at the University of Missouri, caused him to conclude that in areas quite similar to those of this study, the teaching of orthographic projection first followed by pictorial representation was superior to and a more effective approach than teaching pictorial representation followed by orthographic projection. Hepler experimented with college engineering drawing students. The present study was, of course, with high school mechanical

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[2]Earl R. Hepler, "Order of Presenting Orthographic Projection and Pictorial Representation and its Effect on Achievement in Engineering Drawing" (Unpublished Doctoral Dissertation, University of Missouri, Columbia, Missouri, 1957).

drawing students. Additional research may provide a body of evidence that will support some of the findings of these two studies.

APPENDICES

APPENDIX A

QUESTIONNAIRE FOR TEACHERS OF MECHANICAL DRAWING I. IN HIGH SCHOOL

Drafting teachers are confronted with the problem of the order of presenting certain units of instruction to their classes. This particular problem is seeking to ascertain whether presenting orthographic projection first, followed by isometric projection, is superior in learning value, to the student, over presenting isometric projection before presenting orthographic projection.

Your answers to the following questions will be valuable to my study because I respect your teaching experience.

Results of the study will be sent you if you will give your name and address in the space provided below. Thank you for your cooperation.

#1. Do you present orthographic projection before you present isometric projection? (Please circle one) YES NO

If answer to question (#1) is NO do you feel the students visualize better with your order of presentation?

(Please circle one) YES NO

Name:_____

Street:_____

City,State:_____

Please return to-
Ind. Educ. Office
-or-
Study by: Horton Bolin
Rm. 211, Bowen Hall
(Home Address
10903 Sharon Lane
Shawnee, Kansas.)

Space Relations Test.....from Manual for the Differential Aptitude Tests, by: George K. Bennett, Harold G. Seashore and Alexander G. Wesman, The Psychological Corporation, New York, 1959.

The Space Relations test is a measure of ability to deal with concrete materials through visualization. There are many vocations in which one is required to imagine how an object would appear if rotated in a given way. This ability to manipulate "things" mentally, to create a structure in one's mind from a plan, is what the test is designed to evaluate. It is an ability needed in such fields as drafting, dress designing, architecture, art, die-making, and decoration, or wherever there is need to visualize objects in three dimensions.

STUDENT
— DRAFTING TIME RECORD —

NAME: WENDT, GENE HR 6

PLATE NO.	Date Started	Date Finished	Days Req'd.	Total
1	9-26-62	9-28-62	2	
2	9-28-62	10-3-62	5	
3	10-4-62	10-9-62	5	
4	10-10-62	10-12-62	2	
5	10-16-62	10-18-62	2	
6	10-22-62	10-25-62	3	
7	10-26-62	10-31-62	5	
8	11-12-62	11-20-62	8	
9	11-26-62	12-3-62	7	
10	12-3-62	12-11-62	8	
11	12-13-62	12-20-62	7	
12	1-2-63	1-4-63	2	
13	1-4-63	1-8-63	4	
14	1-9-63	1-9-63	1	
15	1-14-63	1-23-63	9	
16	1-24-63	1-30-63	6	
17	1-30-63	2-4-63	5	
18	2-4-63	2-11-63	7	
19	2-11-63	2-18-63	7	
20	2-18-63	2-22-63	4	
21	2-25-63	2-28-63	3	
22	3-1-63	3-18-63	12	
23	3-20-63	3-22-63	2	
24	3-25-63	3-28-63	3	
24			119	4.95/ea

APPENDIX B

Specific Course Objectives

-- Mechanical Drawing I --

Student Outcomes	Activities to Achieve Outcomes
1. To interpret the importance of the drafting industry.	1. Visit in person or via film a drafting or engineering office. 2. Turn in brief paper describing drawing and planning for some home project or planning in relative's or (friend's) work. 3. Use one class period for discussion of #2 (above). 4. Bring out in class discussion and lecture the standards of drafting rooms, personnel, and occupational information.
2. Developing good habits of work.	1. Provide quite specific standards for each problem or project students are to do. 2. Have the drafting room physical conditions as ideal as possible: clean, orderly, and as pleasant as can be to help students to want to work and learn. 3. Measure as many factors of a student's work as objectively as you can. 4. Provide, and encourage students to use equipment, materials, and machines, as accurately and methodically as possible.

Student Outcomes	Activities to Achieve Outcomes
	5. Strongly promote students caring for personal and school equipment correctly.
3. Develop a high degree of skill in use of the tools of the trade.	1. Use care in all demonstrations to promote skill outcomes.
	2. Use series of individual problems from text to give practice in skill development.
4. Help develop recreational and avocational activities.	1. Encourage students to look for projects in sports, or at home to draw that would make living more pleasant or more convenient.
	2. Allow student to take school classtime to draw project he needs, or desires, as near when he desires it as possible.
	3. Encourage projects in drawing and planning in connection with local Industrial Education Club.
5. Develop students' ability to work cooperatively with others.	1. Provide student personnel organization, although limited in drafting area: a. T-square checker b. reproduction technician for printing c. audio-visual and tape rec'd. technician.
	2. Encourage and set up some group projects.
	3. Assign more advanced students to help students needing assistance.
6. Understand labor and management as it applies to drafting.	1. Have a speaker (if possible) from the drafting projession to give both aspects of problems.

Student Outcomes	Activities to Achieve Outcomes
	2. Have speaker (if possible) from labor to give both aspects of problems.
	3. Allow discussion to see students' reaction to each of #1 and #2.
	4. Provide a suggestion box for ideas in conducting a drafting course.
7. Develop an appreciation of good craftsmanship.	1. Orient the classes as objectively as possible to good design and construction criteria.
	2. Arrange a field trip or film on the topic, or visit a good producer of a well designed and constructed article.
	3. Have students analyze products for good and poor design, construction, etc.
8. Develop good habits concerning safety.	1. Strengthen, whenever possible, the safety education carried on in other industrial arts shops.
	2. Check safety features of all tools, machines, and room in general.
	3. Show film on safety in industry as related to the draftsman and planning for construction.
9. Develop ability to solve problems.	1. Provide an opportunity for all students to design and plan several projects.

Student Outcomes	Activities to Achieve Outcomes
	2. Experiment with some type of program for student appraisal of (perhaps grading) of student work.
	3. Problem solving will be done in connection with #4.1 & 2 above.

TURNER HIGH SCHOOL

TEACHER PLANNING FORM
(1) 2 3 4 5 6

Page 1 | SUBJECT Mech. Dwg. I | Code No.

Objectives: Reverse side | Teacher: E. H. Bolin | Grade

Content	Teacher Activity	Student Activity	Materials/Resource people
UNIT I			
Fundamentals of This Graphic Language:		Read Ch. 1 of text.	
A - Dept. & Area Standards	Explanation to students		
B - Issuance of Materials			
1 - Tote drawers	Check:		
2 - T-Square, triangles, scales, supplies, etc.	Receipts 1-Fee 2-Material card 3-Tool rental	Check drawer fit. Read Ch. 2 of text.	Record numbers on student enrollment cards.
	Student Needs: 4 pencils: H, 2-H, 4-H, 6-H. 1 envelope 1 red erasers; 1 art gum		
3 - Sharpen pencils			Have all supplies ready for distribution

Content	Teacher Activity	Student Activity	Materials/Resource people
UNIT I (Continued)			
a - Lead grades and uses	1 erasing shield 1 roll of drafting tape 1 set of drawing instruments		
	Demonstrate: Conical, Chisel	Sharpen pencils Text 2-5;2-6	
4 - Learning to use the tools of drafting	Demonstrate	Try tools Text 2.7; 2.8; thru 2.14.	
a - T-square b - Triangles c - Drafting machines	Demonstrate	Text p. 31 2-27	
d - Parallel-ruling straight edge e - scales and their use	Lecture session with film strip	Use scale for problems assigned	Res. proj. & have film ready

OBJECTIVES

Help students understand:
A - History of and need for Mechanical Drawing; B - Records and Department policies;
C - Supplies needed and why; D - Layout sheets; E - Use of instruments.

Content	Teacher Activity	Student Activity	Materials/Resource people
f - Special tools 1 - beam compass 2 - drop-spring compass 3 - protractor		Text p. 361 Prob. A.1 thru A-11 Quiz over material of Chs. 1 & 2	
C - Lettering 1 - Importance to drafting 2 - Styles 3 - Guidelines a - Spec. Devices b - Always used (guidelines) c - Composition	Explain and Demonstrate Show filmstrip		Proj. and screen
D - Geometrical Constructions	Demonstrate each new problem	Follow text Ch. 4 4.1 thru. 4.28 <u>Do</u>: Prob's. C.1, thru. C.34 pp. 378-380 Follow - Assignment sheet by instr.	Vert. drafting machine and chalkboard.

Content	Teacher Activity	Student Activity	Materials/Resource people
UNIT II Theories of Shape Description I - Two systems are to be tested to ascertain which is more advantageous to present first. A - Orthographic B - Isometric	Present Orthographic Projection first to periods one & six Present Isometric Projection first to periods three & seven Equal instruction is given to both methods of presentation as much as is humanly possible. (This material is in conjunction with experimental research for a thesis.)	(All Students) Do same problems in "D" series "pp. 381, D.1 thru D.66 pp. e90" All students do problems of like difficulty, however not in the same order and at the same time. This allows each student to do his problem independently.	Textbook Ch. 5 "Theory of Shape Description" Ch. 10 "Theory of Size Description" Ch. 14 "Pictorial Drawing" (with special emphasis on isometric projection) Teaching Aids Orthographic reflection box. Filmstrip. Vertical Drafting Mach. presentation board.

Content	Teacher Activity	Student Activity	Materials/Resource people
Unit III			
Theory of Size			
Description			
I - Learn rules of dimensioning and receive practice in their use. II- Learn to apply General rules to specific problems.	Present material and answer questions. Tutor students so they begin correctly.	Do problems in the "H" group, p. 422 in text. This work continues into all groups.	Ch. 10 in Text Ch. 11 gives more information on special techniques.
Unit IV			
Begin Pictorial Drawing			
I - Isometric Drawing II - Cabinet Drawing III - Perspective Drawing	Explain methods and illustrate with drawings.	Each student must incorporate Isometric Drawing into daily plates.	Textbook Ch. 14. Technical Drafting by Giesseck, etc.

Content	Teacher Activity	Student Activity	Materials/Resource People
UNIT V			
Others Areas of Drafting			
I - Sections A - Offset section B - Half section 1 - When to use 2 - Projection isometrically C - Other kinds of sections	Illustrate with help of models	Do problems in text with sections in mind. Ch. 8 needs to be thoroughly studied.	Many models made to show kinds of sections.
II - Inking			
A - Orientation 1 - Habits needed for good results 2 - Care in using ink 3 - Cleanup and care of equipment	Much explanation is needed Get materials ready Have area supervisor system for cleanup.	1 - practice inking on $8\frac{1}{2}$ x 11" sheet 1 - ink tracing of plate student has drawn	ink & holders pen cleaner Ch. 11 in text pp. 141-147

Content	Teacher Activity	Student Activity	Materials/Resource people
UNIT V (Continued)			
III - Project Drawing			
A - Choose type 1 - Hobby cabinet 2 - Household or furniture project	Illustrate ways of solving project situation.	Choose project Make sketch	All previously studied material is called on as the student develops project.
B - Metal 1 - Joints & fastening techniques	Chalk board illustrations to show pupils possible projects.	Begin final drawing	Orthographic projection, isometric projection, etc. may be used.
C - Wood 1 - Joints, materials and fastening.		Restudy Ch. 5 in text pp. 60-73	p. 378 Speedball lettering book.
D - Working drawing		Student's choice	
Make Cover Plate Check in at close of school.	Give examples of special lettering. Check texts for damage--also instruments & tools.	Clean out drawer	

BIBLIOGRAPHY

BIBLIOGRAPHY

BOOKS

Good, C. V., Barr, A. S., and Scates, D. E., The Methodology of Educational Research. New York: Appleton-Century-Crofts, 1941.

Snedecor, George W. Statistical Methods. Ames: The Iowa State University Press, 1956.

PERIODICALS

Flam, August. "A Streamlined Approach to Drafting," School Shop, Vol. 1 (January, 1942), pp. 6-7.

UNPUBLISHED MATERIALS

Stevenson, Glenn L. "A Comparative Study on Two Ways of Presenting Geometrical Construction in an Elementary Mechanical Drawing Course," Unpublished Master's thesis, Kansas State Teachers College, Pittsburg, Kansas, 1945.

Hepler, Earl R. "Order of Presenting Orthographic Projection and Pictorial Representation and its Effect on Achievement in Engineering Drawing," Unpublished Doctoral dissertation, University of Missouri, Columbia, Missouri, 1957.

Norman, Ralph P. "An Experimental Investigation to Determine the Relative Effectiveness of Two Different Types of Teaching Methods in Engineering Drawing," Unpublished Doctoral dissertation, University of Minnesota, 1955.

Richards, Maurice F. "Effect of Emphasizing Time in the Teaching of Engineering Drawing," Unpublished Doctoral dissertation, University of Missouri, 1950.