ABSTRACT OF A THESIS

THE EVALUATION OF A METHOD

OF TEACHING NINTH GRADE GENERAL DRAFTING

Submitted by

Louis L. Josserand

In partial fulfillment of the requirements

for the Degree of Master of Arts

Colorado State College

of

Agriculture and Mechanic Arts

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ABSTRACT

The local situation

The high school in which the writer is a teacher is located in an industrial area where the industries recruit a large portion of their personnel from among the high school graduates who have received training in mechanical drawing. Upon investigating and talking with the factory executives, foremen, and former students who are now employees of these factories, the writer found that a study of current methods of teaching mechanical drawing was needed. The writer was employed in the Drafting Department of both of the major industrial plants in East Moline during the summers of 1936 and 1937 and learned from these experiences the further need for such a study. The superintendent of the high school is also interested in developing methods of teaching that are best adapted to the pupils' needs.

The problem

This thesis, therefore, is a report on the results of an experiment to measure the relative effectiveness of teaching ninth year general drawing through sketching, construction, and the use of simplified instruments. In working out the problem the follow-

ing questions were answered:

1. What are the aims and purposes of mechanical drawing?
2. What shall comprise the contents of the experimental course?
3. What criteria are needed to establish the equivalency of the two groups?
4. What methods and devices are needed to make evaluations?
5. What are the results?

Sources of data

The data needed for solving the proposed problem were obtained from three sources. The first was a review of the research studies relating to the proposed problem; the second source was from employers who hire students who have been trained in mechanical drawing and from employees of the industrial plants, many of whom are graduates and former students of the East Moline High School; and third, the pupils themselves.

Data from research were secured by a critical analysis of all the research studies available that would be of help to the writer in the solving of his problem. The data from 100 employers and 150 employees were obtained by means of personal interviews. Data from pupils were secured by experimentation.

Experimental method

In applying the two teaching procedures, the same course content was given to both groups. The classes were taught by the same teacher, in the same class room, and both met during the afternoon session; the experimental group was taught during the fourth period; and the control group, during the fifth period for the first and second semesters. As will be shown later, the classes were equivalent, and the only variable was the method of instruction--the effect of which was to be determined.

The control group continued its work using the regular drawing equipment, which included a set of drawing instruments, triangles, scale, drawing pencils, and ink. The experimental group was asked to purchase a five-cent rule, a ten-cent compass, drawing pencils, and ink. Each day the woodshop was available to the experimental group so that each member of the class could construct his necessary drafting models from wood or in a few cases from paper before an actual drawing of the model was begun. The instructor was at hand, if help or directions were needed.

The models were constructed actual size, using the measurements of the patterns as given in the textbook. A rule was used, and, in a few cases, the compass for securing accurate measurements and for laying-out all models. Both groups were required to complete 30 drawing plates and a cover sheet. One model at a time was completed and then sketched as the actual drawing. In constructing the first eight drawings, the experimental group was permitted to use a rule as a means of measurement for arranging the drawing on the paper, etc., until they became accustomed to this new method. The remaining 22 plates were then drawn entirely by free-hand sketching and eye-measurement. No instruments whatsoever were used.

Each group was given individual instruction whenever necessary. Related information of the same content was given both classes through lectures, demonstrations, and student reports, which occupied about one period a week. The students of the two classes progressed at their own rate of speed; members of the control group followed the traditional method, used their regular equipment, and drew the plates as given in the textbook, while the experimental group used simplified instruments, sketching, and its models which had been patterned from those printed in the textbook. Records were kept on a progressive-work chart which was posted in the drawing room and was available for the student to see at any time.

Frequent check-up tests were administered showing the essential difference of the method of pupil activity, but the grades were in no way used for testing the results of the experiment. The testing method is described later. At no time were the students of either class told the purpose of the two methods of teaching drawing.

Selection and equivalency of the two groups

Because of a fairly large class enrollment, the pupils were divided on a systematic basis. In determining the equivalency of the groups in a statistical way, the following criteria were used: intelligence quotients, chronological age, school average of the previous semester, previous drawing experience, and scores made on the MacQuarrie Mechanical Ability Test, which was administered to both groups at the beginning of the experiment. In checking up to see how nearly equal the groups were, it was found that there were 29 matched pairs available, and these were then divided into a control group of 29 pupils and an experimental group composed of the same number. The other 52 students were eliminated because of too great a variation in I.Q.'s, age, and mechanical ability scores. All students were electing the subject. In order to use matched pairs, it was necessary to conduct the experiment during the fall and spring semesters.

Comparison of the groups on the basis of various criteria of equivalency

A comparison of the two groups on the basis of various criteria of equivalency is shown in Table 1. From these records, it is evident that Group A and Group B are well-matched. Group A has a slightly higher I.Q. than B; Group B is slightly younger and has a slightly

TABLE 1.--COMPARISON OF THE TWO GROUPS ON THE BASIS OF VARIOUS CRITERIA OF EQUIVALENCY

CRITERIA OF EQUIVALENCY	EXPERIMENTAL GROUP (A)			CONTROL GROUP (B)			t difference
	Mean	SD	SEM	Mean	SD	SEM	
1. I.Q.'s (Otis)	107.93	3.27	1.56	106.68	7.84	1.48	.589
2. School grades	83.86	5.13	.96	83.51	4.92	.93	.260
3. Age (months)	176.58	12.03	2.27	176.20	10.71	2.02	1.247
4. Mechanical Ability (MacQuarrie)	65.00	10.89	2.05	62.58	11.41	2.15	.811

To determine whether the difference between the two groups might be ascribed to chance in the sampling the value of t was determined from the following formula:

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\sigma_{(\bar{X}_A)}^2 + \sigma_{(\bar{X}_B)}^2}}$$

In this study the criterion of significance is two.

lower mechanical average score, while the previous study records and previous drawing experience of the two groups are very nearly equal. According to the various criteria, however, the differences between the groups are not statistically significant.

The outcomes of the experiment

For the purpose of testing the two teaching techniques employed in the experiment, Fischer's Mechanical Drawing Tests, Parts One and Two, were used. In order to make the testing more reliable, it was decided to give the tests at the beginning and again at the end of the experiment. The scores made on the tests both times they were given were compared statistically, and graphs were made for the two groups.

A comparison of the results of these testings is shown in Table 2.

Comparison of achievement of groups with Fischer's test norms

A further comparison of scores at the end of the experiment was made with the standards that accompanied the test. As the groups participating in the experiment were selected and homogeneous and since the established norms for these tests are the results of heterogeneous groups, the writer felt a comparison was necessary. As the test norms were stated in terms of medians, the same terms will be used in this comparison.

TABLE 2.--THE OUTCOME OF THE EXPERIMENT

FISCHER'S M.D. TESTS PARTS I AND II AND TOTAL OF PARTS I AND II	FIRST TIME ADMINISTERED						
	EXPERIMENTAL (A)			CONTROL (B)			t difference
	Mean	SD	SEM	Mean	SD	SEM	
Part I	22.68	6.34	1.20	23.71	5.88	1.11	.295
Part II	11.86	4.94	.93	13.62	5.99	1.13	1.19
Parts I and II	34.55	10.01	1.89	37.06	11.16	2.11	.887

TABLE 2.--THE OUTCOME OF THE EXPERIMENT--Continued

FISCHER'S M.D. TESTS PARTS I AND II AND TOTAL OF PARTS I AND II	SECOND TIME ADMINISTERED						
	EXPERIMENTAL (A)			CONTROL (B)			t difference
	Mean	SD	SEM	Mean	SD	SEM	
Part I	43.44	8.27	1.56	34.42	8.03	1.51	3.89
Part II	37.93	7.66	1.44	29.48	6.99	1.32	4.30
Parts I and II	81.37	13.58	2.56	64.41	13.21	2.49	4.73

To determine whether the difference between the two groups was significant the value of t was determined from the following formula:

$$t = \frac{\overline{X}_A - \overline{X}_B}{\sqrt{\sigma_{(\overline{X}_A)}^2 + \sigma_{(\overline{X}_B)}^2}}$$

In this study the criterion of significance is two.

A comparison of the median score of Group A with the standard median score indicates a standard deviation of 13.58 and a standard error of 3.21 of the median. Two times the standard error (6.42) is not as large as the difference between the two medians (22), so Group A has an achievement which is significantly greater than that represented by the norm of the test.

Group B showed a standard deviation of 13.21 and a standard error of 3.13 of the median. Twice the standard error (6.26) is slightly larger than the difference between the two medians, which is four, so that the difference is not significant from a statistical standpoint.

Since Group A's median was significantly above the standard and Group B's not significant, it is evident that they should be sufficiently different in their achievement for their difference to be statistically significant. The difference between the two medians (18) is larger than twice the standard error of difference (7.15) and is therefore significant.

<u>Summary of findings and discussion</u>

The following statements indicate that the teaching procedure using sketching, construction, and simplified instruments was shown to be superior to the traditional method in the present study:

1. In achievement, as measured by Fischer's Mechanical Drawing Test, Group A was statistically superior in both Parts One and Two, so the total results were strongly in favor of Group A. The first time Fischer's tests were given to the groups, at the beginning of the experiment, Group B excelled on both Parts One and Two and on the combined scores; yet, in the final testing Group A far outranked Group B with a statistical difference of 4.733.

2. The achievement of Group A was significantly higher than the standard median of Fischer's tests, while Group B's median score was not significantly different.

3. In terms of time and accomplishment, Group A was superior to Group B. In the number of plates completed, Group A showed only a slightly higher number, but it must be taken into consideration that, in addition to the number of plates completed, Group A members were also required to construct the same number of models. This shows that Group A did nearly twice as much work as Group B. From the results of Fischer's tests, this was to be expected since the test itself is based on speed and accuracy, and since A was definitely superior to B in the final testing, they were superior in the time element likewise. Group A's median score was equivalent to 50,000 minutes of drawing time, while B's was equivalent to 7,000 minutes according to Fischer's time norms.

4. In comparing the cost of equipment used by each of the groups, it was found that Group A's equipment cost was $0.57, while that of Group B was $1.60. Thus, the cost was less than one-half when the simplified method was used.

5. This study indicates that, for the groups participating in the experiment, the traditional method of teaching drawing as employed in the East Moline High School is definitely inferior when achievement is measured by a particular standardized mechanical drawing test.

6. The results imply that mechanical drawing as taught by the use of simplified instruments, construction, and free-hand sketching is the superior method for the groups participating in this experiment from the standpoint of technical information, performance achievement, finances, and time.

Limitations of the study and problems for further research

The writer realizes that this study has its limitations as to time and number of cases. Ideally, the experiment should be carried on for a period of three years with the experimental and control groups containing at least 100 pupils each. Furthermore, the experiment should be tried by enough other teachers to determine whether the experimental method is generally superior for some teachers and inferior for others. It might be advisable also to determine first whether the locale that will influence results is variable or not.

THESIS

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Submitted by

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COLORADO STATE COLLEGE

OF

AGRICULTURE AND MECHANIC ARTS

July 18, 1940

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY

SUPERVISION BY Louis L. Josserand

ENTITLED THE EVALUATION OF A METHOD OF TEACHING NINTH GRADE GENERAL DRAFTING

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF Science

MAJORING IN Industrial Arts Education

CREDITS 3.5

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Chapter I

INTRODUCTION

General background of the study

In the high schools of Illinois, the beginning work in mechanical drawing consists of an independent half year unit open to all students from the ninth through the twelfth grade of high school. All colleges and universities that are members of the North Central Association accept this unit for college entrance. No previous training is required, but it is a prerequisite to all other mechanical drawing courses. The time allotment for the course is five clock hours per week for eighteen weeks or a total of five thousand four hundred minutes. Mechanical drawing courses in Illinois are governed by the state course of study which is shown in Chart 1. (See Appendix) This state course of study, however, allows each local community considerable freedom to adapt the instruction given in mechanical drawing to its needs.

The emphasis which the local community usually places on the different aspects of mechanical drawing is determined by the objectives which mechanical drawing authorities have found to be important and by local occupational conditions.

Mechanical drawing along with all other subjects of the high school curriculum must contribute its portion of the achievement of the total educational objectives of the secondary school. A list of these general objectives of mechanical drawing found in the Illinois Syllabus together with additional objectives obtained from further research sources are given in Chart 2. (See Appendix)

The high school in which the writer is a teacher is located in an industrial area where the industries recruit a large portion of their personnel from among the high school graduates who have received training in mechanical drawing.

The problem

Upon investigating and talking with the factory executives, foremen, and former students who are now employees of these factories, the writer found that a study of current methods of teaching mechanical drawing was needed. The writer was employed in the Drafting Department of both major industrial plants in East Moline during the summers of 1936 and 1937 and learned from these experiences the great need for such a study. The superintendent of the high school also is interested in developing methods of teaching that are best adapted to the pupils' needs. This thesis, therefore, is a report on the results of an experiment to measure the relative effectiveness of teaching ninth year general drawing through sketching, construction, and the use of simplified instruments.

Two approximately equated groups participated in the experiment. These groups comprised twenty-nine pupils each and were selected from classes in the United Township High School, East Moline, Illinois.

Local situation

East Moline, a city of 12,000 inhabitants, is located on the Mississippi River, and is the smallest of a group of four known as the "Quad Cities" which includes Davenport, Iowa; Rock Island, Moline, and East Moline, Illinois. The combined population of this area is about 150,000. These four cities constitute one of the greatest industrial centers of the United States. East Moline, itself, is the home of the John Deere Harvester Company and the International Harvester Company factories, two of the largest manufacturers of farm implements and machinery in the world. These immense plants ship their products to many nations; South America, Australia, and Russia being their largest markets. At the peak of the production season these two factories together employ more than 6,000 men and women. In addition to these major plants, the Troy Laundry Company and the Buddy L. Toy Manufacturing Company are also located in East Moline, both of which employ large numbers of men and women.

Naturally the population of East Moline has steadily increased, with census reports showing that it has doubled in the last fifteen years. Increasing population has meant an ever growing student body in the high school. When the writer began teaching in East Moline in the fall of 1930 the student body numbered 500; while this year's enrollment was 890.

As the factories and population continue to increase there is also a steadily growing interest among the manufacturers themselves toward the school shops. This has resulted in the organization of the Tri-City Manufacturers' Association of Rock Island, Moline, and East Moline, Illinois. This organization is very active and cooperates with the shop departments of the high schools. In addition to sponsoring apprenticeship training the Association sends representatives to the classroom to lecture on shop topics such as Care of Machines, Tools, Safety, and the like. Each year the students of the Industrial Arts classes have an opportunity to make several " field trips" to observe operations in each of the factories in the Tri-Cities. Explanations and all necessary information regarding the work being done are given to the boys by a guide who accompanies them on the shop tour.

Mr. J. Morgan Johnson, Vocational Director of the Association, has charge of all the apprentice-training in the Tri-Cities. It is his duty to visit shop classes and confer with instructors concerning apprentice prospects. Boys who have done good work in school classes and who show an interest in shop work are placed in the various Drafting and Metal Departments of either John Deere Harvester Company or the International Harvester Company as apprentices. A large percentage of boys is placed in this way. Factory executives tell us that they prefer these boys to those having no shop training in high school, and in very few instances is there a failure among boys who come to them to serve apprenticeships. In several instances boys of the writer's own classes have advanced in a few years' time to positions of department foremen.

The steadily growing interest of the factory executives who look to the school for their future workers and the splendid cooperation of the Manufacturers' Association are resulting in a closer relationship of the school shop and the factory. Thus, these factors have influenced the writer to make a study to measure the relative effectiveness of teaching ninth year general drawing through sketching, construction, and the use of simplified instruments as compared with the traditional method of teaching drawing to determine which one is most desirable for the students. The method that proves to be superior will be the one used in the mechanical drawing department of the East Moline United Township

High School.

Problem analysis

In making an analysis of the steps necessary to carry this experiment forward several major questions arose. There were five:

1. What are the aims and purposes of mechanical drawing?
2. What shall comprise the content of the experimental course?
3. What criteria are needed to establish the equivalency of the two groups?
4. What methods and devices are needed to make evaluations?
5. What are the results?

Mechanical drawing is recognized by many persons as the universal language of Industry and has been the subject of considerable research. Therefore, the writer has carefully reviewed all such research reports to find if any of the foregoing questions have been answered.

Chapter II

REVIEW OF RESEARCH LITERATURE

In reviewing this research literature the writer found only partial answers to questions 1, 2, 3, and 4, but question five was completely unanswered.

The research that bears on question one, "What are the aims and purposes of mechanical drawing?" follows.

Van Deventer made a study in 1933 of mechanical drawing courses in Illinois high schools (19). Through a questionnaire sent to 142 high schools located in all sections of the state the following aspects of mechanical drawing were covered: objectives, organization of courses, content of courses, methods of conducting class work, equipment, teacher training, salaries, and experience.

His study lists these main objectives of mechanical drawing: (1) general education, (2) skill in the manipulative processes, (3) reading and executing working drawings, (4) principles of drawing, (5) vocational preparation, (6) guidance, and (7) aid to other subjects. A further classification of these objectives was made by grouping them under two main headings which were designated as <u>general education</u> and <u>vocational preparation</u>. The replies of the mechanical drawing teachers cooperating in this study consistently recognized these two broad objectives, and they considered the broad general values of the subject equivalent to the specific vocational value.

A survey of the teachings of mechanical drawing in the state of Wisconsin was carried on in 1934 by a committee of the Wisconsin Industrial Arts Association and reported by Waffle (20). It was made for the purpose of determining the content of courses, types of courses taught, objectives, and allocation of school time for this work. The majority of schools participating in the experiment indicated General Education as the objective sought.

An investigation was made in the state of Illinois in 1934 by a selected committee of the Industrial Arts Section of the High School Conference (13:7) for the purpose of selecting a course of study for the high schools of that state.

This study revealed that (a) the aim of education, if summed up might be that of making each individual "socially efficient", or that he must be effective in his economic, domestic, and civil life, and be able to make a wholesome and enjoyable use of his leisure time; (b) mechanical drawing contributes to each phase of this general aim, but most effectively in the economic one which involves preparation for a vocation; (c) the vocation, however, should not be interpreted in the narrow sense of draftsmanship, but rather in the broader sense of preparation for any of the fields of endeavor wherein a knowledge of drafting is of practical utility; (d) to this end knowledge of the fundamental rules and principles of drawing, skill in its techniques, and speed in execution are the most immediate aims.

Since the aims and purposes of mechanical drawing as stated in Van Deventer's study, the Wisconsin Survey, and the Illinois Syllabus were derived from research, they were used as a basis in preparing the content of the course of study used in this experiment. (See Chart 2 in Appendix)

The following research bears on the second major question, "What shall comprise the contents of the course?"

A study was made by Hale (11) in 1932 "to determine, if possible, what should constitute the content of a mechanical drawing course designed to teach pupils how to read, understand, and make the drawings which they were most likely to meet or need in every-day life." He reviewed 102 newspapers, 60 magazines, 126 mailed advertisements, and 158 school library books to discover how frequently drawings occurred in them. He also tabulated the space taken by the drawings. Any type of graphic representations which were produced in a drafting room were considered as a drawing.

It was concluded that some form of drawing was needed in nearly every walk of life, and as a daily experience the majority of people need a knowledge of reading and understanding drawing. The kinds of drawing found to be important were: pictorial drawings, freehand sketches, outdoor drawings, mottoes and emblems, lettering, drawing without dimensions, graphs, interiors, floor plans, sections, silhouettes, diagrams and charts, dimensioned drawings, line maps, drafting conventions, and elevation.

This study shows a race between free-hand sketches and pictorial drawings, both of which probably receive a small amount of attention in the average mechanical-drawing course. Pictorial drawings with a frequency of 4,662, won by a close margin over the 4,602 free-hand sketches found in the literature that was scrutinized.

An investigation was made by Walsh in 1928 of the uses of mechanical drawing in every-day home life (21:14). Through a questionnaire sent to parents he learned whether they performed daily, frequently, seldom, or never certain activities at home involving the use of mechanical drawing or a knowledge of it.

His study revealed that (a) laymen made general use of mechanical drawing and the knowledge that it involves; (b) there seems to be a growing tendency toward more free-hand drawing or technical sketching; (c)

Pictorial drawing is not used much, but the tendency is more toward dimensioned perspective drawings or sketches which show a twenty per cent usage; (d) mechanical drawing should be considered in the scheme of general education.

These findings reveal the need of several types of drawings, such as free-hand sketching that could well be placed in a course in mechanical drawing,

An investigation was made by Cleveland (5:74) in 1938 of the uses made of different kinds of graphic representation by the citizens of Downers Grove, Illinois for the purpose of establishing a non-vocational course in the high school dealing with graphic representations. Through a questionnaire sent to parents and alumni of Downers Grove, and through personal interviews with the teachers he learned how frequently the individual had occasion to read or make different types of drawing.

His study revealed that (a) parents who had not studied drawing use it less in their everyday life than those who have studied it; (b) a greater use was manifested for certain types of drawing than for making them; (c) 21 types of drawing were used daily or frequently by 25 per cent or more of two out of the three groups, parents, alumni, and teachers; (d) on the basis of this usage the following types of drawing should be included in the proposed course: (The ten most frequently used types are listed below).

1. Making mechanical picture drawings
2. Making free-hand picture sketches
3. Making free-hand picture drawings in which dimensions are included
4. Reading free-hand picture sketches in which dimensions are included
5. Making free-hand orthographic sketches
6. Reading free-hand orthographic sketches
7. Making mechanical orthographic sketches
8. Reading mechanical orthographic sketches
9. Using drawing for the purpose of assembling
10. Making sectional views

These findings show the need of giving the pupil training in reading and making the different kinds of graphic representation which the average citizen uses today.

Five copies of newspapers and 15 copies of magazines were studied by Hankhammer (12) in 1930 to determine the amounts and kinds of drawing they contained. He found that 28.5 per cent of the newspaper and magazine space was given to drawing. From this study he concluded: (a) that drawing instruction should be diversified as to types of drawing and that instruction should not be based on abstract exercises; (b) that the data seemed to justify the establishment of two types of courses in drawing, namely; basic interpretative instruction for the rank and file of pupils and specialized courses with a vocational aspect; (d) that all pupils have a need for the minimum understanding of graphic representation.

The writer finds, after reviewing these studies, that recent trends are toward free-hand sketching and its varied application. This is evidence that a change is needed in our present mechanical drawing courses. Some of the newer textbooks (16:44, 22:42) in mechanical drawing have included units which the writer considers to be of more value to the average citizen than some of the units in old, traditional courses. Some of these units deal with free-hand sketching and its varied application. All of this is further evidence of the need for the proposed study.

The content of the course of study used in this experiment was based on the Illinois State Course of Study from the Illinois Syllabus, but as previously stated in the Introduction, the state allows each local community considerable freedom to adapt the instruction given in mechanical drawing to its needs. The writer wished to modify the proposed state course somewhat, so the Wisconsin Course for Mechanical Drawing was analyzed; and since the two proved to be very similar in content, a combination of both was made in constructing the course of study for this experiment.

The following research bears on a part of question three, "What criteria are needed to establish the equivalency of the two groups?"

A study was made by Krueger (14) in 1936 to determine the significance of group influence upon the Otis S.-A. test scores.

The findings show that when the individual and the group test both followed the initial tests, the average for the individual tests was slightly higher. This difference of .42 was also of little significance, since the reliability of the difference between the two means was only 1.05. The results justified the conclusion that the presence of the group had little influence upon the Otis S.-A. tests. Thus, persons taking the tests separately from the group would get about the same test scores as though they had been with the group.

These conclusions are valuable to the writer in that the Otis S.-A. Tests (Higher Examination) were administered to both groups participating in the experiment at the beginning of the school year and were given to the entire group at one time. A copy of the test is found in the Appendix.

MacQuarrie (15) aimed to prepare a test which would not measure intelligence and found only negligibly low correlations (not exceeding .20) between his test scores and performance in intelligence tests . Others have since found somewhat higher correlations with intelligence. Pond (18), for example, has obtained for 83 of the Scovill toolmaker apprentices their scores in the Otis Higher Examination and in several other verbal and non-verbal tests. It was found that the MacQuarrie test correlates .291 with years of schooling, .293 with the Scovill Apprentice Scale, .336 with the O'Connor

Wiggly Block, and .381 with the Otis Higher Examination.

A study was made in 1933 by Babcock and Emerson (4) of the MacQuarrie test for Mechanical Ability in order to determine; (a) the relationship between the total scores of the MacQuarrie test and a measure of intelligence at various chronological age levels; (b) the extent of relationship between the seven sub-tests of the MacQuarrie test and their specific relations to the levels of intelligence at those chronological ages.

The results show that from a group of 400 subjects selected from the New York Public Schools that the distribution of mental ages, as determined by vocabulary, very closely approximated the normal curve. The correlation between MacQuarrie test total score and the level of intelligence became greater with increase in life age between fourteen and twenty year groups. Likewise the correlation between each of the seven sub-tests and level of intelligence became greater with increases in life age between the fourteen and twenty-one year groups.

In an article Bingham (3) reports a study made by Pond of 124 apprentice toolmakers from 16 to 22 years of age to determine the relationship of a person's true score and his obtained score.

This study revealed that the standard error of measurement of a person's total score is not more than one-third of a unit on the standard scale--about five points. In other words, in 68 per cent of the cases a person's true score will vary from his obtained score by not more than plus or minus five points. The sub-tests are a little less reliable, and a person's score may have a standard error of measurement of as much as half a unit on the standard scale.

The above findings are of value to the writer inasmuch as they help to validate his experiment, since the MacQuarrie test for Mechanical Ability was administered to both groups participating in the experiment as one means of equating them. A copy of the test will be found in the Appendix.

The research bearing on question four, "What methods and devices are needed to make evaluations?" is as follows:

A study was made by Fischer (7) in 1930 to obtain a reliable and scientific basis for the choice of problems used in his mechanical drawing tests and to place the tests upon a secure educational foundation. Through a questionnaire sent to over 100 schools representing the various sections of the United States, he secured data relating to courses of study, textbooks used, blue print and mimeographed instructional material employed, as well as to the number of weeks a half year of drawing embodied, the number of periods the class met a week, and the number of minutes in a drawing period. The author determined the amount of space devoted to a particular drawing unit in each textbook mentioned by a careful tabulation of the pages. Using a similar method with the other instructional material, he was able to determine the relative percentage of space given to each instructional unit. He found from his examination that there was a close agreement in regard to the importance of certain major units. Using these as a basis, he selected a series of 130 trial problems which he believed would examine a student's mastery of mechanical drawing. Before making the final choice of problems, the author gave a series of preliminary tests. By a careful tryout and by the grading and tabulation of over 5,000 completed tests covering a period of three years, the present series of Fischer's tests (8) was formulated.

The above findings are of interest to the writer, because Fischer's Mechanical Drawing Tests, Part I and Part II were used twice in the experiment; once at the beginning of the semester and again at the end to test the achievement of the two groups at the conclusion of the experiment. He further believes that this type of test provides a thorough analysis of the student's ability in mechanical drawing, because it covers all types of typical problems arranged in their order of difficulty and based upon the fundamental principles which typify the skills and abilities to be derived from a study of mechanical drawing.

With these criteria, the writer was able, by means of comparison and elimination, to use matched pairs in his experiment.

In an experimental study made by Gates and Taylor (9) in 1926 on the nature of improvement resulting from practice in a motor function, they considered their groups equivalent, because the mean spread of tapping, chronological age, mental age, I.Q., and scores on a number of motor tests were approximately the same.

In an analysis of techniques used in securing equivalent groups, Engelhart (6) in 1930 found it desirable to pair off students so that for each pupil in the experimental group there will be a mate in the control group who has the same mental age or intelligence test score. The fact that each individual member of an experimental group has his mate in a control group makes it possible to claim a greater degree of equivalence so far as the groups are concerned than otherwise would be possible.

Another experiment on lecture demonstration versus the individual laboratory method conducted by Anibel (1) shows that the groups were selected by pairing students whose scores were approximately equal on both Army Alpha Intelligence Tests and on the Otis Group Intelligence Scale. In making this selection, some pupils were shifted from one group to the other until the mean of the Army Alpha scores of the experimental group was very nearly equal to the mean of the Army Alpha scores of the control group and until the mean of the Otis scores of the experimental group was very nearly equal to the mean of the Otis scores of the control group.

The computations and statistical tabulations and comparisons found in this study are based on the methods used by Arkin and Colton (2:36, 122, 129). Some statistical aids were also secured from Greene (10:57) and from Newkirk and Greene (17: 10, 28). However, the writer wishes to point out that while some benefits were derived from the latter two sources, it was Arkin and Colton's book that was indispensable to him in solving the problems of this study.

The findings of the various studies included in the review of literature have proven to be an aid in and a basis for conducting the experiment which is described in the following chapters.

Chapter III

MATERIALS AND METHODS

The data needed for solving the problem were obtained from three sources. The first was a review of the research studies relating to the proposed problem; the second source was employers who hire students who have been trained in mechanical drawing and employees of the industrial plants, many of whom are graduates and former drawing students of the East Moline High School; and the third was the student group itself.

In preparing the content of the course of study for the experiment,the following researches were used: (a) Van Deventer's survey of mechanical drawing courses in Illinois high schools in which the objectives, aims and purposes, organization of courses, content, methods, and equipment were revealed; (b) The Wisconsin Industrial Arts Association Survey for the purpose of determining the content of courses, types of courses, aims and objectives; (c) The investigation made in the State of Illinois in which courses of study, current textbooks, social and economic situation of high school students were analyzed in order to select a course of study for the high schools of that state; (d) Hale's study to determine the content of a mechanical drawing course designed to teach pupils how to read, understand, and make the drawings which they were most likely to meet with or need in everyday life; (e) Walsh's investigation of the uses of mechanical drawing in everyday home life; (f) Cleveland's analysis of the uses of the different kinds of graphic representation used by the citizens of Downer's Grove; and (g) Hankhammer's study of current newspapers and periodicals to determine the amount and kinds of drawings they contained.

These resources were used when equating and comparing the two groups participating in the experiment: (1) Kruger's study to determine the significance of group influence upon the Otis S.-A. test scores; (b) Babcock and Emerson's study of the MacQuarrie test for Mechanical Ability in order to determine the relationship between the total scores of the test and a measure of intelligence at various age levels, and also to determine the relationship between the seven sub-tests of the MacQuarrie test and their specific relations to the levels of intelligence at those chronological ages; (c) Bingham's report of Pond's study to determine the relationship of a person's true score and his obtained score; (d) Fischer's study of his own mechanical drawing tests in order to obtain a reliable and scientific basis for the choice of problems used in them and to place the tests upon a secure educational foundation; (e) Gates' and Taylor's techniques for equating groups which they used in their experiment on the nature of improvement resulting from practice in motor functions; (f) Englehart's analysis of techniques used in securing equivalent groups; (g) Anibel's methods of pairing used in the study made on the lecture demonstration versus individual laboratory method.

As all of the above is research in which large samplings were taken, the authenticity of it is assumed.

Since East Moline is located in an industrial area, and as the industries recruit a large portion of their personnel from the high school graduates who have had training in mechanical drawing, the second source of data was obtained from the employers and employees of these local industrial plants to determine which method of teaching drawing is the most practical to the student in everyday life. The validity of this source was established by securing a wide sampling of cases, or approximately 100 per cent in three different departments; namely, the Executive, Drafting, and Layout.

METHODS

A critical analysis of the data listed was made in order to obtain all that would be of help to the writer in the solving of his problem, and as the researches on the foregoing pages are all that are available, it is felt that the sample is adequate.

Data from the employers were obtained through personal interviews with 100 factory executives, foremen, and members of the Tri-City Manufacturers' Association while the writer himself was employed in the two major plants during the summers of 1936 and 1937. It was felt that these men would be familiar with the needs of shop training, as they come in contact with thousands of workers each year. The writer also talked in detail about the present mechanical drawing course and its application to everyday uses with 150 employees of the Drafting and Layout departments in which he himself worked. Since a large sampling for the above data was made, it is considered adequate.

Methods

In applying the two teaching procedures, the same course content was given to both groups. The classes were taught by the same teacher, in the same classroom, and both met during the afternoon session; the experimental group, the fourth period, and the control, the fifth period during the first and second semesters. The classes being equivalent, the only variable then was the method of instruction--the effect of which was to be determined.

The control group continued its work using the regular drawing equipment, which included a set of drawing instruments, triangles, scale, drawing pencils and ink. The experimental group was asked to purchase a five-cent ruler, a ten-cent compass, drawing pencils and ink. Each day the woodshop was available to the experimental group so that each member of the class could construct his necessary drafting models from wood or in a few cases, from paper before an actual drawing of the model was begun. The instructor was at hand, if help or instructions were needed. The models were constructed actual size, using the measurements of the patterns as given in the textbook. A rule, and, in a few cases, the compass were used for securing accurate measurements and for laying-out all models. Both groups were required to complete 30 drawing plates and a cover sheet. One model at a time was completed and then sketched as the actual drawing. In constructing the first eight drawings,the experimental group was permitted to use a rule as a means of measurement for arranging the drawing on paper, etc.,until they became accustomed to this new method. The remaining 22 plates were then drawn entirely by free-hand sketching and eye-measurement. No instruments whatsoever were used.

Each group was given individual instruction whenever necessary. Related information of the same content was given to both classes through lectures, demonstrations, and student reports which occupied about one period a week. The students of the two classes progressed at their own rate of speed; members of the control group following the traditional method using their regular equipment and drawing the plates as given in the textbook; while the experimental group used simplified instruments, sketching, and their models which had been patterned from those printed in the textbook. Records were kept on a progressive-work chart which was posted in the drawing room and was available for the student to see at any time.

Frequent check-up tests were administered showing the essential difference of the method of pupil activity, but the grades were in no way used for testing the results of the experiment. At no time were the students of either class told the purpose of the two methods of teaching the drawing course.

Selection and equivalency of the two groups

There were 110 mechanical drawing pupils available for the experiment. Because of the fairly large class enrollment, the pupils were divided on a systematic basis. In determining the equivalency of the groups in a statistical way, the following criteria were used: intelligence quotients, chronological age, school average, previous drawing experience, and scores made on the MacQuarrie Test for Mechanical Ability, which was administered to both groups at the beginning of the experiment. In checking to see how nearly equal the groups were, it was found that there were 29 matched pairs from the 110 pupils.

They were then systematically divided into a control group of 29 pupils and an experimental group composed of the same number. The other 52 students were eliminated because of too great a variation in age, I.Q.'s, and mechanical ability scores. As previously stated, this course consists of an independent half year unit open to all students from the ninth through the twelfth grade of high school, so all pupils were electing the subject. The experimental group consisted of 24 freshmen, 2 sophomores, 1 junior, and 2 seniors; while the control group was made up of 25 freshmen, 1 sophomore, 1 junior, and 2 seniors. (See Chart No. 3 in Appendix) The experiment was conducted during both semesters in order to use matched pairs.

The remainder of this chapter will compare the two groups as to intelligence quotients, average school grades of the previous semester, age, previous drawing experience, and MacQuarrie's test scores.

Comparison of the groups on the basis of intelligence quotients

The Otis S.-A. Test of Mental Ability (Higher Examination) is given in East Moline, Illinois to the members of the freshman class, and the scores are placed upon the student's permanent record cards. The I.Q.'s from these record cards have been used in the present study. (A copy of the test may be seen in the Appendix)

As shown by Table 1, the mean of Group A was

107.93, with a standard deviation of 8.27 and a standard error of 1.56 of mean; while Group B had a mean of 106.68, a standard deviation of 7.84 and a standard error of 1.48 of mean. In this case both groups are above normal where a mean of 100 for this test would be considered normal for a large school group. However, since the groups are made up of selected matched pairs this is to be expected, although Group A shows a slightly higher mean than Group B.

To determine whether the difference between the two groups is significant or whether it might be ascribed to chance in the sampling, the value of t was determined from the following general formula:

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{(\sigma_{\bar{X}_A})^2 + (\sigma_{\bar{X}_B})^2}}$$

The calculated value of t is .5896 which indicates that the difference is not significant and may be attributed to chance. In order to be significant the calculated value must exceed two in this study.

Figure 1 is a graphic comparison of the two groups on a basis of magnitude of the I.Q.

Comparison of the groups on the basis of school grades

A comparison of the school grades of the previous semester before the experiment was conducted was made by

TABLE 1.--COMPARISON OF GROUPS A AND B ON THE BASIS OF INTELLIGENCE QUOTIENTS

STUDENT	GROUP	
	A (I.Q)	B (I.Q.)
1	127	120
2	123	119
3	122	115
4	121	115
5	115	115
6	114	114
7	114	113
8	112	112
9	112	111
10	110	111
11	110	109
12	110	109
13	108	109
14	108	108
15	106	108
16	106	108
17	106	107
18	106	106
19	105	106
20	104	105
21	103	103
22	102	101
23	101	101
24	101	100
25	101	97
26	98	97
27	97	95
28	95	90
29	93	90

A (Experimental)

$\bar{X} = 107.93$
$\sigma = 8.274$
$\sigma_{\bar{X}} = 1.564$

B (Control)

$\bar{X} = 106.68$
$\sigma = 7.843$
$\sigma_{\bar{X}} = 1.482$

Calculations to show whether the difference between the two groups is significant.

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\sigma_{(\bar{X}_A)}^2 + \sigma_{(\bar{X}_B)}^2}}$$

$$= \frac{107.93 - 106.68}{\sqrt{(1.564)^2 + (1.482)^2}}$$

$$= .58960$$

(Not significant)

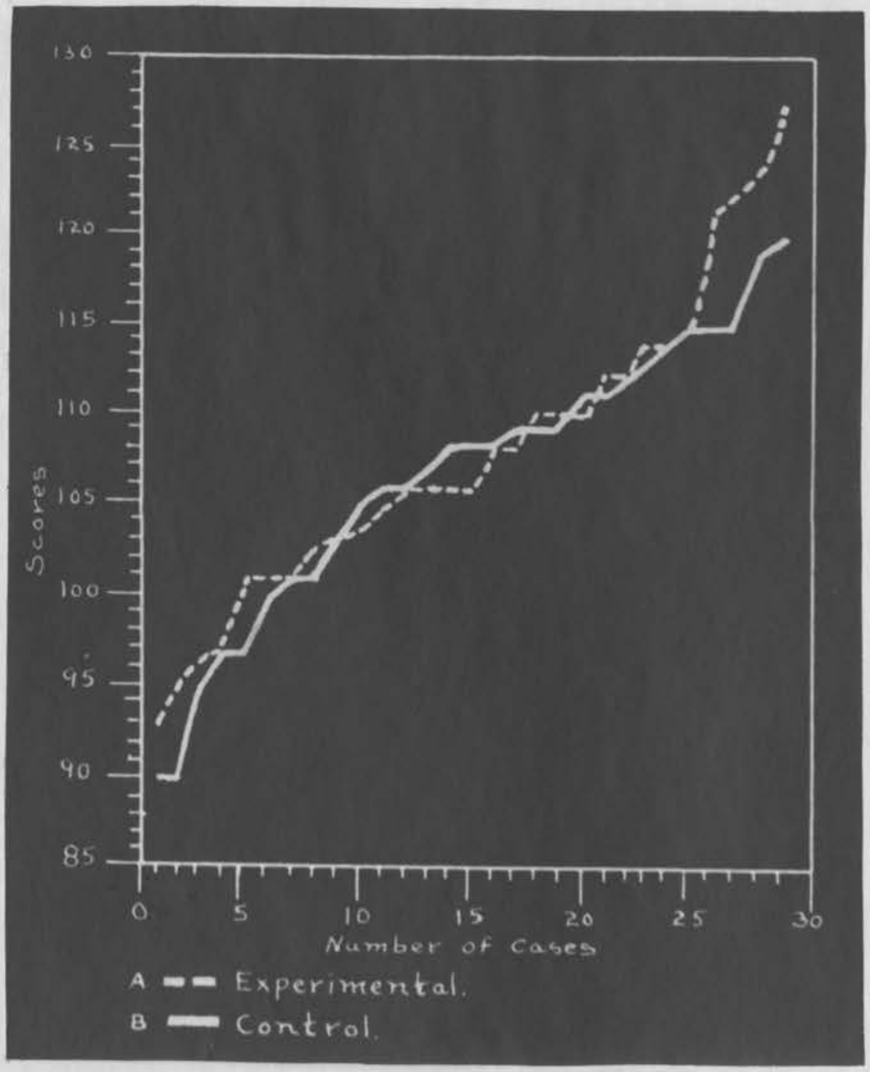

Figure 1.--Graphic comparison of the two groups on a basis of magnitude of the I.Q.

securing the records from the school office for each student. The averages of the grades made by each student are used in the following discussion.

Table 2 shows that the mean of the grades of the 29 pupils of Group A was 83.86, with a standard deviation of 5.13 and a standard error of .969 of mean. Group B had a mean of 83.51, a standard deviation of 4.929, and a standard error of .931 of mean. The slight difference between the records is due to the fact that matched pairs were used, but in order to determine whether it might be significant, the value of _t_ was determined. Since its value was only .2604, the difference between the two groups is without statistical significance and may be attributed to chance.

Figure 2 graphically compares the two groups on a basis of the previous study record. The relatively close similarity of the groups' previous study records can be readily seen from this graph.

Comparison of the groups on the basis of age

The age of each student was secured from the permanent record card in the school office and was recorded in months only for this experiment.

Table 3 shows that the mean age of Group A was 176.58 months, the standard deviation was 12.03 and the standard error 2.27 of mean; while Group B had a mean age of 176.20 months, a standard deviation of 10.71 and

TABLE 2--COMPARISON OF GROUPS A AND B ON THE BASIS OF SCHOOL GRADES OF PREVIOUS SEMESTER

STUDENT	GROUP	
	A (average)	B (average)
1	94	95
2	93	90
3	90	90
4	89	88
5	89	88
6	88	87
7	88	87
8	87	86
9	87	86
10	87	86
11	86	85
12	86	85
13	85	85
14	84	85
15	84	84
16	84	84
17	83	84
18	83	84
19	82	83
20	82	81
21	82	80
22	81	80
23	80	80
24	80	80
25	77	78
26	77	76
27	76	75
28	75	75
29	73	75

Calculations to show whether the difference between the two groups is significant.

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{(\sigma_{\bar{X}_A})^2 + (\sigma_{\bar{X}_B})^2}}$$

$$= \frac{83.86 - 83.51}{\sqrt{(.9699)^2 + (.9317)^2}}$$

$$= .2604$$

(Not significant)

A (Experimental)

$\bar{X} = 83.86$
$\sigma = 5.13$
$\sigma_{\bar{X}} = .9699$

B (Control)

$\bar{X} = 83.51$
$\sigma = 4.92$
$\sigma_{\bar{X}} = .9317$

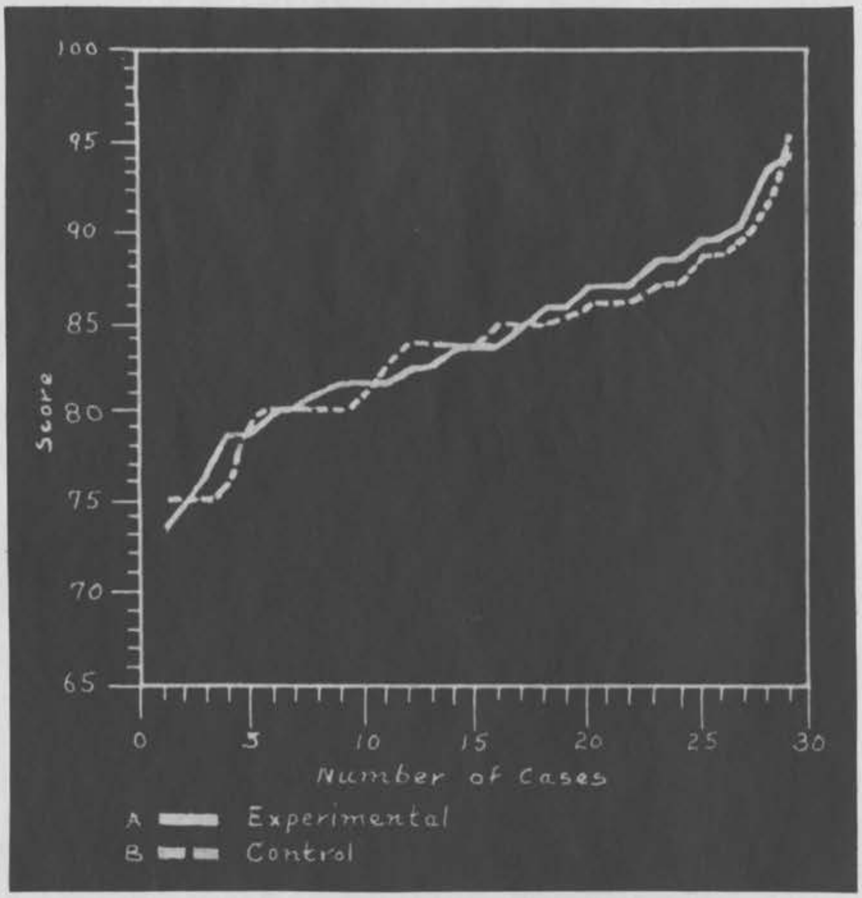

Figure 2.--Graphic comparison of the two groups on a basis of the previous study record.

a standard error of 2.02.

To determine whether the very slight younger age of Group B could be accounted for by chance in the sampling t was calculated. Its value of.1247 indicates that the difference was not statistically significant.

The ages of the two groups are represented graphically in Figure 3 which shows that Group B is composed of a few younger students while Group A has a few older than any in Group B.

Comparison of the groups on the basis of previous drawing experience

As the students participating in this experiment not only came from the East Moline Grade Schools, but also from many outlying districts it was decided to check on the previous drawing experience of each as one means of equating the groups. In Group A there were 15 students who had had some previous drawing and 14 had had none whatsoever, while in Group B there were 16 with drawing experience and 13 without. (See Chart in Appendix)

Comparison of the groups on the basis of mechanical ability

The MacQuarrie Test for Mechanical Ability was given to the students of each group the first week of the semester. As shown by Table 4 Group A had a mean of 65.00 with a standard deviation of 10.89, and a standard error of 2.05 of mean; while Group B had a mean of 62.58 with a standard deviation of 11.41, and a standard error

TABLE 3.--COMPARISON OF GROUPS A AND B ON BASIS OF AGE IN MONTHS

STUDENT	GROUP	
	A	B
1	211	204
2	202	199
3	199	195
4	197	193
5	192	192
6	183	181
7	182	180
8	180	180
9	177	179
10	175	179
11	174	175
12	174	174
13	173	173
14	173	173
15	172	173
16	172	172
17	171	172
18	170	172
19	170	171
20	169	171
21	169	170
22	169	170
23	169	170
24	168	168
25	167	168
26	166	167
27	166	165
28	166	164
29	165	160

A (Experimental) B (Control)

$\bar{X} = 176.58$ $\bar{X} = 176.20$

$\sigma = 12.035$ $\sigma = 10.717$

$\sigma_{\bar{X}} = 2.275$ $\sigma_{\bar{X}} = 2.025$

Calculations to show whether the difference between the two groups is significant.

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{(\sigma_{\bar{X}_A})^2 + (\sigma_{\bar{X}_B})^2}}$$

$$= \frac{176.58 - 176.20}{\sqrt{(2.275)^2 + (2.0258)^2}}$$

$$= .12474$$

(Not significant)

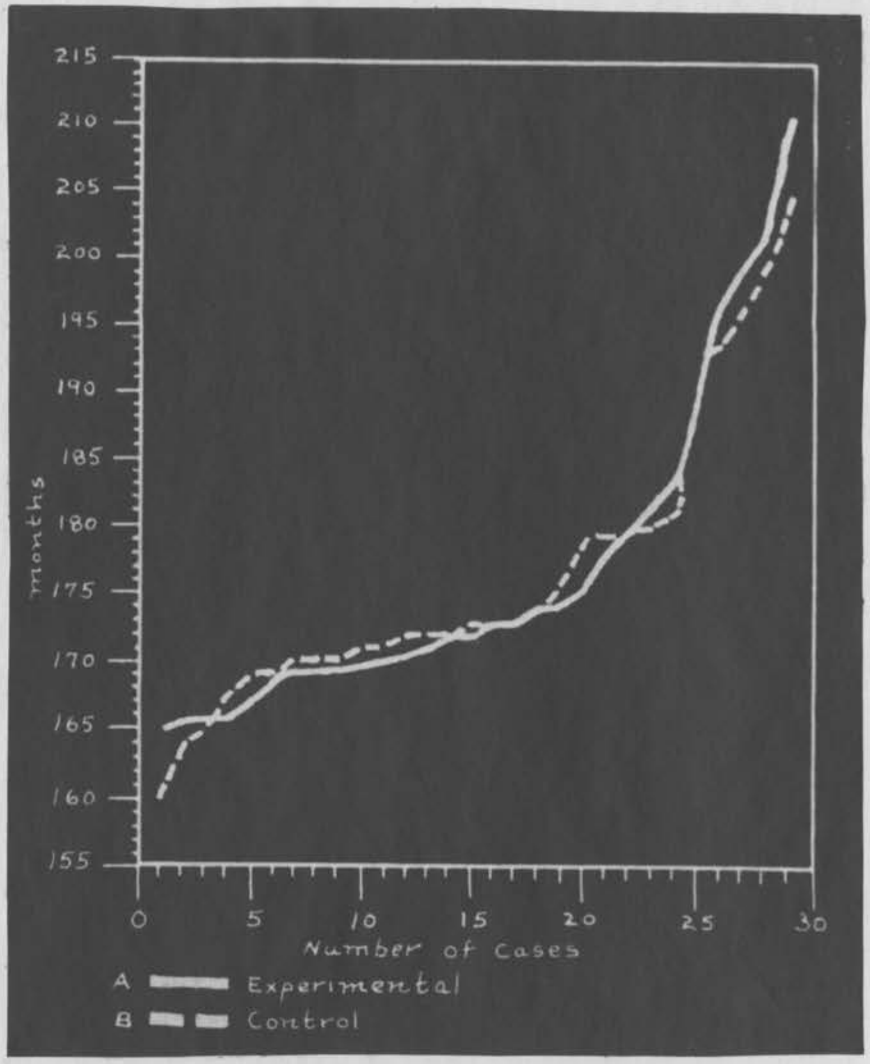

Figure 3.--Graphic comparison of the two groups on a basis of the ages in months.

of 2.15. Although Group A excelled in this test, when t was calculated the difference was not significant, being only .8118.

Figure 4 is a graphic comparison of the two groups on a basis of increasing magnitude of the mechanical ability criterion and shows the similarity of the two in mechanical ability.

Discussion of results found in equating the groups.

From the records of equating, it is evident that Groups A and B are well-matched. It has been seen that Group A has a slightly higher I.Q. than B; while Group B on the average is slightly younger. The previous study records and previous drawing experience of the two groups are about equal. Group B has a slightly lower mechanical ability average than is the case with A. According to the various criteria, however, the difference between the groups is not statistically significant in any case.

The outcomes of the experiment

For the purpose of testing the two teaching techniques employed in the experiment, Fischer's Mechanical Drawing Tests (8) already mentioned were used. In order to make the testing more reliable, it was decided to give the Fischer's test, Parts One and Two at the beginning of the experiment and again at the end

TABLE 4.--COMPARISON OF GROUPS A AND B ON THE BASIS OF MECHANICAL ABILITY

STUDENT	GROUP	
	A	B
1	89	89
2	82	86
3	80	78
4	78	77
5	77	72
6	73	71
7	73	71
8	72	68
9	71	67
10	70	67
11	69	65
12	68	65
13	67	64
14	67	64
15	67	64
16	66	61
17	65	61
18	64	59
19	63	58
20	58	58
21	58	55
22	57	55
23	53	54
24	52	54
25	52	52
26	51	52
27	51	45
28	46	43
29	46	40

A (Experimental)

$\bar{X} = 65.00$
$\sigma = 10.89$
$\sigma_{\bar{X}} = 2.059$

B (Control)

$\bar{X} = 62.58$
$\sigma = 11.41$
$\sigma_{\bar{X}} = 2.156$

Calculations to show whether the difference between the two groups is significant.

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{(\sigma_{\bar{X}_A})^2 + (\sigma_{\bar{X}_B})^2}}$$

$$= \frac{65.00 - 62.58}{\sqrt{(2.059)^2 + (2.156)^2}}$$

$= .8118$
(Not significant)

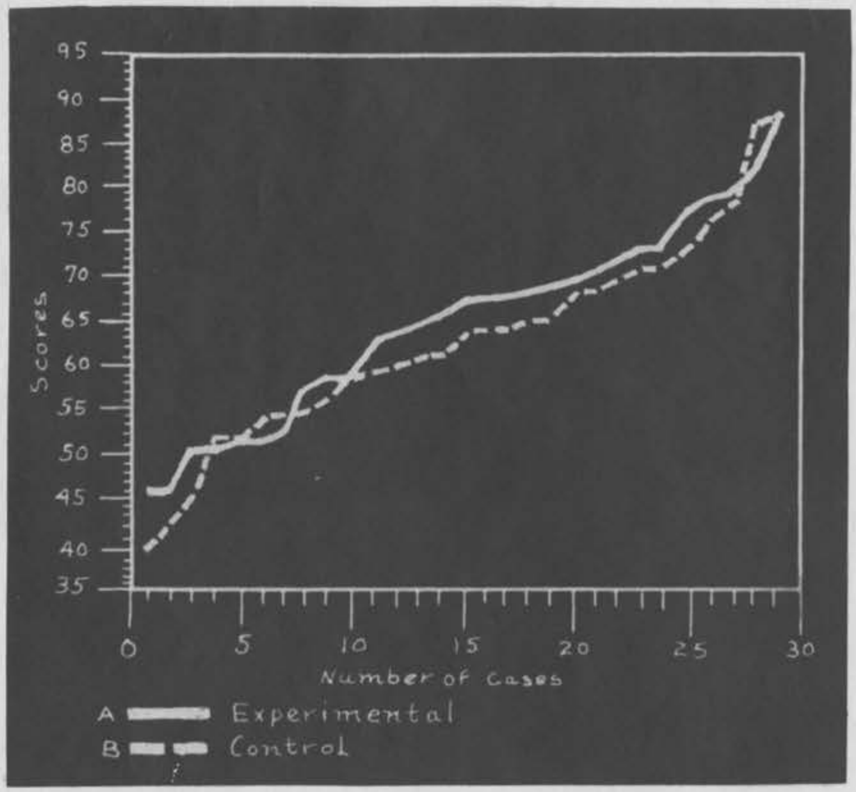

Figure 4.--Graphic comparison of the two groups on a basis of the mechanical ability.

to both groups, and then make comparisons. Part One of the test is designed to test information and Part Two to test skills and application of knowledge. The directions accompanying the test were carefully followed. Part One was administered in 45 minutes; a ten minute rest period was given; and Part Two was administered in 43 minutes.

The scores made on the tests were compared statistically and graphs made for the two groups. A further comparison was made with the standards that accompanied the tests.

The following chapter will present in detail the analysis and comparison of the results on the testing.

Chapter IV

FINDINGS AND DISCUSSION

Fischer's Mechanical Drawing Tests which were used for the testing program consist of two parts. Part One is designed to test technical information. This consists of four sections. The first uses the multiple-response method in checking knowledge of materials and devices used in mechanical drawing. The second gives a multiple choice of correct graphical representations for scales, lines, and geometrical solids. The third requires the writing in of the correct answer for the names of geometric solids and orthographic projections which are represented pictorially. The fourth requires that the student complete drawings where the three views were partially given. The four parts are weighted as to their importance as follows: the first, 25; the second, 14; the third, 9; the fourth, 16--for a total of 64.

Part Two is designed for testing performance. By using a series of three separate sectional tests, the actual drawing ability of the student is measured. The ability to use drawing tools correctly and the ability to make a drawing from descriptive data are specially measured. No test of skill in lettering is made. The three sections as weighted give scores of 12, 6, and 22; for a total of 40.

Fischer's tests were given twice to each group, once at the beginning of the experiment and again at the end. This procedure was followed to give the results of the testing program increased reliability.

COMPARISON OF ACHIEVEMENT OF THE GROUPS ON THE BASIS OF FISCHER'S TESTS

Results for part one(first time administered)

Fischer's tests were administered to both groups the second week of school for the first testing.

Table 5 compares them on the basis of scores made the first time on Fischer's Mechanical Drawing Test, Part One. It will be seen that the mean of Group A is 22.68, with a standard deviation of 6.34 and a standard error of 1.20. Group B has a mean of 23.17, a standard deviation of 5.88, and a standard error of 1.11.

As shown by a comparison of the two means, Group B excelled Group A in this test. To determine whether this superiority is real, *t* was found. The calculated value of *t* was found to be .2953, so the difference is not statistically significant.

It might be well to mention here that while the superiority of Group B at the present time is not significant, it may later prove to be a determining factor

TABLE 5.--COMPARISON OF GROUPS A AND B ON THE BASIS OF FISCHER'S MECHANICAL DRAWING TEST PART ONE (FIRST TESTING)

STUDENT	GROUP	
	A	B
1	35	37
2	35	33
3	34	32
4	32	31
5	31	30
6	28	30
7	27	29
8	27	28
9	26	26
10	25	25
11	24	24
12	23	23
13	22	23
14	22	22
15	22	22
16	22	21
17	21	21
18	21	21
19	19	21
20	19	20
21	19	19
22	18	19
23	17	18
24	16	18
25	16	17
26	16	16
27	15	16
28	14	15
29	12	14

A (Experimental)

$\overline{X} = 22.68$
$\sigma = 6.34$
$\sigma_{\overline{X}} = 1.20$

B(Control)

$\overline{X} = 23.17$
$\sigma = 5.88$
$\sigma_{\overline{X}} = 1.11$

Calculations to show whether the difference between the two groups is significant.

$$t = \frac{\overline{X}_A - \overline{X}_B}{\sqrt{(\sigma_{\overline{X}_A})^2 + (\sigma_{\overline{X}_B})^2}}$$

$$= \frac{22.68 - 23.17}{\sqrt{(1.20)^2 + (1.11)^2}}$$

$$= .2953$$

(Not significant)

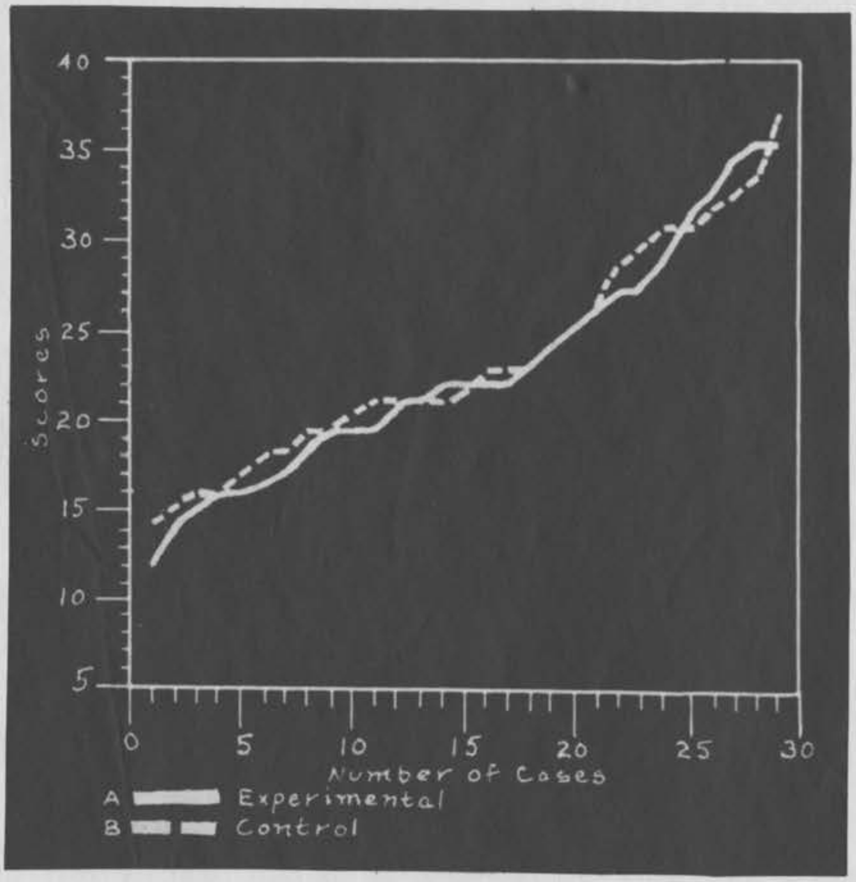

Figure 5.--Graphic comparison of the two groups on a basis of the first test part one on Fischer's standardized mechanical drawing test.

in the outcome of the final results of the testing program.

Figure 5 graphically compares the two groups on a basis of increasing magnitude of the first testing, Part One of Fischer's Mechanical Drawing Test.

Results for part two (first time administered)

Table 6 shows that on Part Two of the test Group A had a mean of 11.86, a standard deviation of 4.94 and a standard error of .934 of mean; while Group B had a mean of 13.62, a standard deviation of 5.99, and a standard error of 1.13. As seen by the two means, Group B again excelled A on Part Two. To determine whether this difference in means is significant t was determined. This value was found to be 1.19, which is less than the criterion of significance, which is over two, so the difference is not statistically significant.

Figure 6 is a graphic comparison of the two groups on Part Two of Fischer's test the first time it was administered.

Combined results

Table 7 gives a comparison of Groups A and B on the basis of the total scores made on Fischer's test Parts One and Two the first time they were administered. The mean of Group A is 34.55, the standard deviation 10.01,

TABLE 6.---COMPARISON OF GROUPS A AND B ON THE BASIS OF FISCHER'S MECHANICAL DRAWING TEST PART TWO (FIRST TESTING)

STUDENT	GROUP	
	A	B
1	24	26
2	21	20
3	20	20
4	19	20
5	16	20
6	15	19
7	15	18
8	14	18
9	14	18
10	14	17
11	14	17
12	14	17
13	13	16
14	12	16
15	11	15
16	11	14
17	11	14
18	10	13
19	9	11
20	9	11
21	8	11
22	8	11
23	7	6
24	7	6
25	7	5
26	6	5
27	6	4
28	5	4
29	4	3

A (Experimental)

$\overline{X} = 11.86$
$\sigma = 4.94$
$\sigma_{\overline{X}} = .9349$

B(Control)

$\overline{X} = 13.62$
$\sigma = 5.99$
$\sigma_{\overline{X}} = 1.1325$

Calculations to show whether the difference between the two groups is significant.

$$t = \frac{\overline{X}_A - \overline{X}_B}{\sqrt{\sigma(\overline{X}_A)^2 + \sigma(\overline{X}_B)^2}}$$

$$= \frac{11.86 - 13.62}{\sqrt{(.9349)^2 + (1.1325)^2}}$$

$$= 1.197$$

(Not significant)

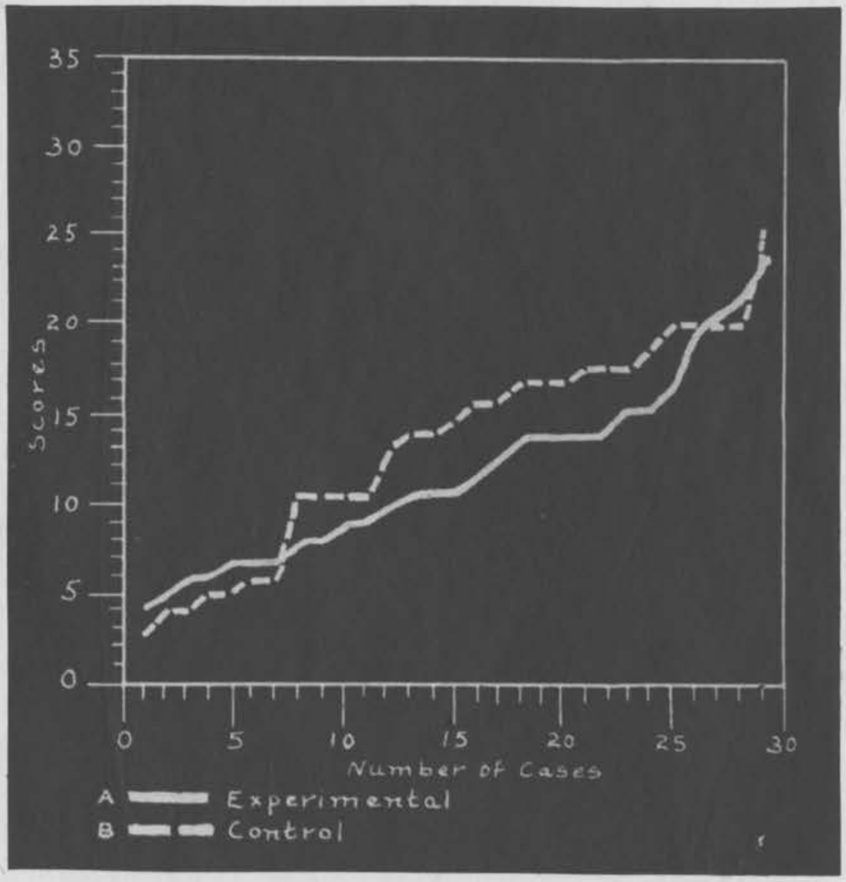

Figure 6.--Graphic comparison of the two groups on a basis of the first test part two on Fischer's standardized mechanical drawing test.

TABLE 7.--COMPARISON OF GROUPS A AND B ON THE BASIS OF TOTAL SCORES MADE ON FISCHER'S TEST (FIRST TESTING)

STUDENT	GROUP	
	A	B
1	59	59
2	56	55
3	48	55
4	47	52
5	45	51
6	43	48
7	42	46
8	41	44
9	38	44
10	37	43
11	37	41
12	37	40
13	34	38
14	33	36
15	33	35
16	32	35
17	32	35
18	32	34
19	31	34
20	28	33
21	28	30
22	27	29
23	26	29
24	26	26
25	25	23
26	23	22
27	21	20
28	21	19
29	20	19

Calculations to show whether the difference between the two groups is significant.

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\sigma_{(\bar{X}_A)}^2 + \sigma_{(\bar{X}_B)}^2}}$$

$$= \frac{34.551 - 37.068}{\sqrt{(1.892)^2 + (2.111)^2}}$$

$$= .8879$$

(Not significant)

A (Experimental)

$\bar{x} = 34.551$
$\sigma = 10.010$
$\sigma_{\bar{x}} = 1.892$

B (Control)

$\bar{x} = 37.068$
$\sigma = 11.169$
$\sigma_{\bar{x}} = 2.111$

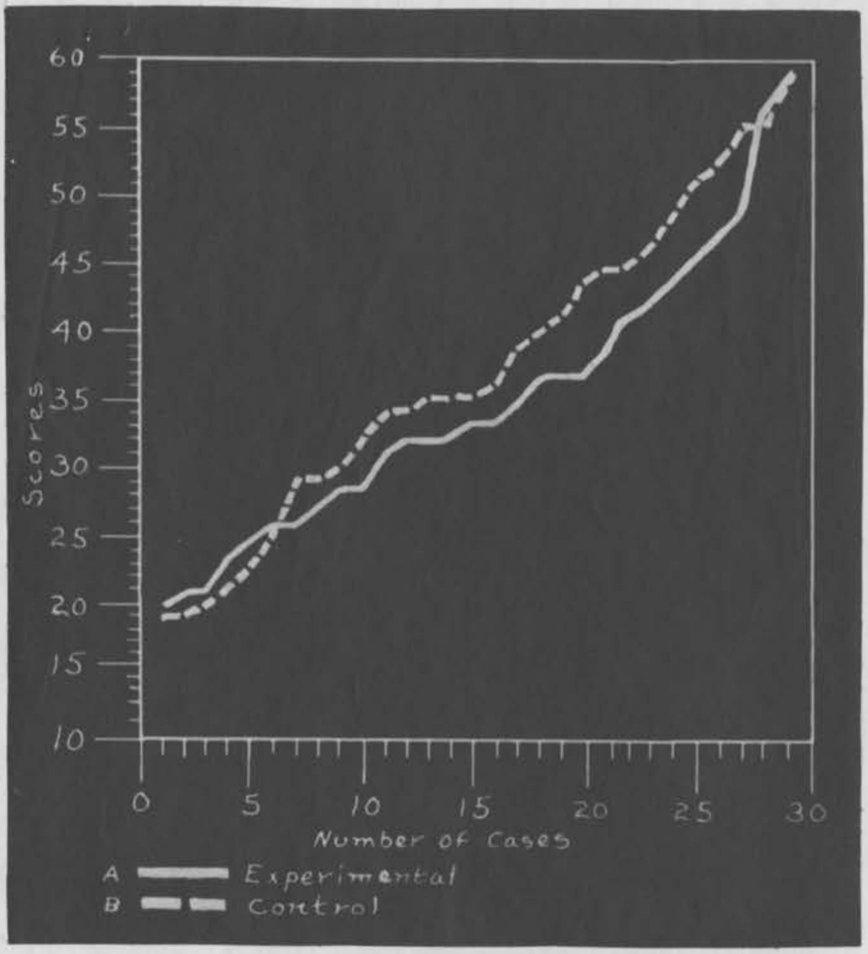

Figure 7.--Graphic comparison of the two groups on a basis of increasing magnitude of the first test parts one and two on Fischer's standardized mechanical drawing test.

and the standard error of 1.89. Group B has a mean of 37.06, a standard deviation of 11.16, and a standard error of 2.11. Since Group B was superior to A on both Parts One and Two the combined scores would naturally be larger. T was calculated and found to be .887 so the superiority of Group B over A is not statistically significant.

As previously stated it will be interesting to note whether or not Group B's apparent superiority over A in the first administration of Fischer's tests will be of significant value in the final testing program.

Figure 7 graphically represents the combined scores of the two groups on the first administration of Fischer's tests.

COMPARISON OF ACHIEVEMENT OF GROUPS ON BASIS OF FISCHER'S TESTS

Results for part one(second time administered)

Table 8 compares the two groups on the basis of scores made on Fischer's Part One the second time it was administered which was at the close of the experiment.

It will be seen that the mean of Group A is 43.44, with a standard deviation of 8.27, and a standard error of 1.56 of mean; while Group B has a mean of 34.43, with a standard deviation of 8.03 and a standard error of 1.51. In comparing the two means one can readily see that Group A is far superior to Group B on this administration of the test. To determine whether this great difference is real t must be calculated. The calculation shows that the value of t is 3.89, much larger than two, which is the criterion of significance.

Figure 8 shows in graphical form the marked superiority of Group A over B in this part of the test.

Results for part two (second time administered)

Table 9 shows a comparison of the two groups on the basis of scores on Fischer's test, Part Two. According to the table Group A had a mean of 37.93, with a standard deviation of 7.66 and a standard error of 1.44; while Group B had a mean of 29.48, with a standard deviation of 6.99 and a standard error of 1.322. T was calculated to determine whether A's superiority was real. The value found was 4.308 which is much larger than the criterion of significance, so the difference is statistically significant.

Figure 9 graphically represents this superiority of A over B. The graph presents a normal appearance but A is shifted upward from B.

Combined results for the second administration

By referring to Table 10 which compares the two

TABLE 8.--COMPARISON OF GROUPS A AND B ON THE BASIS OF FISCHER'S MECHANICAL DRAWING TEST PART ONE (SECOND TESTING)

STUDENT	GROUP	
	A	B
1.	60	51
2	57	50
3	53	50
4	52	45
5	52	43
6	52	42
7	50	40
8	49	39
9	48	38
10	48	38
11	48	38
12	48	38
13	48	37
14	45	35
15	42	34
16	42	34
17	41	32
18	40	32
19	39	31
20	39	31
21	39	30
22	36	30
23	36	29
24	36	29
25	36	26
26	34	25
27	32	24
28	31	22
29	27	20

Calculation to show whether the difference between the two groups is significant.

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\sigma_{(\bar{X}_A)}^2 + \sigma_{(\bar{X}_B)}^2}}$$

$$= \frac{43.44 - 34.92}{\sqrt{(1.56)^2 + (1.51)^2}}$$

$$= 3.895$$

(Significant)

A (Experimental)

$\bar{x} = 43.44$
$\sigma = 8.27$
$\sigma_{\bar{x}} = 1.56$

B (Control)

$\bar{x} = 34.43$
$\sigma = 8.03$
$\sigma_{\bar{x}} = 1.51$

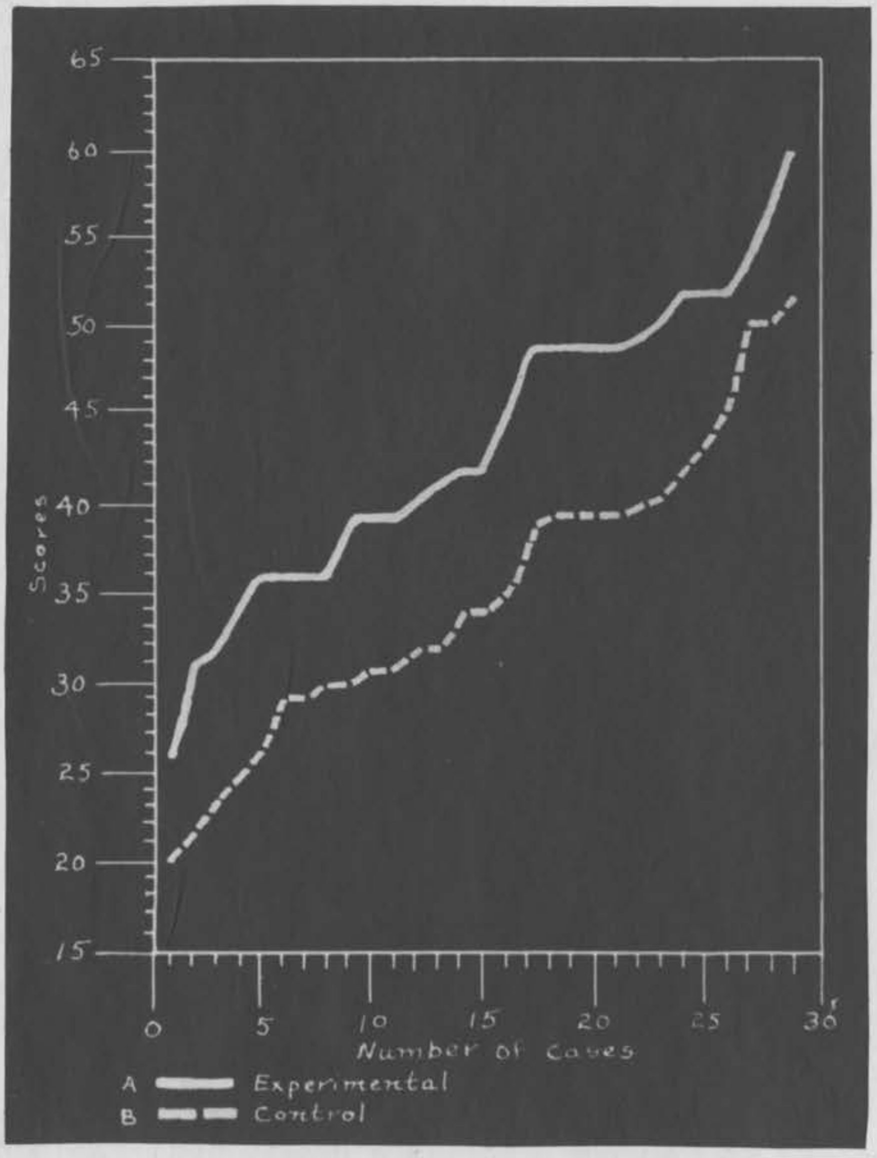

Figure 8.--Graphic comparison of the two groups on a basis of increasing magnitude of the second test part one on Fischer's standardized mechanical drawing test.

TABLE 9.--COMPARISON OF GROUPS A AND B ON THE BASIS OF FISCHER'S MECHANICAL DRAWING TEST PART TWO (SECOND TESTING)

STUDENT	GROUP	
	A	B
1	50	48
2	49	45
3	47	40
4	46	36
5	46	36
6	46	34
7	46	33
8	44	32
9	43	31
10	42	31
11	42	31
12	41	31
13	41	31
14	41	30
15	40	30
16	40	30
17	39	30
18	37	29
19	34	27
20	32	24
21	31	24
22	31	23
23	29	23
24	29	22
25	29	22
26	28	21
27	28	21
28	27	21
29	22	19

A (Experimental) B (Control)

$\bar{X} = 37.93$ $\bar{X} = 29.48$

$\sigma = 7.66$ $\sigma = 6.99$

$\sigma_{\bar{X}} = 1.44$ $\sigma_{\bar{X}} = 1.32$

Calculation to show whether the difference between the two groups is significant.

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\sigma_{(\bar{X}_A)}^2 + \sigma_{(\bar{X}_B)}^2}}$$

$$= \frac{37.93 - 29.48}{\sqrt{(1.44)^2 + (1.32)^2}}$$

$$= 4.308$$

(Significant)

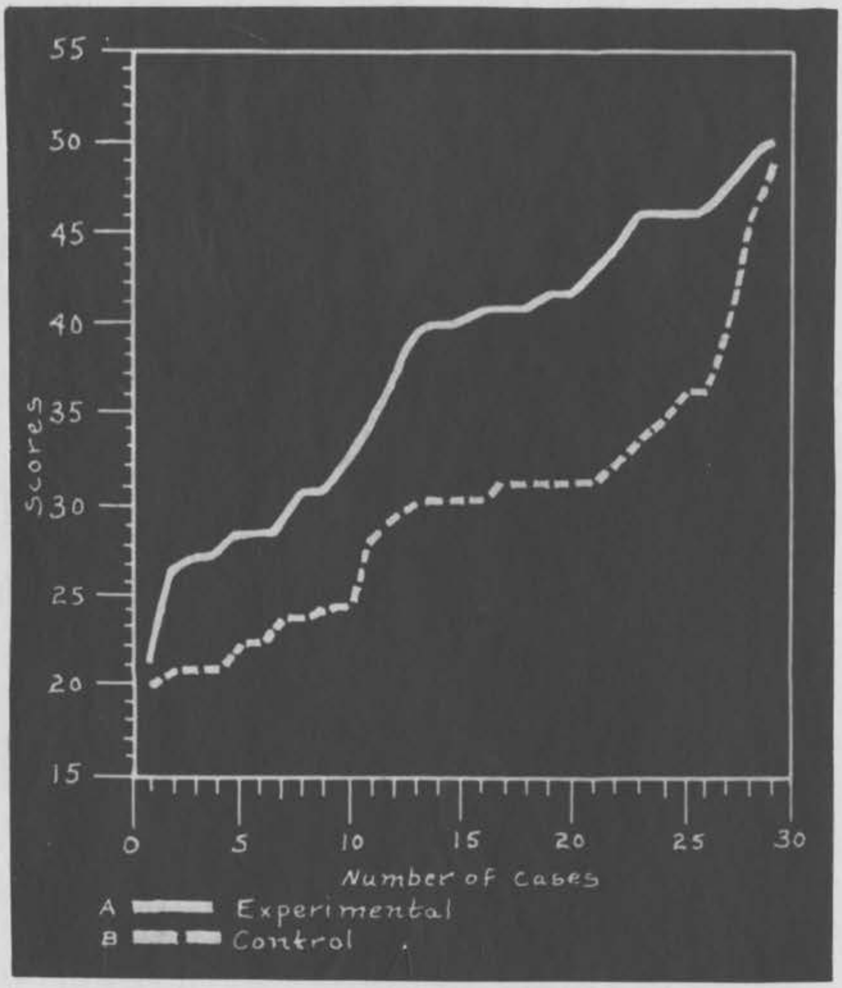

Figure 9.--Graphic comparison of the two groups on a basis of increasing magnitude of the second test part two on Fischer's standardized mechanical drawing test.

groups on the basis of total scores made on Fischer's Mechanical Drawing Tests, Parts One and Two, administered at the close of the experiment, it can be seen that A has a mean of 81.37 with a standard deviation of 13.58, and a standard error of 2.56 of mean; while Group B has a mean of 64.41, a standard deviation of 13.21, and a standard error of 2.49 of mean.

The value of _t_ was found to be 4.733, which is definitely significant; therefore, the difference between the two means is real.

Figure 10 shows that the graph is normal for both groups, but A is shifted upward from B.

COMPARISON OF THE ACHIEVEMENT OF THE TWO GROUPS WITH OTHER CRITERIA OF GROUP EQUIVALENCY

Standard median score of Fischer's tests-second administration

As the groups participating in the experiment were selected and homogeneous and since the established norms for these tests are the results of heterogeneous groups, the writer felt a comparison was necessary. As the test norms were stated in terms of medians, the same terms will be used in this comparison.

A comparison of Group A's median score on Fischer's total test scores with the standard median score as given by the author and publisher may be seen in Table 11, which indicates a standard deviation of 13.58 and a standard error of 3.21. The difference between the standard median score, which is given as 59, and the median of Group A is 22. Two times the standard error (6.42) is not as large as the difference between the two medians, so Group A has an achievement which is significantly greater than that represented by the norm of the test.

Table 12 compares Group B's median score of Fischer's total test scores with the established norms. The standard deviation is 13.21, and the standard error is 3.13. Group B has a median of 63 as compared with the standard median of 59. Twice the standard error (6.26) is slightly larger than the difference between Group B's median and the standard, so that the difference is not significant from a statistical standpoint.

Comparison of groups A and B

Since Group A's median was significantly above the standard median and Group B's was not significant, it is evident that they should be sufficiently different in their achievement for the difference to be statistically significant. Table 13 shows the results to be such. The difference between the medians of the two groups is 18, which is larger than twice the standard error of the difference, which is 7.15, so the difference is significant.

TABLE 10.--COMPARISON OF GROUPS A AND B ON THE BASIS OF TOTAL SCORES MADE ON FISCHER'S TESTS (SECOND TESTING)

STUDENT	GROUP	
	A	B
1	110	99
2	102	84
3	98	82
4	98	81
5	95	80
6	95	75
7	94	74
8	94	73
9	92	72
10	91	71
11	90	69
12	85	68
13	81	67
14	81	64
15	81	63
16	79	62
17	76	60
18	75	59
19	74	58
20	73	57
21	72	56
22	71	56
23	70	54
24	69	52
25	69	50
26	67	49
27	65	48
28	60	44
29	53	41

A (Experimental)

$\bar{x} = 81.37$
$\sigma = 13.58$
$\sigma_{\bar{x}} = 2.56$

B (Control)

$\bar{x} = 64.41$
$\sigma = 13.21$
$\sigma_{\bar{x}} = 2.49$

Calculation to show whether the difference between the two groups is significant.

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\sigma(\bar{X}_A)^2 + \sigma(\bar{X}_B)^2}}$$

$$= \frac{81.37 - 64.41}{\sqrt{(2.56)^2 + (2.49)^2}}$$

$$= 4.733$$

(significant)

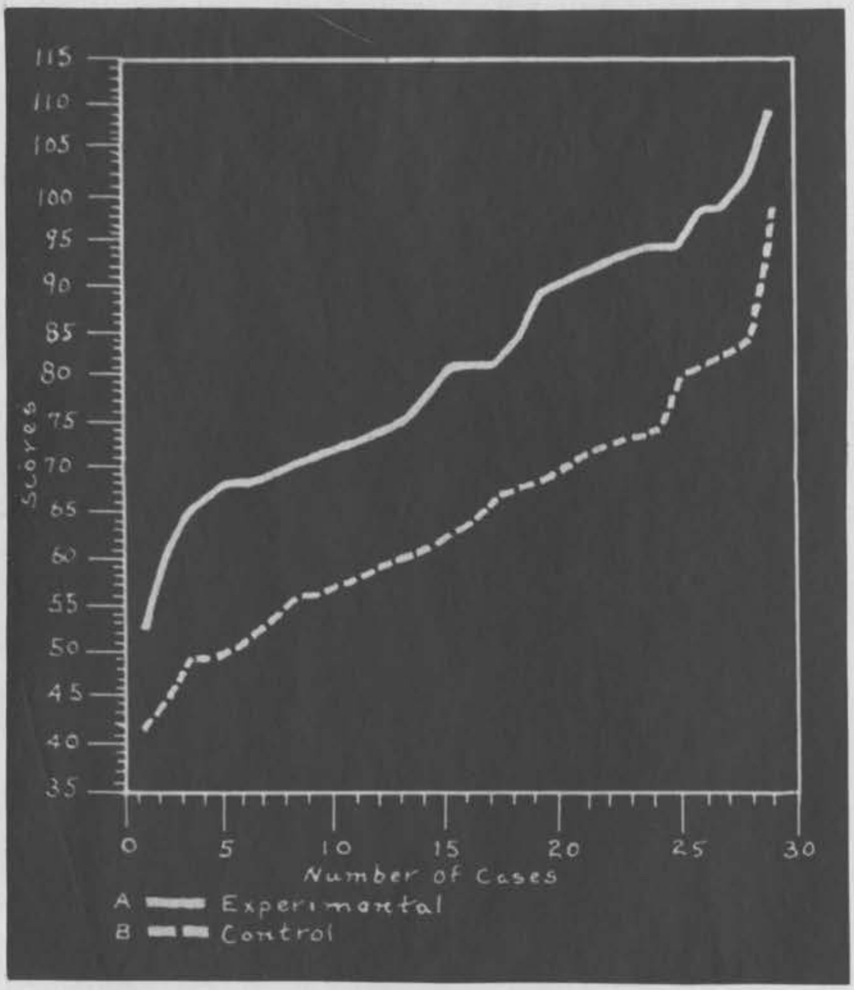

Figure 10.--Graphic comparison of the two groups on a basis of increasing magnitude of the second test parts one and two on Fischer's standardized mechanical drawing test.

TABLE 11.--COMPARISON OF MEDIAN SCORE OF GROUP A WITH STANDARD MEDIAN SCORE OF FISCHER'S MECHANICAL DRAWING TESTS

NUMBER	SCORE	
1	110	
2	102	
3	98	
4	98	
5	95	
6	95	
7	94	
8	94	
9	92	
10	91	
11	90	
12	85	
13	81	
14	81	
15	81------	-Median
16	79	
17	76	
18	75	
19	74	
20	73	
21	72	
22	71	
23	70	
24	69	
25	69	
26	67	
27	65	
28	60	
29	53	

When the scores as achieved by the individuals of Group A are ordered the 15th score equals the median which is 81.

The standard median score for this test is 59. The median for Group A exceeds this by 22 points. To determine whether this difference is significant the standard error of the obtained median is computed.

$$\sigma_{median} = 1.2533 \frac{\sigma}{\sqrt{N - 1}}$$

$$= \frac{1.2533\ (13.5809)}{\sqrt{28}}$$

$$= 3.210$$

Where σ = 13.5809 was computed for given data Table 10.

Hence $\underline{t} = \frac{22}{3.210} = 6.853$

(Significant)

TABLE 12.--COMPARISON OF MEDIAN SCORE OF GROUP B WITH STANDARD MEDIAN SCORE OF FISCHER'S MECHANICAL DRAWING TESTS

NUMBER	SCORE
1	99
2	84
3	82
4	81
5	80
6	75
7	74
8	73
9	72
10	71
11	69
12	68
13	67
14	64
15	63----Median
16	62
17	60
18	59
19	58
20	57
21	56
22	56
23	54
24	52
25	50
26	49
27	48
28	44
29	41

When the scores as achieved by the individuals of Group B are ordered the 15th score equals the median which is 63.

The standard median score for this test is 59. The median for Group B exceeds this by four points.

To determine whether this difference is significant the standard error of the obtained median is computed.

$$\sigma_{median} = 1.2533 \frac{\sigma}{\sqrt{N-1}}$$

$$= \sqrt{\frac{1.2533\ (13.2136)}{28}}$$

$$= \quad 3.130$$

Where σ = 13.2136 was computed for given data Table 10.

Hence $\underline{t} = \frac{4}{3.130} = 1.277$

(Not significant)

TABLE 13.--THE STANDARD ERROR OF THE DIFFERENCE BETWEEN TWO MEANS (STANDARD DEVIATION OF THE THEORETICAL DISTRIBUTION OF DIFFERENCES BETWEEN MEANS OF SAMPLES A AND B)

$$\sigma_D = 1.253\sqrt{\frac{\sigma^2_A}{N_A-1} + \frac{\sigma^2_B}{N_B-1}}$$

Where σ_D is the standard error of the difference of the two obtained medians

$$= \sqrt{\frac{(13.5809)^2}{28} + \frac{(13.2136)^2}{28}}$$

$$= \quad 3.579$$

$$2\sigma_D = \quad 7.158$$

Where

σ_A = Standard deviation of A sample

σ_B = Standard deviation of B sample

N_A = Number of items in first sample

N_B = Number of items in second sample

Median Group A = 81

Median Group B = 63

Difference 18

Since 18 the difference between the medians of Group A and Group B is larger than two standard errors, it is significant.

Comparison of the time element of Groups A and B on Fischer's mechanical drawing tests

Fischer's tests are accompanied by a chart giving a median score curve calibrated in terms of "total" minutes of drawing completed to the date of taking the test." A portion of that curve is shown in Figure 11.

Fifty-four hundred minutes was the time involved in the present study. The chart indicates that the standard median for this amount of time would be 59.

Group A's median score of 81 is equal to about 50,000 minutes of drawing time, while B's median score of 63 is equal to about 7,000 minutes. Both groups were above the median, but Group A far outranked Group B.

To further determine whether the training given the groups as measured by Part One varied from that given by Part Two a comparison was made of the mean score curve for these facts as compared with the median scores for Group A and Group B on each of these parts. On Parts One and Two, Group A corresponded fairly well although they ranked higher on Part Two than on Part One. Group B showed less accomplishment on Part One, but showed an improvement on Part Two. This was probably due to a chance in sampling.

The writer feels that the preceding data provide an answer to the main question of this thesis which is: What is the relative effectiveness of teaching ninth year general drawing by the experimental

TOTAL PARTS ONE AND TWO--FISCHER'S ESTABLISHED NORMS AND GROUP A AND B NORMS COMPARED AGAINST TIME

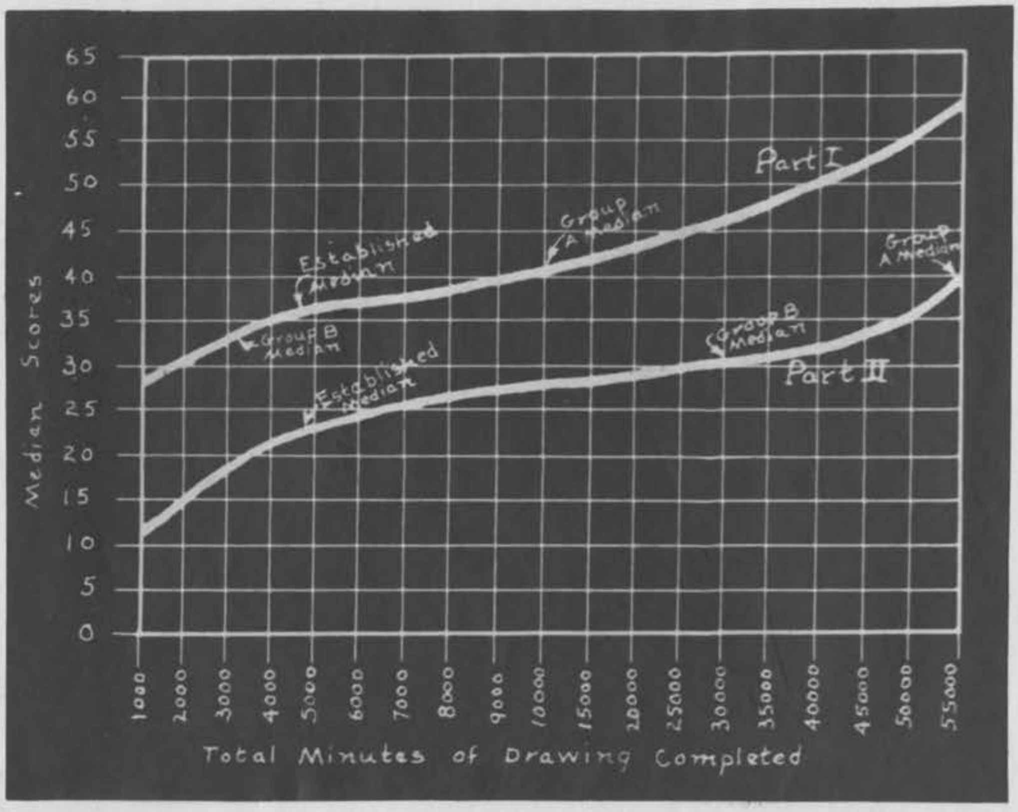

Figure 11.--Total minutes of drawing completed and norms.

TOTAL PARTS ONE AND TWO (SEPARATE)--FISCHER'S ESTABLISHED NORMS AND GROUP A AND B NORMS COMPARED AGAINST TIME

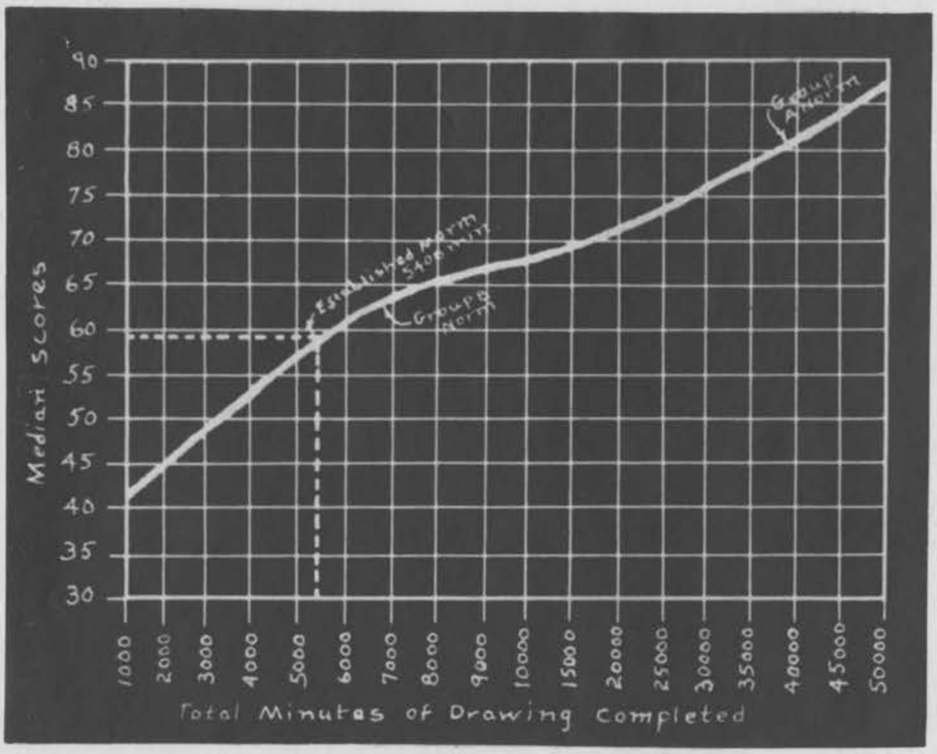

Figure 12.--Total minutes of drawing completed and norms.

method embracing sketching, construction, and the use of simplified instruments as compared with the traditional method?

Discussion

The problem of this thesis is: An experiment to measure the relative effectiveness of teaching ninth year general drawing through sketching, construction, and the use of simplified instruments.

In working out the problem the following questions were answered:

1. What are the aims and purposes of mechanical drawing?

   A list of the aims and purposes of mechanical drawing were obtained from a review of research relating to the proposed problem. A compilation of this accepted list may be found in Chart 1.(Appendix)

2. What shall comprise the contents of the experimental course?

   The contents of this course of study were determined by an analysis of courses of study in general drawing that have been developed through research by two or more states. A combination of the Illinois State Course of Study and the Wisconsin Course for Mechanical Drawing, was made in constructing the course of study for this experiment.

(See Chart 2 in Appendix).

3. What criteria are needed to establish the equivalency of the two groups?

Because of the fairly large class enrollment it was possible to use matched pairs in the experiment. In determining the equivalency of the groups in a statistical way, the following criteria were used: intelligence quotients, chronological age, school average in all subjects for preceding semester, previous drawing experience, and scores made on MacQuarrie's Mechanical Ability Test.

4. What methods and devices are needed to make evaluations?

For the purpose of testing the two teaching techniques employed in the experiment, Fischer's Standardized Mechanical Drawing Test, Parts One and Two was used. In order to make the testing more reliable ,the tests were administered to both groups at the beginning and again at the end of the course. The scores made on the tests were then compared statistically and graphs made for the two groups. A further comparison was made with the standards accompanying the test.

5. What are the results?

In the final testing for achievement as measured by Part One of Fischer's tests, Group A was statistically superior to Group B. The same situation was true for Part Two of the tests. As would be expected, the results for the entire test strongly favored Group A, there being a statistical significance of 4.733.

The achievement of Group A was significantly higher than the standard median score of Fischer's tests, while Group B's median was not significant.

In terms of time accomplishment, Group A was far superior to Group B, having completed an equivalent of 50,000 hours of drawing as compared with B's 7,000 hours according to Fischer's established time norms.

Practical application and recommendations

Since the experimental study indicates that the teaching procedure using sketching, construction, and simplified instruments was shown to be superior to the traditional method in the present study, this method will be used in the mechanical drawing department of the East Moline High School.

Although the conclusions made from this study might be made more meaningful in an experiment carried on with a larger number of students and extended over a period of perhaps three years, the writer feels that since he had a controlled situation, as carefully arranged as was possible, to measure advantages of both methods of teaching that the following recommendations can be made:

1. The experimental method, by means of free-hand sketching, construction and the use of simplified instruments is definitely superior in this study for performance achievement, technical information, time, and from a financial standpoint, and is therefore recommended as a worth-while method of teaching general drawing.

2. From the observed reactions to the techniques employed, the introduction of free-hand sketching, construction, and the use of simplified drawing instruments made for added interest in the experimental class.

3. Because of this interest, there was an increase in the average ability of each student, which in turn helped to make the teaching easier and more successful.

4. This method is also definitely superior in diagnosing individual differences.

Limitations of the study

The writer realizes that this study has its limitations as to time and number of cases. Ideally, the experiment should be carried on for a period of three years with the experimental and control groups containing at least 100 pupils each. No attempt was made to prolong the experiment, as such would have met with administrative difficulty, since the members of the drawing class were not confined to a single grade of school work. Program construction is a difficult matter in arranging for classes that are heterogeneous so far as schoolwork is concerned.

Problems for further research

It is the hope of the writer that further research and additional experiments will be carried on along these same lines so as to strengthen the conclusions.

An experiment which would be of value would be to carry on a similar study for a period of three years covering the fields of architectural, machine and other forms of drawing as well as first year general drawing. There would no doubt be a greater carry-over here, which would place the results on a more positive basis. It would also be interesting to follow this up by a survey of these drawing classes after they leave school and thus determine the actual benefits which were derived from this method of teaching drawing.

Furthermore, the experiment should be tried by enough other teachers to determine whether the experimental method is generally superior or whether it is superior for some teachers and inferior for others. It might be advisable also to determine whether locale that influences results is variable or not.

Chapter V

SUMMARY

The problem

This thesis is a report on the results of an experiment to measure the relative effectiveness of teaching ninth year general drawing through sketching, construction, and the use of simplified instruments.

Sources of data

The data needed for solving the proposed problem were obtained from three sources. The first was a review of the research studies relating to the proposed problem; the second source was employers who hire students who have been trained in mechanical drawing and from employees of the industrial plants, many of whom are graduates and former students of the East Moline High School; and the third source was students themselves.

Method

In applying the two teaching procedures, the same course content was given to both groups. The classes were taught by the same teacher, in the same class room, and both met during the afternoon session; the experimental group was taught during the fourth period and the control, the fifth period during the first and second semesters. As will be shown later, the classes were equivalent, and the only variable was the method of instruction--the effect of which was to be determined.

The control group continued its work using the regular drawing equipment, which included a set of drawing instruments, triangles, scale, drawing pencils and ink. The experimental group was asked to purchase a five-cent ruler, a ten-cent compass, drawing pencils, and ink. Each day the woodshop was available to the experimental group so that each member of the class could construct his necessary drafting models from wood or, in a few cases, from paper before an actual drawing of the model was begun. The instructor was at hand, if help or directions were needed.

The models were constructed actual size, using the measurements of the patterns as given in the textbook. A rule, and in a few cases, the compass were used for securing accurate measurements and for laying-out all models. Both groups were required to complete 30 drawing plates and a cover sheet. One model at a time was completed and then sketched as the actual drawing. In constructing the first 8 drawings, the experimental group was permitted to use a rule as a means of measurement for arranging the drawing on the paper, and the like, until they became accustomed to this new method. The remaining

22 plates were then drawn entirely by free-hand sketching and eye-measurement. No instruments whatsoever were used.

Each group was given individual instruction whenever necessary. Related information of the same content was given both classes through lectures, demonstrations, and student reports,which occupied about one period a week. The students of the two classes progressed at their own rate of speed; members of the control group following the traditional method, using its regular equipment, and drawing the plates as given in the textbook, while the experimental group used simplified instruments, sketching, and its models which had been patterned from those printed in the textbook. Records were kept on a progressive-work chart,which was posted in the drawing room and was available for the student to see at any time.

Frequent check-up tests were administered showing the essential difference of the method of pupil activity, but the grades were in no way used for testing the results of the experiment. The testing method is described later. At no time were the students of either class told the purpose of the two methods of teaching drawing.

Selection and equivalency of the two groups

Because of a fairly large class enrollment, the pupils were divided on a systematic basis. In determining the equivalency of the groups in a statistical way, the following criteria were used: intelligence quotients, chronological age, school average of the previous semester, previous drawing experience, and scores made on the MacQuarrie Mechanical Ability Test, which was administered to both groups at the beginning of the experiment. In checking up to see how nearly equal the groups were, it was found that there were 29 matched pairs available, and these were then divided into a control group of 29 pupils and an experimental group composed of the same number. The other 52 students were eliminated because of too great a variation in I.Q.'s, age, and mechanical ability scores. As the course consists of an independent half year unit open to all students from the ninth through the twelfth grade of high school, all pupils were electing the subject. In order to use matched pairs, it was necessary to conduct the experiment during the fall and spring semesters.

Comparison of the groups on the basis of various criteria of equivalency

Table 14 compares the groups on the basis of various criteria of equivalency.

TABLE 14.--COMPARISON OF THE TWO GROUPS ON THE BASIS OF VARIOUS CRITERIA OF EQUIVALENCY

CRITERIA OF EQUIVALENCY	EXPERIMENTAL GROUP (A)			CONTROL GROUP (B)			t difference
	Mean	SD	SEM	Mean	SD	SEM	
1. I.Q.'s (Otis)	107.93	8.27	1.56	106.68	7.84	1.48	.589
2. School grades	83.86	5.13	.96	83.51	4.92	.93	.260
3. Age (months)	176.58	12.03	2.27	176.20	10.71	2.02	1.247
4. Mechanical Ability (MacQuarrie)	65.00	10.89	2.05	62.58	11.41	2.15	.811

To determine whether the difference between the two groups might be ascribed to chance in the sampling the value of t was determined from the following formula:

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\sigma_{(\bar{X}_A)}^2 + \sigma_{(\bar{X}_B)}^2}}$$

In this study the criterion of significance is two.

From the records of equating, it is evident that Group A and Group B are well-matched. Group A has a slightly higher I.Q. than B; Group B is slightly younger and has a slightly lower mechanical ability average score, while the previous study records and previous drawing experience of the two groups are very nearly equal. According to the various criteria, however, the difference between the groups is not statistically significant.

The outcomes of the experiment

For the purpose of testing the two teaching techniques employed in the experiment, Fischer's Mechanical Drawing Tests, Parts One and Two, were used. In order to make the testing more reliable, it was decided to give the tests at the beginning of the experiment and again at the end to the groups. The directions for administering the test were followed completely. The scores made on the tests both times were compared statistically and graphs made for the two groups. A further comparison was made with the standards that accompanied the test.

Table 15 compares the two groups statistically.

Comparison of achievement of groups A and B with Fischer's test norms

As the groups participating in the experiment were selected and homogeneous and since the established norms for these tests are the results of heterogeneous

TABLE 15.--THE OUTCOME OF THE EXPERIMENT

FISCHER'S M.D. TESTS PARTS I AND II AND TOTAL OF PARTS I AND II	FIRST TIME ADMINISTERED						
	EXPERIMENTAL(A)			CONTROL (B)			t dif-fer-ence
	Mean	SD	SEM	Mean	SD	SEM	
Part I	22.68	6.34	1.20	23.17	5.88	1.11	.295
Part II	11.86	4.94	.934	13.62	5.99	1.13	1.19
Parts I and II	34.55	10.01	1.89	37.06	11.16	2.11	.887

To determine whether the difference between the two groups was significant the value of t was determined from the following formula:

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sigma_{(\bar{X}_A)}^{\ 2} + \sigma_{(\bar{X}_B)}^{\ 2}}$$

In this study the criterion of significance is two.

TABLE 15.--THE OUTCOME OF THE EXPERIMENT--Continued

FISCHER'S M.D. TESTS PARTS I AND II AND TOTAL OF PARTS I AND II	SECOND TIME ADMINISTERED						
	EXPERIMENTAL (A)			CONTROL (B)			t difference
	Mean	SD	SEM	Mean	SD	SEM	
Part I	43.44	8.27	1.56	34.42	8.03	1.51	3.89
Part II	37.93	7.66	1.44	29.48	6.99	1.322	4.30
Parts I and II	81.37	13.58	2.56	64.41	13.21	2.49	4.73

To determine whether the difference between the two groups was significant the value of t was determined from the following formula:

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sigma_{(\bar{X}_A)}^{2} + \sigma_{(\bar{X}_B)}^{2}}$$

In this study the criterion of significance is two.

groups, the writer felt a comparison was necessary. As the test norms were stated in terms of medians, the same terms will be used in this comparison.

A comparison of the median score of Group A with the standard median score indicates a standard deviation of 13.58 and a standard error of 3.21 of the mean. Two times the standard error (6.42) is not as large as the difference between the two medians (22), so Group A has an achievement which is significantly greater than that represented by the norm of the test. Group B showed a standard deviation of 13.21 and a standard error of 3.13 of the median. Twice the standard error (6.26) is slightly larger than the difference between the two medians, which is four, so that the difference is not significant from a statistical standpoint.

Since Group A's median was significantly above the standard and Group B's not significant, it is evident that they should be sufficiently different in their achievement for their difference to be statistically significant. The difference between the two medians is 18, which is larger than twice the standard error of the difference (7.15) and proves the difference to be significant.

Summary of findings and discussion

The following statements indicate that the teaching procedure using sketching, construction, and simplified instruments was shown to be superior to the traditional method in the present study:

1. In achievement as measured by Fischer's Mechanical Drawing Test, Group A was statistically superior in both Parts I and II, so the total results were strongly in favor of Group A. The first time Fischer's tests were given to the groups, at the beginning of the experiment, Group B excelled on both Parts I and II and on the combined scores, yet in the final testing Group A far outranked Group B with a statistical difference of 4.733.

2. The achievement of Group A was significantly higher than the standard median of Fischer's tests, while Group B's median score was not significantly different.

3. In terms of time and accomplishment, Group A was superior to Group B. In the number of plates completed, Group A showed only a slightly higher number, but it must be taken into consideration that, in addition to the number of plates completed, Group A members were also required to construct the same number of models. This shows that Group A did nearly twice as much work as Group B. From the results of Fischer's tests, this was to be expected, since the test itself is based on speed and accuracy and since A was definitely superior to B in the final testing, they were superior in the time element likewise. Group A's median score was equivalent to 50,000 minutes of drawing time, while B's was equivalent to 7,000 minutes according to Fischer's time norms.

4. In comparing the cost of equipment used by each of the groups, it was found that Group A's equipment cost was \$0.57, while that of Group B was \$1.60. Thus, the cost was less than one-half when the simplified method was used.

5. This study indicates that, for the groups participating in the experiment, the traditional method of teaching drawing as employed in the East Moline High School is definitely inferior when achievement is measured by a particular standardized mechanical drawing test.

6. The results imply that mechanical drawing as taught by the use of simplified instruments, construction, and free-hand sketching is the superior method for the groups participating in this experiment from the standpoint of technical information, performance achievement, finances, and time.

Limitations of the study and problems for further research

The writer realizes that this study had its limitations as to time and number of cases. Ideally, the experiment should be carried on for a period of three years with the experimental and control groups containing at least 100 pupils each. Furthermore, the experiment should be tried by enough other teachers to determine whether the experimental method is generally superior or whether it is superior for some teachers and inferior for others. It might be advisable also to determine whether locale that influences results is variable or not.

APPENDIX

Contents

CHART 1. ---

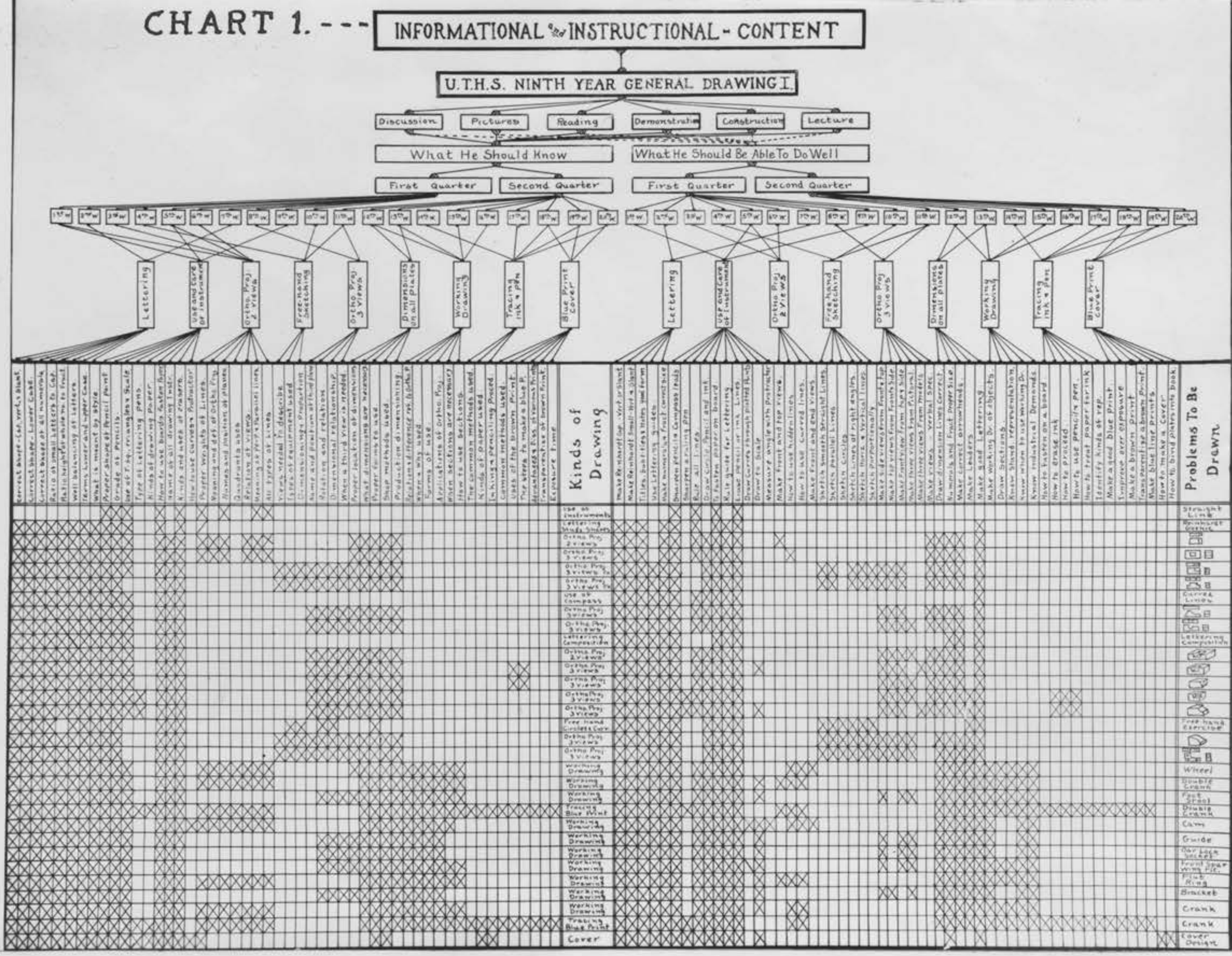
INFORMATIONAL and INSTRUCTIONAL - CONTENT
U.T.H.S. NINTH YEAR GENERAL DRAWING I.
Discussion
Pictures
Reading
Demonstration
Construction
Lecture
What He Should Know
What He Should Be Able To Do Well
First Quarter
Second Quarter
First Quarter
Second Quarter
Lettering
Use and Care of Instruments
Ortho. Proj. 2 Views
Free-hand Sketching
Ortho. Proj. 3 Views
Dimensions on all plates
Working Drawing
Tracing ink a pen
Blue Print Cover
Kinds of Drawing
Problems To Be Drawn
Cover

CHART 2.--

FREQUENCY OF OBJECTIVES AND AIMS FROM SOURCES OF RESEARCH

OBJECTIVES AND AIMS OF MECHANICAL DRAWING

SOURCES	To inculcate habits of neatness and accuracy.	Ethical character.	To develop the ability to visualize in three dimensions.	Vocational and economic effectiveness.	To develop the facilities in reading and abilities to understand the language of Mechanical drawing.	To train in expression.	To develop the habits of independent Thinking.	To train in reflective thinking.	Worthy home membership.	To lay a foundation for further study in mechanical drawing.	To train in association, symbols and meaning.	Mastery of tools, techniques and the Spirit of Learning.	To acquire habits of Wholesome enjoyment.	Wise use of Leisure.	Acquire useful information.	Health and safety.	To contribute to the intelligent choice of Life occupation.	To gain an insight into the draftsman trade.	Faithful citizenship.	To develop skill in the making of elementary freehand sketches.	To train in motor skills.
1. Mechanical Drawing in Illinois (R.F.V.)	X		X		X		X			X							X			X	
2. Syllabus of Mechanical Dr. Course for Ill. H.S.						X		X			X		X		X			X			X
3. Mechanical Drawing in Wisconsin (H.W.W.)		X		X					X			X		X		X			X		

CHART 3.--HIGH SCHOOL CLASSIFICATION OF GROUPS A AND B

CLASS	A	B
Freshman	24	25
Sophomore	2	1
Junior	1	1
Senior	2	2
Total	29	29

CHART 4.--PREVIOUS DRAWING EXPERIENCE OF THE GROUPS

ANSWERS	A	B
Yes	15	16
No	14	13
Total	29	29

CHART 5.--AVERAGE NUMBER OF PLATES COMPLETED BY GROUPS A AND B

GROUPS	AVERAGE NUMBER OF PLATES COMPLETED
A	33
B	32

OTIS SELF-ADMINISTERING TESTS OF MENTAL ABILITY

By Arthur S. Otis, Ph.D.

Formerly Development Specialist with Advisory Board, General Staff, United States War Department

MANUAL OF DIRECTIONS AND KEY (*Revised*)

For Intermediate and Higher Examinations

Contents

Introductory

Contents. In this manual will be found the complete directions for administering and scoring the Intermediate and Higher Examinations, directions for interpreting the scores in the light of the educational problems which the tests will help solve, and directions for applying the results of the test to the solution of those problems.

Scope. The Higher Examination together with the Intermediate Examination constitute the Otis Self-Administering Tests of Mental Ability, covering the range from the 4th grade to the university. The Higher Examination is designed for high school students and college freshmen. The Intermediate Examination is designed for Grades 4 to 9. The Higher and Intermediate Examinations are similar in form, but they differ in content and difficulty.

Forms. Each examination is issued in four alternative forms, Forms A, B, C, and D, alike except in content.

Special Features

Self-administration. In each of these examinations provision is made for the student to read for himself on the first page of the examination booklet all the directions needed for the examination. As the 75 items constituting each examination are in a single list, these are answered by the examinee without interruption. The examiner, therefore, has merely to distribute the blanks, see that all understand the printed directions, and give the signal to begin. He may then leave the class in charge of an assistant. For this reason the tests have been called " self-administering " tests.

Simplified scoring. In addition to the underlining of the correct one of several alternative answers, as is customary in group tests of mental ability, provision is made in these examinations for placing the number of the answer in a single column at the edge of each page. This simplifies the scoring to the extent that the whole examination can be scored in less than one minute.

Variety of test material. The form of the examinations admits of the use of a wide variety of types of questions instead of the limited number of types in the ordinary examination.

Flexible time limit. Provision is made for administering the examinations with a time limit of either 20 or 30 minutes. The 20-minute time limit may be used for general survey purposes or with normal school and college students. The 30-minute time limit should be used when time allows, as it will give a more accurate measure.

Ease of figuring IQ's. A chart is provided by which the IQ of the examinee can be found directly from the score and age in years and months merely by locating a point on the intersection of two lines. No arithmetical calculation or reference to tables is necessary.

Improved Percentile Graph. There is provided in each package of Examinations a new form of percentile graph on which percentile curves may be drawn, if desired, showing vividly the distributions of scores of any group or groups of examinees. With each percentile graph is furnished a scale chart by which the drawing of the percentile curves is reduced to the simplest terms.

Interpretation Chart. A chart is provided upon which the scores of a class or school may be plotted and the pupils divided into fast-moving, regular, and slow-moving groups and regraded within these groups, or otherwise classified, merely by drawing lines on the chart. Account is taken of mental ability, brightness, and chronological age in classifying by this method. It is not necessary to use the Interpretation Chart in order to interpret scores in these tests. However, it will be found a distinct aid and convenience.

Historical

These examinations are modeled after a group test of mental ability designed by the author in January, 1918, for use in a large commercial establishment in Connecticut. In that test the principle of self-administration was embodied, involving the single list of questions, the printed initial directions, and the provision for answers in single columns.

KEY
Higher Form D
Page 2

1. (3)
2. (20)
3. (2)
4. (G)
5. (T)
6. (4)
7. (2)
8. (5)
9. (540)
10. (2)
11. (4)
12. (3)
13. (1)
14. (4)
15. (2)
16. (4)
17. (4)
18. (8)
19. (3)
20. (31)
21. (3)
22. (1)
23. (2)
24. (2)
25. (5)

Published by World Book Company, Yonkers-on-Hudson, New York, and Chicago, Illinois

Acknowledgments

The author is indebted to many persons for helpful suggestions and criticisms in connection with the Self-Administering Tests of Mental Ability. Special mention is due the following, who gave hearty coöperation in the administration of tests for standardization purposes: Mr. J. C. Amon, Bellevue, Pennsylvania; Mr. H. H. Murphy, Hastings, New York; Mr. T. H. Schutte, State Teachers' College, Moorhead, Minnesota; Dr. John P. Herring, Bloomsburg State Normal School, Bloomsburg, Pennsylvania; Dr. Virgil E. Dickson, Oakland, California; Dr. E. E. Lewis, Rockford, Illinois; Mr. Henry D. Rinsland, Ardmore, Oklahoma; Mr. E. D. Price, Enid, Oklahoma; and Mr. Franklin Thomas, Professor of Civil Engineering, California Institute of Technology, Pasadena, California. Mrs. Otis has devoted many hours to scoring, tabulating, and correlating.

The author is indebted to Dr. E. E. Keener, Director of Instructional Research, Chicago Public Schools, and C. Everett Myers, Research Secretary, Pennsylvania State Education Association, for assistance in standardizing Form C.

Directions for Administering

Who may administer examination. Any teacher after a little preparation can satisfactorily administer either the Intermediate or Higher Examination. The best preparation for administering either is to take it. The principal should invite his teachers to take the examination and score their own papers. Any teacher who is interested in mental-ability testing should welcome the opportunity to experience the taking of an examination, as this will give her the best appreciation of what the examination tests. Those administering an examination should realize that it is very important that conditions be uniform throughout the school and must be the same in the school being tested as in every other school where the examination has been given. For this reason, everything which needs to be said in administering the test is given below in boldface type, and the teacher should give these instructions verbatim, reading if necessary. If one teacher urges the students to work as rapidly as possible and another teacher urges them to work as carefully as possible, the results may be entirely different and not comparable. The teacher, therefore, should say nothing that is not prescribed, except to make clear the meaning of what is on the first page of the examination blank.

When to give examination. The best time to give the examination is probably at the opening of school in the morning, although the time of day probably does not have a serious effect upon the score.

Directions for administering. To administer either the Intermediate or the Higher Examination, Form A, B, C, or D, begin by addressing the students as follows:

"We are going to give you this morning [afternoon] some new and interesting tests. We will now pass the test papers and as soon as you receive a paper you may begin to read the first page and do as it directs, filling the blanks, etc. Do not open or turn over the paper. Part of the test is to see if you can follow directions."

Have monitors pass the papers, one to each student, right side up. See that every student is supplied with two pencils (or a pen) and an eraser.

Allow a reasonable time for all to finish reading the first page and trying the samples. A few laggards may be disregarded. Then say, "**Is there any one who does not understand the first page?**" Give any explanations necessary to make sure that all understand what is explained on the first page.

If a time limit of 20 minutes is to be used, say, "**This will be a short test. You will be told to stop at the end of 20 minutes instead of 30. Find the number 20 in the upper left-hand corner of the page and make a ring around it.**" Be sure that all do this.

Then say, "**Now turn the page and begin,**" and note the exact time. No further instructions are necessary.

If the principal or superintendent is administering the examination, he may now leave the class in charge of the teacher or an assistant, with instructions to give no further directions and answer no questions; to stop the work at the end of exactly 30 (or 20) minutes and have the papers collected. The person in charge during the examination will do well to move quietly about the room at the beginning of the examination and see that all are indicating the answers in a proper manner. If an examinee is found who is not placing the numbers in the parentheses, he should be told to do so.

Directions for Scoring

The correct answers to the 75 items of both forms of the Intermediate and Higher Examinations are given on the margins of this manual. To score the examination, open the manual to the pages containing the answers to the form of the examination to be scored, fold open the manual and clip the pages together. Place the manual over the examination paper so that the appropriate Key is adjacent to the answers given on the examination paper. Place a check mark after each correct answer or a cross after each incorrect or omitted answer, or both checks and crosses.

If two answers are given for any one item, count the item wrong. This is quite likely to occur with Item 55 in Form A of the Higher Examination.

Number 37 in Form A and Number 57 in Form B of the Higher Examination count as wrong if the alphabet has been marked in any way.

If a paper is found in which the examinee has omitted to place the numbers in the parentheses but has otherwise indicated the answers, the scorer should write in the parentheses the numbers representing the answers of the examinee so far as these may be determined, and then score accordingly, but deduct one point from the total score for failure to follow the direction to place the numbers in the parentheses.

If the examinee has failed to make all his letters like printed capitals, score the paper as if all letters were printed capitals, but deduct one point for failure to follow the direction.

Whenever an examinee has used an irregular method of taking the examination, score the paper according to the obvious intent of the examinee and then deduct one point for each general direction not followed. Indicate such deduction by placing a -1 with a circle around it opposite the first instance where the direction has not been followed. Let his score represent the fairest measure of his ability that can be estimated.

The score in the examination is the number of correct answers. First, count up the correct answers and write the number on

KEY
Intermediate
Forms A and C
Page 4

52. (5)
53. (4)
54. (9)
55. (2)
56. (3)
57. (4)
58. (E)
59. (6)
60. (1)
61. (L)
62. (E)
63. (2)
64. (2)
65. (5)
66. (4)
67. (2)
68. (4)
69. (1)
70. (O)
71. (32)
72. (2)
73. (16)
74. (13)
75. (2)

KEY
Intermedia
Forms A and
Page 3

27. (1
28. (4
29. (L
30. (1
31. (5
32. (3
33. (4
34. (3
35. (1
36. (2
37. (2
38. (4
39. (Y
40. (30
41. (5
42. (2
43. (N
44. (1
45. (4
46. (3
47. (
48. (
49. (
50. (
51. (

the margin of the last page. Then verify the score by counting the incorrect and omitted answers. Thus, suppose the number of correct answers counted is 40. Count the incorrect and omitted answers beginning 41, 42, etc., and see that you end with 75. Then enter the score in the space provided on the first page of the blank. Do not trust the counting of correct answers only, as it is very easy to make a mistake. The checking of correct answers should be gone over by a second scorer, for even the best scorers will make mistakes.

Recording Scores

The Class Record. The scores should be entered on the Class Record which is provided with each package of examination blanks. Before entering the scores, arrange the papers of a class either in alphabetical order or in the order of magnitude of the score, according to preference. Next, enter the name of each student and his age in years and months. Then enter his score in the proper column according to the time limit used. Directions for filling the remaining columns will be given under "Interpretation of Results."

20-Minute time limit. If a 20-minute time limit has been used, the scores may be transmuted into terms of 30-minute time-limit scores in order that they may be compared with norms or other 30-minute scores. This may be done by means of Table 1.

TABLE 1[1]

20-MIN.	30-MIN.	20-MIN.	30-MIN.	20-MIN.	30-MIN.	20-MIN.	30-MIN.	20-MIN.	30-MIN.
1	1	16	20	31	40	46	59	61	71
2	2	17	22	32	41	47	60	62	71
3	4	18	23	33	43	48	61	63	72
4	5	19	24	34	44	49	62	64	72
5	6	20	26	35	45	50	63	65	73
6	7	21	27	36	46	51	64	66	73
7	9	22	28	37	48	52	64	67	74
8	10	23	30	38	49	53	65	68	74
9	11	24	31	39	50	54	66	69	74
10	13	25	32	40	51	55	67	70	75
11	14	26	33	41	53	56	68	71	75
12	15	27	35	42	54	57	68	72	75
13	17	28	36	43	55	58	69	73	75
14	18	29	37	44	56	59	70	74	75
15	19	30	39	45	58	60	70	75	75

Standardization

Selection of items. In selecting items for the Intermediate and Higher Examinations, the Advanced Examination was drawn upon freely. An equal number of items of other types, some of which are new, were included in order that the examination might cover a large variety of questions and therefore afford a more comprehensive measure of mental ability. Preliminary editions containing more than enough items were administered to about 1000 high school students in Oakland, California, and Rockford, Illinois, and to 1000 grammar school pupils in Moorhead, Minnesota. These students were divided in each case into two groups, a "good group" and a "poor group." The same number were taken from each grade for both groups. The good group constituted the young students, and the poor group the old students. These groups had reached the same average educational status, therefore, but at different rates. Now it is the rate at which a student can progress through school that the mental-ability test is chiefly used to predict. Therefore this is believed to be the best criterion by which to judge the validity of each item that goes into the test. The number of times each item was passed by each group was then found and only those items chosen which showed a distinct gain in number of passes by the good group over the number of passes by the poor group in spite of the fact that the median age of the good group was over two years less than that of the poor group. Each item justified its inclusion, therefore, because it distinguished between students who progressed slowly and those who progressed rapidly.

Arrangement in order of difficulty. The items in each form of each examination have been arranged in the order of difficulty, according to the number of passes of each item by the students taking the preliminary editions.

Practice Effect

Whenever a second form of a test is given after a first form, especially when the two forms have been made very much alike, students tend to do better on the second test. The effect of the first test is generally termed "practice effect," but it may include a number of effects. Among these is general familiarity with the method, resulting in ability to get under way more quickly, lessened nervousness, memory of mode of attack of certain types of problems, etc.

A study was made of the effect of practice when a second form of the Intermediate or Higher Examination was given the next day after the first form. The average gain in the second score was 4 points in each case. Therefore in such a case 4 points would have to be subtracted from the score in the second test to make allowance for the effect of practice.

Interpretation of Results

Mental ability and brightness. There are two aspects of the mental quality of an individual which must not be confused. One is his degree of **mental ability** and the other his degree of **brightness.** The term "mental ability" refers to that innate mental quality which increases with age, whereas the term "brightness" refers to that constant quality which determines the rate of growth of the mental ability of an individual and the degree of mental ability which he will eventually reach.

Mental ability is measured by the individual's score in the test. A measure of his brightness is obtained by comparing his score with that of others of his own age. The distinction is best shown by reference to the Interpretation Chart.

The Interpretation Chart. An Interpretation Chart is provided in each package of Examinations to facilitate the interpretation of scores. Interpretation Charts for the Intermediate and Higher Examinations are given on the two sides of the same sheet. In the sample Interpretation Chart shown in Figure 1 (page 9) a point is plotted for each of the 276 pupils in Grades 5 to 8 of a grammar school. The height of each point

[1] This table was derived from a study of 20- and 30-minute scores in the Higher Examination only. It is therefore only approximate for the Intermediate Examination. It is assumed, however, that the 20-minute time limit will seldom be used with the Intermediate Examination.

1. (4)
2. (2)
3. (3)
4. (2)
5. (5)
6. (3)
7. (4)
8. (2)
9. (1)
10. (4)
11. (H)
12. (2)
13. (5)
14. (2)
15. (1)
16. (3)
17. (3)
18. (9)
19. (3)
20. (2)
21. (6)
22. (4)
23. (T)
24. (2)
25. (2)
26. (1)

represents the score of an individual in the Intermediate Examination according to the scale at the left. The horizontal position of each point represents the age of the individual according to the scale at the foot of the chart.

The normal or "average" individual of the age of just 10 years is expected to make a score of just 23 points.[1] The normal individual of the age of just 11 years is expected to make a score of just 31 points, etc., as indicated by the heavy curved line through the middle of the chart (best seen in the blank chart). This may be called the normal curve and shows the **norm** or normal score to be expected from an individual of any given age. The curve becomes level at the age of 18 years, as shown in the Interpretation Chart for the Higher Examination, and may be considered as extending to the right indefinitely beyond 18 years at the same level. The derivation of this curve will be described below.

Mental maturity. A child's mental ability increases from birth, year by year, month by month, just as does his height, until he reaches his maximum, when he is said to have reached mental maturity. The normal curve may be thought of as the curve of growth in mental ability of the hypothetical exactly normal individual.

The age at which mental maturity is reached is difficult to decide, since the amount of mental development during the last year in which there is any development is very slight. In the Interpretation Chart for the Higher Examination the age at which mental maturity is reached is taken to be 18 years.

While individuals may reach mental maturity at about the same age, they nevertheless reach it with widely differing amounts of mental ability, just as they reach mature adult stature at differing heights. The degree of mental ability at which the normal individual reaches mental maturity is also very difficult to determine, since it is not possible to obtain a large group of completely unselected individuals (chosen at random from the whole population) at the various ages between 15 and 18. The norm for adults (persons of 18 years or over), however, has been called 42 in the Higher Examination, as shown by the upper limit of the normal curve. This is the equivalent of 59 points in the Intermediate Examination. The choice of this norm for adults is only an estimate based on all available data.

Derivation of norms. The positions of the normal curves in the two charts were established according to the judgment of the author upon consideration of (1) the median scores of the various age groups among about 120,000 pupils whose scores in the Higher or Intermediate Examinations have been reported to date, (2) the median scores of the several grade groups in relation to the median ages of these grade groups, (3) the norms for the various ages obtained from the norm table for the Advanced Examination by means of tables for converting scores into terms of the Higher and Intermediate Examinations, (4) the correlations between scores in the Higher and Intermediate Examinations and mental ages by the Herring Revision of the Binet-Simon Tests, and (5) correspondence between the Intermediate and Higher Examinations themselves. The position of the normal curve in neither chart accords exactly with any of these data, but it constitutes in either case a sort of average of the various groups of data.

[1] Unless otherwise stated the score referred to is the 30-minute time-limit score.

The aim has been to establish scores which are normal for unselected age groups, not merely for public school pupils. The scores of high school students, therefore, tend to average somewhat higher than the norms.

True mental age. Originally the term "mental age" referred to the degree of mental ability which is normal for a given age. Thus, "having a mental age of 15 years" meant "having a degree of mental ability just normal for the age of 15 years." This degree of mental ability is measured by a score of 36 in the Higher Examination. Having a mental age of 17, according to this definition, meant making a score just normal for 17-year-olds, which is a score of 41. Mental ages so found may be called true mental ages. Since the score of 42 is the norm for adults (taken to mean any person of 18 years or over), there is no age for which a score above 42 is the norm; therefore, of course, no score above 42 can be expressed as a true mental age.

The term "Mental Age" (capitalized), however, has now come to have a special meaning and to denote measures of mental ability — i.e., scores — in the Binet-Simon Tests. Binet Mental Ages below about 13 years are true mental ages. Above that, especially above 16 years, they are merely scores. They are called Mental Ages merely for the sake of consistency. The Binet Mental Age of 17, for example, represents a degree of mental ability considerably above that which is normal for the age of 17 or, indeed, for any age.

The Binet Mental Age of 16 years is generally taken as the norm for adults in figuring IQ's. There is a growing opinion among psychologists, however, that the Binet Mental Age which is the norm for adults is appreciably lower than 16 years.[1] The correlations between the Binet Scale and the Higher Examination confirm this belief. The correspondence between Binet Mental Ages and Scores in the Higher Examination, as indicated in the Interpretation Chart, is based partly upon the correlation between the Higher Examination and the Herring Revision of the Binet-Simon Tests and partly upon the age norms. At any rate, Binet Mental Ages appear to express degrees of mental ability in excess of that normal for the corresponding chronological ages even below the age of 15 years. For this reason IQ's obtained by the method provided herein[2] may be slightly higher than those obtained by the Binet Scale for the older students, but it is believed that they more nearly correspond with what the Binet IQ's of these students were when they were younger.[3]

Measures of mental ability. Each of the six scales at the left side of the Interpretation Chart for the Higher Examination is a measure of mental ability. The scales are so placed that values having the same height are corresponding measures of mental ability as far as may be determined. Thus a score of 40 points in the Higher Examination with a 30-minute time limit is the equivalent of a score of 31 in the Higher Examination with a 20-minute time limit, a score of 57 in the Intermediate Examination, a score of 120 in the Advanced Examination, a Binet Mental Age of 15 years 0 months, and a T-score of 62.[4]

[1] See Lewis M. Terman, "Mental Growth and the IQ," *Journal of Educational Psychology*, September, 1921.

[2] See "Measures of brightness" below.

[3] See "Validity of Mental Age equivalents" below.

[4] For the meaning and significance of a T-score, see William A. McCall, "A Uniform Method of Scale Construction," *Teachers College Record*, January, 1921.

27. (4)
28. (A)
29. (1)
30. (3)
31. (4)
32. (H)
33. (2)
34. (4)
35. (2)
36. (3)
37. (1)
38. (3)
39. (4)
40. (2)
41. (3)
42. (5)
43. (E)
44. (2)
45. (D)
46. (3)
47. (3)
48. (2)
49. (W)
50. (5)
51. (1)

52. (2)
53. (M)
54. (2)
55. (D)
56. (3)
57. (G)
58. (5)
59. (3)
60. (8)
61. (1)
62. (O)
63. (2)
64. (L)
65. (3)
66. (2)
67. (16)
68. (M)
69. (C)
70. (2)
71. (13)
72. (5)
73. (6)
74. (17)
75. (2)

Any individual whose score is plotted above the normal curve may be considered as brighter than normal, and any individual whose score is plotted below the normal curve may be considered as duller than normal.[1] The distance at any point above or below the normal curve is a measure of the brightness of the individual. A 14-year student making a score of 35 in the Higher Examination has a lesser degree of mental ability but a greater degree of brightness than a 15-year student making a score of 37.

Measures of brightness. Brightness is generally measured in terms of the Intelligence Quotient (IQ), which is customarily found by dividing the individual's Binet Mental Age by his chronological age (decimal point dropped). In the case of mental-ability tests other than the Binet Tests it is customary to give Binet Mental Age equivalents of scores in order that these may be used in finding IQ's. It has been found, however, that IQ's so derived have an appreciably wider range than those obtained by means of the Binet Tests and are therefore not comparable with the latter. Now the IQ was invented for use with the Binet Tests and should retain its original significance, or else it will become relatively meaningless. It seems that the term " Intelligence Quotient " is coming to have a legal recognition, but IQ's as sometimes derived from group tests of mental ability bear little relation to IQ's derived by the Binet Tests. It is the purpose of the author to use the term " IQ " only in its original significance.

Unless it is distinctly understood how IQ's were derived in any case, however, they should be designated by some means such as National IQ's, Otis IQ's, or Binet IQ's. The term " IQ," when not so qualified or understood, must be interpreted as referring to actual Intelligence Quotients found by means of the Binet Tests.

Validity of Mental Age equivalents. It follows from the above statements regarding the greater range of IQ's for each age group when obtained by group tests than when obtained by the Binet Tests, that Binet Mental Age equivalents are actual equivalents *for normal children only.* Thus a score of 38 in the Intermediate Examination corresponds to a Binet Mental Age of 12 years when made by a child of approximately 12 years. But if made by a 10-year child, for example, it represents a Binet Mental Age of only 11½ years, since according to the chart a 10-year child making a score of 38 has an IQ of only 115. This lack of constant correspondence between scores and Binet Mental Ages is inherent in all group tests and is due to the lesser accuracy of group tests. This phenomenon seems not to be generally appreciated, as witnessed by the now prevalent custom of converting scores into Binet Mental Age equivalents. There is no Binet Mental Age equivalent of a score in any group test of mental ability which is valid for all ages of individuals. For that reason it is believed that the most scientific method of obtaining IQ's from scores in group tests, which are comparable with Binet IQ's, is by comparison of the variabilities of scores of individuals of the various age groups in the group test and in Binet Tests, as described below.

Mental Age equivalents as such are not necessary to the use of the Higher or Intermediate Examinations. Scores are quite sufficient as measures of mental ability and IQ's as measures of brightness. IQ's can be obtained from scores in the Otis Self-Administering Tests without Mental Age equivalents.

In order to compare scores with Mental Age equivalents of scores in other group tests or to find IQ's comparable with those obtained from other group tests, however, Binet Mental Age equivalents are given to scores in both examinations. These may be obtained from the Interpretation Chart for the Higher Examination. Binet Mental Age equivalents of scores in the Intermediate and Higher Examinations are given also in Tables 2*a* and 2*b*.

TABLE 2*a*

BINET MENTAL AGE EQUIVALENTS OF SCORES IN THE INTERMEDIATE EXAMINATION

SCORE	MA	SCORE	MA	SCORE	MA	SCORE	MA	SCORE	MA
1	7- 4	16	9- 0	31	11- 0	46	13- 1	61	15-11
2	7- 5	17	9- 2	32	11- 2	47	13- 3	62	16- 1
3	7- 6	18	9- 3	33	11- 3	48	13- 5	63	16- 3
4	7- 7	19	9- 5	34	11- 5	49	13- 7	64	16- 6
5	7- 8	20	9- 7	35	11- 6	50	13-10	65	16- 8
6	7- 9	21	9- 8	36	11- 8	51	14- 0	66	16-11
7	7-10	22	9-10	37	11-10	52	14- 2	67	17- 2
8	7-11	23	10- 0	38	12- 0	53	14- 4	68	17- 5
9	8- 0	24	10- 1	39	12- 1	54	14- 6	69	17- 8
10	8- 2	25	10- 3	40	12- 2	55	14- 8	70	17-10
11	8- 4	26	10- 4	41	12- 4	56	14-10	71	18- 0
12	8- 5	27	10- 6	42	12- 6	57	15- 0	72	18- 3
13	8- 7	28	10- 7	43	12- 8	58	15- 2	73	18- 5
14	8- 9	29	10- 9	44	12-10	59	15- 5	74	18- 7
15	8-11	30	10-10	45	12-11	60	15- 8	75	18- 9

TABLE 2*b*

BINET MENTAL AGE EQUIVALENTS OF SCORES IN THE HIGHER EXAMINATION

SCORE	MA	SCORE	MA	SCORE	MA	SCORE	MA	SCORE	MA
1	7-10	16	10- 8	31	13- 5	46	16- 0	61	17-11
2	8- 0	17	10-10	32	13- 7	47	16- 2	62	18- 0
3	8- 2	18	11- 0	33	13-10	48	16- 3	63	18- 2
4	8- 4	19	11- 3	34	14- 0	49	16- 5	64	18- 3
5	8- 6	20	11- 5	35	14- 2	50	16- 6	65	18- 5
6	8- 9	21	11- 7	36	14- 4	51	16- 8	66	18- 6
7	8-11	22	11-10	37	14- 6	52	16- 9	67	18- 8
8	9- 2	23	12- 0	38	14- 8	53	16-10	68	18- 9
9	9- 4	24	12- 2	39	14-10	54	17- 0	69	18-11
10	9- 7	25	12- 4	40	15- 0	55	17- 2	70	19- 0
11	9- 9	26	12- 6	41	15- 2	56	17- 3	71	19- 2
12	10- 0	27	12- 8	42	15- 4	57	17- 5	72	19- 3
13	10- 2	28	12-10	43	15- 6	58	17- 6	73	19- 4
14	10- 4	29	13- 0	44	15- 8	59	17- 8	74	19- 5
15	10- 6	30	13- 3	45	15-10	60	17- 9	75	19- 6

Age norms. The norms in the Intermediate or Higher Examination for the various ages may be read from the appropriate Interpretation Chart by noting the points at which the normal curve cuts the vertical age lines, or may be taken from Table 3 or Table 4.

[1] Here "normal" means exactly median in brightness. The term "normal," however, is often used to refer to all individuals whose scores are reasonably close to the norms for their respective ages.

1. (4)
2. (2)
3. (3)
4. (2)
5. (2)
6. (3)
7. (3)
8. (3)
9. (3)
10. (H)
11. (1)
12. (W)
13. (8)
14. (4)
15. (1)
16. (5)
17. (40)
18. (3)
19. (4)
20. (5)
21. (7)
22. (5)
23. (5)
24. (4)
25. (3)
26. (4)

TABLE 3

AGE NORMS IN INTERMEDIATE EXAMINATION (30-MINUTE TIME LIMIT)

YEARS		8	9	10	11	12	13	14	15	16	17	18 or over
MONTHS	0	7	15	23	31	38	44	49	53	56	58	59
	1	8	16	24	32	39	44	49	53	56	58	
	2	8	16	24	32	39	45	50	53	56	58	
	3	9	17	25	33	40	45	50	54	57	58	
	4	10	18	26	34	40	46	50	54	57	58	
	5	10	18	26	34	41	46	51	54	57	58	
	6	11	19	27	35	41	46	51	55	57	59	
	7	12	20	28	35	42	47	51	55	57	59	
	8	12	20	28	36	42	47	52	55	58	59	
	9	13	21	29	36	43	48	52	55	58	59	
	10	14	22	30	37	43	48	52	56	58	59	
	11	14	22	30	37	43	49	53	56	58	59	

TABLE 4

AGE NORMS IN HIGHER EXAMINATION (30-MINUTE TIME LIMIT)

YEARS		12	13	14	15	16	17	18 or over
MONTHS	0	23	28	32	36	39	41	42
	1	24	28	32	36	39	41	
	2	24	29	33	37	39	41	
	3	25	29	33	37	40	41	
	4	25	29	33	37	40	41	
	5	25	30	34	37	40	41	
	6	26	30	34	38	40	42	
	7	26	30	34	38	40	42	
	8	27	31	35	38	40	42	
	9	27	31	35	38	41	42	
	10	27	31	35	39	41	42	
	11	28	32	36	39	41	42	

Norms for college students. The scores of 2516 college students in the Higher Examination have been reported to date from 21 colleges and universities. Ten of the 21 used 20-minute time limits. Reducing all the scores to a 30-minute basis, the median score of these 2516 students is 53 points. The median scores of the 21 colleges and universities were as follows (30-minute time limit): 37, 39, 45, 46, 51, 51, 52, 53, 53, 54, 55, 55, 56, 56, 57, 59, 61, 62, 62, 64, and 65.

Various percentile scores of the 2516 college students are shown in Table 5.

TABLE 5

SHOWING VARIOUS PERCENTILE SCORES OF 2516 COLLEGE STUDENTS IN THE HIGHER EXAMINATION

Percentile	0 (Lowest)	3	10	25	50 (Median)	75	90	97	100 (Highest)
20-MINUTE BASIS	16	25	30	36	41	49	55	61	75
30-MINUTE BASIS	20	32	39	46	53	62	67	71	75

Derivation of IQ Scale. According to Dr. Terman,[1] IQ's found by the Stanford Revision of the Binet-Simon Tests are distributed very closely in accordance with the law of normal distribution and with the middle 50 per cent falling within the range of IQ's from 92 to 108.

Due partly, no doubt, to the form of the Intermediate and the Higher Examinations, the steps in difficulty between items being smaller in the first part of each examination than in the last part, the distributions of scores of the several age groups have approximately the same variability, as far as can be determined. These distributions tend to be approximately normal, and are such that the middle 50 per cent of scores of each age group tend to fall within 8 points above and below the norm for that age. Fortunately, therefore, each point in the score of an individual above or below the norm for his age represents a point in IQ above or below 100. If an individual's score exceeds the norm for his age by 12 points, his IQ is 112.

How to find the IQ of an individual. The IQ of an individual may be found in either of two ways. One is as follows: Add to 100 the number of points by which a pupil's score exceeds the norm for his age, or subtract from 100 the number of points by which a pupil's score falls below the norm for his age. A simple and easy way to obtain the same result is to add 100 to the score of the individual and subtract from this sum the score which is the norm for his age. (The norm for individuals over 18 years may be taken as 42 points in the Higher Examination and as 59 points in the Intermediate Examination.) Thus, if a 15-year student's score in the Higher Examination is 34, the norm for his age being 36, his IQ is $34 + 100 - 36 = 98$.

A second method of finding an IQ is to plot the score of the individual in the appropriate Interpretation Chart by placing a dot on the horizontal line representing his score and on the vertical line representing his age. If the dot falls on a curve, the IQ of the individual will be stated at the end of the curve in the IQ column at the right. Thus, if a student of 15 years, 4 months, makes a score of 31 in the Higher Examination, his IQ is 94. If the point falls between two curves, the IQ may be estimated closely enough by noting its position relative to the curve above or below.

The IQ of each student may be entered after his name on the Class Record, in the column headed "IQ."

Index of Brightness. A measure of brightness used in connection with the Otis Group Intelligence Scale is the Index of Brightness. The relation between IQ's obtained by the Higher Examination and the Index of Brightness as found by the Advanced Examination is shown in the IQ and IB columns in the Interpretation Chart. This same correspondence holds good for IQ's obtained by the Intermediate Examination. If IQ's are used, it is not necessary to find IB's. Both IQ's and IB's serve the same purpose.

Percentile Rank. Another measure of brightness is called the "Percentile Rank." If a student exceeds 75 per cent of unselected individuals of his own age in score, he is said to have a Percentile Rank (PR) of 75, and the same for any other per cent. The scale of Percentile Ranks extends, therefore, from 0 to 100. A PR of 50 represents exact normality and corresponds to an IQ or IB of 100.

[1] L. M. Terman, *Measurement of Intelligence* (Houghton Mifflin Company, Boston), page 79.

Assuming distributions of scores for the various age groups to be in accord with the law of normal distribution, the Percentile Rank of an individual may be found from his IQ or IB by reference to the PR column at the right of the Interpretation Chart for the Higher Examination. This correspondence holds also between IQ's, IB's, and PR's for the Intermediate Examination. If desired, the student's PR may be entered also on the Class Record. This is optional.

Grade status. Table 6 shows the grade status corresponding to various 30-minute scores in the Intermediate and Higher Examinations. For example, a score of 11 in the Intermediate Examination is a grade status of 2.8 — that is, it is the norm for the end of the eighth month of the second grade; a score of 30 in the Higher Examination is the norm for the beginning of the eighth grade. These values are based on the tables of norms and Table 31 of *Statistical Method in Educational Measurement* (World Book Company).

TABLE 6 (*Revised*)

Intermediate Examination						Higher Exam.	
Score	Grade Status	Score	Grade Status	Score	Grade Status	Score	Grade Status
11	2.8	26	4.8	41	6.8	30	8.0
12	3.0	27	4.9	42	7.0	31	8.3
13	3.2	28	5.0	43	7.2	32	8.5
14	3.3	29	5.1	44	7.4	33	8.8
15	3.4	30	5.2	45	7.6	34	9.1
16	3.5	31	5.4	46	7.9	35	9.4
17	3.6	32	5.5	47	8.1	36	9.7
18	3.7	33	5.6	48	8.3	37	10.0
19	3.9	34	5.8	49	8.5	38	10.3
20	4.0	35	5.9	50	8.8	39	10.7
21	4.1	36	6.0	51	9.1	40	11.0
22	4.3	37	6.2	52	9.4	41	11.4
23	4.4	38	6.3	53	9.7	42	11.8
24	4.5	39	6.4	54	10.0	43	12.2
25	4.7	40	6.6	55	10.3	44	12.6

TABLE 7

SHOWING DISTRIBUTION OF SCORES OF 24,724 PUPILS IN THE 6TH GRADE IN THE INTERMEDIATE EXAMINATION

Score	Age: 9 to 9-11	10 to 10-11	11 to 11-11	12 to 12-11	13 to 13-11	14 to 14-11	15 to 15-11	16 or over	Totals
75			1						1
70-74		3	19	8					30
65-69		31	116	49	10	6			212
60-64	1	66	344	193	28	2	3		637
55-59	3	97	551	336	87	24	5	1	1104
50-54	3	142	912	586	197	79	21		1940
45-49	7	183	1130	1084	340	138	34	7	2923
40-44	6	162	1193	1061	491	208	50	11	3182
35-39	6	207	1221	1241	668	280	106	11	3740
30-34	9	155	1003	1180	761	338	150	24	3620
25-29	7	115	784	935	700	360	171	27	3099
20-24		83	457	612	556	328	179	8	2223
15-19	1	34	241	341	353	220	117	26	1333
10-14	1	7	75	134	150	89	58	14	528
5-9		2	11	27	25	31	23	6	125
0-4			6	7	4	4	4	2	27
Totals	44	1287	8064	7794	4370	2107	921	137	24724

Median age: 12 yr. 5 mo. Median score: 41.

Tables 7, 8, and 9 show the distributions of scores in the Intermediate and the Higher Examinations. Similar data have been compiled for the other grades but cannot be given for lack of space.

TABLE 8

SHOWING DISTRIBUTION OF SCORES OF 35,278 PUPILS IN THE 8TH GRADE IN THE INTERMEDIATE EXAMINATION

Score	Age: 11 to 11-11	12 to 12-11	13 to 13-11	14 to 14-11	15 to 15-11	16 to 16-11	17 to 17-11	18 or over	Totals
75		1	3	6	1				11
70-74	14	96	303	182	48	9			652
65-69	28	324	1177	740	213	50	4		2536
60-64	53	227	1710	1327	432	93	10		3852
55-59	39	426	1828	1753	732	168	16	2	4964
50-54	44	441	1771	1933	1025	219	42	2	5477
45-49	22	313	1468	1822	1102	295	54	2	5088
40-44	28	253	1187	1567	1052	313	38	6	4444
35-39	26	197	790	1122	849	268	50	10	3312
30-34	16	139	513	820	605	237	28	6	2364
25-29	9	76	244	393	423	160	28	2	1335
20-24	9	38	146	242	221	106	28	10	800
15-19	1	17	60	102	63	50	4		297
10-14		7	12	33	28	13	4		97
5-9	2	1	10	5	7	4			29
0-4			2	6	9	3			20
Totals	301	2556	11224	12053	6810	1988	306	40	35278

Median age: 14 yr. 3 mo. Median score: 49.

TABLE 9

SHOWING DISTRIBUTION OF SCORES OF 15,715 PUPILS IN THE 12TH GRADE IN THE HIGHER EXAMINATION

Score	Age: 14 to 14-11	15 to 15-11	16 to 16-11	17 to 17-11	18 to 18-11	19 to 19-11	20 or over	Totals
75	1		1					2
70-74		5	19	11	5	2	1	43
65-69	2	31	78	128	43	10	4	296
60-64	4	40	283	312	123	31	11	804
55-59	3	75	465	454	227	62	23	1309
50-54	10	125	628	970	484	147	52	2416
45-49	7	96	770	1247	462	219	76	2877
40-44	4	78	532	1280	750	227	92	2963
35-39		40	415	960	686	268	101	2470
30-34	1	28	211	495	455	172	66	1428
25-29		10	85	213	216	112	43	679
20-24		1	27	85	97	60	17	287
15-19		5	11	31	27	18	5	97
10-14			4	10	5	3	5	27
5-9				5	4	4		13
0-4				1	1	2		4
Totals	32	394	3529	6202	3585	1337	496	15715

Median age: 17 yr. 7 mo. Median score: 44.

KEY
Higher Form A
Page 2

1. (3)
2. (30)
3. (4)
4. (2)
5. (1)
6. (2)
7. (14)
8. (4)
9. (3)
10. (2)
11. (5)
12. (6)
13. (3)
14. (1)
15. (240)
16. (4)
17. (1)
18. (4)
19. (5)
20. (4)
21. (8)
22. (2)
23. (2)
24. (5)
25. (2)
26. (2)

Application of Results

Purposes of mental-ability tests. The chief administrative purposes for which mental-ability tests are given are: (1) the division of the pupils of a grade or the students of a class into more homogeneous divisions, usually in order that instruction of different degrees of enrichment may be given, (2) the regrading of pupils so that the pupils of each grade are more homogeneous in mental ability and are therefore more easily taught together, (3) the division of pupils of a school into groups which will progress at different rates.

The reader should consult *Intelligence Tests and School Reorganization*, by L. M. Terman and others (World Book Company), for a detailed discussion of the purposes and uses of tests of mental ability in regrading and classifying.

Division of classes. If it is desired to divide the students of a class into more homogeneous groups for instruction purposes, this may be done either on the basis of score or on the basis of IQ. Division on the basis of score would be made as follows:

Classification according to score. Find the distribution of the scores of the class. If the scores are plotted on the Interpretation Chart, this may be done by placing in the column under "Totals" at the left the number of dots on each horizontal line. (If desired, the frequencies of the various class intervals, 0–4, 5–9, etc., may be entered in the same column. These will be used in drawing a percentile curve on the Percentile Graph.) By means of this distribution the class may be divided into any number of divisions for differentiated instruction. Thus, let us suppose it is desired to divide a class into three divisions, A, B, and C, on the basis of score. This would be done as follows: Count down the distribution until one third the total number of scores has been counted. At this point draw a line across the distribution to mark the lower limit of score of Group A. Next count down another third and draw another line marking off Group B from Group C. Referring now to the Class Record, where each student's score appears opposite his name, the division designation, A, B, or C, may be placed opposite each student's name in the column headed "Classification."

This method is illustrated in the sample Interpretation Chart in Figure 2. Here 105 9th-year students are divided into three classes of 35 students each on the basis of score.

Classification according to brightness. If it is desired to divide the students of a class into divisions on the basis of brightness, this may be done by dividing the distribution of IQ's in the same way as suggested above for dividing the distribution of scores. To find the distribution of IQ's, count the dots between each two adjacent curves, including those which touch the lower but not the upper curve. Place the number of dots in the column headed "Totals" at the right, as shown in the sample charts. As a check on accuracy in counting the dots, it will be well to add these numbers and see that the sum corresponds to the number of students in the class.

Considerations governing method of classification. Two methods of classification have been described. Which should be used? It will be found that the dispersion of scores of any age group is so great in comparison with the rather narrow range of age norms for high school ages, that the resulting classifications by the two methods are very nearly the same. Even when classified by IQ, the superior division consists of students whose scores are nearly all higher than those of the next division, etc. It remains for further research to discover which is the better method. It is possible that if the classification is made for the purpose of determining groups which will cover the curriculum of the high school in different amounts of time, classification on the basis of IQ may be the better method, whereas if it is to establish sections which will take work of differing degrees of intensity, classification on the basis of score may be the better.

Regrading. If it is felt that the pupils of a school are very badly graded, so that the 6th grade, for example, is believed to contain some pupils who could do satisfactory work in the 7th or 8th grade and some who should be in the 5th grade to do the best work, the pupils may be regraded on the basis of score in a mental-ability test. The ideal grading would be that in which the pupils of the 6th grade all make scores higher than those in the 5th grade and lower than those in the 7th grade, etc. Practically this is impossible.

The next best procedure is to select those pupils from the 6th grade who make very high or very low scores and to promote or demote these. No hard and fast rule can be laid down for this. The number of pupils to be shifted depends partly on the amount of overlapping of ability between grades and partly on the character of the instruction possible in the school. Where relatively individual instruction is possible, homogeneous grouping is not so essential. It is probably best to begin regrouping slowly, taking first those whose scores deviate most from the median score of the grade and whose scholarship in the judgment of the teacher accords with their scores, and promoting or demoting these pupils one grade or one-half grade. If conditions warrant or seem to require it, they may be further promoted or demoted later. Later, also, more pupils may be regraded, until by degrees the grades will become more nearly homogeneous.

Multiple-track plan. A plan of school organization called the "multiple-track plan," in use in Oakland, California, and elsewhere, is one in which the pupils of the school are divided into groups (generally three, sometimes five) which progress at different rates. Thus there may be fast-moving, normal, and slow-moving classes, covering the first eight grades in say 7, 8, and 9 years, respectively.

A situation illustrating the need of reclassification is that shown in the sample Interpretation Chart in Figure 1. In this chart are plotted the scores of 276 pupils in Grades 5 to 8 of a grammar school. The scores of the different grades are plotted by different marks. It will be seen that the different grades overlap very markedly. Each grade contains both young pupils making high scores, who are therefore very bright, and old pupils making low scores, who are therefore very dull.

Division of pupils into groups to progress at different rates should be made on the basis of brightness. It is recommended by Terman that the brightest 15 per cent of the pupils of a school be placed in fast-moving classes (where numbers permit) and the dullest 15 per cent in slow-moving classes. The selection of these pupils should be made, therefore, on the basis of IQ (or IB or PR). A convenient method of making the division is illustrated in Figure 1 in the case of the 276 pupils. Of this number 15 per cent is about 40. Therefore the brightest 40 (according to IQ) should be placed in the fast-moving group and the dullest 40 in the slow-moving group.

The method of making the division by means of the chart

● ○ × △ INTERPRETATION CHART. For Intermediate Examination

Grades plotted 5th, 6th, 7th and 8th Number 276 Form used A Time limit 30 min. Date Oct. 1 1922

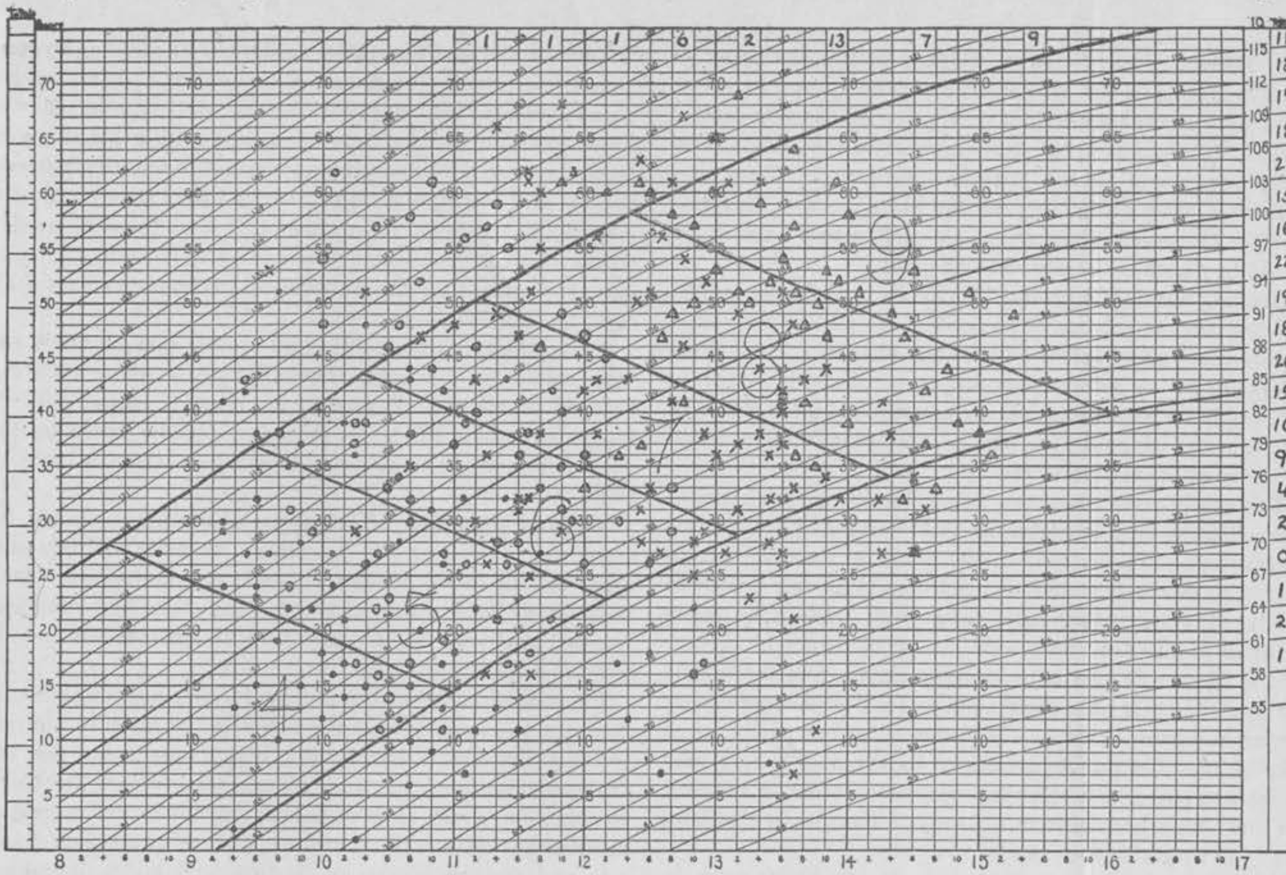

FIG. 1

INTERPRETATION CHART. For Higher Examination

Classes plotted Ninth Year Number 105 Form used A Time limit 30 min. Date Oct. 1 1922

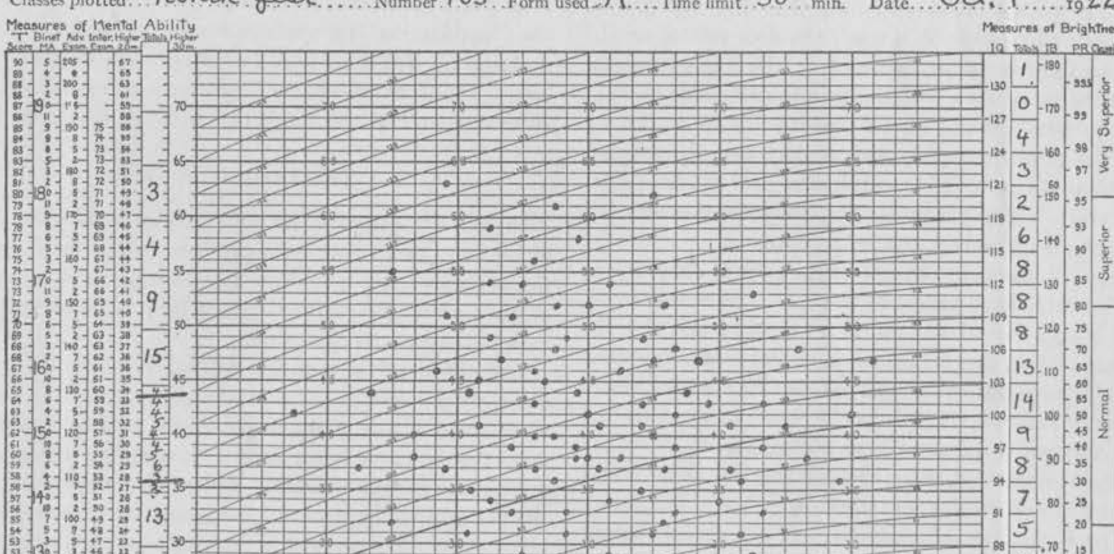

FIG. 2

KEY

Higher Form B

Page 2

1. (3)
2. (20)
3. (3)
4. (G)
5. (T)
6. (2)
7. (2)
8. (2)
9. (450)
10. (4)
11. (4)
12. (6)
13. (5)
14. (3)
15. (3)
16. (4)
17. (3)
18. (8)
19. (3)
20. (17)
21. (4)
22. (1)
23. (2)
24. (2)
25. (5)

is as follows: Find the curve which separates the upper 40 cases according to IQ. If no curve cuts off approximately 40 cases, draw a curve which does, making it parallel to the printed curves. The pupils whose scores are plotted above this curve should be placed in the fast-moving class. Similarly find or draw a curve which separates the lower 40 cases according to IQ. The pupils whose scores are plotted below this curve should be placed in the slow-moving group.

Grading within the group. The pupils of the three groups, fast-moving, normal, and slow-moving, are still to be graded. Ideally this would be done on the basis of score. Thus, if the 196 pupils in the normal group are to be placed in Grades 5, 6, 7, and 8, the lowest fourth or 49, according to score, would be placed in the 5th grade, the next 49, according to score, would be placed in the 6th grade, etc.

This would result, however, in placing in one grade pupils who, although very homogeneous as to score, had a very wide range of ages. The pupils of the 6th grade, for example, according to this plan, might range in age from a little over 9 years to nearly 16 years. Practically, therefore, it may seem more desirable to take some account of the age of the child. A very simple way to do this is by drawing lines across the middle band of the chart at a slight slant instead of horizontally, as shown in Figure 1; in this way age is automatically taken account of. The pupils represented by the dots in each area so marked out, while somewhat less homogeneous as to score, are much more homogeneous as to age. The greater the slant, the more weight is given to age.

In the sample chart provision is made for skipping certain pupils into the 9th grade, demoting others into the 4th grade, and dividing the remaining pupils into four groups of 40 each which would be placed in the 5th, 6th, 7th, and 8th grades.

If the slanting-line method is used, the dots plotted in the Interpretation Chart must be identified, or else it will be necessary to plot the score of each pupil again to determine in what grade he should be. It has been found feasible to do this by numbering the pupils consecutively on the Class Record and writing each pupil's number in small figures near the dot representing his score. If this is done, the pupils whose scores fall within a given area may be identified at once.

The number of cases represented in the sample chart is too small to illustrate the division of the fast- and slow-moving groups into grades — and, indeed, in a school of this size the establishment of fast- and slow-moving classes would doubtless entail grave administrative difficulties; but in a school where there are many more pupils, this would be done in exactly the same way as shown in the case of the normal group.

It must be remembered that the classification which would be effected by any of the above methods is rather in the nature of a goal to be worked toward gradually. It is doubtful whether it would ever be wise to reorganize a school completely on any of these plans at one time, especially on the basis of one test. It would be better, doubtless, to promote or demote extreme cases, as explained above, and as these show themselves to be properly placed others may be shifted. The teachers' independent judgments should weigh equally with the test results in determining which pupils should be regraded or in what grade any individual pupil should be placed. Indeed, the regrading should be done according to the judgment of the teachers *in the light of the test results.*

Educational and vocational guidance. In advising a young high school student regarding his educational future or his vocation, his degree of brightness should be considered. It seems probable that an entering student with a PR of 90 or higher may safely be permitted to attempt to finish high school in $3\frac{1}{2}$ or even 3 years. A student with a PR of 50 or less should certainly be prevented from attempting more than the regular course. Any one interested in research will do well to investigate the degree of brightness necessary to complete successfully the high school in $3\frac{1}{2}$ or 3 years.

A boy or girl having a PR of 75 or over may be safely encouraged to go to college. Doubtless many whose PR's are between 50 and 75 will succeed in college if industrious. A boy or girl whose PR is less than 25 probably should be dissuaded from going to college. Here again there is need of research.

Similarly the degree of brightness of a student should be considered in advising him regarding a vocation. Bright students should be encouraged to enter the professions. Dull ones should be helped to choose a trade. The Stenquist Mechanical Aptitude Tests[1] may help to discover the proper trend of a boy's education.

Classification Test. If it is desired to give a general achievement test in any grade from the fourth to the ninth in addition to the Intermediate Examination, it is recommended that the Classification Test[1] be used. The Classification Test is a combination of the Intermediate Examination and a general achievement test covering reading, arithmetic, spelling, grammar and diction, geography, history and civics, literature, vocabulary, physiology and hygiene, and general information, including music and art. Form A of the Classification Test contains Form A of the Intermediate Examination, and Form B of the Classification Test contains Form B of the Intermediate Examination. The time limit on each of the two parts is one-half hour. The correlation of the Classification Test and the Stanford Achievement Test was found by Dr. E. E. Keener to be .83.

The Percentile Graph

In order to compare the score of any pupil with the scores of the class as a whole or to compare two or more classes, the most effective way is to draw a percentile curve for each grade or class on the Percentile Graph, a copy of which is included in each package of Examinations.

Definition of percentile curve. A percentile curve is a smooth line having a horizontal length representing 100 per cent of the scores of any group of individuals and so drawn that any point on the curve has a height representing the amount of a given score and a horizontal position on the graph representing the per cent of the scores of the group that is exceeded by the given score. The method of drawing a percentile curve is given in full below. One not familiar with percentile curves will appreciate their significance after studying the directions for drawing them.

A percentile curve shows at a glance not only the median score of a class but also the range and variability of the scores. It shows at a glance just what per cent of the scores of the class is exceeded by the score of any given individual and just what per cent of the class attains or exceeds any given score. Two or

[1] Published by World Book Company, Yonkers-on-Hudson, New York.

1. (3)
2. (15)
3. (4)
4. (2)
5. (3)
6. (1)
7. (14)
8. (2)
9. (5)
10. (2)
11. (3)
12. (5)
13. (2)
14. (2)
15. (240)
16. (4)
17. (3)
18. (1)
19. (3)
20. (2)
21. (6)
22. (2)
23. (4)
24. (3)
25. (4)
26. (2)

more curves on the same graph show very vividly the amount of overlapping of the scores of different classes.

Directions for Drawing a Percentile Curve

General procedure. The steps taken in drawing the percentile curve are: (1) distributing the scores, (2) finding the subtotals — number of cases to and including those in each class interval, (3) reducing these subtotals to per cents of the number of cases in the group, (4) locating points in the graph representing these per cents, and (5) drawing a smooth curve through these points.

Provision is made for distributing the scores of two groups of individuals on one Percentile Graph sheet, and from these distributions two percentile curves may be drawn. This does not mean, however, that only two curves may be drawn on one graph. The scores of additional groups may be distributed on other Percentile Graph sheets or any sheet of paper and as many curves drawn on one graph as may be conveniently distinguished.

Distributing the scores. In one of the columns headed "Tallying," distribute the scores of a class by putting a short mark opposite the interval of score within which the score of each individual falls. The sample Percentile Graph (Fig. 3) shows that in the freshman class two individuals had scores between 60 and 64, two had scores between 55 and 59, five had scores between 50 and 54, etc. If the scores of a class have been plotted on an Interpretation Chart, the number of scores falling within each interval of score may be copied directly on to the Percentile Graph sheet in figures, as shown in the sample in the case of the sophomore class. This will save distributing the scores again. The number of tallies or the figure in the Tallying column which tells the number of scores falling within any given interval of scores is called a "frequency." The frequency of freshman scores between 45 and 49, for example, is 8.

Finding the subtotals. Begin at the bottom of the column of frequencies and place in the square to the right of each frequency the sum of the frequencies up to and including those in that group. In the "Subtotal" column, under "Freshman," there is 1 score in the first interval, a subtotal of 2 to and including the second interval, a subtotal of 4 to and including the third interval, etc., and 50 to and including the last interval. This last "subtotal" (50) should equal the number of students in the class, as entered at the top of the column.

Reducing subtotals to per cents. In the column headed "Per cents," write opposite each subtotal the per cent that subtotal is of the whole number of students in the class. In the sample, under Freshman, 1 is 2 per cent of 50, 2 is 4 per cent of 50, 4 is 8 per cent of 50, etc., and 50 is 100 per cent of 50.

It is not necessary to reduce subtotals to per cents when use is made of the Scale Chart printed on the back of the Percentile Graph. The manner of using the Scale Chart is given below.

Locating points in the graph. First place a dot at the left edge of the graph on the horizontal line representing the lower limit of the lowest class interval containing a score. Next, place on the next line above, a dot having a distance to the right of the left margin of the graph equal to the first number in the per cents column, according to the scale at the foot of the graph. (In the sample the second dot in the percentile curve for the freshmen is placed 2 units from the edge of the graph.) Next, place on the next line above, a dot having a distance to

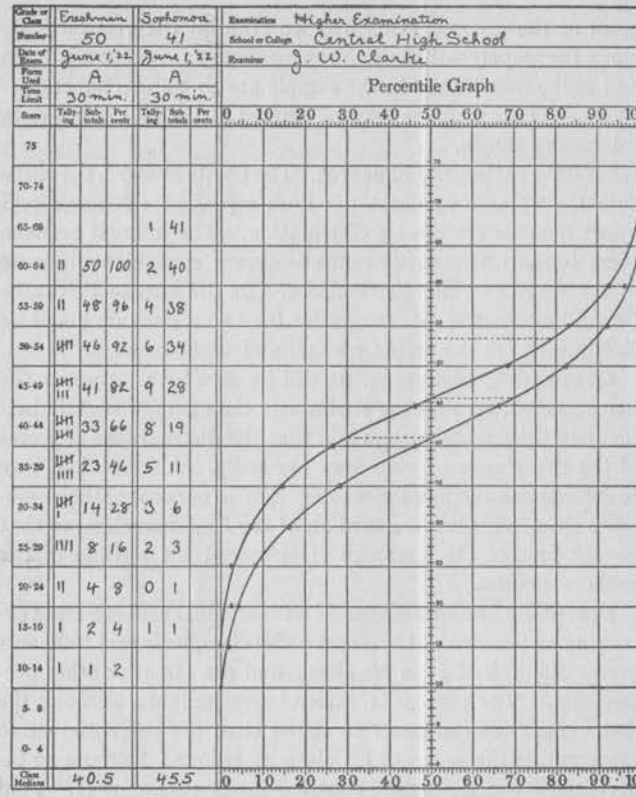

Fig. 3

the right of the margin representing the next per cent, etc. (The third dot represents 4 per cent, etc., and the last dot represents 100 per cent.)

Use of Scale Chart. The Scale Chart on the back of the Percentile Graph is provided to simplify the process of plotting the points in the graph. It is used as follows: Let us take the case of the freshman class, there being 50 students in the class. Find Scale 50 on the Scale Chart according to the numbers at the right. This line is divided into exactly 50 equal parts by the slanting lines in the chart. Each space, therefore, represents $\frac{1}{50}$ or 2 per cent of the width of the graph. The second dot in the freshman percentile curve is to be placed just $\frac{1}{50}$ of the distance to the right of the margin. This is just 1 space on Scale 50. The third dot is to be placed just 2 spaces to the right of the margin, the fourth point just 4 spaces to the right of the margin, etc., according to Scale 50 in the Scale Chart. By the use of Scale 41 the points have been plotted in the same way for the sophomore class.

By folding the Scale Chart on the proper scale and applying it to the Percentile Graph,[1] the width of the graph may be divided into any number of equal parts from 40 to 100. By letting 2 or 4 graduations represent 1 unit or letting 1 graduation represent 2 units, the width of the graph may be divided into any number of equal parts from 10 to 200.

Drawing the curve. Draw a smooth curve through the dots plotted as described above. This is the percentile curve.

Finding median score of class. The point where the percentile curve cuts the 50-percentile line represents the median

[1] If only one Percentile Graph is at hand, the proper distances may be transferred from the Scale Chart on the back by means of a strip of paper.

score of the group.[1] This may be read on the vertical scale along the 50-percentile line. The median scores of the freshman and sophomore classes in the sample are 40.5 and 45.5, respectively. These medians may be entered at the foot of the data columns as shown.

Finding variability of scores. The points at which the curve cuts the 25 and 75 percentile lines represent the lower and upper quartile scores of a distribution. The interval between these is the interquartile range — a very convenient measure of the scatter of the distributions. In the sample Percentile Graph the interquartile ranges for the two classes are about 14 points each (freshmen, 33.5 to 47, and sophomores, 39 to 53).

Overlapping of classes. It will be seen by a glance at the percentile curves that the sophomore class is only slightly better than the freshman class and that the distributions of scores of the two classes overlap very markedly. A convenient way to express this overlapping is to say that 30 per cent of the sophomore class fall below the median of the freshman class, or that 30 per cent of the freshman class exceed the median of the sophomore class.

Percentile rank in class. If an individual makes a score exceeding 25 per cent of the scores of his class, he is said to have a percentile rank of 25 in his class; and the same for other percentages. The percentile rank of any individual among the members of his class may be found from the percentile curve representing the scores of his class as follows: Suppose an individual in the sophomore class has made a score of 53. Find the point 53 on the vertical scale in the Percentile Graph and move the pencil horizontally to the point at the same height on the percentile curve. This point represents on the horizontal scale a percentile rank of 79. The percentile rank of the individual among the members of his class is, therefore, 79, which means that his score exceeds the scores of 79 per cent of his class. A score of 53 represents a Percentile Rank of 89 among the members of the freshman class.

In so far as mental ability, as measured by this examination, is an indication of the scholarship to be expected from a student, the percentile rank of a student in class may be taken as showing how he should stand in this regard to the class as a whole.

The meaning of "percentile rank in class" must be distinguished from that of "Percentile Rank," a measure of brightness, referring to the rank of an individual among a large unselected group of his own age.

Reliability and Validity

Reliability. By "reliability" is meant the degree to which the scores of the test are consistent in measuring whatever the test measures. Reliability is determined by means of correlation between different forms of the same test. The coefficients of correlation were found between Forms A and B of both examinations as follows:

Higher Examination, Grades 7 to 12:

Group I, Form A first, 128 cases, $r = .917 \pm .009$ } avg. .921
Group II, Form B first, 125 cases, $r = .925 \pm .009$

Intermediate Examination, Grades 4 to 9:

Group I, Form A first, 215 cases, $r = .953 \pm .006$ } avg. .948
Group II, Form B first, 212 cases, $r = .943 \pm .007$

[1] The value so found may not be exactly the same as the median found in the usual way by counting to the middle paper in order of score, but if not, the median score found by means of the curve is considered to represent the distribution better and to be in that sense more accurate.

The values of the probable error of a score determined from these groups were respectively 2.56 and 2.68 points for the Higher Examination and 2.85 and 2.78 for the Intermediate Examination. The probable error of a score in either examination, therefore, is slightly over $2\frac{1}{2}$ points. This means that the score in either examination will be correct within about $2\frac{1}{2}$ points in half the cases. As has been shown, this means also that the probable error of an IQ is about $2\frac{1}{2}$ points.

Validity. There is no direct method, of course, of finding the true validity of the tests — the degree to which they measure the hypothetical quality we call mental ability. The method of standardization is perhaps the best assurance as to the validity of the tests. Various other indications are available, however. The coefficient of correlation between the Higher Examination and the Advanced Examination taken two years earlier was .889 for 180 cases in Grades 7 to 12. The average of four coefficients of correlation between the Higher and Intermediate Examinations, averaging about 100 cases each in groups covering Grades 7 to 9, was .842. The correlation between scores in the Higher Examination and "scholarship" is reported by Clarence W. Proctor, Principal of High School, Bangor, Maine, as follows:

Grade 11, number of cases 240, $r = .55$
Grade 12, number of cases 204, $r = .57$

The correlation between scores in the Higher Examination and scholarship as reported by the teachers of 157 high school freshmen in Oakland, California, was .59.

The correspondence between scores in the Higher Examination and letter ratings used in connection with Alpha is shown in Table 10.

TABLE 10

Alpha Ratings	Alpha Scores	Scores in Higher Examination
A	135–212	58–75
B	105–134	49–57
C+ . . .	75–104	39–48
C	45–74	28–38
C− . . .	25–44	20–27
D	15–24	15–19
E	0–14	0–14

A high score. One student has been reported to have made a perfect score of 75 points in the Higher Examination in 20 minutes. This student is characterized by the professor of educational psychology of the college as follows:

"The person is a young man just past 21 years of age. He had very poor high school training due to the fact that the schools in his section of North Carolina are not what they should be. He is finishing college in $3\frac{1}{2}$ years with about 8 quarter-hours to spare. I have looked up his college record and find that he has grades of A's or B's. There are no C's, D's, or F's. He won the scholarship medal at college before he came to this institution. (He entered here as a senior.) He is a good mixer, and I do not believe that he puts in very many hours on his studies.

"The father is a rather successful farmer. In fact, from what I can gather, he is the best farmer in his neighborhood. An older brother is a professor in a college. I have had this young man in several classes. It is my firm conviction that he could finish the average college course in two years."

Test Service Bulletins. The reader is invited to send to the World Book Company for free copies of the Test Service Bulletins for further information about testing.

OTIS SELF-ADMINISTERING TESTS OF MENTAL ABILITY

By Arthur S. Otis

Formerly Development Specialist with Advisory Board, General Staff, United States War Department

95

HIGHER EXAMINATION: FORM A

20

For High Schools and Colleges

Score............

Read this page. Do what it tells you to do.

Do not open this paper, or turn it over, until you are told to do so. Fill these blanks, giving your name, age, birthday, etc. Write plainly.

Name...Age last birthday......years
First name, initial, and last name

Birthday.................................Class.......................Date...................19....
Month Day

School or College..................................City..

This is a test to see how well you can think. It contains questions of different kinds. Here is a sample question already answered correctly. Notice how the question is answered:

Which one of the five words below tells what an apple is?
1 flower, 2 tree, 3 vegetable, 4 fruit, 5 animal..............................(4)

The right answer, of course, is "fruit"; so the word "fruit" is underlined. And the word "fruit" is No. 4; so a figure 4 is placed in the parentheses at the end of the dotted line. This is the way you are to answer the questions.

Try this sample question yourself. Do not write the answer; just draw a line under it and then put its number in the parentheses:

Which one of the five words below means the opposite of north?
1 pole, 2 equator, 3 south, 4 east, 5 west..............................(3)

The answer, of course, is "south"; so you should have drawn a line under the word "south" and put a figure 3 in the parentheses. Try this one:

A foot is to a man and a paw is to a cat the same as a hoof is to a — what?
1 dog, 2 horse, 3 shoe, 4 blacksmith, 5 saddle..............................(2)

The answer, of course, is "horse"; so you should have drawn a line under the word "horse" and put a figure 2 in the parentheses. Try this one:

At four cents each, how many cents will 6 pencils cost?..............................( )

The answer, of course, is 24, and there is nothing to underline; so just put the 24 in the parentheses.

If the answer to any question is a number or a letter, put the number or letter in the parentheses without underlining anything. Make all letters like printed capitals.

The test contains 75 questions. You are not expected to be able to answer all of them, but do the best you can. You will be allowed half an hour after the examiner tells you to begin. Try to get as many right as possible. Be careful not to go so fast that you make mistakes. Do not spend too much time on any one question. No questions about the test will be answered by the examiner after the test begins. Lay your pencil down.

Do not turn this page until you are told to begin.

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EXAMINATION BEGINS HERE:

1. The opposite of hate is (?)
   1 enemy, 2 fear, 3 love, 4 friend, 5 joy.......... (
2. If 3 pencils cost 5 cents, how many pencils can be bought for 50 cents?.......... (
3. A bird does not always have (?)
   1 wings, 2 eyes, 3 feet, 4 a nest, 5 a bill.......... (
4. The opposite of honor is (?)
   1 glory, 2 disgrace, 3 cowardice, 4 fear, 5 defeat..........
5. A fox most resembles a (?)
   1 wolf, 2 goat, 3 pig, 4 tiger, 5 cat..........
6. Quiet is related to sound in the same way that darkness is related to (?)
   1 a cellar, 2 sunlight, 3 noise, 4 stillness, 5 loud..........
7. A party consisted of a man and his wife, his two sons and their wives, and four children in each son's family. How many were there in the party?..........
8. A tree always has (?)
   1 leaves, 2 fruit, 3 buds, 4 roots, 5 a shadow..........
9. The opposite of economical is (?)
   1 cheap, 2 stingy, 3 extravagant, 4 value, 5 rich..........
10. Silver is more costly than iron because it is (?)
    1 heavier, 2 scarcer, 3 whiter, 4 harder, 5 prettier..........
11. Which one of the six statements below tells the meaning of the following proverb? "The early bird catches the worm."..........

    1. Don't do the impossible.
    2. Weeping is bad for the eyes.
    3. Don't worry over troubles before they come.
    4. Early birds like worms best.
    5. Prompt persons often secure advantages over tardy ones.
    6. It is foolish to fret about things we can't help.

12. Which statement above tells the meaning of this proverb? "Don't cry over spilt milk."....
13. Which statement above explains this proverb? "Don't cross a bridge till you get to it."....
14. An electric light is related to a candle as an automobile is to (?)
    1 a carriage, 2 electricity, 3 a tire, 4 speed, 5 glow..........
15. If a boy can run at the rate of 6 feet in $\frac{1}{4}$ of a second, how many feet can he run in 10 seconds?
16. A meal always involves (?)
    1 a table, 2 dishes, 3 hunger, 4 food, 5 water..........
17. Of the five words below, four are alike in a certain way. Which is the one not like these four?
    1 bend, 2 shave, 3 chop, 4 whittle, 5 shear..........
18. The opposite of never is (?)
    1 often, 2 sometimes, 3 occasionally, 4 always, 5 frequently..........
19. A clock is related to time as a thermometer is to (?)
    1 a watch, 2 warm, 3 a bulb, 4 mercury, 5 temperature..........
20. Which word makes the truest sentence? Men are (?) shorter than their wives.
    1 always, 2 usually, 3 much, 4 rarely, 5 never..........
21. One number is wrong in the following series. What should that number be?
    1 4 2 5 3 6 4 7 5 9 6 9..........
22. If the first two statements following are true, the third is (?) All members of this club are Republicans. Smith is not a Republican. Smith is a member of this club.
    1 true, 2 false, 3 not certain..........
23. A contest always has (?)
    1 an umpire, 2 opponents, 3 spectators, 4 applause, 5 victory..........
24. Which number in this series appears a second time nearest the beginning?
    6 4 5 3 7 8 0 9 5 9 8 8 6 5 4 7 3 0 8 9 1..........
25. The moon is related to the earth as the earth is to (?)
    1 Mars, 2 the sun, 3 clouds, 4 stars, 5 the universe..........
26. Which word makes the truest sentence? Fathers are (?) wiser than their sons.
    1 always, 2 usually, 3 much, 4 rarely, 5 never..........

27. The opposite of awkward is (?)
1 strong, 2 pretty, 3 short, 4 graceful, 5 swift..............................

28. A mother is always (?) than her daughter.
1 wiser, 2 taller, 3 stouter, 4 older, 5 more wrinkled..........................

29. Which one of the six statements below tells the meaning of the following proverb? "The burnt child dreads the fire."..

1. Frivolity flourishes when authority is absent.
2. Unhappy experiences teach us to be careful.
3. A thing must be tried before we know its value.
4. A meal is judged by the dessert.
5. Small animals never play in the presence of large ones.
6. Children suffer more from heat than grown people.

30. Which statement above explains this proverb? "When the cat is away, the mice will play."

31. Which statement above explains this proverb? "The proof of the pudding is in the eating."

32. If the settlement of a difference is made by mutual concession, it is called a (?)
1 promise, 2 compromise, 3 injunction, 4 coercion, 5 restoration.................

33. What is related to disease as carefulness is to accident?
1 doctor, 2 surgery, 3 medicine, 4 hospital, 5 sanitation.........................

34. Of the five things below, four are alike in a certain way. Which is the one not like these four?
1 smuggle, 2 steal, 3 bribe, 4 cheat, 5 sell....................................

35. If 10 boxes full of apples weigh 400 pounds, and each box when empty weighs 4 pounds, how many pounds do all the apples weigh?..

36. The opposite of hope is (?)
1 faith, 2 misery, 3 sorrow, 4 despair, 5 hate..................................

37. If all the odd-numbered letters in the alphabet were crossed out, what would be the tenth letter not crossed out? Print it. *Do not mark the alphabet.*
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z..........................

38. What letter in the word SUPERFLUOUS is the same number in the word (counting from the beginning) as it is in the alphabet? Print it..

39. What people say about a person constitutes his (?)
1 character, 2 gossip, 3 reputation, 4 disposition, 5 personality.................

40. If $2\frac{1}{2}$ yards of cloth cost 30 cents, how many cents will 10 yards cost?.....................

41. If the words below were arranged to make a good sentence, with what letter would the second word of the sentence begin? Make it like a printed capital.
same means big large the as..

42. If the first two statements following are true, the third is (?) George is older than Frank. James is older than George. Frank is younger than James.
1 true, 2 false, 3 not certain..

43. Suppose the first and second letters in the word CONSTITUTIONAL were interchanged, also the third and fourth letters, the fifth and sixth, etc. Print the letter that would then be the twelfth letter counting to the right..

44. One number is wrong in the following series. What should that number be?
0 1 3 6 10 15 21 28 34..

45. If $4\frac{1}{2}$ yards of cloth cost 90 cents, how many cents will $2\frac{1}{2}$ yards cost?.....................

46. A man's influence in a community should depend upon his (?)
1 wealth, 2 dignity, 3 wisdom, 4 ambition, 5 political power.....................

47. What is related to few as ordinary is to exceptional?
1 none, 2 some, 3 many, 4 less, 5 more...

48. The opposite of treacherous is (?)
1 friendly, 2 brave, 3 wise, 4 cowardly, 5 loyal.................................

49. Which one of the five words below is most unlike the other four?
1 good, 2 large, 3 red, 4 walk, 5 thick...

50. If the first two statements following are true, the third is (?) Some of Brown's friends are Baptists. Some of Brown's friends are dentists. Some of Brown's friends are Baptist dentists.
1 true, 2 false, 3 not certain..

51. How many of the following words can be made from the letters in the word LARGEST, using any letter any number of times?
great, stagger, grasses, trestle, struggle, rattle, garage, strangle..............

52. The statement that the moon is made of green cheese is (?)
1 absurd, 2 misleading, 3 improbable, 4 unfair, 5 wicked.........................

 Do not stop. Go on with the next page.

53. Of the five things following, four are alike in a certain way. Which is the one not like these four?
1 tar, 2 snow, 3 soot, 4 ebony, 5 coal..

54. What is related to a cube in the same way in which a circle is related to a square?
1 circumference, 2 sphere, 3 corners, 4 solid, 5 thickness..........................

55. If the following words were seen on a wall by looking in a mirror on an opposite wall, which word would appear exactly the same as if seen directly?
1 OHIO, 2 SAW, 3 NOON, 4 MOTOR, 5 OTTO..

56. If a strip of cloth 24 inches long will shrink to 22 inches when washed, how many inches long will a 36-inch strip be after shrinking?..

57. Which of the following is a trait of character?
1 personality, 2 esteem, 3 love, 4 generosity, 5 health..........................

58. Find the two letters in the word DOING which have just as many letters between them in the word as in the alphabet. Print the one of these letters that comes first in the alphabet.
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z..........................

59. Revolution is related to evolution as flying is to (?)
1 birds, 2 whirling, 3 walking, 4 wings, 5 standing..........................

60. One number is wrong in the following series. What should that number be?
1 3 9 27 81 108..

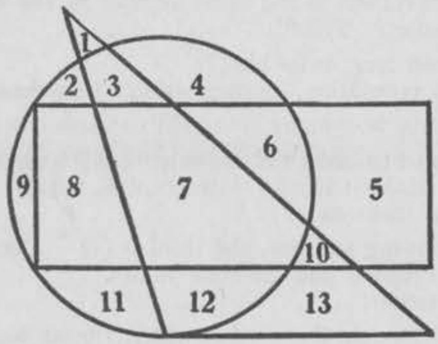
61. If Frank can ride a bicycle 30 feet while George runs 20 feet, how many feet can Frank ride while George runs 30 feet?..

62. Count each N in this series that is followed by an O next to it if the O is not followed by a T next to it. Tell how many N's you count.
N O N T Q M N O T M O N O O N Q M N N O Q N O T O N A M O N O M.......

63. A man who is averse to change and progress is said to be (?)
1 democratic, 2 radical, 3 conservative, 4 anarchistic, 5 liberal..........................

64. Print the letter which is the fourth letter to the left of the letter which is midway between O and S in the alphabet..

65. What number is in the space which is in the rectangle and in the triangle but not in the circle?



66. What number is in the same geometrical figure or figures as the number 8?................

67. How many spaces are there that are in any two but only two geometrical figures?..........

68. A surface is related to a line as a line is to (?)
1 solid, 2 plane, 3 curve, 4 point, 5 string..

69. If the first two statements following are true, the third is (?) One cannot become a good violinist without much practice. Charles practices much on the violin. Charles will become a good violinist.
1 true, 2 false, 3 not certain..

70. If the words below were arranged to make the best sentence, with what letter would the last word of the sentence end? Print the letter as a capital.
sincerity traits courtesy character of desirable and are..........................

71. A man who is influenced in making a decision by preconceived opinions is said to be (?)
1 influential, 2 prejudiced, 3 hypocritical, 4 decisive, 5 impartial..................

72. A hotel serves a mixture of 2 parts cream and 3 parts milk. How many pints of cream will it take to make 15 pints of the mixture?..

73. What is related to blood as physics is to motion?
1 temperature, 2 veins, 3 body, 4 physiology, 5 geography..........................

74. A statement the meaning of which is not definite is said to be (?)
1 erroneous, 2 doubtful, 3 ambiguous, 4 distorted, 5 hypothetical..................

75. If a wire 20 inches long is to be cut so that one piece is $\frac{2}{3}$ as long as the other piece, how many inches long must the shorter piece be?..

MacQuarrie Test for Mechanical Ability

96

By T. W. MacQuarrie, Ph.D.

This test is an attempt to provide a standard performance for the measurement of mechanical ability.

The term **mechanical ability** has never been carefully defined, in fact, a complete analysis would be very difficult. We assume that it takes mechanical ability to do the work of the mechanic, but we have a feeling that such ability is also used in greater or less degree by the barber, typist, motorman, waiter, telephone operator, tailor, plasterer, dentist, draftsman, baseball pitcher and pianist. These, and many others in addition to the mechanics, require manipulative skill, recognition of space relations, speed, muscular control, visual acuity, and all those accomplishments which we usually associate with the mechanical trades.

No estimate of mechanical ability can be anything but rough. Nor is an accurate measurement necessary. There is no valid evidence at present to show that the carpenter requires more mechanical ability than the machinist, nor that the house painter must develop greater skill than the plumber. As a matter of fact, men with various degrees of mechanical ability do function in the same trade. If we had a definite minimum norm for entrance to each mechanical trade, then it would be important to have accurate measurements. Since there are no such norms, the best we can do is to say that a candidate for a mechanical vocation should show a high degree of mechanical ability before money is spent upon his training. There are not so many mechanics in the country that we need to take candidates haphazard. If we are to increase efficiency, we must train only those best fitted for the work.

If a shop foreman were asked to judge a strange mechanic, he would probably have the man do a piece of work in the trade. The skill he showed in handling his tools, the speed with which he worked, and the quality of his product would determine the man's rating in the mind of the foreman. Other competent foremen, however, would no doubt give the man different ratings, for it is a fact, here as elsewhere, that judges disagree.

In view of the fact that there is no standard piece of work requiring mechanical ability, this test has been developed with the hope that it might meet such a need. It is very simple. It requires for its material—paper, and for the single tool used—a lead pencil. It takes very little time to give and score. It has a high reliability and a satisfactory validity. Women and girls can take it as well as boys and men. It is well adapted to ages of ten years and up. Some eight and nine year olds even have made good scores. It has a very low correlation with inteligence test results, indicating that it measures something different. Those who take the test find it interesting, and teachers of shop work have approved of it as a mechanical job. They feel that it requires many of the abilities they use in making a table, or an elbow, or a piston ring. Considerable statistical evidence has been produced already to show that it is a satisfactory measure of general mechanical ability, and it is offered to those interested with the hope that it will be of service in selecting candidates for the mechanical trades.

At the present time, many counselors in junior and senior high schools, and a number in universities are placing scores on this test on the personnel cards of their students. In that way they have always on hand a standard measure of mechanical ability, and they may offer

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advice when the proper time comes which is something more than the usual off-hand guess. One dental college is already using the test to get an estimate of the aptitude of their candidates for training in manipulating dentistry. Dental training costs the student about ten thousand dollars, and the man who has little mechanical ability cannot possibly be a success.

A boy or girl should make a high score in mechanical ability before being approved by the counselor for a mechanical trade. Our estimates are bound to be rough, and we shall be more nearly right if we accept high scores only. A subject with an average score might be approved for a mechanical trade under specially favorable conditions, but it is very doubtful if a school is warranted in attempting to train anyone who makes a low score. In general it will be found that those who make low scores are not very much interested in mechanical trades, and respond readily to suggestions for other vocations.

Norms have been worked out for ages from ten to twenty. There is a wide range of scores for every age, and a great deal of overlapping. There is little increase from age to age, but it is rather steady. About a thousand cases, mostly school and college students were used to compute the norms. Later additions will change them somewhat, but not to any great extent.

For each age the mean is given, and also norms a standard deviation below and above the mean. A score which is near the highest norm for the age might well be considered high, one near the mean is average, and one near the lowest norm is certainly low. In the table given below, a few cases above the range were included with the twenties, and a few cases below were included with the tens.

AGE NORMS

Equalled or Exceeded by: Age	Very Low (93%)	Low (84%)	Low Average (69%)	Average (50%)	High Average (31%)	High (16%)	Very High (7%)
10 years	14	18	22	26	30	34	38
11 years	23	28	32	37	42	46	51
12 years	27	33	38	44	50	55	61
13 years	31	37	43	49	55	61	67
14 years	33	40	46	53	60	66	73
15 years	36	43	50	57	64	71	78
16 years	37	45	52	60	68	75	83
17 years	39	47	55	63	71	79	87
18 years	41	49	57	65	73	81	89
19 years	43	51	59	67	75	83	91
20 years	44	52	60	68	76	84	92

In interpreting the above norms it might be said that the subject who gets a score that is **high** would be about number sixteen from the top in a hundred unselected cases of that age arranged in the order of their mechanical ability. A **low** score would indicate that he would be about number sixteen from the bottom, and an **average** score would be in the middle.

A full description of this test will be found in the January, 1927, number of **The Journal of Personnel Research.**

DIRECTIONS

The usual rules for group test procedure, standard directions and standard conditions, apply in this case.

Ordinary school lead pencils, of medium hardness (No. 2) should be supplied. They should be sharpened on a pencil sharpener at both ends each time before using. (After the first sharpening they can be kept in proper condition very easily.) Other pencils should not be permitted.

A stop watch is desirable. The time can be taken from an ordinary watch which has a second hand, but a stop watch is easier to use, and more satisfactory.

Commands for starting and stopping should be given sharply and so all can hear. Where necessary, comments may be made at the end of practice tests for the benefit of those who start before the signal, or who do not stop promptly.

The examiner should pass quickly from each record test to the following practice test in order to interfere with attempts to add records after time is called. It is desirable, however, to take sufficient time on a practice test to be sure instructions are fully understood before going on to the record test.

Where large groups are being tested it is advisable to have one or more trained assistants in the room in order to assure standard procedure.

Where tests are given frequently, and to rather large groups, it is desirable for the examiner to have copies of the practice forms made on large sheets of cardboard to be hung up before the class. The instructor can then refer to them when giving directions.

GIVING THE TEST

(As soon as booklets and pencils are distributed.)

Fill in the blanks on the cover, but do not open the booklets.

(Allow about two minutes.)

This is a test to see what you can do with your hands and eyes. Use the pencils provided, as they are all the same. If a lead breaks, use the other end of your pencil, and go right on. You will have opportunity for practice before each test. Do your work as well as you can and as fast as you can. The signal will be READY, GO! and READY, STOP! Be sure to start and stop instantly.

Turn to Page 2. Fold your booklets back flat each time, like this. (Examiner illustrates.)

PAGE TWO

This is the practice test for TRACING.

Notice the little black triangle under the word START. You are to begin at the little triangle and draw a curved line through the small openings in the vertical lines without touching them. Draw first to the right and then back to the left in one continuous line. (Examiner should illustrate by holding up a test form, and showing how to do it.)

READY. Put pencils on the little triangles, GO!

(THIRTY SECONDS.)

READY, STOP. (Allow about two seconds between READY and STOP on all tests.)

Now look at your work to see if you have made any mistakes. You should be able to see clear space at every opening between your pencil line and the printed line.

Turn the booklet over to Page 3.

PAGE THREE

This is the real TRACING test. The instructions are the same.

READY, GO!

(FIFTY SECONDS.)

READY, STOP!

Turn to Page 4.

(The examiner should see that the booklets are folded back each time a page is turned.)

PAGE FOUR

This is the practice test for TAPPING. Here you are to put three pencil dots in each circle just as fast as you can. Start at the left of each line and work to the right, as you do in writing. Count to yourself as you tap, and very fast, 1, 2, 3 — 1, 2, 3, etc. Try to make just three dots each time, but do not stop to correct. Speed is of more importance than accuracy. You do not need to strike hard nor raise your pencils high. Be sure to start and stop instantly.

READY, GO!

(TEN SECONDS.)

READY, STOP!

Cross out any dots you made after the STOP signal.

(Do not permit further practice in tapping, as an element of fatigue will enter and spoil the test. In fact it is best to allow a moment for relaxation before going on.)

Turn to Page 5.

PAGE FIVE

This is the real test for TAPPING. The instructions are the same.

READY, GO!

(THIRTY SECONDS.)

READY, STOP!

Turn to Page 6.

PAGE SIX

This is the practice page for the DOTTING test.

Here you are to put one dot in each circle, as fast as you can. Follow the string. Dots must be clearly within the circles, and only one dot will be counted for any circle.

READY, GO!

(FIFTEEN SECONDS.)

READY, STOP!

Now see if you have made any mistakes. There should be just one dot in each circle, and it should not touch the circumference. (Be somewhat deliberate here.)

PAGE SEVEN

This is the real DOTTING test. Put one dot in each circle just as fast as you can.

READY, GO!

(THIRTY SECONDS.)

READY, STOP!

Turn to Page 8.

PAGE EIGHT

In this test you are to copy each of the figures in the dotted space to the right of it. The little circles show you where to begin. There is a dot for every corner. Your lines do not have to be straight, but they should begin and end on dots. Correct, if you wish, but do not waste time erasing.

(The examiner should illustrate, and may have to assist individuals with further explanations.)

READY, GO!

(TWENTY SECONDS.)

READY, STOP!

Check your work to see if you have copied the figures correctly.

(Some additional explanations may be necessary, but the examiner must guard against wasting time with the few who do not really understand.)

Turn to Page 9.

PAGE NINE

This is the real COPYING test. Work across the page in each row. (This is not vital, but helps somewhat in scoring.)

READY, GO!

(TWO AND ONE-HALF MINUTES.)

READY, STOP!

Turn to Page 10.

PAGE TEN

This is the LOCATION test. Notice the letters in the large square, and the five dots in each of the small squares below. For each dot in a small square, there is a letter in the same place in the large square. Put right on each dot the letter that stands in its place in the large square. For instance, the upper dot in the first small square is in the position of the letter K in the large square, so you will put a letter K on that dot.

READY, GO!

(THIRTY SECONDS.)

READY, STOP!

In the small square at the left you should have V. K, N, E, K. In the one at the right you should have U, E, M, O, C.

(Take a little time here for consideration of errors.)

Turn to Page 11.

PAGE ELEVEN

This is the real LOCATION test.

READY, GO!

(TWO MINUTES.)

READY, STOP!

Turn to Page 12.

PAGE TWELVE

Here is a pile of blocks, all the same size and shape. On five of the blocks, you will see X's. You are to find out how many blocks touch each block that has an X on it, and then mark the number right on the X. For example, the lowest block which has an X on it touches four other blocks. Please locate them now and place a 4 on the X. Put it there now, and you may have twenty seconds in which to number the other X's.

READY, GO!

(TWENTY SECONDS.)

READY, STOP!

You should have 2, 4, 4, 7, 4.

(Allow a moment for consideration.)

Turn to Page 13.

PAGE THIRTEEN

This is the record test for BLOCKS.

READY, GO!

(TWO AND ONE-HALF MINUTES.)

READY, STOP!

Turn to Page 14.

PAGE FOURTEEN

This is the PURSUIT test. Notice the numbers in the little squares at the left, where the curving lines begin. Follow each line by eye from the square where it begins at the left to the square where it ends at the right. Remember the number at the beginning of the line, and put it in one of the small squares at the end. Do not be disturbed if two lines end in the same place, but just use both squares for your answers. Do not use your pencils to follow the lines if you can possibly help it. You will work much faster if you depend entirely upon your eyes.

READY, GO!

(FIFTY SECONDS.)
READY, STOP!

Your answers should read from top to bottom: 10, 3 and 8 together, 4, 2, 7, 5, 1, blank, 9, 6.

(Some further instructions may be necessary in individual cases.)

Turn to Page 15.

PAGE FIFTEEN

This is the real PURSUIT test.

Do not follow the lines with your pencils if you can help it.

READY, GO!

(TWO AND ON-HALF MINUTES.)
READY, STOP!

Close the booklets.

(Booklets and pencils should be collected promptly.)

SCORING THE TEST

Scoring for this test is very easy, and highly objective. It is good practice to score at one time, the same page right through all of the pamphlets. When all of the forms have been checked, the results should be recorded in the blank spaces on the cover, and the final score determined.

TRACING, PAGE THREE

This test has been placed first in the battery because the pencils are then in good condition.

Score is the number of openings through which the pencil line passes without touching. If to the scorer the line seems to touch as it passes through an opening, the attempt is counted an error. There is a total possible score of eighty, twenty openings in each row. One good method of scoring checks all the errors first, and then subtracts from the total attempted. If more than one attempt is made at an opening, credit is given for only one correct. Touching the printed line at a point other than an opening does not count an error. Short breaks in the pencil line are not noted, but if the total response is merely a series of dashes at the openings, no credit is given. Occasionally all of the tracing is done to the right. Full credit should be given in this case for openings properly passed.

TAPPING, PAGE FIVE

In such a test as this slight approximations may be made. The score is one-third of the number of dots, approximately the number of circles attempted. Since this test is an attempt to measure motility, all dots are counted even if they are not wholly within the circles, or even if some of them are entirely without the circles. The directions are merely for the purpose of spreading the dots so they can be counted. Occasionally more or less than three dots will be made in a circle, but usually they will contain just three. The scorer should glance over the page to see if most of the circles have the required three dots, and if that number appears to be in the great majority, the score is simply the number of circles attempted. If there is much variation the dots may be counted and divided by three, using the nearest whole number for the score.

DOTTING, PAGE SEVEN

The score in this test is one-third of the number of correct responses. This is not a test of motility, but rather of aiming, and no dot is counted unless it is clearly within the circle, and does not touch the circumference. If in doubt whether it touches or not, mark it wrong. It is best to check the errors first, and then subtract their number from the number attempted. Only one dot can be counted for any circle. Divide the total by three to get the score, using the nearest whole number.

COPYING, PAGE NINE

Score is the number of correct lines on the page. To be correct, a line must have proper length and direction

It is not penalized by previous incorrect lines, however. That is, it does not have to be in correct position with reference to the starting circle, but it should have proper length and direction and be intended evidently for a certain line in the figure. Lines should begin and end on dots, but slight discrepencies in this respect should be disregarded.

Scorer should take a general view of each figure, and if it is a correct copy, count 4 for it. Where some errors have been made, all correct lines should be counted and added to the total.

LOCATION, PAGE ELEVEN

Score is the number of dots correctly lettered. Beginning at the upper left, and following the string of small squares around to the upper right the answers are as follows, reading from the top down in each small square. F J O C F, L P N B K, D H P A H, C G R V E, K S Z C M, A H W Y G, B U D L H, E M T W J.

These letter answers may be written beside the proper squares on a used form, and then the squares may be cut out making a stencil that will aid much in scoring. Scores for each square may be marked right on the square and totaled later.

BLOCKS, PAGE THIRTEEN

Score is the number of blocks correctly marked. The strip printed below indicates the answers. Cut out the strip very close to the figures and paste it on a piece of cardboard, cutting the latter to fit. Then the strip may be placed between the upper and lower rows of blocks, and the answers will be in proper order for the X's to which they apply.

PURSUIT, PAGE FIFTEEN

Score is number of squares correctly numbered. The answers are as follows:

Upper left: 9, 4, 5, 1, 10, 8, 6 & 7,—, 2, 3.
Lower left: 9, —, 3 & 10, 8, 7, 1, 4, 5, 2, 6.
Upper right: 3 & 7, 8, 10, 2, 4, 6, —, 1, 5, 9.
Lower right: —, 1, 3, 6, 5, 10, 8, 2 & 9, 4, 7.

Cut out a rectangle of cardboard or heavy paper three inches by four and a quarter. This card will fit in between the answer columns. Record the answers given above at the proper places, and scoring will be made easier. Answers may be recorded for each section and totaled later.

TOTAL SCORE

Record the form scores on the front cover of the booklet. The total score is the sum of the form scores divided by three, using the nearest whole number.

5 6 6 7 5 4 3 5 4 6 5 5 4 4 3
3 2 5 4 7 4 5 2 3 4 6 5 5 8 4

MACQUARRIE TEST for MECHANICAL ABILITY

A Simple Group Performance Test for the Use
of School Counselors and Personnel Managers

By T. W. MacQuarrie, Ph. D.

FILL IN THE BLANKS BELOW, BUT DO NOT OPEN THE BOOKLET

City.................................... Date..........................

School............................Grade.............................

................................., ...
(Print your last name) (Print first name and initial)

Age, last birthday............Date of birthday ....

Published by
California Test Bureau
3636 Beverly Blvd., Los Angeles, Calif.

RECORD

Tracing..........................

Tapping..........................

Dotting..........................

Copying..........................

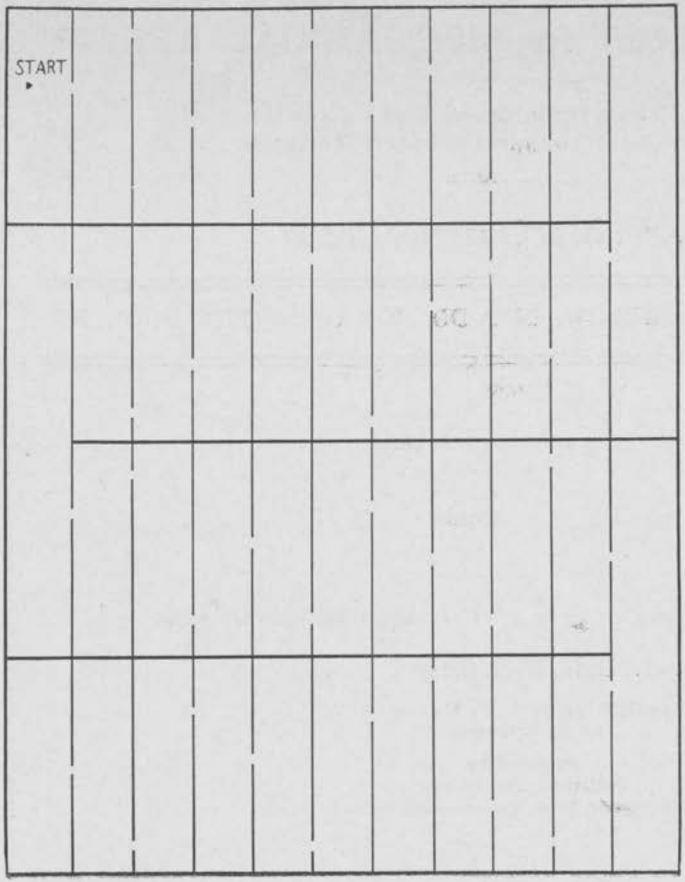
Location..........................

Blocks..........................

Pursuit..........................

Total 3)..........................

Score: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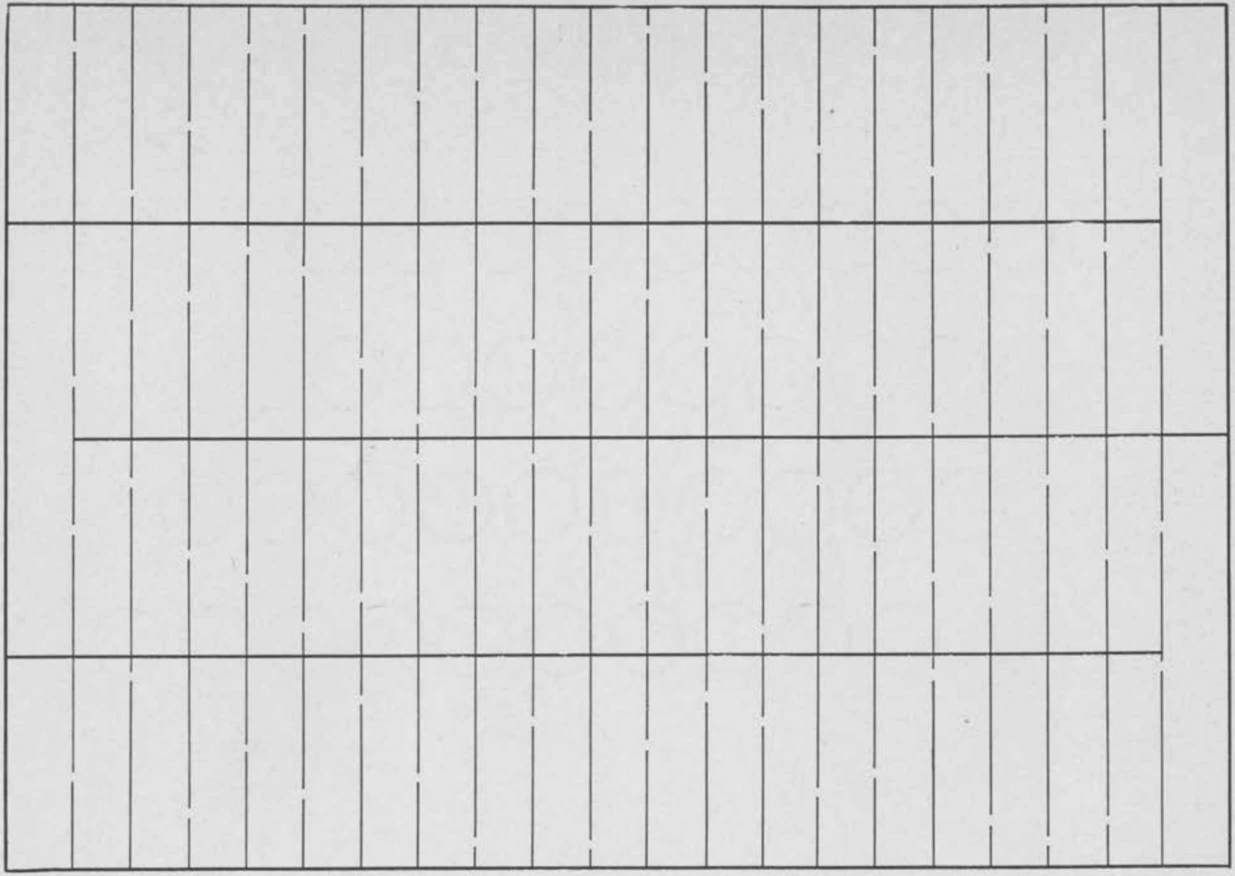
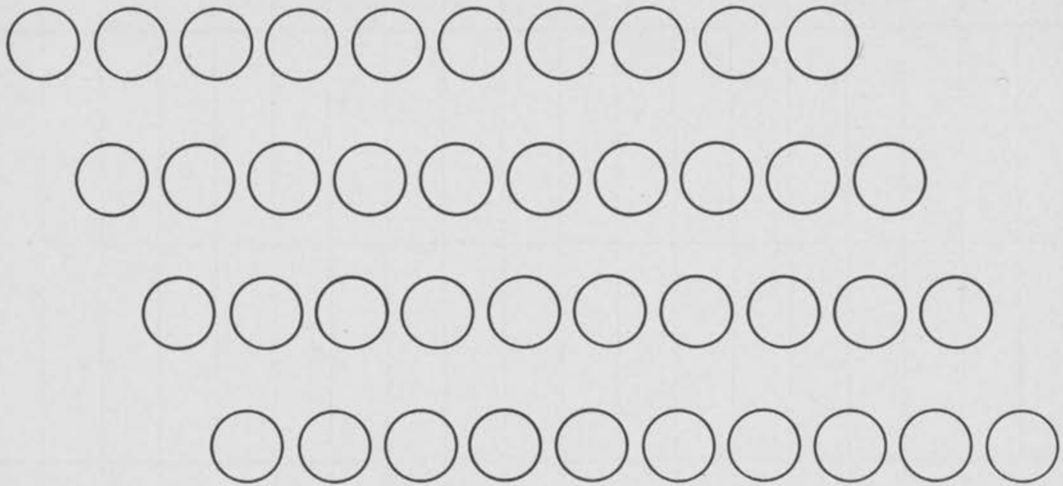
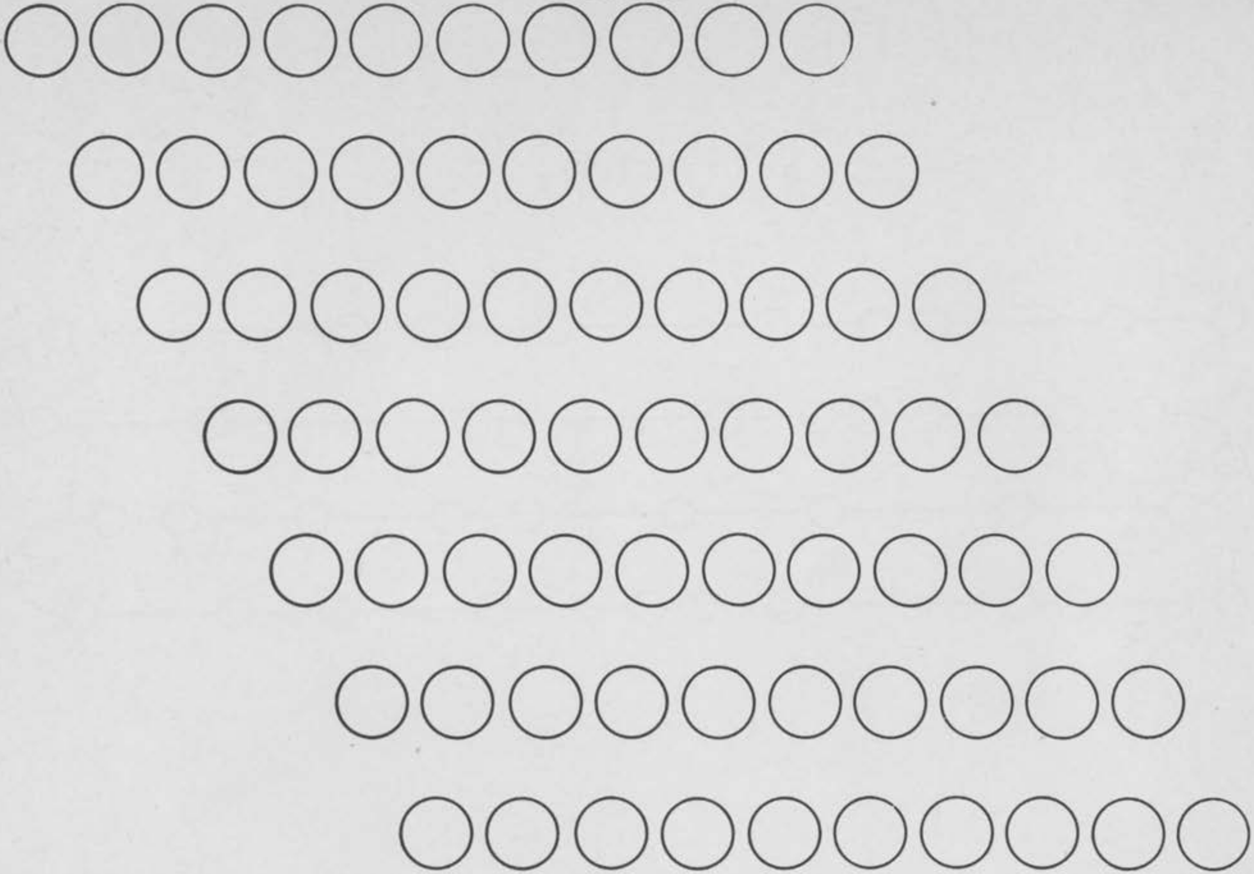


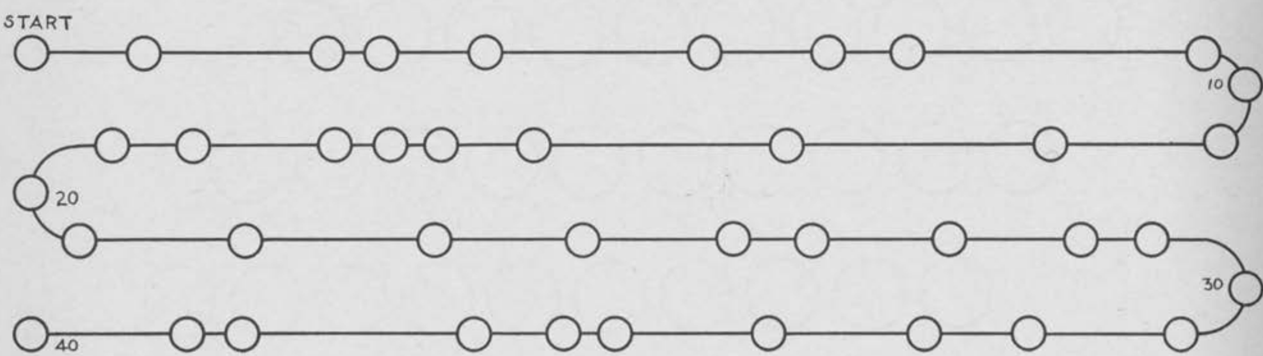
Score. . . . .

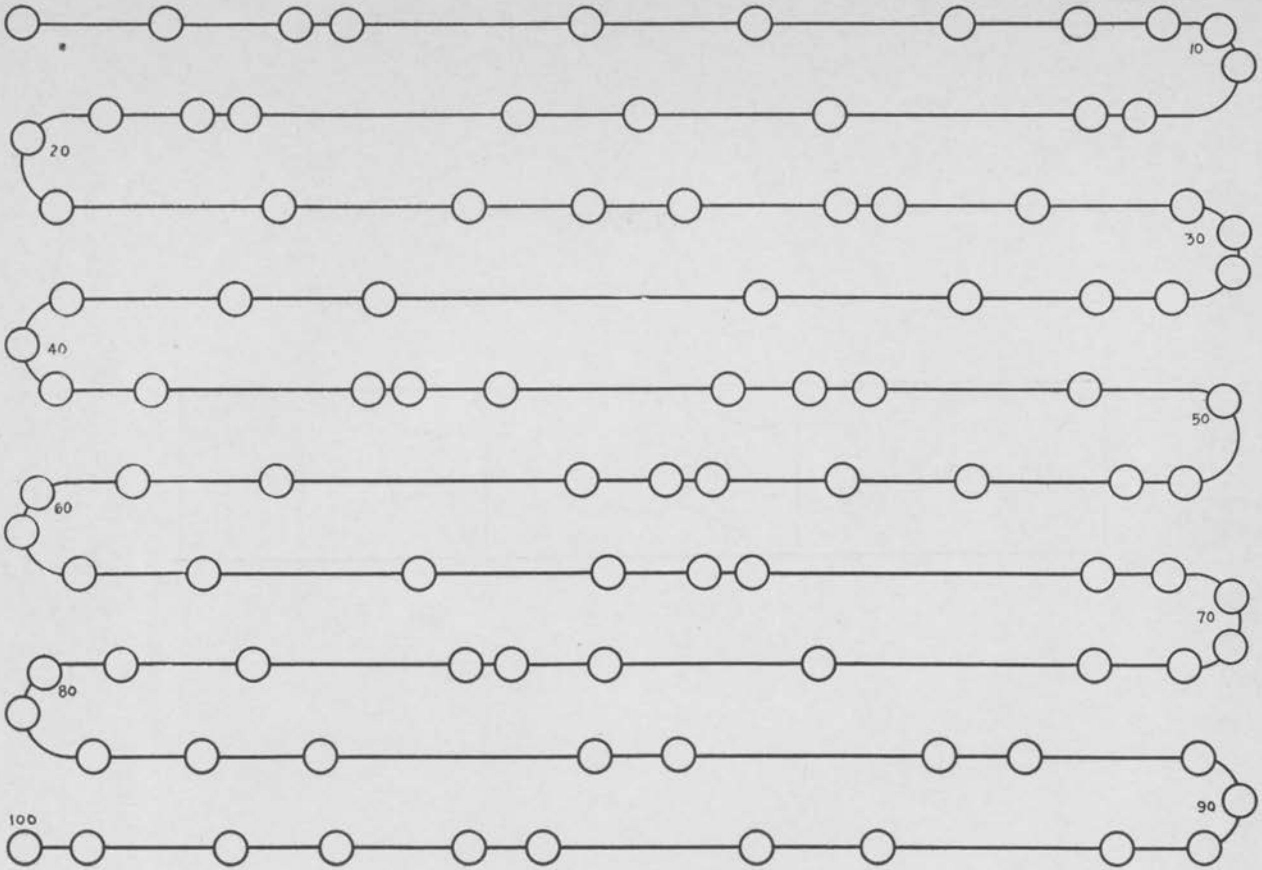




Score. . . . .

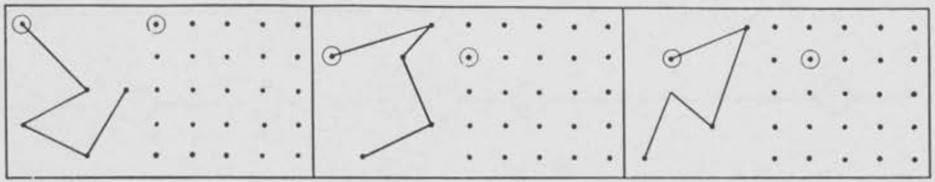
DOTTING

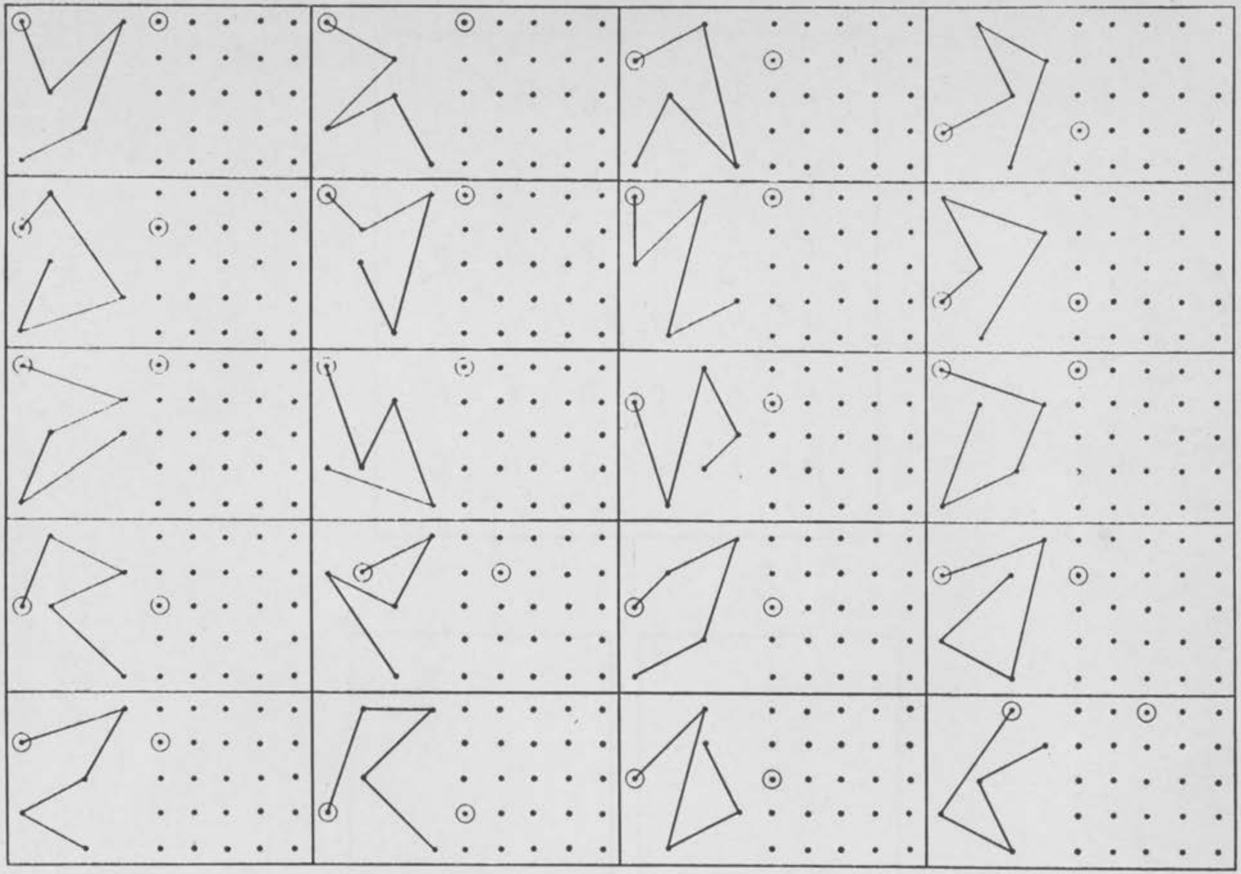




Dots............÷3=................

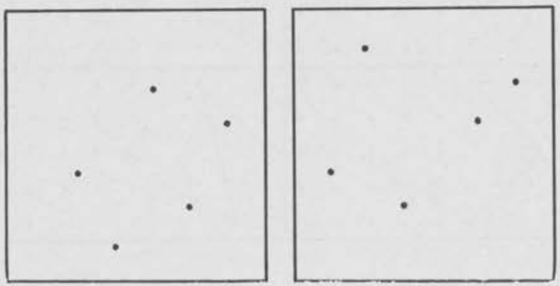
COPYING

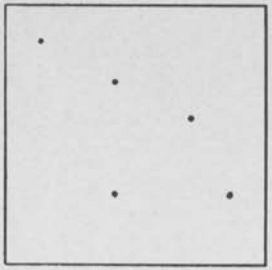


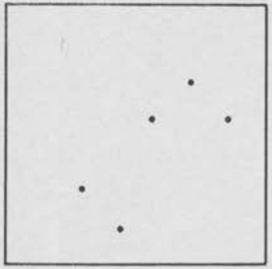


Score. . . . .

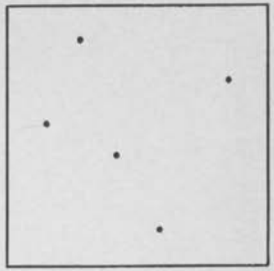
F	E	D	C	B	A
G	H	J	K	L	M
T	S	R	P	O	N
U	V	W	X	Y	Z
A	B	C	D	E	F
M	L	K	J	H	G

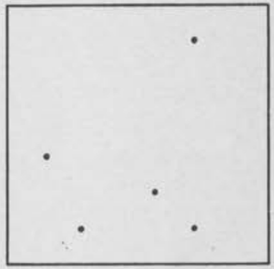


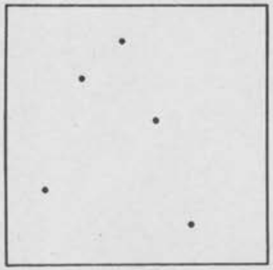


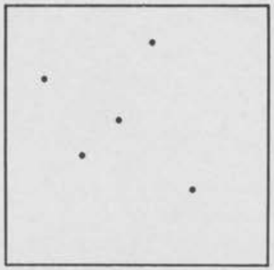


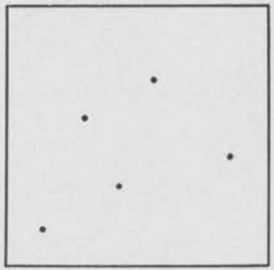
F	E	D	C	B	A
G	H	J	K	L	M
T	S	R	P	O	N
U	V	W	X	Y	Z
A	B	C	D	E	F
M	L	K	J	H	G

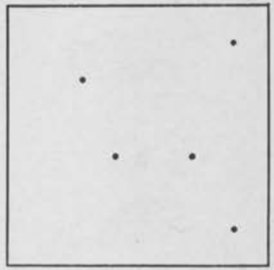






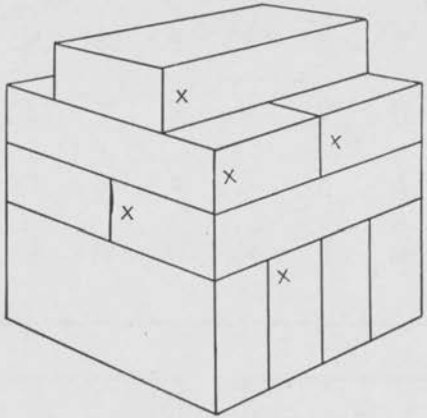


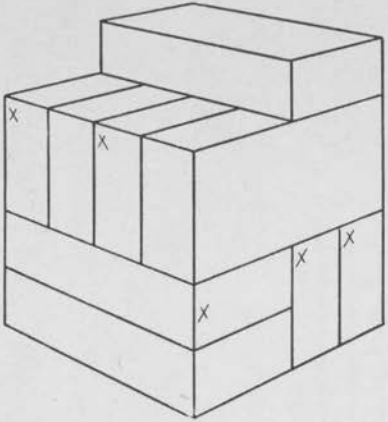
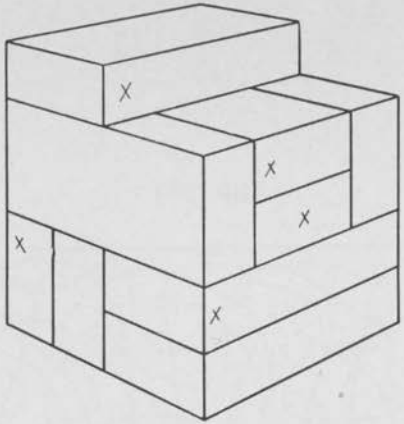
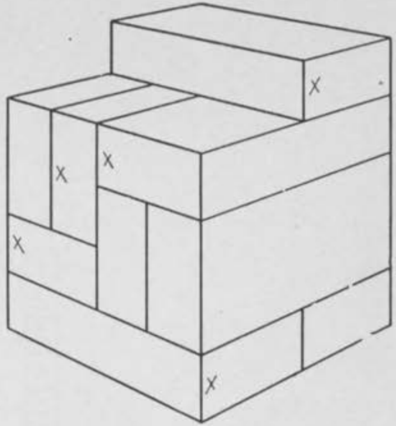
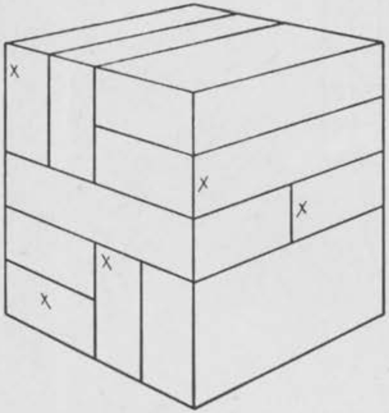
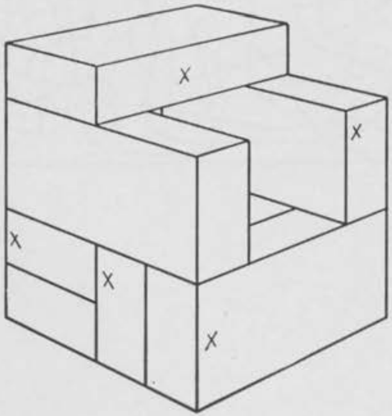
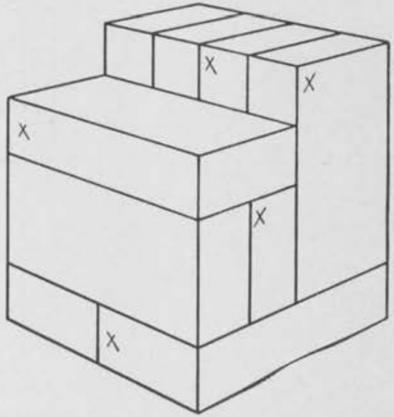




Score.................. . . .

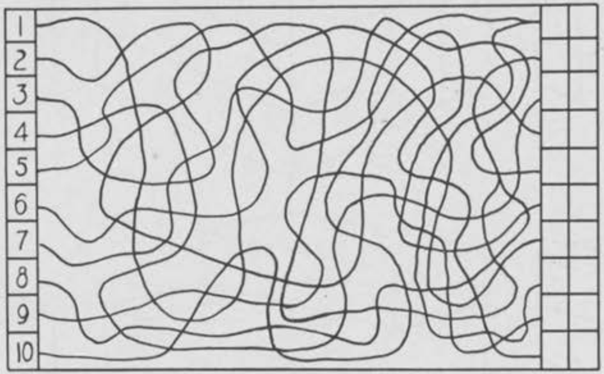
BLOCKS

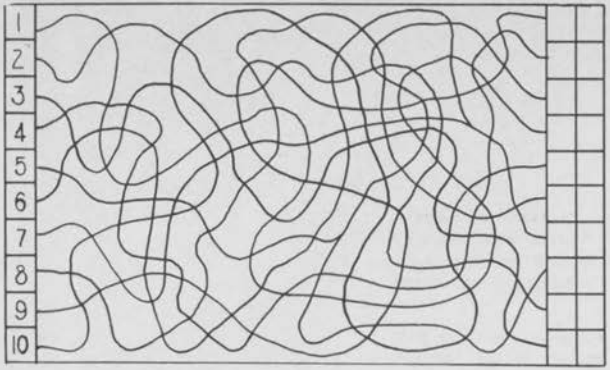


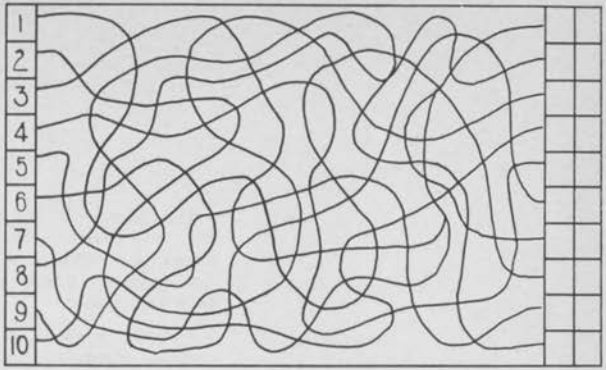







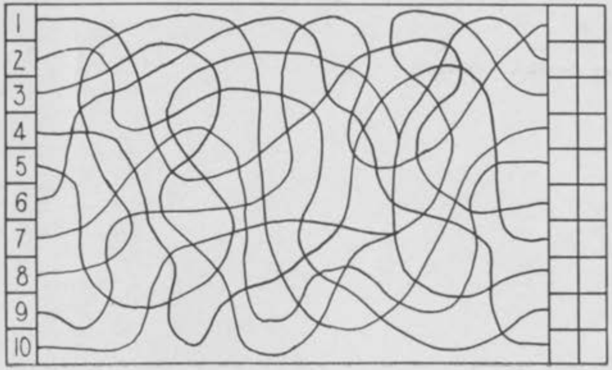
Score.................. . . .

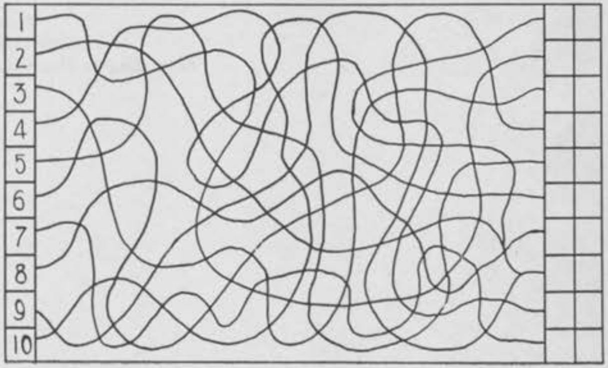
PURSUIT











Score. . . . .

This booklet is put up in packages of twenty-five, with complete directions, scoring keys, available norms, etc. The price is $1.50 per package, f.o.b. Los Angeles. Checks should accompany all orders from individuals.

A tryout package of five copies of the test with complete directions will be mailed to any address upon receipt of fifty cents.

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MECHANICAL-DRAWING TESTS
for
High Schools, Trade Schools, and Entering College Students

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Manual for Teachers

INTRODUCTION

Need for Drawing Tests. Mechanical drawing, due to its direct application to so many phases of industrial and commercial life, has assumed a prominent place in the school curriculum. Many cities have inserted this study in the junior high school and continued it through the senior high school into the first year of college. The smaller communities, due to lack of local demand, have devoted but little time to the work, frequently alternating a half year of drawing with a half year of shopwork. The larger cities, urged on by industrial establishments, have gone into great detail in obtaining skill and accuracy from the students. So also with the method of instruction. While one city has a well-organized course, using the best textbooks obtainable, and supplemented with blue prints, trade catalogs, and commercial drawings, another community may use antiquated methods, allowing the students to transfer a drawing from a finished blue print of the problem by means of scale and dividers.

This great difference in time, method of instruction, and instructional material employed, would indicate that there is a distinct need for a series of typical problems arranged in their order of difficulty and based upon the fundamental principles which typify the skills and abilities to be derived from a study of mechan-

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ical drawing. The instructor is able to analyze how effectively he has taught his subject and how well the students have assimilated the instructional material by the mastery his students show in the solution of these problems. The student can also see for himself wherein his weaknesses lie. This method eliminates guesswork in grading which is so frequently influenced by copying drawings from books and blue prints, or by pure instrumental ability. Many teachers have tried to test their students by means of frequent quizzes or an examination at the end of the term. In either case, due to the few problems that it was possible to give, the boys who received low grades often felt that they had been asked just the questions they did not know and consequently were not getting a "square deal." The author believes that a series of valid tests with many problems of all types will solve this difficulty and satisfy both the student and the teacher by providing a reliable analysis of a student's real ability in mechanical drawing. By comparing the median score made by his students with that of a similar grade throughout the United States, the instructor can quickly determine whether his students are above or below the average for the United States and also to what extent.

Obtaining the Data for Validation. To obtain a reliable and scientific basis for the choice of problems for the tests, the author secured data relating to courses of study, textbooks used, blue print and mimeographed instructional material employed, as well as to the number of weeks a half year of drawing embodied, the number of periods the class met a week, and the number of minutes in a drawing period from over 100 schools representing the various sections of the United States. The author determined the amount of space devoted to a particular drawing unit in each textbook mentioned by a careful tabulation of the pages. This amount was then compared with the total number of pages of instructional material in the book. Using a similar method with the other instructional material where blue-print or mimeographed courses were used, he was able to determine the relative percentage of space given to each instructional unit. Without here enumerating the minor units, the author found from his examination that there was a close agreement in regard to the importance of certain major units. These main units may be classified as follows:

MECHANICAL DRAWING
FUNDAMENTAL INSTRUCTIONAL UNITS

1. Use of Instruments
2. Lettering
   - Letters
   - Numbers and Fractions
   - Symbols
3. Projection Drawing
   - Orthographic Projection
   - Developments
     - Parallel
     - Radial
   - Oblique Views
   - Revolution of Solids
   - Sections of Solids
4. Geometrical Constructions
   - Lines
   - Angles
   - Figures
   - Solids
5. Pictorial Representations
   - Isometric Drawing
   - Perspective Drawing
   - Technical Sketching

Using this classification as a working basis, and keeping in mind the many minor units under each major unit, the author selected a series of 130 trial problems which he believed would examine a student's mastery of mechanical drawing. The amount of material devoted to a unit in this preliminary test series and also in the final form, is in proportion to the space given that unit as found in the textbooks and instructional material examined.

Before making the final choice of problems the author gave a series of preliminary tests. By a careful tryout, and the grading and tabulation of over 5,000 completed tests covering a period of three years, the present series was formulated.

Verification of Results. Validity of the Tests. A series of tests embodying the instructional units previously outlined, consisting of 130 problems, was printed and distributed throughout the United States. The author marked and tabulated the results of over 2,500 completed tests. A second series was prepared utilizing these test results as well as the suggestions of the coöperating teachers. This enabled the author to rearrange the problems in their practical order of difficulty when the nonvalid problems were omitted. This new series was again tried with 150 high-school students to verify the placing of problems in their order of difficulty and to secure the correct timing for each test. This latter tryout produced no variation in the order of difficulty previously established. The tests were then printed and tried out in 60 representative schools in the various sections of the United States. The author graded and tabulated 2,500 of these completed tests.

In order that the medians would be as accurate as possible, the total number of minutes of drawing work which a student had completed in a half year was taken as a time unit. Using this time unit, the classes were chosen so that approximately equal numbers of students were used for each integral time division, ranging from junior-high-school classes, completing 1,000 minutes of drawing, to first-year-college classes, completing 48,500 minutes of drawing. The median scores of each group were carefully plotted. It was found that the line connecting these points approximated a smooth ascending curve, which we may call the median curve of scores throughout the United States for this series of tests.

By comparing the median score made by his class with the median score as shown by the curve, an instructor can quickly determine whether his students are above or below the average of the United States and also to what extent.

Coëfficient of Reliability. In order to determine the coëfficient of reliability of the tests, the author gave the same tests twice to 150 sophomore high-school students. A correlation of .792 was obtained. This coëfficient is known as the Reliability Coëfficient. It indicates to what exactness the tests measure. A reliability coëfficient of .792 is considered as satisfactory for tests of this type.

THE DRAWING TESTS

Part I. Technical-Information Tests
Part II. Performance Tests

To secure the best results, both Parts I and II should be given. Each part can be given in a drawing period of 45 minutes. The teacher may give Part I one day, and Part II the next. The exact timing for each test should be rigidly adhered to, otherwise the standard norms will be unreliable for comparative purposes.

PART I

Technical-Information Tests

By means of a series of four tests the instructional units are approached from different angles, enabling the instructor to better determine in just which phase of drawing the student is weak, or which units have not been emphasized sufficiently. The problems are selected to examine his understanding of representative drawing, descriptive drawing, and analytical drawing. The first test uses the multiple-response method. The student is asked to select and underscore the correct answer from four answers which follow a statement. In Test No. 2, he is asked to underscore the correct answer when given a series of illustrations to choose from. Test No. 3 requires the student to write the correct answer to a statement which is illustrated, and, in Test No. 4, he is told to supply the missing lines in a partially finished three-view drawing of an object illustrated by an isometric sketch of the object. This series of tests examines the student's knowledge of correct drawing technique, his ability to mentally visualize the form of the object in the pictorial representation described in the statement, and also his ability to visualize a three-dimensioned drawing when a sketch of the object is given, and to translate it into its proper views upon a two-dimensioned surface.

PART II

Performance Tests

Using a series of three tests, the actual drawing ability of the student in making a finished drawing is measured. This includes his ability to use his drawing tools correctly, ability to make a drawing from descriptive data, and ability to make geometrical constructions. By completion we mean the time required for three fourths of the class to complete the problems. There are always some students who do not know the subject and cannot complete it in any length of time. Furthermore, in each test the problems increase in difficulty so that while a student having but one year of drawing cannot be expected to go beyond a certain length, the more advanced students may be able to complete the more difficult ones and so advance in each test according to their degree of proficiency.

Test No. 3 has been divided into No. 3-A and No. 3-B. Schools in which the shop or trade side of drawing is emphasized should give No. 3-A, omitting 3-B. Those emphasizing the theoretical side of drawing and those students contemplating entering an engineering college upon graduation should take No. 3-B, omitting 3-A. Both groups must take Tests 1 and 2 of Part II.

It is not the purpose of this series of tests to measure "ability to letter," which would require a separate test, but rather ability to recognize correct procedure in lettering, which involves the placing of letters in words, use of numbers and fractions in dimensioning, and the correct use of symbols in mechanical-drawing practice.

INSTRUCTIONS FOR GIVING THE TESTS

PART I

Technical-Information Tests

MATERIAL. A pencil only may be used for all four tests.
(If the teacher so desires, a scale and triangle may be used in connection with the pencil for Test No. 4.)

TIMING.

Time to pass papers, read directions, and fill blanks	5 minutes.
Time allowed for Test No. 1	9 minutes.
Time allowed for Test No. 2	8 minutes.
Time allowed for Test No. 3	6 minutes.
Time allowed for Test No. 4	15 minutes.
Total	43 minutes.

DISTRIBUTING THE TESTS. Announce to the class that *the test leaflet must not be opened or in any way examined until the signal to begin is given by the instructor.* Have the number of leaflets required for each row of pupils counted out and placed in a pile on the first desk of each row. At the signal "Go" from the teacher, have them passed backward in the row. Each pupil is to take the uppermost leaflet as the pile reaches him. This eliminates the confusion of pupils moving about the room and saves time. While the leaflets are being passed, the students should be instructed to get the necessary drawing materials ready for work. As soon as the tests are distributed and the material placed upon the drawing desk, the students should sit at attention.

GIVING THE TESTS. At a signal from the teacher, the students will fill in the blanks at the top of the test booklet, writing their name, school, etc., as directed. Under "Grade," use designation with which the students are familiar. Some prefer 9-B; 9-A; 12-A. Others Freshman, Soph., Jun., or Sr., and still others I-B; I-A; etc.

The instructor will explain to the class that he will read aloud the instructions. Each student will follow, reading them silently. Instructor reads aloud as follows:

GENERAL INSTRUCTIONS TO THE STUDENT

These tests are designed to assist you to determine for yourself just how well you have mastered your drawing work. You are asked to follow instructions and do your own work; do not use books or reference material, and start and stop exactly upon the teacher's signal. There are usually more questions than you can answer in the given time, so do not worry if you cannot finish. Answer them in their correct order, to the best of your ability and without wasting any time.

A drawing pencil is the only tool necessary for these tests. For Test No. 4 the use of a scale or triangle is permissible.

The problems are of this type:

Test No. 1. Underscore the correct answer in pencil.

A ball has the shape of a—

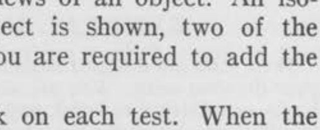
Cube Sphere Prism Oblong

As "sphere" is the correct answer, we place a line under it, thus: <u>Sphere</u>.

Test No. 2. Underscore the correct answer in pencil.

Which triangle is a right-angled triangle?

As "C" is the correct answer, we place a line under it, thus: <u>C</u>



Test No. 3. Instead of underscoring the correct answer, you will be asked to write the answer in the space provided for it.

Test No. 4. You will be asked to complete three views of an object. An isometric view (pictorial representation) of the object is shown, two of the views are drawn, and the third partly finished. You are required to add the missing lines.

You are given a certain length of time to work on each test. When the teacher indicates that the time is up for the test you are working at, you must stop immediately and proceed with the next test.

When the teacher gives the signal "Go," turn the page and begin.

(Pause a few minutes to see that all are ready for the test, then continue.) At the signal "Stop," sit at attention until given signal "Go" for Test No. 2. Now, all ready, "Go."

As indicated at the top of each test, allow the following time:

Allow 9 minutes for Test No. 1. At signal "Go," start Test No. 2.
Allow 8 minutes for Test No. 2. At signal "Go," start Test No. 3.
Allow 6 minutes for Test No. 3. At signal "Go," start Test No. 4.
Allow 15 minutes for Test No. 4. At signal "Stop," collect tests.

The last student in each row can collect the tests for his row.

If the instructor follows these instructions carefully, the entire series of four tests of Part I can be given in a drawing period of 45 minutes.

PART II

Performance Tests

MATERIAL. Drawing board; set of instruments; T square; 45-degree triangle; nicely sharpened drawing pencil; scale; thumb tacks.

TIMING.

Time to pass papers, read directions, and fill blanks	5 minutes.
Time allowed for Test No. 1 and Test No. 2 combined	16 minutes.
Time allowed for Test No. 3 (either 3A or 3B)	22 minutes.
Total	43 minutes.

Notice to Teachers:

Test No. 3 is arranged so that the teacher may choose between Series 3-A and Series 3-B. Many teachers who emphasize the theoretical aspect of mechanical drawing may wish to use Series 3-B. Others who emphasize the shop side prefer Series 3-A. Either series is allowed the same amount of time. Series 3-B is especially adapted for students who will continue their work in an engineering college or those taking a three- or four-year drawing course. The last few problems of Series 3-B will enable the instructor to see who the superior students are.

DISTRIBUTING THE TESTS. Pass the test leaflets as explained in Part I. While the leaflets are being passed the students should be instructed not to open the booklets. They should get their drawing materials ready for work, with T square on the drawing board, and triangle, set of instruments, drawing pencil, etc., in position.

GIVING THE TESTS. At a signal from the teacher, the students will fill in the blanks at the top of the test booklet, writing their name, school, etc., as directed. Under "Grade," use designation with which the students are familiar. Some prefer 9-B; 9-A; 12-A. Others Freshman, Soph., Jun., or Sr.; and still others I-B; I-A, etc.

The instructor will explain to the class that he will read aloud the instructions. Each student will follow, reading them silently. Announce to class whether you wish them to work Test No. 3-A or Test No. 3-B. Instructor then reads aloud, as in Part I.

GENERAL INSTRUCTIONS TO THE STUDENT

These tests are designed to assist you to determine for yourself just how well you have mastered your drawing work. You are asked to follow instructions and to do your own work; do not use books or reference material, and start and stop immediately upon the teacher's signal. There are usually more questions than you can answer in the given time, so do not worry if you cannot finish. Answer them in their correct order, to the best of your ability, and without wasting any time.

You will need your drawing board, T square, triangles, scale, pencil compass, nicely sharpened drawing pencil, and thumb tacks. Place these on your drawing board so that you will be ready to work when the signal is given.

The problems are of this type:

Test No. 1. Some problems will be given to see how well you understand the use of the scale, mixed numbers, and angles.

Test No. 2. You will be asked to do some geometrical problems. In this type of work be sure not to erase any of your construction lines.

Test No. 3. You will be asked to draw, by means of projection lines, three views of an object. This test must be mounted on the drawing board. Your work will be judged on accuracy, placing of views, dimensioning, (when called for), and neatness of work.

Test No. 3-A is adapted for trade schools or schools where working drawings are emphasized.

Test No. 3-B is adapted for schools emphasizing the principles of sections and oblique or auxiliary views.

You are given a certain length of time to work on each test. When the teacher indicates that the time is up for the test you are working at, you must stop immediately and proceed with the next test.

When the teacher gives the signal "Go," turn the page and begin.

(Pause a few minutes to see that all are ready for the test, then continue.) At the signal "Stop," sit at attention until given signal "Go" for the next test. You will do Test No. 1 and Test No. 2 together without stopping in between. At signal "Stop," proceed with Test No. 3-A or Test No. 3-B as the case may be.

Now, all ready—"Go."

As indicated at the top of each test, allow the following time:

Allow 16 minutes for Tests 1 and 2 combined.

Allow 22 minutes for Test No. 3 (either 3-A or 3-B).

Many teachers use these tests in place of an examination at the end of a semester's work. In such a case, Part I may be given one day and Part II the next day. Others wish to determine how well prepared their entering second-, third-, or fourth-year classes are. For this purpose the four tests of Part I are given the first day the class enters, as the only drawing instrument needed is a pencil. The author has found it very helpful to have his entering college students work out Part I. This gives the teacher an excellent check as to whether or not the student has had enough preliminary drawing to take an advanced course or needs a review course. Part II may be given as a whole or any separate test may be given when the class has completed that particular unit of instruction. By a diagnostic analysis of the test results, explained later in the Manual under the heading, "Problem Analysis," the instructor can readily determine the units his students have not mastered or which he has not emphasized sufficiently in his teaching.

MARKING THE TESTS

For convenience in marking, a set of "Marking Keys" containing the correct answers for each problem are given. The following will explain the various factors in detail:

PART I

TEST No. 1. Answers are counted as either right or wrong. A correct answer receives 1 point. Hold marking chart with answers along edge of Test No. 1 sheet for quick checking, as explained on Key Sheet. Check wrong answers only, using cross ($\times$). Score is total number of problems minus number of wrong.

Maximum number of points possible for Test No. 1 is 25.

TEST No. 2. Answers are counted as either right or wrong. A correct answer receives 1 point. Hold marking chart with answers under each horizontal group of problems.

Maximum number of points possible for Test No. 2 is 14.

TEST No. 3. Answers are counted as either right or wrong. A correct answer receives 1 point. Hold marking chart as in Test 2.

Maximum number of points possible for Test No. 3 is 9.

TEST No. 4. Problems 1 and 2 are so simple that they are counted as either right or wrong, receiving 1 point each. As the other problems are more complex, the author adopted the multiple-point method of scoring. Each set of similar lines receives 1 point. Thus, in Problem 3, the maximum score obtainable would be 4 points. To assist teachers in tabulating, each line or set of similar lines is indicated by a letter on the marking chart. As the placing of center lines for circles, cylinders, and cones is a very important factor in drawing technique, a point is given for this type of line as indicated by (D) in Problem 3.

Maximum number of points for Test No. 4 is 16.

Place the score for each test in space provided in upper right-hand corner of page 1. Add these scores. The result is the total score the student makes on Part I.

PART II

TEST No. 1. Problem 1. Great variation exists in the various sections of the United States in regard to the use of the dash between feet and inches (6′—6⅞″). When the dash is omitted, no deduction is made. Similarly the position of the bar of the fraction varies according to local practice. To enable the instructor to grade these variations from the sample shown, a "Variation Grading Sheet" is given on page 5 of Marking Key, Part I. When the dimension is not given correctly with relation to feet and inches, no credit is given.

Maximum number of points possible for Problem 1 of Test No. 1 is 4.

Problem 2. To take care of the variations prevalent throughout the United States a "Variation Grading Sheet" is given on page 5 of Marking Key, Part I. When the dimension is not given correctly with reference to the number of degrees, no credit is given.

Maximum number of points possible for Problem 2 of Test No. 1 is 3.

Problem 3. One point is allowed for correct measurement, and 1 when the line is made a dash line.

Maximum number of points possible for Problem 3 of Test No. 1 is 2.

Problem 4. As we are checking for the correct use of the scale in this part, give 1 point when scaled dimension is correct. One point is allowed when the mixed number including the (″) symbol is correctly made, and one point when the arrowheads are correctly placed.

Maximum number of points possible for Problem 4 of Test No. 1 is 2.

NOTE: To assist in checking quickly, mark off on a piece of paper the correct lengths for Problems 3 and 4 and use this as a measuring device for the completed tests.

Maximum number of points possible for all of Test No. 1 is 12.

TEST No. 2. The problems are either right or wrong. Therefore, 1 point is allowed for the correct solution of each problem. Many different methods may be used by the student to solve a geometrical problem. The instructor must decide whether the pupil's method is correct if different from that shown on the Key Sheet. Several of the most common possible variations are shown on page 6 of Marking Key, Part I.

Maximum number of points possible for Test No. 2 is 6.

TEST No. 3-A. The objective of this problem is to measure the actual drawing ability of the student in making a finished working drawing; therefore, each unit is marked separately. For convenience, the units are scored as follows:

Placing of Views, 1 point	Side view directly opposite and on a line with the front view. Indicated by letter (A).
The Drawing Proper, 12 points	Twelve distinct lines or sets of lines must be made. This includes letters (B to M).

Placing of the Dimensions, 9 points — The instructor may decide the correctness of dimension lines. Mastery is concerned with the ability to dimension each important unit so that the problem can actually be constructed. This includes letters (N to V).

Maximum number of points possible for Test No. 3-A is 22.

TEST No. 3-B. To assist the instructor in tabulating, each line or set of similar lines is indicated by a letter on the marking chart. The correct lines are shown in heavy type.

Problem 1.	Maximum number of points possible is	7
Problem 2.	Maximum number of points possible is	3
Problem 3.	Maximum number of points possible is	2
Problem 4.	Maximum number of points possible is	8
	Total possible	20

NOTE: In checking Problem 4, mark with a check (√) each line or set of lines correctly drawn, as shown on Marking Key. Add the checks and get score. If student makes upper half in section and lower half in elevation, allow only one half of the points made as his score. When all is shown in section or all in elevation, give no credit.

Place the score for each test in space provided in upper right-hand corner of page 1. Add these scores. The result is the total score the student makes on Part II.

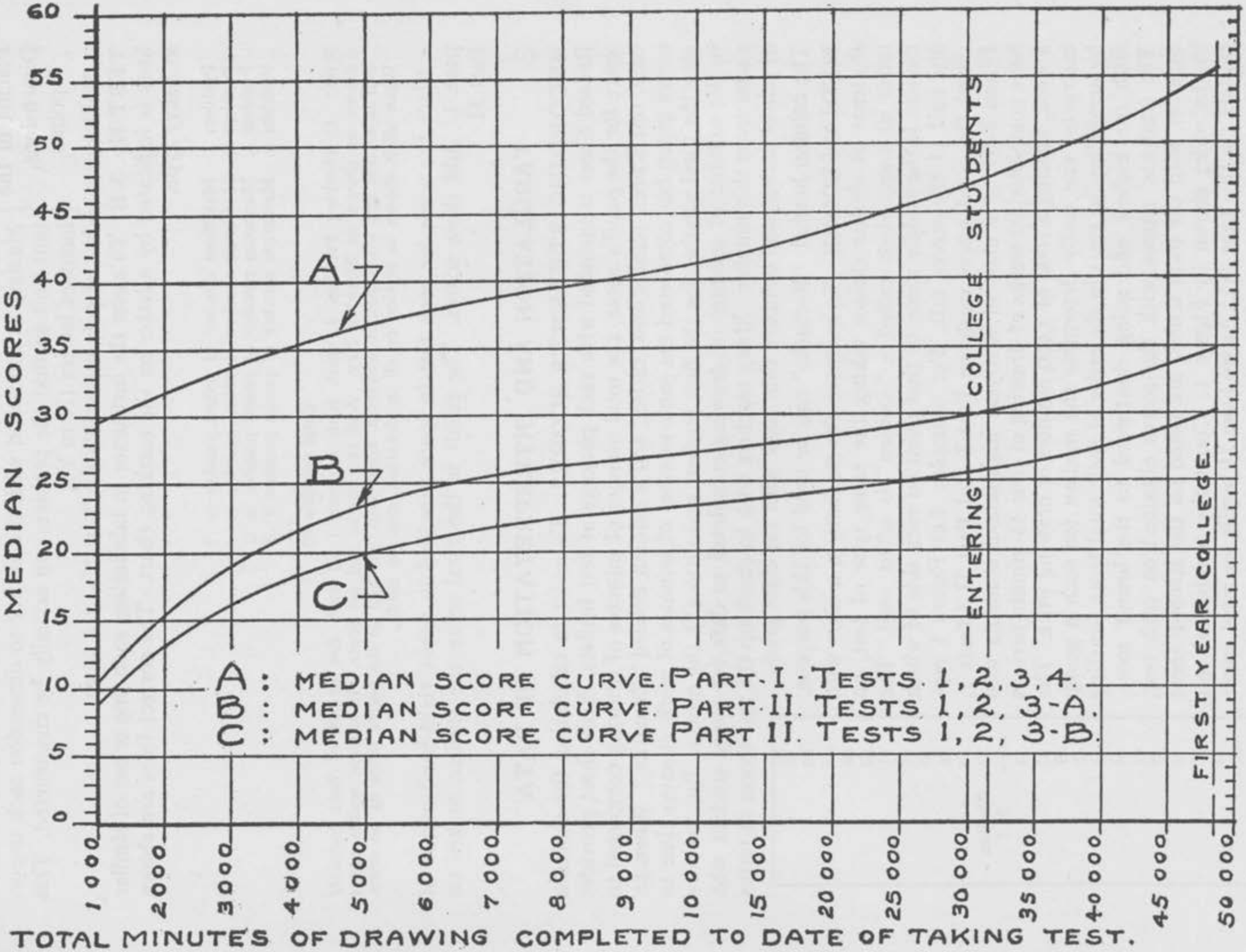
TABULATION AND INTERPRETATION OF DATA

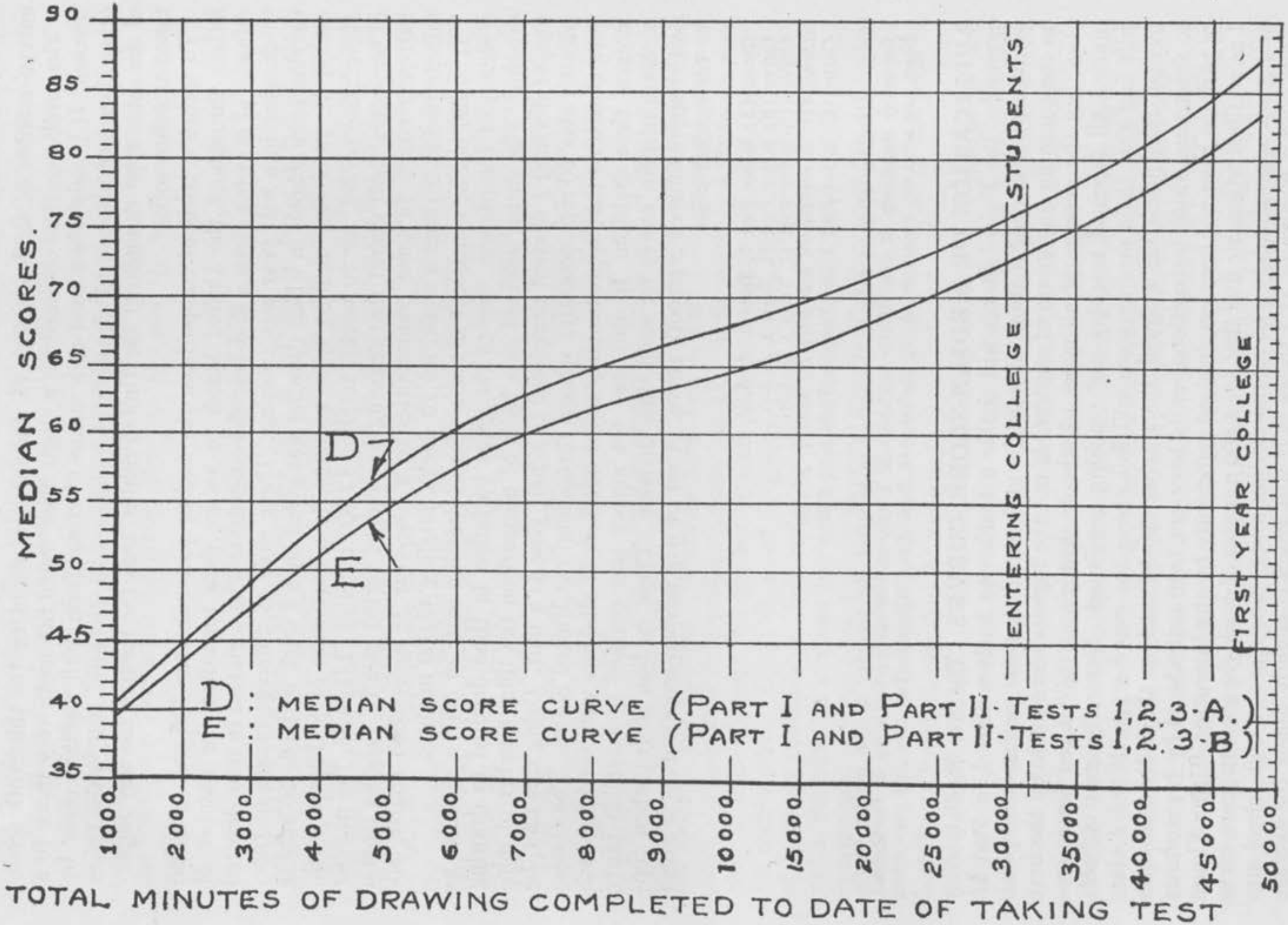
RECORDING STUDENT'S SCORES. To assist in tabulating the scores a Record Sheet is included with each package of test leaflets. This sheet provides space for the pupil's name, the total number of minutes of drawing completed to date, test scores, total scores, rating, and a column headed "Remarks." When an entire group has completed the same number of minutes of work, it saves time to give the total number for the first student and ditto (") the others. But, be sure to list number of minutes of drawing completed to date for every student who varies from this number. Many teachers wish to check up the test scores in terms of school rating, and compare this mark with the class grade. The column headed "Remarks" can be used for this purpose.

MEDIAN SCORE. To compare the students in a class with students of similar classes taking the same type of test, an index of comparison called a "median" is often used. The median is the middle score, or that point on each side of which one half of the scores fall. For example: Let Figure 1 represent the total scores made on Part I and Part II (Tests 1, 2, and 3-B) by a class of first-year high-school students who have completed 20 weeks of drawing of four 45-minute periods a week, making a total of 3,600 minutes of drawing work. The instructor can easily determine the median for such a group by arranging the tests in the order of their total score, starting with the highest and going downward to the lowest score. The students' names with the scores obtained on each test, together with the total scores, are listed on the Record Sheet in the order shown in Figure 1. Count the number of test leaflets (in this case 24). As we have 24 pupils we must count up 12, getting test score 51, and counting down 12, arriving at test score 52. The median with this even number of scores

73	
69	
65	
64	
62	
61	
57	
57	
56	
54	
52	Median
	51.5
51	
51	
51	
47	
45	
44	
41	
37	
32	
30	
28	
20	
Total students—24	

Fig. 1


MEDIAN SCORES
60
55
50
45
40
35
30
25
20
15
10
5
0
A
B
C
ENTERING COLLEGE STUDENTS
FIRST YEAR COLLEGE
A : MEDIAN SCORE CURVE. PART I. TESTS. 1, 2, 3, 4.
B : MEDIAN SCORE CURVE. PART II. TESTS 1, 2, 3-A.
C : MEDIAN SCORE CURVE PART II. TESTS 1, 2, 3-B.
1 000
2000
3000
4 000
5 000
6 000
7 000
8 000
9 000
10 000
15 000
20 000
25 000
30 000
35 000
40 000
45 000
50 000
TOTAL MINUTES OF DRAWING COMPLETED TO DATE OF TAKING TEST.


MEDIAN SCORES.
90
85
80
75
70
65
60
55
50
45
40
35
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
15000
20000
25000
30000
35000
40000
45000
50000
TOTAL MINUTES OF DRAWING COMPLETED TO DATE OF TAKING TEST
D
E
ENTERING COLLEGE STUDENTS
FIRST YEAR COLLEGE
D : MEDIAN SCORE CURVE (PART I AND PART II · TESTS 1, 2, 3 · A.)
E : MEDIAN SCORE CURVE (PART I AND PART II · TESTS 1, 2, 3 · B)

would be halfway between 51 and 52 or $\frac{51 + 52}{2}$ case there is an uneven number of students, say, 25, the median would be the thirteenth score.

The median as thus obtained for a single class would not mean very much to a teacher. It is only when used as a means of comparison with medians made by other classes of his, or with classes in the same school, or better still, with classes of the same type throughout the United States, that the median has any importance attached to it.

To secure a basis of comparison, the author sent out over 300 multigraphed letters throughout the United States to secure data regarding the number of minutes of drawing given a first-year drawing class. The variation in time devoted to drawing in a half year was amazing. There were 45 different ranges of time, varying from schools in which drawing was given once a week with one 50-minute period for 20 weeks, totaling 1,000 minutes, to a maximum of 5 times a week, 120-minute period, for 20 weeks, totaling 12,000 minutes. Likewise, the number of semesters (half years) that drawing was taught varied greatly, ranging from a half-year course in some communities to a four-year (8 semesters) course, 60-minute period, 5 times a week, for 20 weeks, totaling 48,000 minutes.

It would not be consistent to use a year of drawing work or even a semester as a means of comparison, due to the great variation in time devoted to drawing existing. The author selected as a basis of comparison the total number of minutes of drawing a student completed in a half year as a unit. Using this unit, he selected over 60 representative schools throughout the United States. The classes were chosen so that approximately equal numbers of students were used for each integral time division. In this way the author was enabled to establish fairly accurate median scores for each time division. These median scores when connected approximated a smooth curve. A set of five median-score curves is given for the teacher's use.

Curve (A) is for Part I, Tests 1, 2, 3, 4.
Curve (B) is for Part II, Tests 1, 2, 3-A.
Curve (C) is for Part II, Tests 1, 2, 3-B.
Curve (D) is for Part I and Part II, Tests 1, 2, 3-A.
Curve (E) is for Part I and Part II, Tests 1, 2, 3-B.

NOTE: It will be of great help to the author in verifying the accuracy of the median curves for many thousands of cases if the teachers will kindly detach the carbon copy of the Record Sheet and send to: Ferdinand A. P. Fischer, 848 Park Ave., Wilmette, Ill.

APPLICATION OF MEDIAN-SCORE CURVES. The five median-score curves for the United States will enable a teacher to analyze Part I or Part II separately, or in combination. It must be understood that the median-score point on the curve for any group of students is not the highest score made by the best class, but the average of all types of schools throughout the United States embracing all types of teaching and teaching conditions. Naturally, most schools will find that their median score will fall above the curve score. When a class median falls below the average, the teacher should analyze the individual tests to determine which instructional units have not been assimilated by his students or perhaps have not been emphasized sufficiently by the instructor. Using Figure 1 as an illustration, we find that for 3,600 minutes of work the median-score curve (E) gives approximately 49.5 as the median score. The class of high-school students with a median of 51.5 shows that this group is slightly above the average of the United States.

QUARTILES. Many teachers wish to determine which students' scores fall in the upper fourth of their group, those who are average, and those falling in the lower fourth of the class. For this purpose the quartile scores are valuable. By counting down one fourth the number of total scores, the upper quartile score is obtained, which, for convenience, we will call Q_1. All scores above Q_1 are in the upper quarter of the class. By counting up one fourth of the number of total scores, the lower quartile (Q_2) is obtained. All scores falling below Q_2 are in the lower one fourth of the class. Between Q_1 and Q_2 we have the average student.

PROBLEM ANALYSIS

BAR DIAGRAMS. Many teachers find it helpful to make a bar diagram which will show at a glance which problems the class has not mastered. A simple method is to lay out a number of units corresponding to the number of problems in a test on a horizontal axis, and a number of units corresponding to the number of students taking the tests on a vertical axis. The height of each vertical column, or bar, will be determined by the number of correct answers that are given for the problem under consideration. The bars should lessen in height toward the last problem of each test. Any great deviations from this descending height diagram will show the problems which have not been mastered by the class. In Test No. 4, Part I, due to the multiple-point scheme of marking, the bar diagram will be of a rhythmic type. The easiest points of each problem elevate the bars above the difficult points of the preceding problem. This is also the case in Part II, Tests 1, 3-A, and 3-B.

While this method is very efficient for analyzing the scores of large groups of students, a simpler method may be used for a single class or when comparing a few classes. For example: When marking Test I, Part I, jot down on a slip of paper the numbers of the problems from 1 to 25. While marking a student's test, place a mark opposite the number of each problem he does incorrectly. Do this for each student. Count these off in groups of five. Then tabulate the number of incorrect problems in their order of difficulty. This will show the problems which the class as a whole has not answered satisfactorily. By looking up the instructional units embodied in the incorrect answers the instructor can determine very satisfactorily which units the class has not mastered or perhaps have not been emphasized sufficiently in the classwork. Any one test or all of the tests of both Parts I and II can thus be analyzed.

SCHOOL RATING. Test scores, which divide a class into groups by the median or quartile method, are valuable to the teacher. But the average student does not understand them very readily. He is interested to know whether or not he made a grade of 90, 85, 80, 75, or failed the test. To satisfy this demand, the author inserted in the Record Sheet a column headed "Rating."

While there is disagreement among psychologists and statisticians as to the correct percentages for each group, there is a substantial agreement that scholarship marks should be distributed symmetrically about their average. Many schemes have been devised, each having its adherents. These schemes are usually derived from the Normal Probability Curve. If the base line is divided into equal parts and vertical lines are drawn at the points of division, the middle and larger areas will contain the greatest number of cases, decreasing on either side as we approach the ends of the curve. Translated into school ratings, the following examples will illustrate the diversity of opinions: E. H. Cameron in his *Educational Psychology* suggests:

7% of test scores fall in the A group.
24% of test scores fall in the B group.
38% of test scores fall in the C group.
24% of test scores fall in the D group.
7% of test scores fall in the E group.

A. I. Gates in his *Psychology for Students of Education,* gives:
3% A; 22% B; 50% C; 22% D; 3% E.

M. R. Trabue in *Measuring Results in Education* suggests:
2% A; 23% B; 50% C; 23% D; 2% E.

The base line of the Probability Curve may be divided into more than five divisions. For example, a mathematical device known as Pascal's Triangle—for "Coefficients in the Binomial Theorem" uses this scheme.

```
            1
          1   1
        1   2   1
      1   3   3   1
    1   4   6   4   1
  1   5  10  10   5   1
1   6  15  20  15   6   1
```

Using a six-division basis: 1, 5, 10, 10, 5, 1 (Total 32).

1/32 of the total test scores would fall in the A group.
5/32 of the total test scores would fall in the B group.
10/32 of the total test scores would fall in the C group.
10/32 of the total test scores would fall in the D group.
5/32 of the total test scores would fall in the E group.
1/32 of the total test scores would fall in the F group.

Many of the teachers throughout the United States reported that in their drawing classes the number of excellent students of (A) grade and the number of failures was approximately 4%, with the large average group comprising 50% of the class. Using this proportion as a sample, our distribution would be:
Best 4% A; Next 21% B; Middle 50% C; Next 21% D; Failing 4% E.

When grading on a basis of 75 as passing, and below 75 as failing, this distribution would become:

4%	A	95 to 100.
21%	A—	90 to 94.99
50%	B	85 to 89.99
	B—	80 to 84.99
21%	C	75 to 79.99
4%	D	Below 75—failing.

Applying this distribution to the group of test scores made by the 24 high-school students, the median grading score of 85 would correspond to a Test median score of 51.5. Then:

4% of 24 pupils is .96 or 1 pupil would get a grade of A.
21% of 24 pupils is 5.04 or 5 pupils would get a grade of A—.
21% of 24 pupils is 5.04 or 5 pupils would get a grade of C.
4% of 24 pupils is .96 or 1 pupil would get a grade of D (failing).
50% of 24 pupils is 12.00 or 12 pupils would get a grade of B and B—.

In small classes, the fractional pupils under A; A—; C and D would be counted as 1 and reduce the remainder that much. Therefore, the 50-per cent group is counted last, being the difference between the entire number of students and those under A, A—, C, and D.

This method is a quick approximation by which test scores can be converted into class grades. These can be placed in the column headed "Rating" on the Record Sheet. In the column headed, "Remarks" the instructor may record the grade he has given his students in their regular drawing work. In case the instructor desires to get an even finer distribution, he can use Pascal's Triangle and carry the subdivisions to very fine gradations.

SUMMARY

The author hopes that these tests will be of assistance to teachers of drawing in evaluating the work of their students and the success of their own teaching. They are designed to test the various units of instruction found most fundamental to mechanical-drawing courses throughout the United States. They may be used in various ways:

1. As an examination given at the end of the term. Instead of purchasing a sheet or two of drawing paper for his examination, the student will purchase the test booklets. In this way the matter of financing the tests is easily disposed of.

2. They can be used at the beginning of the semester to determine how well students entering from other schools are equipped to do the work before them. This is especially true of entering college students.

3. In large school systems, where classes are formed by efficiency grouping, the tests offer an excellent method of differentiating students in regard to mechanical-drawing ability.

4. The group method of instruction enables the instructor to give a certain test when that particular unit has been completed by the class.

5. The five median-score curves enable the instructor to see in which unit of instruction (technical information, or performance ability) his students are weak, and also to what extent as compared to the average for that grade of work in the United States.

6. Using as a unit the amount of work completed in minutes to date affords a quick method of comparing any particular group of students from the junior high school up through the first year of college.

7. The bar-diagram method of analysis offers the teacher a splendid insight as to just what problems his students have not mastered or have not been emphasized sufficiently in class.

8. The tests offer a valuable check between the school grade given by the teacher and what a student can really do. Often a student receives a low school mark due to indifference, laziness, lack of interest, lack of application, etc. The test scores of such a pupil will often enable the teacher to awaken him, demonstrating the ability he really possesses if he will but apply himself.

9. For survey purposes in comparing the various schools in a system.

Marking Keys are arranged to facilitate rapid and efficient grading of the completed tests.

MARKING KEY PART - I. TEST NO. 2.

Allow one point for each problem.
Problems are right or wrong. No fractional points.

① B C

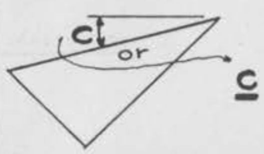
② A

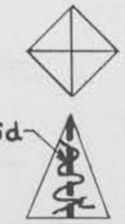
③ D E -A B

④ N K

⑤ " Inch

⑥ $1\frac{1}{4}$"

⑦


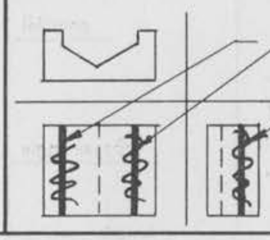
⑧ Should be solid


⑨


⑩ Rectangular Pyramid

⑪ Should be solid.


⑫ ellipse

⑬ Should be dash
Should be dash.


⑭ B

Maximum score:
__14__ Points

MARKING KEY PART - I. TEST NO. 3.

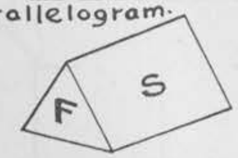
Allow one point for each problem solved correctly.

① Rectangle, or Parallelogram.

② Triangle, or Equilateral Triangle

③ Right Vertical Cylinder, Circular Cylinder, or Cylinder

④ All three letters must be correct.
_C_ Front.
_B_ Side.
_A_ Top.

⑤ If student labels side view (F) and front view (S) then (F) = rectangle and (S) = triangle.
(F.) Triangle
(S.) Rectangle or Parallelogram.


⑥ Perpendicular, 90°, or right angles.

⑦ Correct when both terms are right.
Rectangular Pyramid

⑧ Correct when both terms are right.
Perspective (or Upper)
Isometric or Oblique.

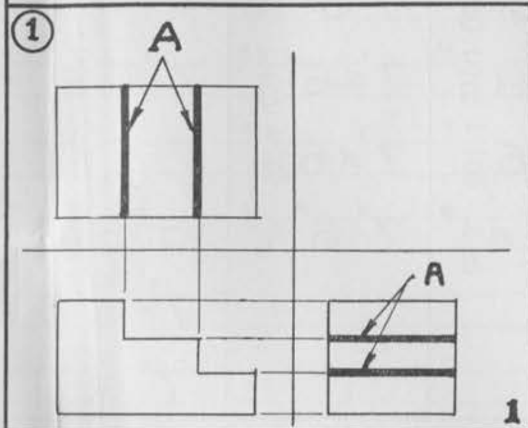
⑨ Correct when both terms are right.
Hexagonal Prism.

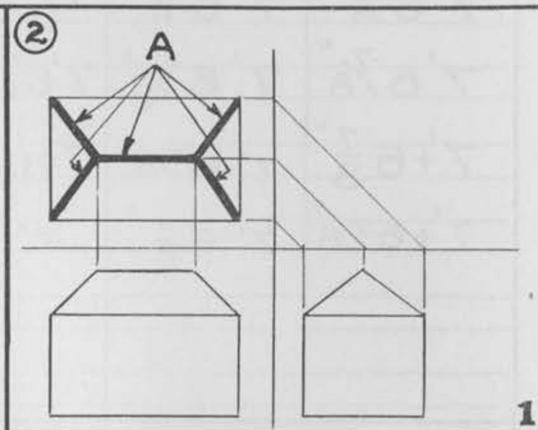
Note: In ⑤ ⑦ ⑧ ⑨ both terms must be correct.
In ⑤ when student omits to label object but has names of figures correct give full credit for the problem.

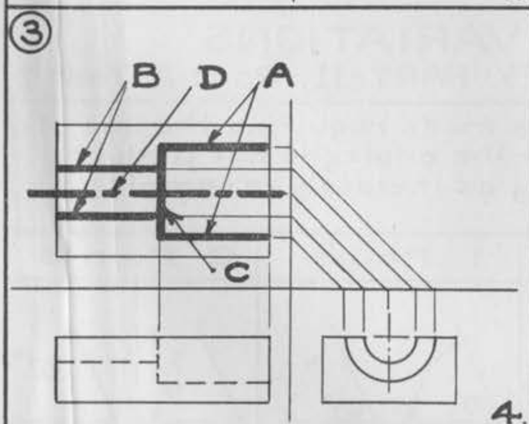
Maximum score:
__9__ Points

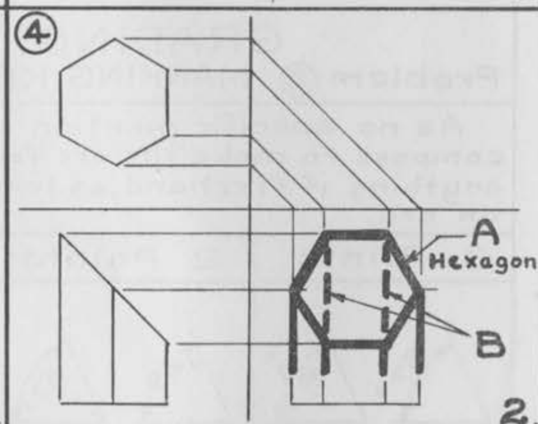
MARKING KEY PART - I. TEST NO. 4.

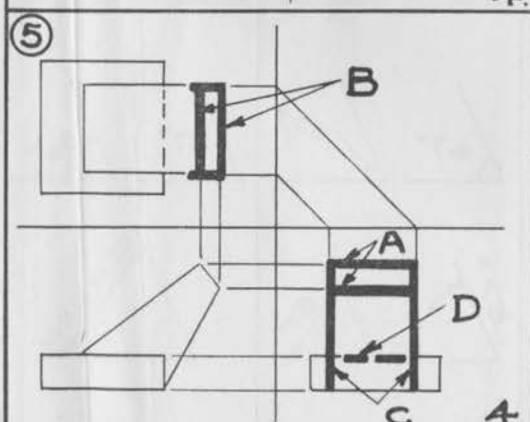
Letters refer to lines to be drawn by student. A letter counts for one point, allowed for a single line or set of lines according to the key. Maximum number points for each problem shown in lower right corner.

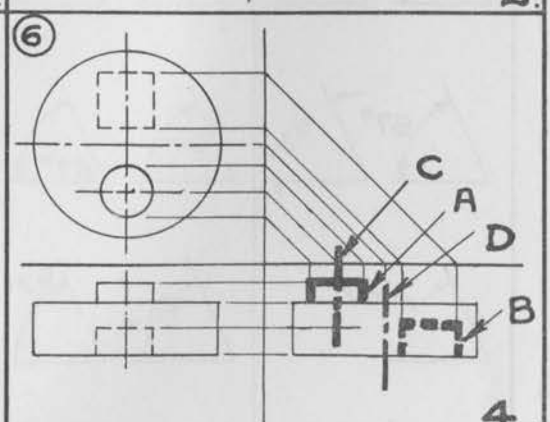












Maximum score: 16 Points.

GRADING VARIATIONS.

Problem ① MARKING KEY. PART-II - Page - 2. Test-1.

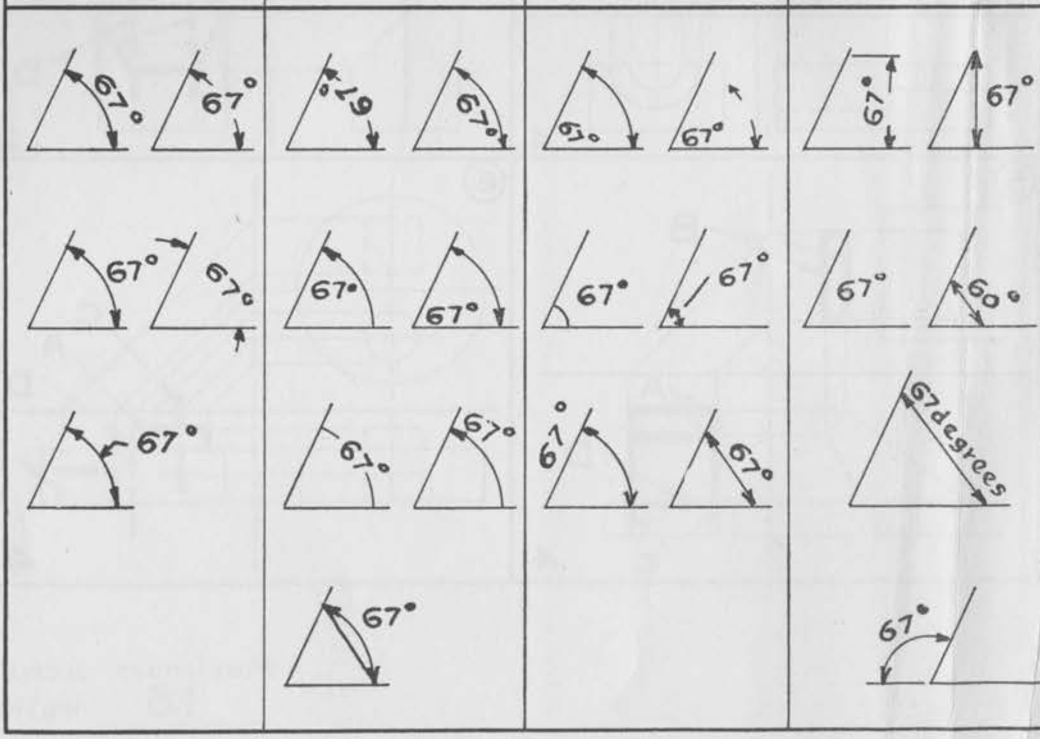
4 Points	3 Points	2 Points	1 Point	O Points.
7'6 7/8"	7'6 $\frac{7}{8}$"	7' 6 7/8"	7'6" $\frac{7}{8}$"	O points when the dimension is wrong.
7'6 $\frac{7}{8}$"	7'6 $\frac{7}{8}$"	7'-6" $\frac{7}{8}$"	7'6" 7/8	
7'6 7/8"	7'6 7/8"	7'6" and $\frac{7}{8}$"	7'x6" $\frac{7}{8}$"	7"6 $\frac{7}{8}$'
7'+6 $\frac{7}{8}$"	7' 6 7/8"	7 ft. 6 $\frac{7}{8}$"	7'x6 $\frac{7}{8}$"	7 $\frac{6}{8}$"
7'+6 7/8"	7' 6 $\frac{7}{8}$"	7'-6 $\frac{7}{8}$"	7'-6" $\frac{7}{8}$"	6'6 $\frac{7}{8}$"
				7'- $\frac{6}{8}$" 6"
				7' $\frac{7}{8}$"

GRADING VARIATIONS

Problem ② MARKING KEY. PART-II. - Page-2. Test-1.

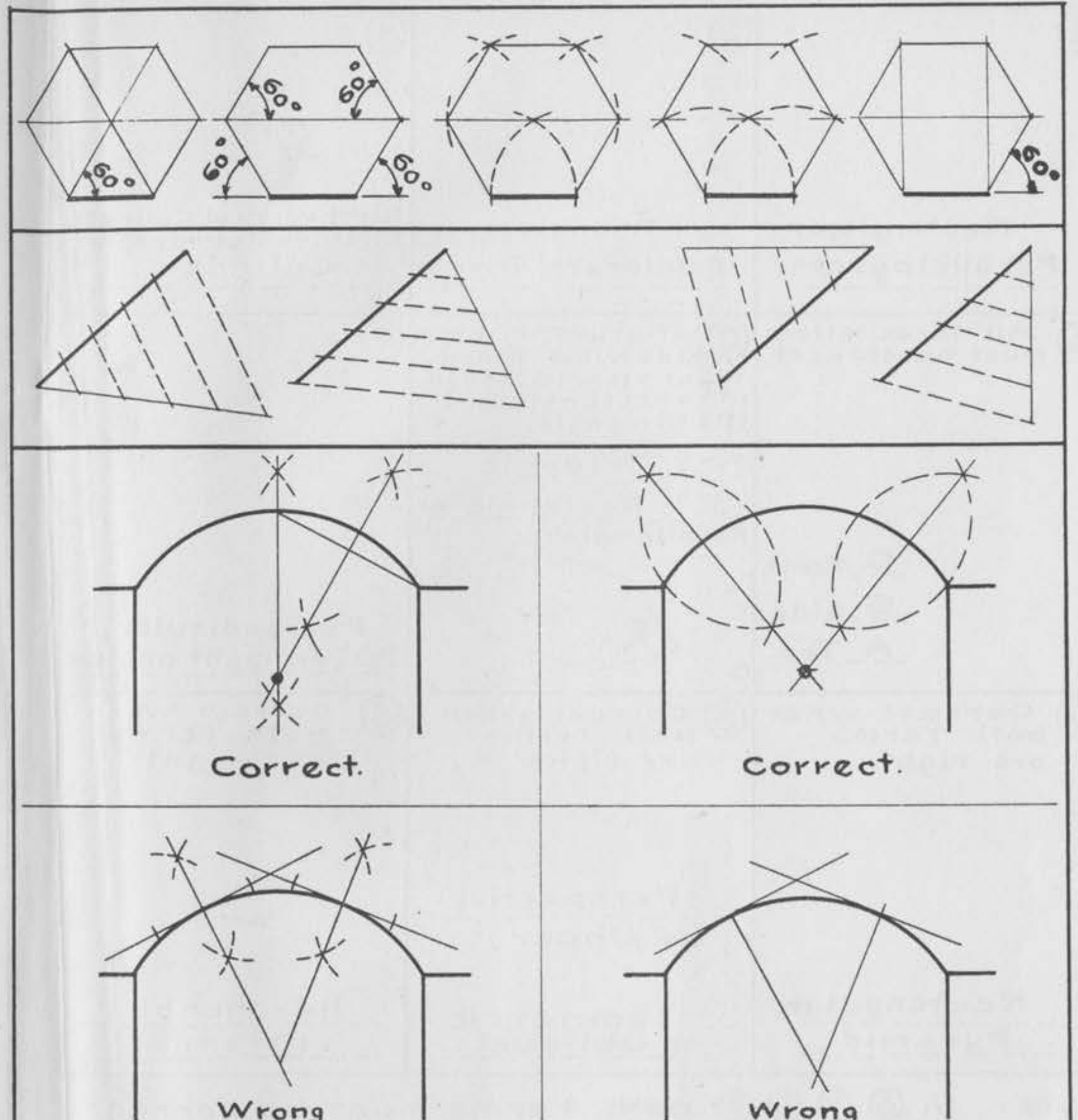
As no specific mention is made requiring the use of a compass to make the arc for the angle, do not deduct anything if freehand, as long as it closely resembles an arc.

3 Points	2 Points	1 Point	O Points

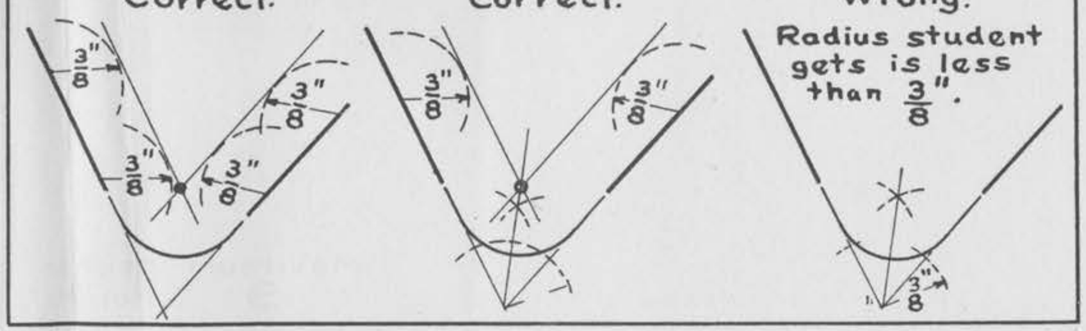


GRADING VARIATIONS

Test No. 2. MARKING KEY PART-II- Page-2.



The student cannot get the point of tangency to the curve accurate enough. He guesses until he gets the correct center. Mark this method wrong.



Place left edge of Page 2, Part I, of Test Sheet along this line ⟶ with (1) of Marking Key opposite (1) of Test Sheet.

MARKING KEY

PART I

MECHANICAL DRAWING TESTS

BY

FERDINAND A. P. FISCHER, M.A.

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Engineering Drawing,
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Chicago, Illinois.

PART I

Tests 1, 2, and 3 follow Key exactly. Test 4 is graded by points. Care must be exercised to determine whether the student has projected his lines correctly. Each line or set of lines counts a point when projected correctly.

Pages 5 and 6 illustrate the Grading of Variations from samples shown on page 2 of Marking Key—Part II.

To assist the author to secure more accurate norms please mail carbon copy of RECORD SHEET to Ferdinand A. P. Fischer, 848 Park Ave., Wilmette, Ill.

PART I

TEST NO. 1

Left edge of Page 3, Part I, along this line ⟶ (14) of Key opposite (14) of Test Sheet.

1	left side
2	4-H
3	90
4	radius
5	180
6	feet
7	start at left and work to right
8	projection lines
9	parallel
10	obtuse angle
11	length width
12	at 90° to each other
13	circle
14	horizontal
15	triangular prism
16	triangles
17	vertical plane
18	triangle
19	square prism
20	rectangle
21	cylinder
22	circle
23	ellipse
24	rectangle
25	ellipse

MAXIMUM SCORE 25

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PART I

TEST NO. 1

DIRECTIONS: Underscore the correct answer in pencil. Time: 9 minutes.

1. Against which edge of the drawing board is the head of the T square placed by a right-handed person?
   bottom   top   left side   right side
2. We are told to use a fairly hard lead pencil to block in the construction lines of our drawing. Which one of the following would you use?
   HB   4-H   B   No. 3
3. A circle is cut into four equal parts by the vertical and horizontal diameters. How many degrees in each part?
   45   60   90   30
4. The line which extends from the center of a circle to the circumference is called—
   diameter   diagonal   radius   tangent
5. Which of the following angles makes a semicircle?
   60   90   360   180
6. The symbol (′) is used to denote—
   degrees   angle   feet   perpendicular
7. When inking a drawing we use the following procedure—
   start at bottom and work upward   start at right and work to left
   start at left and work to right
8. The lines which extend from one view to another in a three-view drawing are called—
   center lines   dimension lines   extension lines   projection lines
9. What relation do the four wheels of a wagon have to each other?
   perpendicular   parallel   tangent   at right angles
10. When the hour hand is at 9 o'clock and the minute hand at 4, the angle between them is called—
    acute angle   right angle   30° angle   obtuse angle
11. Underline the dimensions which a surface must have—
    length   thickness   width   height
12. Two lines which are perpendicular to each other must always be—
    up and down   horizontal   at 90° to each other   parallel
13. If we draw a curved line so that every part of it is equally distant from a part within, which we will call the center, what is the name of the figure formed?
    cube   ellipse   circle   oval

Go right on to next page

14. We often read the statement that "water seeks its own level." Underscore the word which you think most nearly explains this level.
    oblique   horizontal   vertical   inclined
15. Which of the following is a solid?
    square   rectangle   circle   triangular prism
16. A square is divided into two parts by a diagonal. The two pieces formed are—
    rectangles   triangles   ovals   squares
17. The face of a wall clock lies in a plane. It is called a—
    horizontal plane   oblique plane   inclined plane   vertical plane
18. A hexagon is divided by drawing lines connecting its points into six equal parts. What is the name of the figure formed by one of these parts?
    triangle   hexagon   rectangular plane   ellipse
19. A certain solid is made up of six faces. The top and bottom faces are square, but the four other faces are rectangles. It is a—
    hexagonal prism   cone   square pyramid   square prism
20. A vertical equilateral triangular prism is placed so that its rear face is parallel to the vertical plane. The front view will be drawn as a—
    triangle   rectangle   cylinder   rhomboid
21. The development of the surface of a certain solid has the following appearance—a rectangle with a circle at both the top and bottom. This is the surface development of a—
    rectangular prism   right vertical cone   cylinder   triangular prism
22. A spool is cut by a plane perpendicular to its axis. The section cut is a—
    rectangle   ellipse   circle   pyramid
23. When a right vertical cylinder is inclined at an angle, and we look down upon it, the top surface appears as a—
    circle   rectangle   cube   ellipse
24. A 4 by 4-inch timber is cut at an angle to its long axis. The cut does not go through either the top or bottom of the timber. The section cut is a—
    circle   rectangle   square   triangle
25. A right vertical cone is cut by a plane at 45° to the vertical axis. The section does not cut through the base. The oblique view of this section is a—
    rectangle   circle   oblong   ellipse

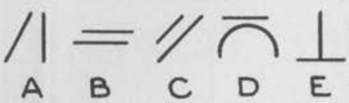
Score:

Right.___________

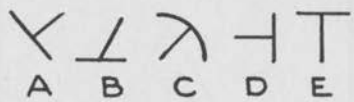
Do not start the next test until told to do so

Read carefully and follow the instructions for each problem

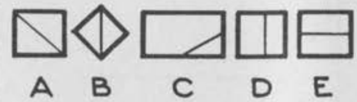
(1) Underscore letters of lines which are parallel



(2) Underscore letters of lines which are perpendicular



(3) Underscore letters of lines which represent diagonals



(4) Underscore letters incorrectly made

Kite Rent

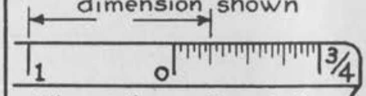
Crow SunK

(5) Underscore symbols which are correctly labelled

′ Degree ° Second

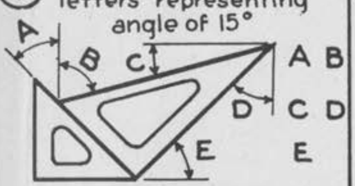
″ Inch ⊥ Parallel

(6) Underscore number corresponding to dimension shown



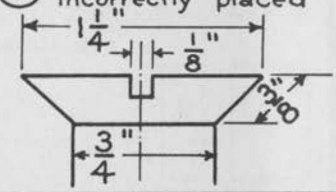
$\frac{1}{4}$" $1\frac{1}{2}$" $1\frac{1}{4}$" $\frac{3}{4}$"

(7) Underscore letter or letters representing angle of 15°



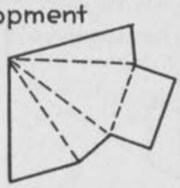
(8) In the drawing of this square pyramid cross out line or lines not drawn correctly

(9) Cross out dimension incorrectly placed



(10) Underscore object of which this is a surface development

Square prism
Right vertical cone
Rectangular pyramid
Triangular pyramid



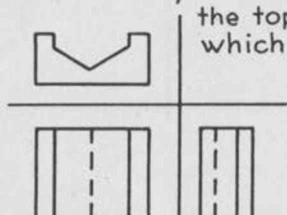
(11) In the drawing of this hollow cylinder, cross out line or lines not drawn correctly

(12) Underscore the correct oblique view cut by plane "A – B"

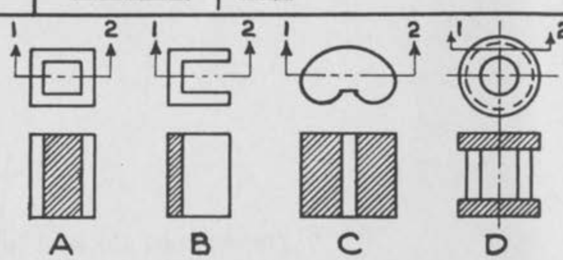
circle ellipse

square rectangle

(13) Cross out lines not drawn correctly in this projection the top view of which is correct



(14) Underscore letter or letters indicating correct section cut by plane "1 – 2"



Score:

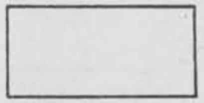
Do not start the next test until told to do so Right ---------

Time: 6 minutes

Test No. 3

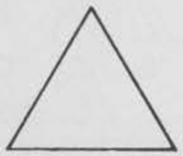
In pencil write the correct answer in space allowed

(1) Give name of Figure represented



____

(2) Give name of figure represented



____

(3) Give name of Figure represented

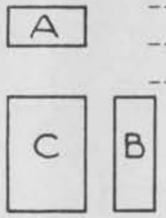
____

(4) Place appropriate letter for view in space below

___Front view

___Side view

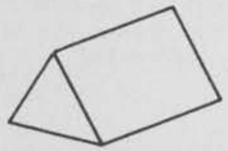
___Top view



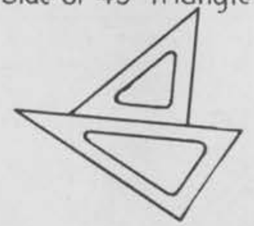
(5) Label front view of sketch (F) and side view (S). Give name of figures represented by (F) and (S)

(F.)__________

(S.)__________

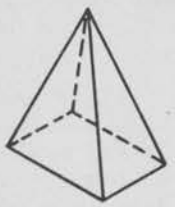


(6) What is the relation of the longest side of 60° triangle to right-hand side of 45° triangle



____

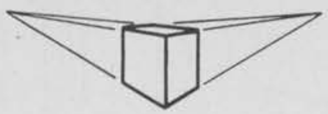
(7) Give name of figure represented



____

____

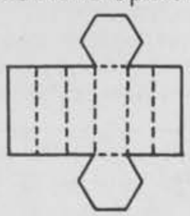
(8) Tell which figure is drawn in perspective? What is other drawn in?



____

____

(9) Give name of object of which this is a development



____

____

Score:

Right__________

Do not start the next test until told to do so

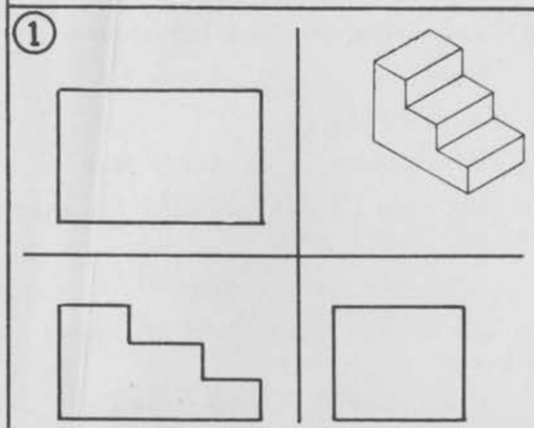
Time: 15 minutes

Test No. 4

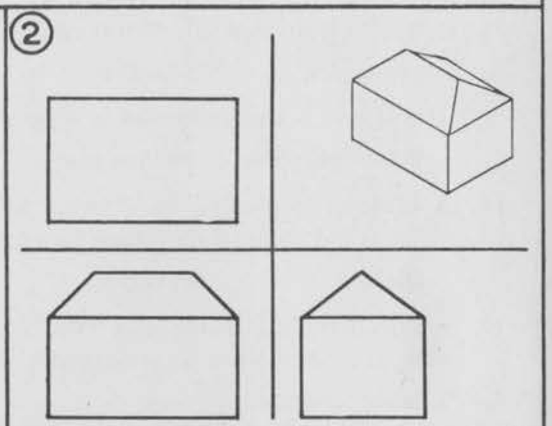
Notice: This test need not be mounted on the drawing board

Complete all three views putting in all visible and invisible lines missing, as well as center lines where needed.
You can do this freehand if carefully done, or with scale and triangles if you so desire.

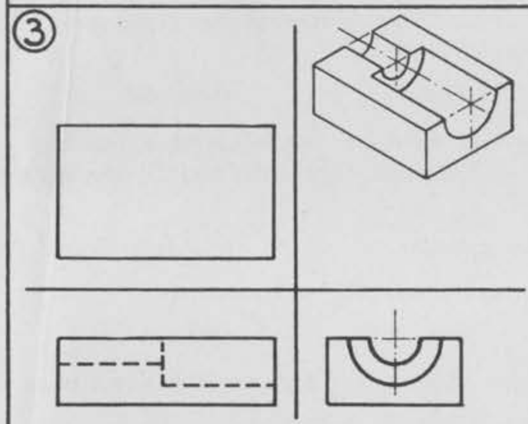
(1)



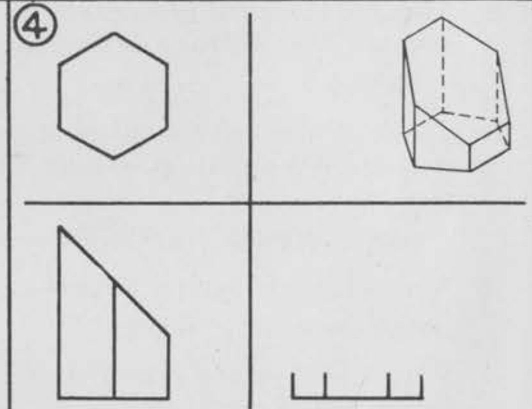
(2)



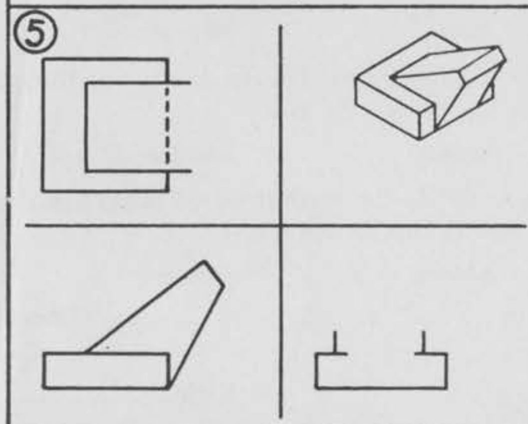
(3)



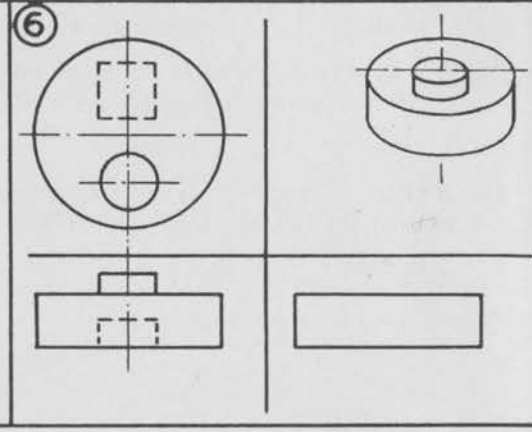
(4)



(5)



(6)



Score:

Points made__________

Finish of tests

Mechanical Drawing Tests

for

High Schools, Trade Schools, and Entering College Students

BY

FERDINAND A. P. FISCHER, M.A.
Instructor Engineering Drawing,
Crane Junior College, Chicago, Ill.

PART I

Test	Score
1	
2	
3	
4	
Total	

PART I
TESTS 1, 2, 3, 4
TECHNICAL INFORMATION TESTS

The student will please fill in the blanks below.
Do not turn page until you are told to do so.

School .... City and State ....

Grade .... Student's Name ....

When was your last birthday? .... How old were you then? .... yrs.

GENERAL INSTRUCTIONS TO THE STUDENT

These tests are designed to assist you to determine for yourself just how well you have mastered your drawing work. You are asked to follow instructions and to do your own work; do not use books or reference material, and start and stop exactly upon the teacher's signal. There are usually more questions than you can answer in the given time, so do not worry if you cannot finish. Answer them in their correct order, to the best of your ability and without wasting any time.

A drawing pencil is the only tool necessary for these tests. For Test No. 4 the use of a scale or triangle is permissible.

The problems are of this type:

Test No. 1. Underscore the correct answer in pencil.

A ball has the shape of a—

Cube **Sphere** **Prism** **Oblong**

As "sphere" is the correct answer, we place a line under it, thus: **Sphere**

Test No. 2. Underscore the correct answer in pencil.

Which triangle is a right-angled triangle?

As "C" is the correct answer we place a line under it, thus: C


A B C

Test No. 3. Instead of underscoring the correct answer you will be asked to write the answer in the space provided for it.

Test No. 4. You will be asked to complete three views of an object. An isometric view (pictorial representation) of the object is shown, two of the views are drawn, and the third partly finished. You are required to add the missing lines.

You are given a certain length of time to work on each test. When the teacher indicates that the time is up for the test you are working at, you must stop immediately and proceed with the next test.

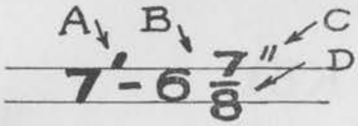
When the teacher gives the signal "Go," turn the page and begin.

The Bruce Publishing Company, Milwaukee, Wisconsin

PART-II.
MARKING KEY. TEST NO.1

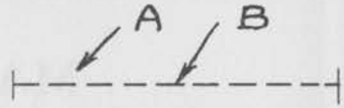
A letter represents a symbol, line or set of lines and counts for one point in marking.
See KEY-PART-I-Page 5 for grading variations, Prob. ① & ②

①



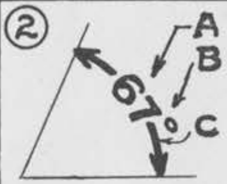
A - Symbol (').
B - Mixed number
C - Symbol (")
D - Fraction
} correctly made and placed.

③



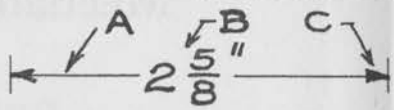
A - Correct measurement.
B - Dashes.
(Mark off on piece of paper lengths for ③ & ④ as a check in scoring tests).

②



A - Whole number
B - Symbol (°).
C - Dimension arc.
Must be correctly made and placed.

④



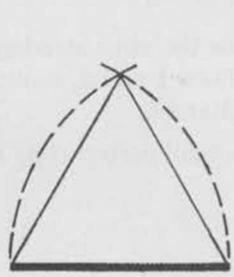
A - Correct measurement.
B - Mixed number and (").
C - Arrow heads placed correctly. (If number is above a solid line mark correct)

Maximum score 12 Points.

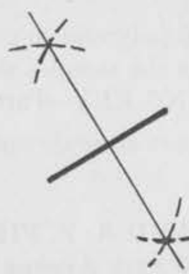
TEST NO. 2.

Many different methods may be used by student to solve each problem. Instructor must decide if pupil's method is correct.

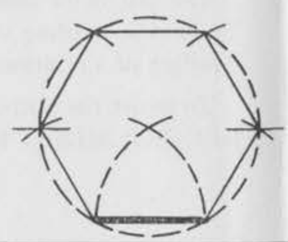
①



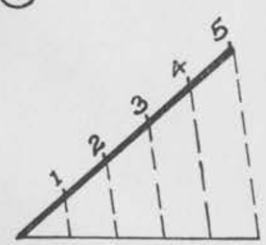
②



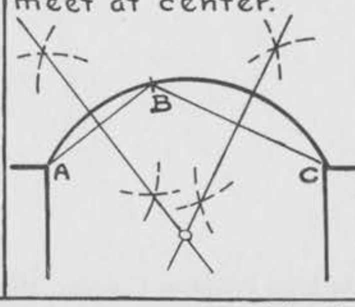
③



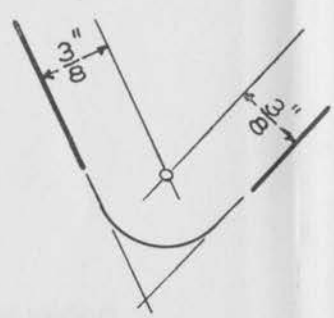
④



⑤ Select any three points (A, B, C). Perpendicular bisectors meet at center.



⑥



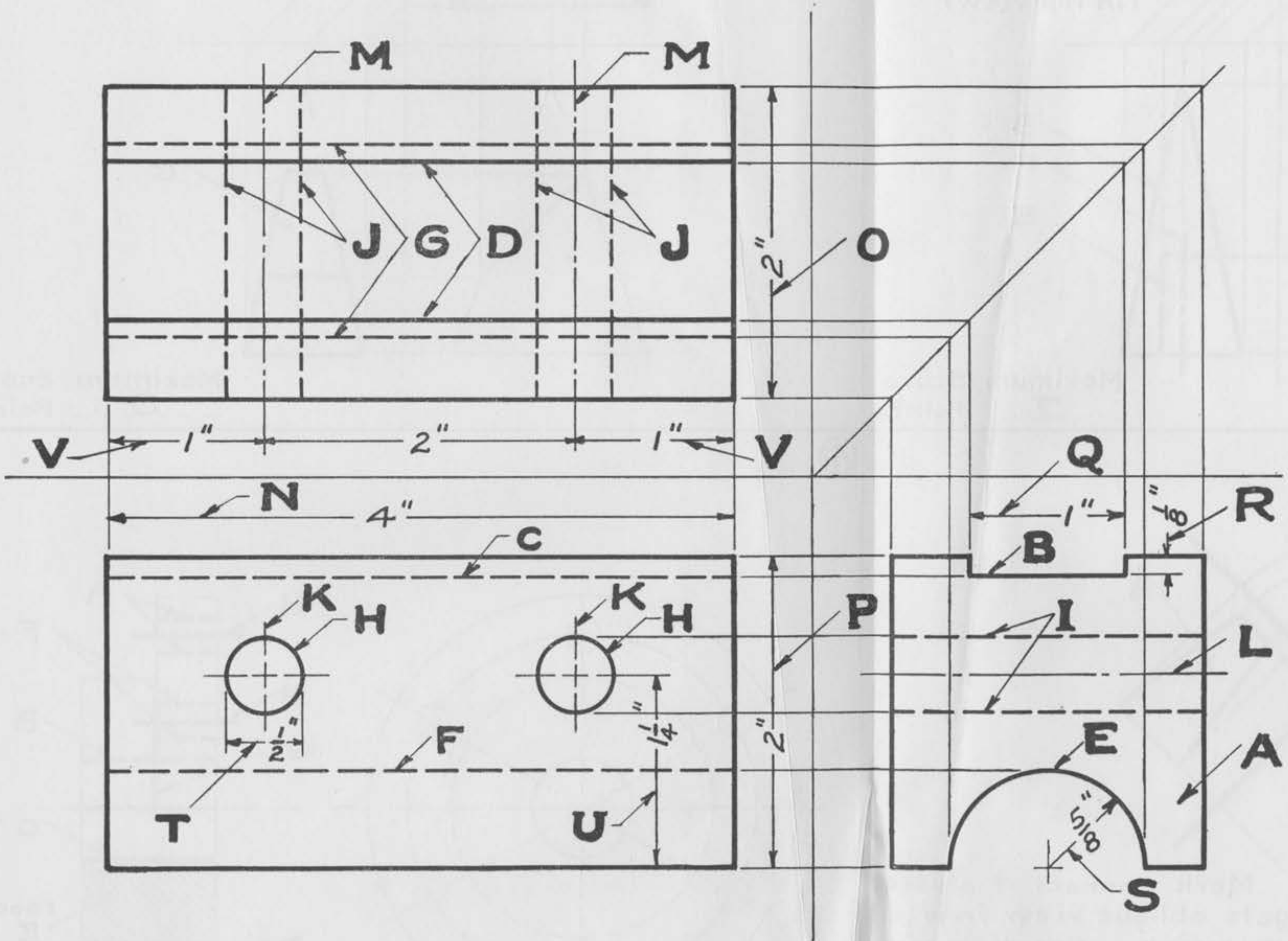
Maximum score 6 Points

Note:
A few possible solutions are given on Page 6. Marking Key. Part I.

MARKING KEY - TEST NO. 3. SERIES-(A).

The objective of this problem is to measure the actual drawing ability of the pupil in making a finished working drawing. Therefore, each unit is scored separately. The units as indicated by letters are scored in points as shown below.

The instructor may decide the correctness of the placing of dimension lines. Mastery is concerned with the ability to dimension each important unit so that the problem can actually be constructed.



Check (√) in this order with a blue or red pencil each line or set of lines correctly drawn. Add checks to get total score.

LETTER	
A	Side view directly in line with front view. (Some students prefer to use the axes of projection method, others not, in placing the views. Either way is given credit for one point.)
B	Slot in side view.
C	Slot in front view.
D	Slot in top view.
E	Groove in side view.
F	Groove in front view.
G	Groove in top view.
H	Hole in front view.
I	Hole in side view.
J	Hole in top view.
K	Center lines of holes in front view.
L	Center lines of holes in side view.
M	Center lines of holes in top view.

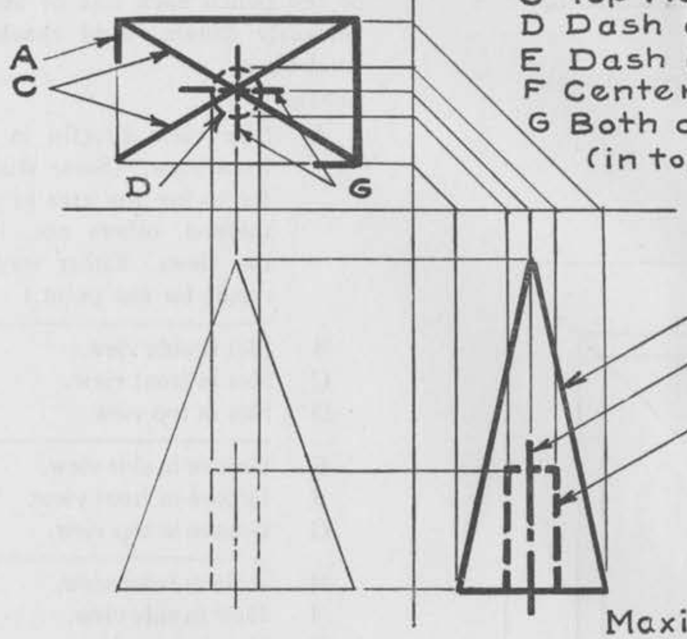
Placing of Dimensions

N	4″ length.
O	2″ width.
P	2″ height.
Q	1″ width of slot.
R	1/8″ depth of slot.
S	5/8″ radius of groove.
T	1/2″ diameter of hole.
U	1/4″ height of center of hole above the base.
V	1″ distance from center of hole from end.

Maximum score 22 Points.

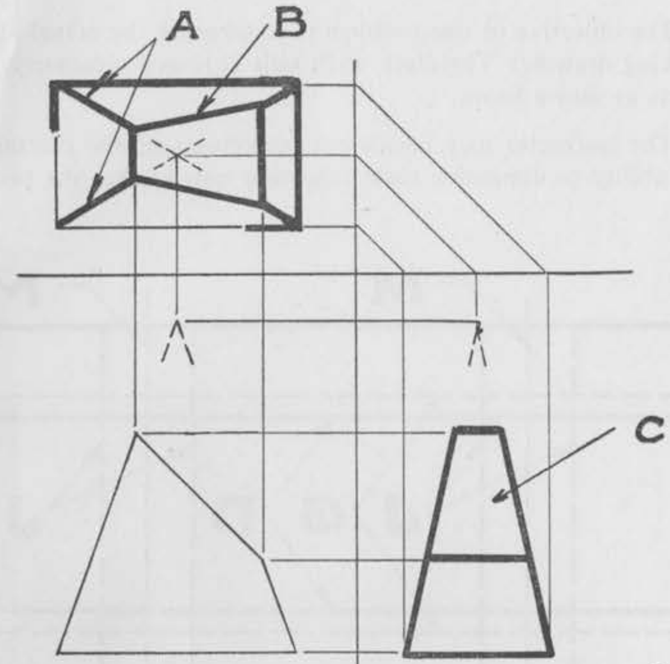
① A letter counts for one point, allowed for a single line or set of lines according to the key.

A...Top View...(rectangle).
B Side View (triangle).
C Top View (diagonals).
D Dash circle.
E Dash cylinder.
F Center line.
G Both center lines (in top view).



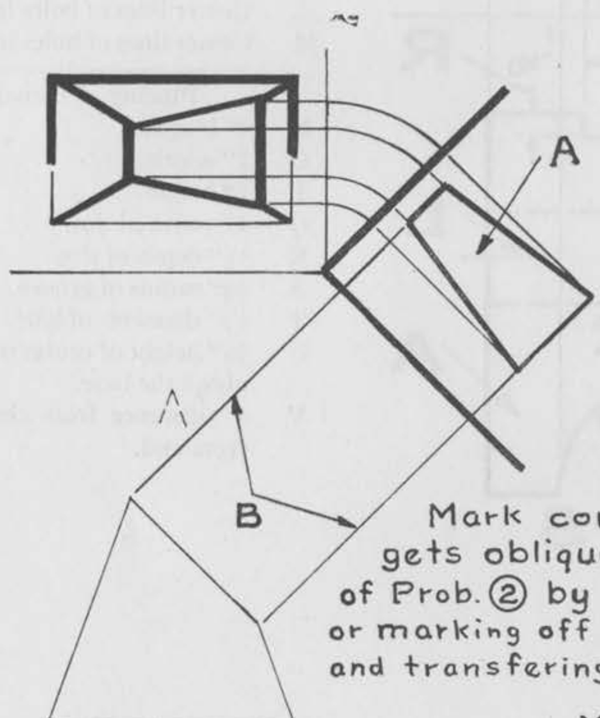
Maximum Score: ___7___ Points.

②



Maximum Score: ___3___ Points.

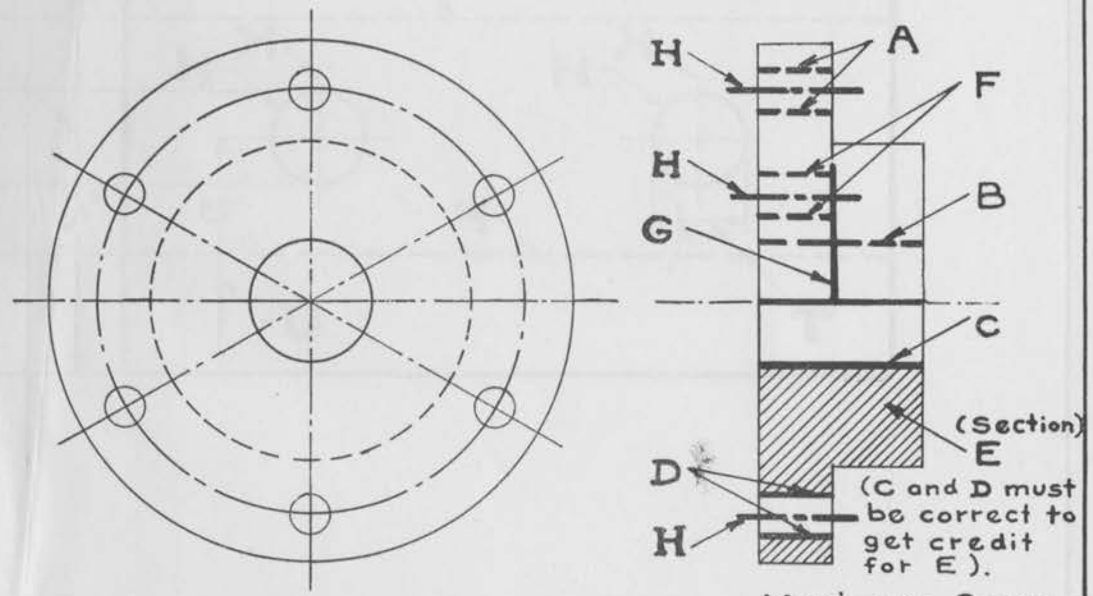
③



Mark correct if student gets oblique view from (B) of Prob. ② by using dividers or marking off on piece of paper and transfering to Prob. ③.

Maximum Score: ___2___ Points.

④



(C and D must be correct to get credit for E).

Maximum Score: ___8___ Points.

Total Maximum 20 Points.

MARKING KEY

PART II

for

Mechanical Drawing Tests

BY

FERDINAND A. P. FISCHER, M.A.

Instructor Engineering Drawing

Crane Junior College, Chicago, Illinois

The instructor must use his good judgment in grading all on the same standard. To help in grading variations from the samples shown for Tests 1 and 2, consult Grading of Variations on MARKING KEY—Part I, pages 5 and 6.

To assist the author to secure more accurate norms, please mail carbon copy of RECORD SHEET to

FERDINAND A. P. FISCHER

848 Park Avenue

WILMETTE, ILLINOIS

Published by The Bruce Publishing Company, Milwaukee, Wisconsin.

Printed in the United States of America.

Time (1 and 2): 16 minutes

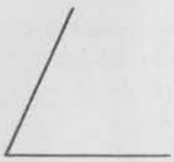
Test No. 1

This test need not be mounted on the drawing board

(1) In guide lines below indicate numerically the statement using proper symbols

Seven feet six and seven-eighths inches

(2) Properly dimension numerically the angle of sixty-seven degrees shown at right



(3) Draw lines indicated from point (A) to the right and measure with your scale distance required

A horizontal dash line one and eleven sixteenths inches long

(A) .

(4) A horizontal dimension line two and five eighths inches long, drawn to scale of $\frac{3}{4}" = 1"$ Put arrow heads and dimensions in proper place.

(A) .

Score

Points made ________

Go right on to test No. 2

Test No. 2

Draw by geometrical construction
Do not erase any of your construction lines

(1) Draw equilateral triangle with given line as a side

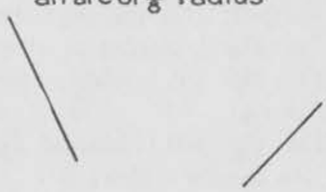
(2) Draw perpendicular bisector of given line

(3) Construct regular hexagon with given line as a side

(4) Divide given line into five equal parts

(5) Find center of circle which makes this arc

(6) Prolong these lines and connect them by an arc of $\frac{3}{8}"$ radius



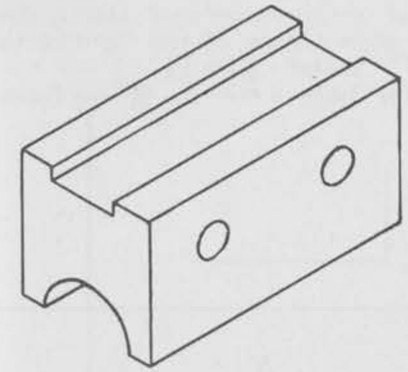
Score:

Number right----------

Do not start the next test until told to do so

In space below complete a three-view working drawing of the pattern shown by the sketch and fully described. Fully dimension your drawing. Scale full size.

Your work will be judged on accuracy, arrangement, dimensioning, and neatness of work. Show center lines where needed.

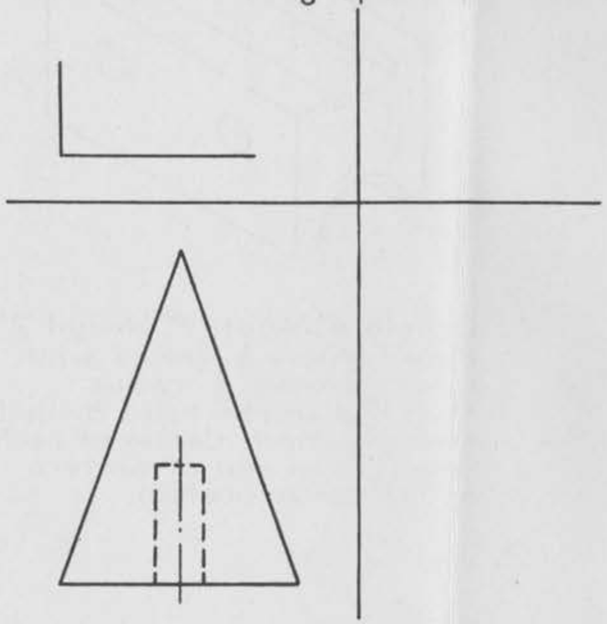


Length 4", Width 2", Height 2".
Upper groove $\frac{1}{8}$" deep, 1" wide.
Lower groove $\frac{5}{8}$" radius.
Two $\frac{1}{2}$" diameter holes drilled through pattern. Center of each hole 1" from end of pattern and $1\frac{1}{4}$" above bottom.

Score:

Points made ________

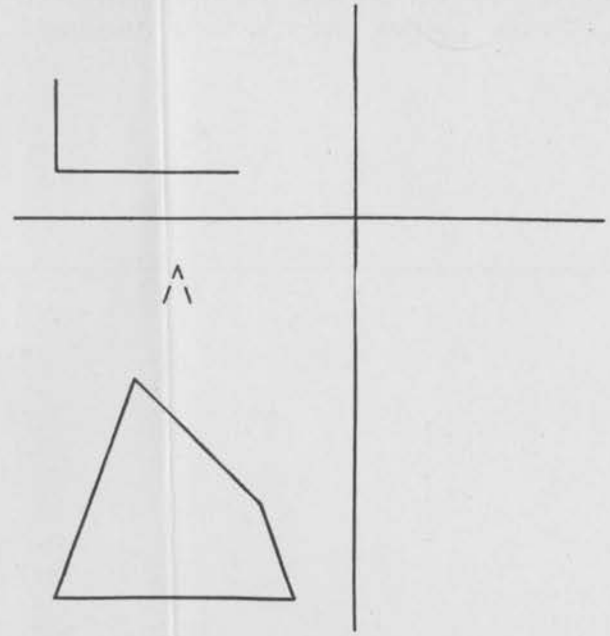
① By means of projection and using dimensions given, finish the top and side views of the right rectangular pyramid
Altitude = $1\frac{3}{4}$" Base = $\frac{3}{4}$" x $1\frac{1}{4}$".
A $\frac{1}{4}$" diameter hole extends $\frac{5}{8}$" up from the middle of the base



Score:

________ Points

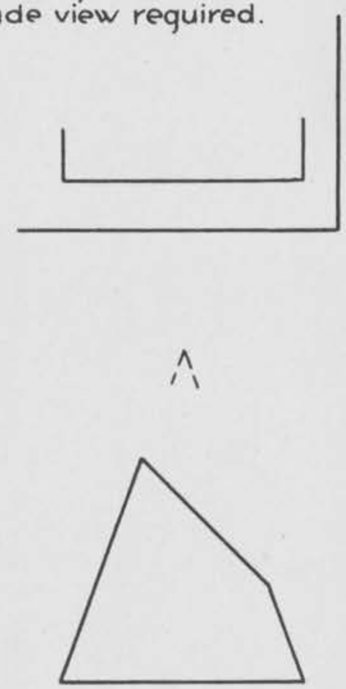
② Using dimensions of problem 1, draw three views of problem 1 and draw three views of pyramid when top is cut off as shown in front view Omit hole in base.



Score:

________ Points

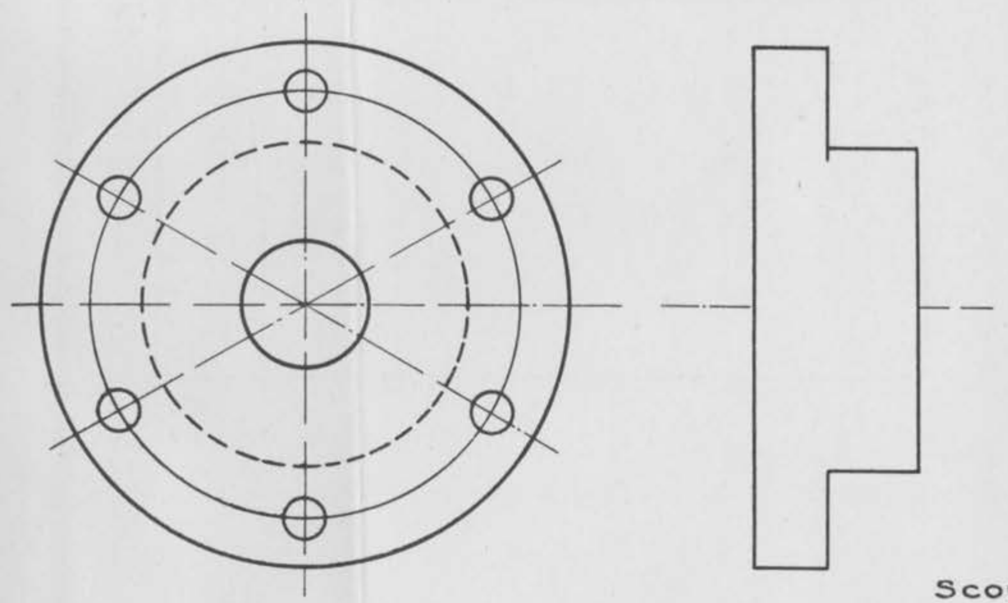
③ Using dimensions of problem 1, draw by means of an oblique or auxiliary view the true size and shape of the cut section
No side view required.



Score:

________ Points

④ Complete the end view of this iron casting. Make upper half of the end view in elevation and lower half in section.
Symbol for cast iron in section is 



Score:

________ Points

Mechanical Drawing Tests

for

High Schools, Trade Schools, and Entering College Students

BY

FERDINAND A. P. FISCHER, M.A.
Instructor Engineering Drawing,
Crane Junior College, Chicago, Ill.

PART II

Test	Score
1	______
2	______
3-A	______
3-B	______
Total	______

PART II
TESTS 1, 2, 3
PERFORMANCE TESTS

The student will please fill in the blanks below.
Do not turn page until you are told to do so.

School ....City and State....................................

Grade ....Student's Name....................................

When was your last birthday?................ How old were you then? ....yrs.

INSTRUCTIONS TO THE STUDENT

These tests are designed to assist you to determine for yourself just how well you have mastered your drawing work. You are asked to follow instructions and to do your own work; do not use books or reference material, and start and stop immediately upon the teacher's signal. There are usually more questions than you can answer in the given time, so do not worry if you cannot finish. Answer them in their correct order, to the best of your ability and without wasting any time.

You will need your drawing board, T squares, triangles, scale, pencil compass, nicely sharpened drawing pencil, and thumb tacks. Place these on your drawing board so that you will be ready to work when the signal is given.

The problems are of this type:

Test No. 1. Some problems will be given to see how well you understand the use of the scale, mixed numbers, and angles.

Test No. 2. You will be asked to do some geometrical problems. In this type of work be sure not to erase any of your construction lines.

Test No. 3. You will be asked to draw by means of projection lines three views of an object. This test must be mounted on a drawing board. Your work will be judged on accuracy, placing of views, dimensioning (when called for), and neatness of work.

Test No. 3-A is adapted for trade schools or schools where working drawings are emphasized.

Test No. 3-B is adapted for schools emphasizing the principles of sections and oblique or auxiliary views.

You are given a certain length of time to work on each test. When the teacher indicates that the time is up for the test you are working at, you must stop immediately and proceed with the next test.

When the teacher gives the signal "Go," turn the page and begin.

The Bruce Publishing Company, Milwaukee, Wisconsin

Printed in the United States of America

RECORD SHEET

Mechanical Drawing Tests By Ferdinand A. P. Fischer

School.................... City and State.................... Teacher....................

No. of times class meets per week .... Length of class period (minutes) .... No. of weeks drawing is given in a school year ....

Name of Student List by total score (*highest score to lowest in descending order*) either Part I and II combined or Part I or Part II, whichever is given.	Total number minutes of drawing completed to date.	PART I				Total PART I	PART II				Total PART II	Total I and II	Rating	Remarks
		TEST NUMBERS					TEST NUMBERS							
		1	2	3	4		1	2	3A	3B				
		Maximum Possible					Maximum Possible							
		25	14	9	16	64	12	6	22	20				

Carbon copy of page 4 on this page. Retain this entire sheet.

RECORD SHEET

Mechanical Drawing Tests By Ferdinand A. P. Fischer

School.................... City and State.................... Teacher....................

No. of times class meets per week .... Length of class period (minutes) .... No. of weeks drawing is given in a school year ....

Name of Student List by total score (*highest score to lowest in descending order*) either Part I and II combined or Part I or Part II, whichever is given.	Total number minutes of drawing completed to date.	PART I				Total PART I	PART II				Total PART II	Total I and II	Rating	Remarks
		TEST NUMBERS					TEST NUMBERS							
		1	2	3	4		1	2	3A	3B				
		Maximum Possible					Maximum Possible							
		25	14	9	16	64	12	6	22	20				

Carbon copy of page 1 on this page. Mail this entire sheet to author.

RECORD SHEET

Mechanical Drawing Tests By Ferdinand A. P. Fischer

School........................ City and State........................ Teacher........................

No. of times class meets per week .... Length of class period (minutes) .... No. of weeks drawing is given in a school year ....

Name of Student List by total score (*highest score to lowest in descending order*) either Part I and II combined or Part I or Part II, whichever is given.	Total number minutes of drawing completed to date.	PART I				Total PART I	PART II				Total PART II	Total I and II	Rating	Remarks
		TEST NUMBERS					TEST NUMBERS							
		1	2	3	4		1	2	3A	3B				
		Maximum Possible					Maximum Possible							
		25	14	9	16	64	12	6	22	20				

(Continued from Page 1)

To assist the author in securing more accurate norms, please place carbon between pages 2 and 3. List the students by groups having had the same number of minutes of drawing. If you have more pupils than lines provided on page 1, continue on page 4, placing the carbon between pages 2 and 3. Detach half the sheet (pages 3-4) and mail to the author, FERDINAND A. P. FISCHER, 848 Park Ave., Wilmette, Ill., or THE BRUCE PUBLISHING COMPANY, 129 E. Michigan St., Milwaukee, Wis.

RECORD SHEET

Mechanical Drawing Tests By Ferdinand A. P. Fischer

School........................ City and State........................ Teacher........................

No. of times class meets per week .... Length of class period (minutes) .... No. of weeks drawing is given in a school year ....

Name of Student List by total score (*highest score to lowest in descending order*) either Part I and II combined or Part I or Part II, whichever is given.	Total number minutes of drawing completed to date.	PART I				Total PART I	PART II				Total PART II	Total I and II	Rating	Remarks
		TEST NUMBERS					TEST NUMBERS							
		1	2	3	4		1	2	3A	3B				
		Maximum Possible					Maximum Possible							
		25	14	9	16	64	12	6	22	20				

(Continued on Page 4)

To assist the author in securing more accurate norms, please place carbon between pages 2 and 3. List the students by groups having had the same number of minutes of drawing. If you have more pupils than lines provided on page 1, continue on page 4, placing the carbon between pages 2 and 3. Detach half the sheet (pages 3-4) and mail to the author, FERDINAND A. P. FISCHER, 848 Park Ave., Wilmette, Ill., or THE BRUCE PUBLISHING COMPANY, 129 E. Michigan St., Milwaukee, Wis.

TABLE I.--DATA FOR MEMBERS OF GROUP A (CONSTRUCTION, SKETCHING AND SIMPLIFIED INSTRUMENT METHOD) AS TO AGE, INTELLIGENCE QUOTIENT, SCORES MADE ON MECHANICAL ABILITY TEST, AVERAGE GRADES OF PREVIOUS SEMESTER, AND ACHIEVEMENT SCORES (FIRST AND SECOND TESTING)

STUDENT	AGE (MO.)	I.Q.	AV. GRADE	MECH. APT.	FISCHER'S TEST (FIRST TIME)			FISCHER'S TEST (SECOND TIME)		
					Pt. I	Pt. II	Total	Pt. I	Pt. II	Total
E.D.	169	102	83	69	15	8	23	36	31	67
A.D.	197	106	84	58	31	14	45	57	41	98
J.D.	172	105	81	82	17	8	25	41	28	69
E.D.	166	108	76	58	19	19	38	31	22	53
H.E.	172	114	87	89	21	16	37	39	31	70
C.F.	192	106	85	73	28	14	42	48	46	94
L.H.	169	103	84	73	22	15	37	48	46	94
G.H.	175	104	82	52	14	12	26	27	42	69
B.H.	183	95	77	46	16	4	20	40	34	74
G.K.	174	106	89	67	26	7	33	50	41	91
F.R.	180	106	80	67	24	7	31	32	28	60
A.S.	173	97	73	52	25	7	32	36	37	73
S.T.	170	101	87	65	16	10	26	42	29	71
J.W.	170	115	88	68	32	11	43	48	44	92
J.M	166	114	84	53	22	6	28	42	39	81
L.M.	171	112	82	71	27	20	47	52	29	81
J.H.	177	101	77	63	12	9	21	36	40	76
B.K.	173	108	82	67	21	11	32	48	42	90
D.M.	166	110	87	77	19	15	34	39	46	85
R.H.	169	127	94	64	27	14	41	52	43	95
E.H.	182	101	80	51	22	6	28	45	27	72
A.L.	168	123	93	78	35	21	56	53	49	102
J.M.	174	121	90	72	35	24	59	60	50	110
G.M.	202	112	83	80	34	14	48	52	46	98
A.M.	169	110	86	70	16	5	21	34	41	75
E.O.	165	122	89	66	23	14	37	49	32	81
J.P.	211	93	75	46	18	9	27	36	29	65
R.T.	199	98	88	51	19	13	32	39	40	79
L.Z.	167	110	86	57	22	11	33	48	47	95

TABLE 2.--DATA FOR MEMBERS OF GROUP B (CONSTRUCTION, SKETCHING AND SIMPLIFIED INSTRUMENT METHOD) AS TO AGE, INTELLIGENCE QUOTIENT, SCORES MADE ON MECHANICAL ABILITY TEST, AVERAGE GRADES OF PREVIOUS SEMESTER, AND ACHIEVEMENT SCORES (FIRST AND SECOND TESTING)

STUDENT	AGE (MO.)	I.Q.	AV. GRADE	MECH. APT.	FISCHER'S TEST (FIRST TIME)			FISCHER'S TEST (SECOND TIME)		
					Pt. I	Pt. II	Total	Pt. I	Pt. II	Total
P.L.	173	103	84	64	20	15	35	35	24	59
N.T.	172	105	75	58	22	13	35	42	21	63
D.D.	199	90	80	86	14	6	20	34	23	57
A.G.	171	109	85	58	23	11	34	39	45	84
D.S.	165	115	75	52	21	5	26	22	22	44
V.M.	204	106	80	65	25	11	36	43	31	74
M.B.	173	108	86	71	15	4	19	25	31	56
J.R.	167	100	83	55	16	3	19	31	27	58
K.V.	180	95	78	64	19	4	23	26	30	56
R.G.	175	106	85	61	30	14	44	31	23	54
E.H.	180	107	85	61	18	11	29	32	36	68
R.T.	173	97	84	40	23	6	29	38	33	71
T.R.	172	101	75	54	17	5	22	20	21	41
J.B.	164	115	90	67	31	20	51	40	40	80
R.A.	160	119	87	52	32	20	52	38	31	69
G.C.	168	112	88	72	26	18	44	30	22	52
J.D.	170	101	84	77	33	26	59	45	30	75
M.D.	179	108	86	54	16	17	33	29	31	60
E.H.	170	111	84	43	19	11	30	30	19	49
C.M.	171	113	86	68	21	14	35	37	36	73
H.H.	179	115	81	64	28	18	46	38	34	72
B.W.	170	120	95	89	30	17	47	51	48	99
H.H.	195	114	88	71	37	18	55	50	31	81
A.V.	172	111	87	78	21	20	41	38	29	67
R.G.	174	109	85	45	29	19	48	29	21	50
P.S.	192	108	80	65	21	17	38	32	30	62
H.O.	193	90	80	59	24	16	40	34	30	64
S.W.	168	97	90	55	18	16	34	24	24	48
L.T.	181	109	76	67	23	20	43	50	32	82

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