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A Study to Determine the Effect on Student Achievement of Graphic Materials Integrated in a Fifth Grade Curriculum

Harold Irving Goodwin
Central Washington University

A STUDY TO DETERMINE THE EFFECT ON STUDENT ACHIEVEMENT OF GRAPHIC MATERIALS INTEGRATED IN A FIFTH GRADE CURRICULUM

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Harold Irving Goodwin

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Donald J. Murphy, COMMITTEE CHAIRMAN

Eldon E. Jacobsen

George Sogge

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TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS

I. THE PROBLEM

Statement of the problem. The purpose of this study is to ascertain the effect of express instruction with graphic materials on the achievement of fifth grade pupils when such materials are integrated with the several content areas. The study is undertaken to determine the advisability of inclusion of such instruction in the fifth grade curriculum of the Port Angeles, Washington, public schools.

Significance of the study. Graphs, charts, and tables as a means of conveying information are increasing in magazines, newspapers, and publications for students. The effectiveness of this medium is gaining increasing recognition.

However, a comprehensive survey of available literature reveals a general absence of information pertaining to methods of teaching graph skills as an integral part of a specific subject or curriculum.

Insufficient progress has been made in the adaptation of graphs, charts, and tables to classroom teaching. This study is designed to help fill an apparent need for graphic instruction at the fifth grade level in the Port Angeles school system.

Philosophy of the study. The utilization of graphs and tables in our changing society is quantitatively increasing. In regard to this situation, Overman writes, "The use of graphs to represent statistical data is so common in newspapers, magazines, and books that it is the duty of the schools to teach their pupils how to make and interpret such graphs."[1]

If it is an objective of education to teach students of all ages to synchronize with and understand their environmental stimuli, then teaching must take cognizance of the use of graphic materials as one tool in the development of that goal. "If a citizen, young or old, is to interpret the world about him," concludes Stutz, "he needs to develop skill in reading the various graphic means through which information today is transmitted. Realistic teaching must, therefore, give attention to the effective use of . . . graphic . . . materials."[2]

The utilization of graphs in education must be in terms of its relationship to other educational activities rather than for its own

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[1]James R. Overman, Principles and Methods of Teaching Arithmetic (New York: Lyons and Carnahan, 1920), p. 15.

[2]Frederick H. Stutz, et al., "Interpreting Material Presented in Graphic Form," National Council for the Social Studies, Yearbook, 1953, Chap. IX, p. 178.

terminate ends. Brown and Coffman make clear this point with this concise statement, "The graph should not be taught as an end in itself, but as a means to an end. It should be used to supplement, not supplant analysis."[3]

It is consistent with the nature of this study to help fulfill the growing need for increased graphic materials as an integral part of classroom teaching. Writes Dale, "If it is not an integral part of the assignment, it might as well not be included."[4]

II. DEFINITIONS OF TERMS

Educational terminology is often rather confusing because words or phrases sometimes include variant shades of meanings. Through the duration of this study terms defined below shall consistently have only a single meaning. The clarification of the terms will be enhanced if the reader attaches to terms the meanings herein expressed.

Express instruction. The term express instruction shall be used with specific reference to the teaching of the sixteen lesson plans,

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[3]Joseph C. Brown and Lotus D. Coffman, How to Teach Arithmetic (New York: Row, Peterson and Company, 1914), pp. 319-320.

[4]Edgar Dale, Audio-Visual Methods in Teaching (New York: The Dryden Press, 1948), p. 294.

which comprise the basis for the study, by the four teachers of the experimental teacher group.

Graphic materials. The meaning attached to this term shall be considered to include only the wall graphs, charts, tables, dittoed graphs, and crayon drawings of various types of lamps that were used in conjunction with the lesson plans.

Achievement. For the purpose of this study the term achievement shall be construed to mean growth in specific skills and abilities pertaining to graphic materials as measured by a standardized test.

Integration. The term integration shall be interpreted to mean the graphic materials were correlated with the actual classroom teaching being concurrently carried on in the Port Angeles school system.

Content areas. This term refers only to the specific subjects included in the study--arithmetic, reading, geography, and science.

CHAPTER II

RELATED RESEARCH

I. HISTORY OF GRAPHS

The basic principle upon which graphs are based was discovered more than three centuries ago in France. "In 1637," Arkin and Colton write, "Rene Descartes described for the first time the principle on which the modern graph is based. Through the use of lines drawn perpendicular to one another he was able to represent the values of parts of numbers by the use of points on the resulting plane."[1]

The significance of this discovery was not generally realized by scholars, for little use was made of Descartes' discovery for more than 150 years when in the 1870's Chrome, Gaspari, Boetticher, and von Hoeck of Germany, Beaufort of France, and Playfair of England employed graphs extensively to present statistical data.[2]

The first use of this discovery was made in schools of France

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[1]Herbert Arkin and Raymond R. Colton, How to Use Pictorial Statistics (New York: Harper and Brothers, 1937), p. 1.

[2]Ibid., p. 2.

in 1869. Strickland, citing Funkhouser, wrote that Lavasseur used various kinds of diagrams and cartograms as wall charts in his geography textbooks for use in the French secondary schools. There was no evidence that texts in geography other than those of Lavasseur and the more general works of Reclus made any appreciable use of geographic methods before the beginning of the twentieth century.[3] Strickland, still citing Funkhouser, reported that geographic materials were first introduced into American texts shortly before the turn of the century in the form of simple bar graphs, pie diagrams, historical curves, and cartograms.[4]

Since the turn of the century the utilization of graphic materials in texts on the elementary level has proceeded slowly. A recent survey by the writer of the most current arithmetic and science texts of six major publishing companies revealed only limited space devoted to this medium. The use of graphic materials as an effective means of communicating information has not kept pace with increasing needs for this method of instruction.

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[3]Ruth Strickland, A Study of the Possibilities of Graphs as a Means of Instruction in the First Four Grades of the Elementary School (New York: Bureau of Publications, Teachers College, Columbia University, 1938, p. 2, citing H. Gray Funkhouser, Historical Development of the Original Representation of Statistical Data (Bruges: St. Catherine Press, Ltd., 1937.

[4]Loc. cit.

II. SYNOPSES OF PREVIOUS GRAPH STUDIES

A review of the literature available to the writer produced ten separate studies which have been conducted and reported in the area of graphic materials. Seven of the studies dealt with the grade placement of graphs without teaching graphic interpretation during the course of the investigations. The following are brief synopses of these seven studies and their results.

The Eells study.[5] Eells conducted his study in 1926. He tried to determine the relative effectiveness of two types of graphs --sub-divided circle and bar graphs. Eells made 15 sets of graphs, each set consisting of a subdivided circle and a bar graph, each of which communicated the same idea. Pupils estimated the percentage of each sector of the circle graph. Three days later they were required to estimate the percentage indicated by the bar graphs. The results were analyzed on the basis of error of judgment.

Results: Eells reported that his findings indicated the circle graphs were as easy to read as a bar graph showing component parts. Eells said that circle graphs were read more accurately than bar graphs.

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[5]Morton S. Malter, "Studies of the Effectiveness of Graphic Materials," Journal of Educational Research, XLVI (December, 1952), p. 263.

The Mathews Study.[6] Mathews' 1926 study included four types of graphs--line, bar, circle, and pictographs in grades 4, 7, 8, and 12. The graphs were taken from social studies materials which had been published. Mathews' graphs made no attempt to measure similar concepts on the various types of graph forms used. Students were given time to study the graphs and were then asked questions about the graphs. The test was for comprehension rather than for recall of test material.

Results: Mathews' study revealed that circle graphs were the easiest to read, the line graph the most difficult, and the bar graph between the two.

The Croxton and Stryker study.[7] This 1927 study was conducted to ascertain, on the college level, the relative merits of circle and bar graphs. In this study 13 sets of graphs--circle and bar--were presented for testing. Unlike Eells, who tested for each type of graph on different days, Croxton and Stryker presented both types of graphs in a single testing period. Graphs were shuffled so that graphs showing the same concept were not shown consecutively. Results were based upon error of judgment.

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[6] Ibid., p. 264.

[7] Malter, op. cit., p. 263.

Results: These experimenters report that no conclusive statement can be made regarding the relative effectiveness of either type of graph.

The Thomas study.[8] Thomas conducted a study in 1933 attempting to establish the grade placement of circle, horizontal bar, line, and two-dimensional diagrams for grades four to seven. No attempt was made to show the same concepts with the different types of graphs. In this study the pupils were to answer questions in three different areas--reading of rank, the use of a key, and the interpretation of the significance of the graph. The basis of evaluation was the number of correct responses to the various questions.

Results: According to the statistical analysis, the line graph was the most difficult graph in all three categories. All the other graphs were regarded as relatively easy.

The Goetsch study.[9] In 1936 Goetsch conducted a study in grades five to eight to determine the relative merits of bar, line, circle, and pictographs. The experimenter prepared graphs to fit

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[8]K. C. Thomas, "The Ability of Children to Interpret Graphs," The Teaching of Geography, Thirty-second Yearbook of the National Society for the Study of Education (Bloomington, Illinois: Public School Publishing Company, 1933), pp. 424-494.

[9]Malter, op. cit., p. 264.

several functions of graphs as he so interpreted the functions. The subjects of the experiment were given a study period after which questions of a recall nature were asked. A similar recall test was conducted with the same students after two weeks.

Results: Goetsch concluded that different graphs were best for different types of materials rather than for any specific grade level. A bar graph might be best for one type of information and yet present a different type of material rather poorly. In general, line graphs were judged to be the most difficult and ineffectual.

The Washburne study.[10] In 1927 Washburne carried out a study in grades seven to nine. He constructed a number of types of graphs, the information on each being constant. The pupils in the experiment were required to respond directly from the graph rather than by recall. The graphs were rated for effectiveness in communicating specific amounts and concepts.

Results: Washburne concluded that bar graphs were the easiest on which to understand relative amounts while the line graph was superior for relative increases, decreases, or fluctuations. The

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[10] J. N. Washburne, "An Experimental Study of Various Graphic, Tabular, and Textual Methods of Presenting Quantitative Material," The Journal of Educational Psychology, XVIII (September, 1927), pp. 361-376, pp. 465-476.

pictograph was rated superior to all other graphs in both respects.

The Wrightstone study.[11] Wrightstone conducted his study in 1936 in grades seven to twelve. He attempted to determine the relative merits of pictorial and conventional graphs. The study used eighteen sets of graphs, each set containing a pictorial graph and a conventional graph communicating the same concept. Two separate groups of students were used. Group one was exposed to the pictorial graphs and group two to the conventional type graph. Both groups were given an immediate recall test and a similar test after a delayed period.

Results: Wrightstone found that no significant difference existed between the pictorial and conventional group of graphs.

Two major implications may be drawn from the seven preceding studies. First, the studies seem to indicate that no conclusive evidence exists indicating that any one type of graph is best adaptable to a given grade level. Secondly, it may be stated that the results indicate that several types of graphs may be equally effective in presenting the same specific and general types of information.

Three studies have been reported which basically differ with the

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[11] J. W. Wrightstone, "Conventional Versus Pictorial Graphs," Progressive Education, XIII (October, 1936), pp. 460-462.

seven studies above. In each of these studies a method of teaching was employed in the attempt to determine the grade placement of the various types of graphs.

The Strickland study.[12] In 1938 Strickland attempted to determine the grade placement of graphs for grades one to four by utilizing various types in conjunction with teaching units in the social studies. She wished to determine the use of graphs on three points: (1) intelligence, (2) grade level, and (3) minimum instruction necessary to obtain satisfactory understanding of graphs. The same graphs were used in grades one and two because of the similarity of the units --travel and transportation.

Individual and group tests were given near the end of the study periods. A twenty per cent response above chance expectations was considered as indicative of successful response.

Six types of graphs were used--developmental picture chart, unit pictograph, bar graph with figures, bar on grid, line graph, and circle graph. Graphs were arranged so that the difficulty increased as the study progressed. Teaching periods of thirty minutes daily by

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[12] Ruth Strickland, A Study of the Possibilities of Graphs as a Means of Instruction in the First Four Grades of the Elementary School (New York: Bureau of Publications, Teachers College, Columbia University, 1938).

the regular classroom teacher were augmented in some cases by special teachers.

Results: The final conclusions indicated, in general, that no great difference existed between the various types of graphs except in grade one in which circle and line graphs were considerably more difficult than the other types. Thirty minutes of instruction were found to be ample for instructional purposes.

The Thorp study.[13] Thorp conducted her study in 1933 in grades five to eight. Thorp differed with the Strickland study in that Thorp provided intensive drill type lessons in the teaching of the graphic skills while Strickland integrated her material into teaching units. Two groups were established, a control and an experimental, for the study. Four types of graphs were used by Thorp--bar, line, circle, and pictographs. Results were based upon what was called a reasonable response.

Results: The study indicated that pictographs were more easily understood while bar graphs, line graphs, and circle graphs became increasingly difficult in that order. No specific grade level was

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[13]Mary Thorp, "Studies of the Ability of Pupils in Grades Four To Eight to Use Geographic Tools," The Teaching of Geography, Thirty-second Yearbook of the National Society for the Study of Education, (Bloomington, Illinois: Public School Publishing Company, 1933), pp. 494-506.

reported best for any certain type of graph.

The Bamberger study.[14] The most recently reported study in which teaching was a factor in grade-placement was in 1942 in grades four to seven. Circle graphs, line graphs, and bar graphs were used in this study.

Experimental and control groups were set up on the basis of intelligence, mental age, and initial graph-reading ability. The experimental group was exposed to daily teaching periods of twenty minutes for five weeks. At the termination of the experimental period a test was administered on which the results were based.

Results: The type of graph best suited for the grades used in the study was reported to be the circle graph. The other graphs were variable according to the type of question asked.

A summary of the three experiments in which teaching was an important factor of the grade placement of the graph type approximates the implications reached for the group of seven studies. Nothing of a conclusive nature was determined by the sum of the group of three studies concerning grade placement of graphs.

The importance of these reported studies to the ongoing study

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[14] Malter, _op. cit._, p. 268.

is primarily two-fold. First, the research evidence presented in the ten studies failed to indicate that any single type of graph was superior to the other graph types for a given grade level. The studies rather indicated that the type of graph an experimenter might choose for presentation of information would depend largely upon the type of material to be placed in graphic form. Since the research studies reported above are inconclusive concerning grade placement of graphs, and because the present study involved four separate content areas presenting a variety of types of material, the writer was free to choose the types of graphs best suited for the particular needs of the content areas. Secondly, the studies of Bamberger, Strickland, and Thorp indicate that satisfactory results may be obtained with teaching periods up to thirty minutes. The teaching periods in the present study are of approximately thirty minutes duration.

III. SELECTION OF GRAPH FORMS

Reported studies of the use of graphs available to the writer failed to reach conclusive research evidence that a specific graph type was superior to other graph types at any designated grade level. In lieu of the inconsistent research results, the writer was free to select graphic forms which best suited the material to be presented.

Prior to the selection of graphic forms, the fifth grade course of study was investigated to determine the prescribed subject matter for each of the selected content areas. The material for the lesson plans was chosen to corroborate the prescribed subject matter. With the determination of the content of the lesson plans, the selection of graphic forms was possible.

The line graph. This graph type was selected for use in conjunction with the arithmetic area. The material to be presented was quite specific in nature. Analysis of the graph content would require accurate rather than estimated answers. East describes the use of the line graph by stating:

> The line graph can show with a fair degree of accuracy the directions and trends of changing conditions. It is a quite difficult graph for many people to read, however, and its use should be made clear as it is being drawn. It can be very useful where there are many cases or many values to be shown, where the time sequence is continuous, and where accuracy is important.[15]

Inasmuch as the students were being exposed to graphs for the first time, only a simple form of the line graph was used.

The bar graph. Reading and bar graphs were combined in the second content area. The type of information expressed in this

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[15]Marjorie East, *Display for Learning* (New York: The Dryden Press, 1952), pp. 94-95.

area dealt more with general trends gleaned from reading texts than the more specific area of arithmetic. Answers were generally only approximations rather than highly specific responses. East briefly summarized bar graphs by saying, "In this kind of graph you are not trying to present ideas with absolute accuracy. You are trying to show general relationships."[16] Only single bar graphs were used.

The circle graph. The writer chose circle graphs as best fitted for the material to be presented in geography. The material was largely suited to be component parts of a larger whole. Estimations predominated in this content area and circle graphs are well suited for this type of interpretation. "When the numbers represented are parts of a whole, the relative sizes of the parts are well represented by making them parts of a single geometric figure. A good figure for this purpose is the circle," write Taylor and Mills.[17] Further verification of this viewpoint is given by Stokes, "It is an excellent practice to have the children explain relations. Most children . . . attach importance to such things as equal spaces between bars in bar-graphs

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[16] Ibid., p. 92.

[17] E. H. Taylor and C. N. Mills, Arithmetic for Teacher-Training Classes (New York: Henry Holt and Company, 1949), p. 361.

and fairly accurate estimates of the sectors of a circle graph."[18]

Tables. Science was considered the most appropriate content area for the conversion of tables into graphs. The easy understanding of daily temperature, which correlated with the science unit on weather, and the students' previous work with line graphs, to which the tables were converted, complemented the science topic. Since tables are quite specific in nature, the conversion to line graphs was selected.

The use to which each type of graph was put is basically in concurrence with the implications of the ten reported studies, all of which were in basic agreement that graph content must in the end determine the graphic form to be used.

IV. SKILL AND MENTAL DEVELOPMENT

Graphs may be thought of as being explanatory drawings used to aid in showing quantities, structures, or relationships. Graphs are, however, abstractions and vary widely in their range of difficulty. The development of these skills must not be left to chance alone. Writes Brueckner and Grossnickle, "Just as we are able to

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[18] C. Newton Stokes, Teaching the Meanings of Arithmetic (New York: Appleton-Century-Croft, Inc., 1951), pp. 429-430.

develop mastery of computational skills by systematic practice, so we should try to develop skill through systematically planned practice in the analysis and interpretation of graphic, tabular, and other forms of visual presentations of quantitative data."[19]

An important result of systematic study of the skills involved in graphic interpretation is the rapidity of obtaining valuable information that might otherwise be obscure. Write Arkin and Colton, "As much information may be obtained in five minutes as would require whole days to imprint on the memory in a lasting manner by a table of figures."[20] Fuller emphasizes the necessity of teaching the skills in graphic interpretation as against simple isolated exposure by saying, "Reference to or exhibition of a graph is not teaching with or from it because mere looking will probably not give much information. Unless one definitely understands a device, he cannot use it effectively."[21]

Development of the ability of pupils to do critical and quantitative thinking is a fundamental part of graphic interpretation. In

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[19]Leo J. Brueckner and Foster E. Grossnickle, _How to Make Arithmetic Meaningful_ (Philadelphia: The John C. Winston Company, 1947), p. 443.

[20]Arkin, _op. cit._, p. 1.

[21]Kenneth A. Fuller, "Using Graphs," _Social Education_, XVII (January, 1953), p. 268.

regard to this purpose Fuller states, ". . . this type of tool. . . can be an aid to the pupil's growth in understanding and the skills involved in quantitative thinking."[22] The same author further finds that rudimentary knowledge of graphs is essential so that pupils will not easily misinterpret figures. The skills used in selecting information and in the drawing of conclusions, which he states are important functions in the development of critical thinking, are involved in the interpretation of graphs.[23]

One of the clearest illustrations of the use of graphic materials as a factor in the development of quantitative thinking is given by Brueckner and Grossnickle:

> The interpretation of graphic and tabular materials provides excellent training in quantitative thinking. For example, the teacher can use as the basis for the arithmetic lesson an interesting graphic presentation of social information, either on a large wall chart or in a textbook. By well-chosen questions the teacher can lead the children to name the topic about which the graph gives information, to tell what facts are presented, to read numbers given in the graph, to explain how the graph was constructed, to locate details on the graph, to note relationships, to compare values, to consider trends revealed by the data, to draw conclusions based on the graph and to suggest ways of extending or improving the graph. These and other similar exercises applied in the study of a variety of graphic and tabular materials provide excellent practice in quantitative thinking.[24]

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[22]Fuller, loc. cit. [23]Fuller, loc. cit.

[24]Brueckner, op. cit., pp. 441-442.

The sum total of the benefits of the study of graphs may be found in Fuller's statement, "Efficient reading and understanding of graphic materials forms another basic aid in the development of an intelligent and responsible citizen."[25]

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[25]Fuller, _op. cit._, p. 270.

CHAPTER III

RESEARCH DESIGN

I. ADMINISTRATIVE CONTACT AND APPROVAL

The execution of the research project would not have been possible without the knowledge, approval, and assistance of the entire administrative personnel of the school system.

The initial administrative official contacted was the writer's building principal who, after a detailed explanation of the proposed experiment, approved of the plans and thereupon acted as an emissary in the establishment of favorable contacts with the Curriculum Director and ultimately with the Superintendent of Schools of Port Angeles. After a comprehensive explanation of the study, the school district consented to the project and agreed to assume the financial obligation of providing the necessary standardized tests. The writer's principal provided released time in order that the experimenter would be free to administer both sets of tests on a system-wide basis. Approval of the plans and consent to carry on the testing and experimental program in the several buildings was granted by the various principals, thus completing approval on behalf of the administration.

II. SELECTION OF THE STANDARDIZED TEST USED

The basic criterion which the standardized test to be employed had to meet was the test's capacity to measure the specific skills and abilities through which the interpretation of graphic materials are made possible. "Graphs, tables, and charts are tools for giving knowledge and, as such, require the use of specific skills and abilities," writes Spitzer and associates.[1]

A survey of available standardized tests revealed that the test which most adequately conformed to the desired criterion was the Iowa Every-Pupil Tests of Basic Skills: Work-Study Skills, Grades 5-9, hereafter referred to as the Iowa Work-Study Skills Test. State Spitzer and co-authors, ". . . these tests are directly concerned only with certain basic skills and abilities, and are not intended to measure total achievement in any given subject or grade."[2]

Since the lessons in the study are integrated with the existing course of study to form a modified course of study and are not based upon isolated learning for its own sake, it is significant that Spitzer

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[1]Herbert F. Spitzer, et al., Examiner's Manual for Test B--Advanced, Work-Study Skills, Grades 5-9, Iowa Every-Pupil Tests of Basic Skills (New York: Houghton-Mifflin Company, 1945), p. 23.

[2]Herbert F. Spitzer, et al., Manual of General Information, Iowa Every-Pupil Tests of Basic Skills (New York: Houghton-Mifflin Company, 1945), p. 53.

and associates further note, "The pupil's ability to use the skills acquired is tested in situations approximating, as closely as possible in a paper and pencil test, the actual situations in which he may have occasion to use these skills."[3]

A further judgment of the test's relevancy to the study pertains to the writings of Good, Barr, and Scates, "The prime consideration in the construction and administration of tests is validity--that is, representation of the influence of factors that the test is supposed to measure."[4] Validity of the _Iowa Work-Study Skills Test_ is explained by the test's authors:

> It may be noted that the _Iowa Every-Pupil Tests of Basic Skills_ are characterized by unusually liberal time allowances. The time allowed _per question_ is, on the whole, considerably greater than that allowed in any similar widely distributed standardized test material. These liberal time limits tend to raise the validity of the tests.[5]

Reliability coefficients for the standardized test at the fifth grade level are not listed in the test manual. Coefficients for the advanced battery at the seventh grade level are .65 for Form L and .75 for Form O. On a composite of grades six, seven, and

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[3]_Ibid._, p. 9.

[4]Carter V. Good, _et al._, _The Methodology of Educational Research_ (New York: Appleton-Century-Croft, 1941), p. 319.

[5]Herbert F. Spitzer, _op. cit._, p. 61.

eight the full subtest on graphs is given as .70. These coefficients indicate that the reliability of the measuring instrument is only moderate.

Bryan, discussing the relative merits of the selected test in a critical analysis, summarizes:

> The Iowa Every-Pupil Tests of Basic Skills are designed to measure educational growth in certain specific skills involved in learning. They are not concerned with the measurement of subject matter achievement as such. In terms of their objectives, the tests appear to be quite valid. In the opinion of the reviewer, the scores are, with some exceptions, sufficiently reliable for judicious use in diagnosis. . . . Probably the most outstanding feature insofar as content is concerned is the inclusion of the work-study test, the scope of the content of which is unique with these batteries.[6]

The Iowa test selected best met the needs and purposes of the study, and for this reason it was selected.

III. CONSTRUCTION OF GRAPHS

The desirability of integrating the lesson plans into the existing curriculum made it mandatory for the writer to construct his own set of graphs. Fortunately, "The field of education," Modley notes, "is the only one in which self-made charts are definitely advised . . ."[7]

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[6]Mirain M. Bryan, "The Iowa Every-Pupil Tests of Basic Skills," *The Fourth Mental Measurement Yearbook*, ed. Oscar K. Buros, (New Jersey: The Gryphon Press, 1953), p. 41.

[7]Rudolf Modley, *How To Use Pictorial Statistics* (New York: Harper and Brothers, 1936), p. 151.

The need for accuracy in portraying the desired information is very important in graphic representation. Faulty construction of graphs would lead to the misconstruing of the represented data. Three major areas in which self-made graph accuracy is essential are the grid, the scale, and the title.

The grid. Accurate portrayal of graphic information depends to a great extent upon the proximity of the horizontal and vertical placement of the grid lines. Arkin and Colton write, "In general, a graph with a ratio of width to height of between 1.25 and 1.75 to 1 seems to give the best results."[8] These figures were the guides used in the self-made graphs.

The scale. The frequency of scale values on a graph is determined largely by the ease of interpretation which they afford. Arkin and Colton record that excessive scale values hinder rather than help the reading of plotted points on a graph since only approximate and not exact values are determined from a graph.[9] Only sufficient scale values were used on the graphs to convey the desired information and teach the desired skills.

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[8]Herbert Arkin and Raymond R. Colton, Graphs: How To Make and Use Them (New York: Harper and Brothers, 1936), p. 14.

[9]Arkin, op. cit., p. 12.

The title. Titles should be stated in simple terms in as few words as possible. Titles were made to be self-explanatory to conform to the rule laid down by Arkin and Colton who state, "The subject of the graph should be completely defined and explained by the title."[10]

The dimensions. All wall graphs were made on 24 x 36 inch sheets of oak tag board. The grid lines and graph lines were of black Flo-Master ink. For those graphs on which the instructional value would not be exemplified by the use of ink on other than the grid lines, construction paper was used. All graphs were of sufficient size as to be easily readable in the back row of each classroom. Dittoed graphs were so constructed that their dimensions were in direct ratio to the wall graphs. Dittoed graphs were made on 8 1/2 x 11 inch duplicator paper.

IV. SELECTION OF TEACHERS

Teacher selection was based upon voluntary enlistment into the confines of the study. As many teachers as possible were desired for the experiment, the largest possible number usable being eight of the nine fifth grade teachers in the school system.

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[10] *Loc. cit.*

Each teacher was individually contacted and instructed as to the general scope and operational procedures of the study. Each teacher was given free choice of either participation or non-participation in the project. The first eight teachers contacted willingly consented to participate, making the selection of the teachers complete.

V. FIRST TEST

Preparatory to the administration of the first series of tests was the formulation of a testing schedule. A schedule was drawn up by the writer and submitted orally to both teachers and principals. The acceptance of the test schedule signaled the beginning of the test program.

The administration of Form L of the Iowa Work-Study Skills Test was made during the first four days of the week beginning January 25, 1955, to the two hundred fifty-nine students present in the eight participating rooms. Approximately ninety minutes was consumed for each room tested, making possible the testing of two rooms daily. Tests were commenced at 9:00 a.m. and 10:35 a.m. during the days of testing. No tests were given during the afternoons.

All tests were administered in their entirety in strict compliance with the procedures laid down in the Examiner's Manual. Each test was given using the single-period method rather than the optional two-part method. Each day's tests were corrected, the raw scores translated into grade-equivalent scores, and each room's mean score determined. Upon completion of the first testing phase the rooms were divided into control and experimental groups.

VI. SELECTION OF CONTROL AND EXPERIMENTAL GROUPS

The division of the eight participating rooms into control and experimental groups was based upon the results of the first standardized test administered in January. Individual raw scores were converted into grade-equivalent scores. These figures were totalled for each individual room and the total divided by the number of students in each room. Thus a mean score was derived for each room.

The rooms were categorized into control and experimental groups so that the averages of their room mean scores were as nearly equal as possible. The average of the mean scores of the control group was 5.52 while the experimental group average was 5.47. The control group contained 135 students and the experimental group 124 students on the pre-test. The data with regard to categorizing rooms into control and experimental is shown by Figure 1.

All classes in the study were grouped heterogeneously at the end of their fourth school year on the basis of ability rating cards filled in by the fourth grade teachers. New students entering the fifth

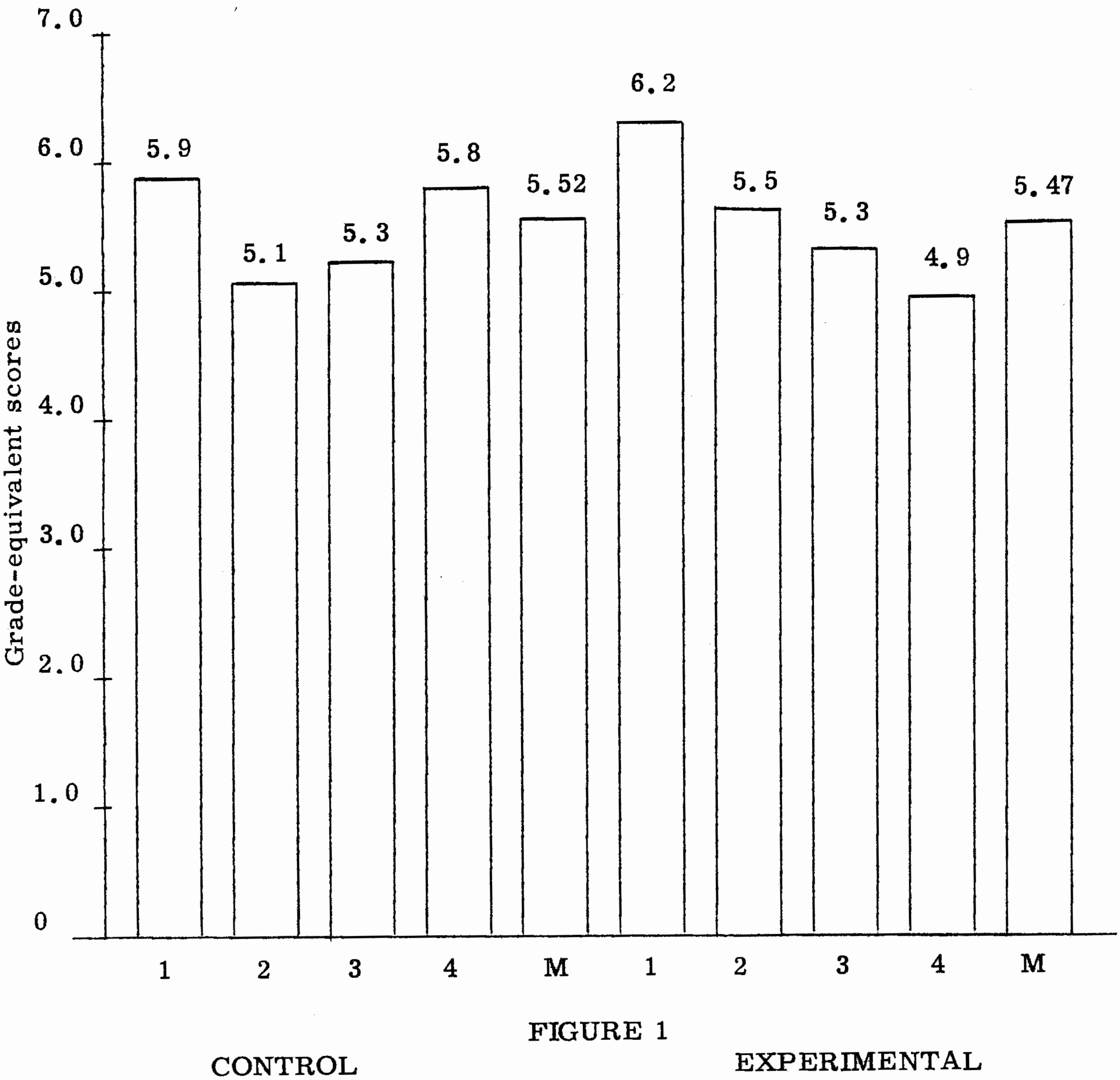

FIGURE 1

DIVISION OF CLASSES INTO CONTROL AND EXPERIMENTAL GROUPS BASED ON PRE-TEST INDIVIDUAL ROOM MEAN SCORES OF IOWA EVERY-PUPIL TEST OF BASIC SKILLS grade were placed by a building principal so that his rooms were as nearly equal in size as possible. Sizes of classes among the school varied from a high of forty to a low of twenty-eight on the pre-test.

VII. STRUCTURE OF THE EXPERIMENTAL METHOD

Concurrent with the issuance of the lesson plans, oral instructions were given to the experimental teachers on the necessity of following the lesson directions carefully. It was emphasized again that the lessons were to be treated as a regular part of their instructional program.

Each member of the experimental group of teachers was provided with a complete set of sixteen lesson plans and accompanying graphic materials. The lessons were divided into four major areas--arithmetic, reading, geography, and science. Each major area was devoted to one type of graph. Arithmetic was devoted to line graphs, reading to bar graphs, geography to circle graphs, and science to the conversion of tables into line graphs. In each major area there were four individual lessons and a separate introductory list of major objectives covering the four lesson plans in that unit.

Daily lesson plans consisted of a heading giving lesson number, date to be taught, and the subject to which the lesson pertained. Materials needed to aid in teaching the lesson were listed for each individual lesson plan. Following the materials list was a step-by-step procedure outlining the method to be used in teaching the lesson, thus insuring as great a condition of uniformity of teaching as possible. Large wall graphs were used in support of most of the lessons as teaching aids for illustrative and instructional purposes. Some of the lessons culminated in a dittoed graph to be interpreted by the children. Students having difficulty interpreting dittoed graphs were given help in the meanings of questions since dittoed graphs were for instructional rather than testing purposes. Other lessons were summed up through oral questioning with the students illustrating their responses.

All lessons were planned for teaching periods of one-half hour duration, but the actual amounts of time given to each lesson varied slightly according to the conditions within each classroom. Lessons were taught at the time during which the subject to which they pertained was regularly taught. Lessons were taught sequentially each Tuesday and Thursday, with one exception for a holiday, over a two-month period. The selection of the dates for teaching the lessons coincided with the units being taught in the classrooms through a pre-arrangement with the experimental teachers. The use of Tuesdays and Thursdays was selected for the purpose of uniformity of teaching intervals among all of the teachers. The days used were arbitrarily selected prior to the construction of the specific lesson plans.

Teachers collected the dittoed graphs after each lesson and turned them over to the experimenter for correction and analysis. The graphs were then returned to the students. A complete set of lesson plans may be found in Appendix A.

VIII. RE-TESTING

Immediately following the completion of the teaching of the lesson plans Form O of the standardized test was administered to both control and experimental classes. Re-testing was conducted by the writer in strict compliance with the directions for test administration. The same sequence of testing was followed as previously used in the initial testing phase during January. The second phase was completed April 2, 1955. Tests were corrected, raw scores determined and changed into grade-equivalent scores. The scores for both tests were submitted to statistical analysis, the results being reported in Chapter IV. Only results for students who were present for both forms of the test were included in the computations.

IX. LIMITATIONS OF THE STUDY

The findings of this experiment are influences by a number of limitations:

1. The number of standardized tests measuring specific skills and abilities in the interpretation of graphs, charts, and tables is extremely limited, affording small choice of selection.

2. The writer had only limited previous experience in the administration of standardized tests.

3. Equation of the participating classrooms into experimental and control groups hinged upon the results of a single, rather than on multiple tests.

4. Absenteeism among several of the students during the teaching of the lessons would influence their results in the corresponding skills on the standardized test.

5. Fluctuations in the measuring instrument due to its only moderate reliability may influence the results.

CHAPTER IV

RESULTS

The principal consideration of the study was to determine the degree to which pupil achievement in work-study skills was changed by emphasis on graphic materials as a means of modifying a fifth grade course of study. Four classes served as experimental groups and were compared with four control classes which followed the usual course procedures. Several comparisons were necessitated to determine the significance of changes that occurred. Small samples were employed and comparison between two groups at a time was the experimental design employed. Consequently, the t-test of significance was used in all instances.

It was first necessary to determine whether or not the group selected as the control group and the group selected as the experimental group were functionally equivalent at the beginning of the experiment. The mean grade-equivalent score on the Iowa Work-Study Skills Test was found for the total of the experimental group and the total of the control group from January administrations. Table I, line one, presents the two means and a t difference which is so small as to be definitely attributable to chance. Consequently, it

TABLE I

COMPARISON OF MEAN SCORES FOR FIFTH GRADE PUPILS ON THE IOWA EVERY-PUPIL TEST OF BASIC SKILLS FOR CLASSES USING USUAL COURSE OF STUDY AND CLASSES EMPHASIZING GRAPHIC MATERIALS

Test	Means for Combined Classes Forming Experimental and Control Groups		Mean Difference	Standard Error of Mean Difference	t	Degrees of Freedom	Level of Significance
Pre-test	Experimental Mean = 5.51	Control Mean = 5.58	.07	.20	.35	228	Not Significant
Post-test	Experimental Mean = 6.29	Control Mean = 5.73	.56	.18	3.11	228	.01 >
Pre- with Post-test	Control Mean = 5.58	Control Mean = 5.73	.15	.17	.88	118	Not Significant
Pre- with Post-test	Experimental Mean = 5.51	Experimental Mean = 6.29	.78	.18	4.33	110	.01 >

seems reasonable to assume that the groups were relatively equal in study skills at the beginning of the experiment. Whatever minor difference that might have existed at the beginning of the experiment, if any, favored the control group.

The experimental group was introduced to a modified course of study with emphasis on instruction in the interpretation of graphic materials as described in Chapter III. This emphasis was continued for eight weeks. At the conclusion of teaching experiment, the control and experimental groups were given a second form of the standardized test. The difference in mean scores from the April administrations was tested to ascertain whether or not the experimental group had gained amount of growth significantly greater than the control group. Table I, line two, shows the means of the two groups at the end of the teaching experiment. The difference is shown to be significant beyond the one per cent level of confidence favoring the group in which the use of graphic materials was stressed. This suggests that if similar teaching procedures were used for similar groups in repetitions of this experiment a difference in means greater than zero, favoring the experimental group, would be expected to occur ninety-nine times out of one hundred.

To amplify the findings of the total group comparisons the control group's means on the pre- and post-tests were tested to see if the group using usual procedures had gained a significant amount in the graph section of the work-study skills. Table I, line three, represents the pre- and post-test means for the control group classes and the t-test difference which is found to be not significant. The results indicate that usual course procedures did not produce a significant amount of growth in the work-study skills.

A similar test was performed on the means of the pre- and post-tests for the experimental group of classes to determine whether or not the amount of growth, as a result of the introduction of the experimental teaching method, was statistically significant. Table I, line four, shows the mean growth in work-study skills in the experimental group between administrations of the standardized test. The difference is shown to be significant beyond the one per cent level of confidence reaffirming that the teaching procedures in classes emphasizing graphic materials can be expected to produce an amount of growth in graphic interpretation beyond the growth expectations of the usual course of study. The evidence presented in Table I strongly indicates that the method used in the experimental group was instrumental in producing significantly favorable results in graphic interpretation not found in the usual course procedures.

Further development of the analysis of pre- and post-test mean scores employed matched pair comparisons for each of the eight individual classes. To each control and experimental room's mean pre-test score was added an assumed growth of 2.3 months (.23 grade-equivalent) to cover the period between administrations of the standardized tests. Mean differences were found between the corrected pre-test and the actual post-test means of each individual class. These obtained mean differences were used in the t-test of significance.

Table II, lines one to four, show the means of the pre- and post-tests for each of the classes comprising the control group. The minus mean difference scores for control classes three and four indicate that those rooms gained less than the assumed growth of 2.3 months. The mean differences and resulting t's for each room in the control group show that none of these classes gained a significant amount. This reaffirms the point that the usual course procedures do not produce a significant increase in growth of pupil achievement in the graph area of the work-study skills.

Table II, lines five to eight, show the means of the pre- and post-tests for the classes in the experimental group. The means on the pre-tests were corrected in the same manner as the pre-test means of the control group classes. The mean differences are shown to be significant beyond the one per cent level of confidence for each of the four classes. It may be reasonably inferred that the introduction

TABLE II

ANALYSIS OF INDIVIDUAL ROOM MEAN SCORES FOR FIFTH GRADE PUPILS ON THE IOWA EVERY-PUPIL TEST OF BASIC SKILLS FOR CLASSES USING USUAL COURSE OF STUDY AND CLASSES EMPHASIZING GRAPHIC MATERIALS

Tests	Mean for Individual School Classes		Mean Difference	Standard Error of Mean Difference	t	Degrees of Freedom	Level of Significance
	Form L	Form O					
Pre- with Post-test	Control 1 Mean = 6.16*	Control 1 Mean = 6.22	.06	.17	.35	26	Not Significant
Pre- with Post-test	Control 2 Mean = 5.39*	Control 2 Mean = 5.52	.13	.14	.93	31	Not Significant
Pre- with Post-test	Control 3 Mean = 5.57*	Control 3 Mean = 5.45	-.12	.16	.75	33	Not Significant
Pre- with Post-test	Control 4 Mean = 6.09*	Control 4 Mean = 5.99	-.12	.16	.75	25	Not Significant
Pre- with Post-test	Experimental 1 Mean = 6.34*	Experimental 1 Mean = 6.80*	.46	.11	4.18	24	.01 >
Pre- with Post-test	Experimental 2 Mean = 5.79*	Experimental 2 Mean = 6.46*	.67	.16	4.19	29	.01 >
Pre- with Post-test	Experimental 3 Mean = 5.75*	Experimental 3 Mean = 6.54	.79	.10	7.90	26	.01 >
Pre- with Post-test	Experimental 4 Mean = 5.01*	Experimental 4 Mean = 5.56	.55	.14	3.93	28	.01 >

* Mean modified by adding assumed normal growth of 2.3 months (.23) to each pre-test score.

of the experimental teaching method was responsible for the significantly favorable changes of pupil achievement in the experimental groups.

The procedure chapter reported only moderate reliability for the graph subtest of the standardized test used. Results of the four control classes' mean change from pre- to post-test when tested using the t-test show that none of the classes gained significantly. However, the mean differences for each of the four experimental classes show an amount of growth significantly beyond the one per cent level of confidence. This strongly suggests that the changes which occurred were not a result of chance fluctuations in the measuring instrument but rather was a function of the new teaching method.

The results of Tables I and II strongly indicate that the acceptance of the modified course of study with emphasis on graphic materials may be expected to produce significantly more growth in graphic interpretation than the existing course of study. The evidence presented indicates that the modified program is a superior method for obtaining pupil achievement in understanding graphic materials and deserves consideration for adoption into the Port Angeles course of study at the fifth grade level.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATION

I. SUMMARY

The purpose of this study was to determine the degree of pupil achievement resulting from specific instruction in the interpretation of graphic materials. The experimental method employing four control classes and four experimental classes was the research technique used.

The experiment was carried on at the fifth grade level in the Port Angeles, Washington, public schools. Eight heterogeneously grouped classes containing two hundred fifty-nine pupils were employed. A standardized test, the Iowa Every-Pupil Tests of Basic Skills: Work-Study Skills, was administered to the eight classes in January, 1955. Only the section of the standardized test pertaining to graphs, charts, and tables was used in the experiment although the entire test was administered each time. Test scores were converted into grade-equivalent scores and the mean for each room determined. The eight individual classes were arranged into two groups of four each so that both groups' average scores were as nearly equivalent as possible. The difference in group averages was .05 (.5 month) in favor of the group selected as the control group.

Immediately after the division of the participating rooms into control and experimental groups the teachers of the experimental classes were provided with complete sets of sixteen lesson plans and accompanying graphic materials. The lessons were designed to teach the interpretation of graphic materials when such instruction is correlated to the classes' usual subject matter, producing a modified course of study. The control group of classes were to follow the usual course procedures.

The sixteen lesson plans were divided into four content areas with each area employing a different type of graph or table. Arithmetic was matched with line graphs, reading with bar graphs, geography with circle graphs, and science converted tables into graphs. A total of four lessons were devoted to each of the four content areas. Individual lessons were taught Tuesdays and Thursdays for a period of eight weeks. Each lesson was of approximately thirty minutes duration.

At the conclusion of the experimental teaching a second form of the standardized test was administered to all classes in both the control and experimental groups. Grade-equivalent scores for all pupils were determined. The results of the pre- and post-test scores for those pupils who were present for both tests--two hundred thirty pupils--were submitted to a comprehensive statistical analysis.

Small samples were employed in the study and the comparison between two groups at a time was the experimental design. Therefore, the t-test of significance was used in all cases. The first series of tests were performed to determine (1) whether or not the control group and the experimental group were functionally equivalent at the outset of the experiment; (2) whether or not a significantly statistical difference existed (a) between the control group and the experimental group post-tests, (b) between the control group's pre- and post-test, and (c) between the experimental group's pre- and post-tests.

Results of the t-tests revealed that the difference between the control group and the experimental group at the beginning of the experiment was not significant and that the two groups were functionally equivalent in the graphs, charts, and tables subtest at the beginning of the experiment. On the post-test for the control group and the experimental group a significant difference beyond the one per cent level of confidence was found favoring the experimental group. The results for the control group's pre- and post-tests revealed no significant growth while the growth for the experimental group between administrations of the pre- and post-tests was found to be significant beyond the one per cent level of confidence.

Pre- and post-test results for each individual room were compared using the t-test of significance. It was found that no significant change occurred in any of the control group classes. However, for each of the experimental group classes a change significant beyond the one per cent level of confidence was found between pre- and post-test administrations of the standardized test.

II. CONCLUSIONS

1. The control group and the experimental group were evenly equated so that no significant difference existed between the two groups in achievement in the graphs, charts, and tables, section of the work-study skills on the pre-test.

2. Express instruction in the interpretation of graphic materials integrated in the course of study significantly altered pupil achievement on the post-test.

3. A significant amount of growth in graphic skills and abilities occurred in the experimental group as a result of the introduction of the experimental teaching that did not occur in the control group following the usual course of study.

4. Individual rooms in the control group did not show significant amounts of growth between the pre- and post-test administrations.

5. Individual rooms in the experimental group did show a significant amount of growth between the pre- and post-test administrations.

6. The inclusion of similar graphic materials in the course of study may be expected to produce an amount of pupil achievement significantly beyond the usual course procedures.

III. RECOMMENDATION

The research evidence presented as a result of this study shows that the modified course of study emphasizing instruction in graphic materials produced significant amounts of pupil achievement that did not occur in the classes following the usual course procedures. The evidence indicates that the modified program is a superior method for obtaining pupil achievement in graphic interpretation. It is, therefore, recommended that the administration of the Port Angeles, Washington, public schools consider the adoption of the modified course of study at the fifth grade level.

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APPENDIX A

Lesson Plans

Major Aims of Instruction for Graph

Lessons 1 Through 4

Line Graphs

1. To introduce the purpose and parts of a line graph.

2. To teach comprehension from the title and sub-title of a line graph.

3. To teach the skill of reading amounts from a line graph.

4. To teach the skill of comparing two or more values read from a line graph.

5. To teach the skill of grasping outstanding facts from a line graph.

Lesson Plan #1
Tuesday, February 1, 1955
Arithmetic

Materials: Chalkboard, chalk, yardstick, wall graph #1, envelope #1, and a thumb tack.

Procedure:

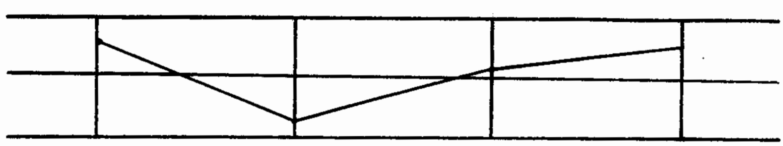
1. Introduce graphs to your class by posing to them questions which elicit from them ways to find and record the comparative heights of several of the children in the class.

2. After their suggestions have been made and discussed ask several of the students to help you try a way of which they did not think. Have several of the students line up along the chalkboard in random order.

3. Place a dot on the chalkboard at the height of each pupil. Place the child's name at the top of the chalkboard above the child's dot.

4. Connect each of the dots consecutively with straight lines between them.

5. Using your yardstick, draw a grid over the connected lines.



6. Place each horizontal line of the grid 3 inches apart starting 48 inches above the floor to a point above the tallest pupil's height.

7. Place the inch numbers beside the horizontal grid lines.

8. Explain to the class that they have helped construct the important parts of a simple line graph by which they may record the heights of several of their classmates.

9. Point out that the horizontal grid lines are all equally spaced, and the vertical grid lines are also equally spaced although the horizontal and vertical spacings may not necessarily be the same distances apart.

10. Underscore several of the horizontal lines with your hand and ask the class what these lines indicate. (Height in inches of the pupils.)

11. Trace several of the vertical lines and ask the class what these lines tell them. (The children whose names appear above the line.)

12. Illustrate that the use of grid lines helps us find and understand the information on the graph by locating on the graph the height of one or two children.

13. Ask the class what the names of the pupils across the top of the graph represent. (Names of the pupils on the graph whose height has been recorded.) Write the sub-title, names of Pupils, across the top of the graph.

14. Ask the class what the numbers along the left hand side of the graph represent. (Height in inches of the pupils.) Write the sub-title, Height in Inches, along the left hand side of the graph.

15. Ask the class for a suitable title for this graph and write it by the graph. Accept the best title the class offers.

16. Bring out wall graph #1. Tack it to the wall. From envelope #1 extract the six paper figures. Correlate the placing of the figures on the grid showing height in inches and name of pupil to the same thing on the graph made on the board. As each figure is placed upon the graph have a child tell the number of inches it represents.

17. Point out that both graphs show the same type of information.

End of Lesson

Lesson Plan #2
Thursday, February 3, 1955
Arithmetic

Materials: Wall graphs #1 and #2, dittoed graph #1, and tacks.

Procedure:

1. Introduce the lesson by briefly reviewing the grid lines, title, and sub-titles of the first lesson's graph and how it was constructed.

2. Tell the pupils they are going to work with another line graph today.

3. Bring out wall graph #2 and tack it to the board.

4. Ask the children to read the title of the graph. Then ask them if they can tell from the title the content of the graph.

5. Have the class read the sub-titles and give their meanings.

6. Review the point that the grid lines are equally spaced, and also that they help us easily read the line graph by helping us locate the information. Illustrate by locating one or more scores on the graph.

7. Interpret several of the scores on the graph by using such questions as:

   a. How many problems did Hap work correctly? (Let a member of the class locate the information.)
   b. Who worked more problems correctly, Miles or Helen?
   c. Who worked the most problems correctly in the test?

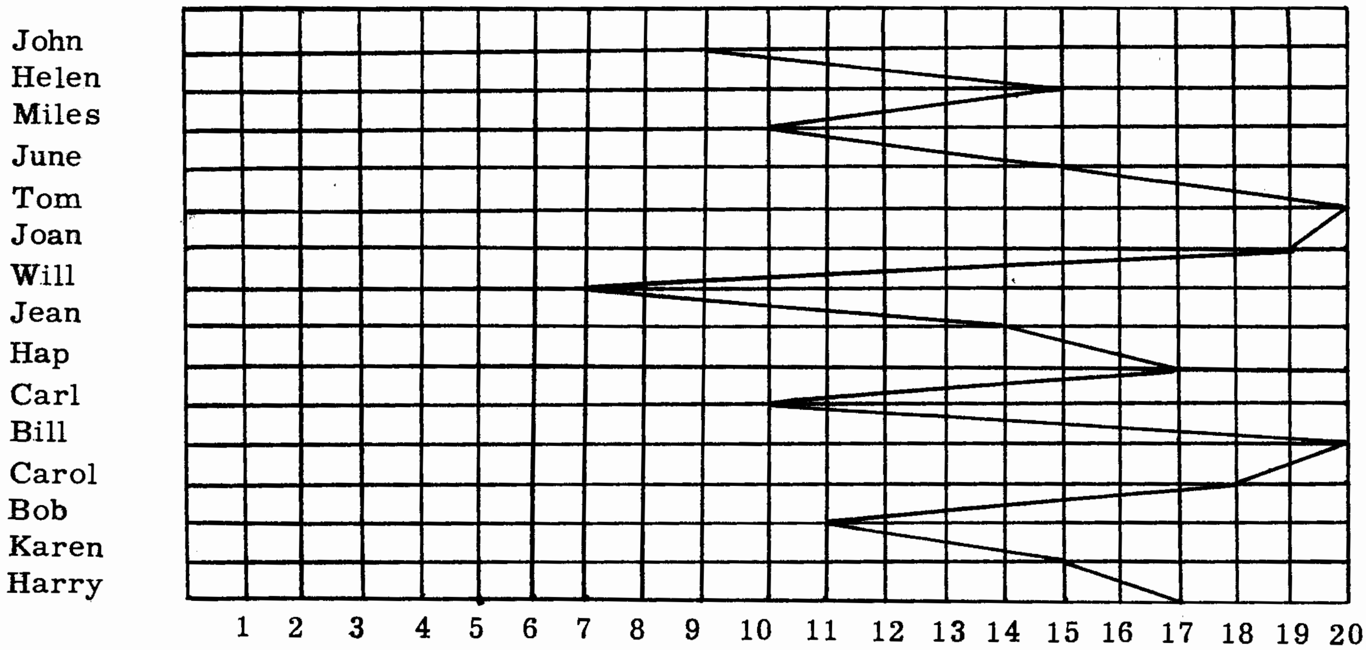
8. Be sure the class understands the process of finding the information on the graph. Then pass out the copies of the dittoed graph #1.

9. Direct the pupils to read the title and sub-titles, then to briefly study the graph. Tell them to answer the questions on the paper by reading the graph on their paper and placing their answers on the line after each question.

End of Lesson

Dittoed Graph #1

Arithmetic Test Results



1. How many problems were in the test? __________

2. How many pupils took the test? __________

3. What is the title of the graph? __________

4. How many students worked all the problems correctly? __________

5. How many students worked exactly half the problems correctly? ______

6. Which student had only half as many correct as did Joan? __________

7. Which student had twice as many correct as John? ________

8. Harry worked how many more problems correctly than Bob worked? _____

9. Who had the more problems correct, Karen or Jean? _________

10. What is the total number of problems Will, Helen, and Joan worked correctly altogether? __________

Lesson Plan #3
Tuesday, February 8, 1955
Arithmetic

Materials: Chalkboard, chalk, and dittoed graph #2.

Procedure:

1. Introduce the lesson by asking how many of the class have taken a trip to Forks in an automobile. Bring out that the trip is about 70 miles and ask them how many miles they would have to travel per hour if the trip took 2 hours.

2. Ask the class to help figure out an arithmetic problem that is something like a trip to Forks.

3. The problem: Five families take a trip. They all travel the same number of hours (8) during the trip. Family A averages 50 miles per hour, Family B averages 45 miles per hour, Family C averages 40 miles per hour, Family D averages 55 miles per hour, and Family E averages 60 miles per hour. How far did each family travel during their 8 hours of driving?

4. Let the pupils solve the problem on their papers. List the answers on the board so all may see them easily.

5. Tell the class that this information can be put on a graph which will make it easy to record, easy to read, and easy to understand.

6. Pass out dittoed graph #2.

7. Point out to the class the two (2) important parts of the graph--the names of the families and the total distance traveled.

8. Bring out the point that each horizontal line represents a difference of 20 miles traveled. Show that the shortest distance shown on the graph is 300 miles and the longest distance shown is 500 miles.

9. Point out that each vertical line represents the family whose name appears below it.

10. Ask the class to find the place on their graph at which the first dot should be placed to represent the distance Family A traveled. Check around the room to be sure all the children have the correct place.

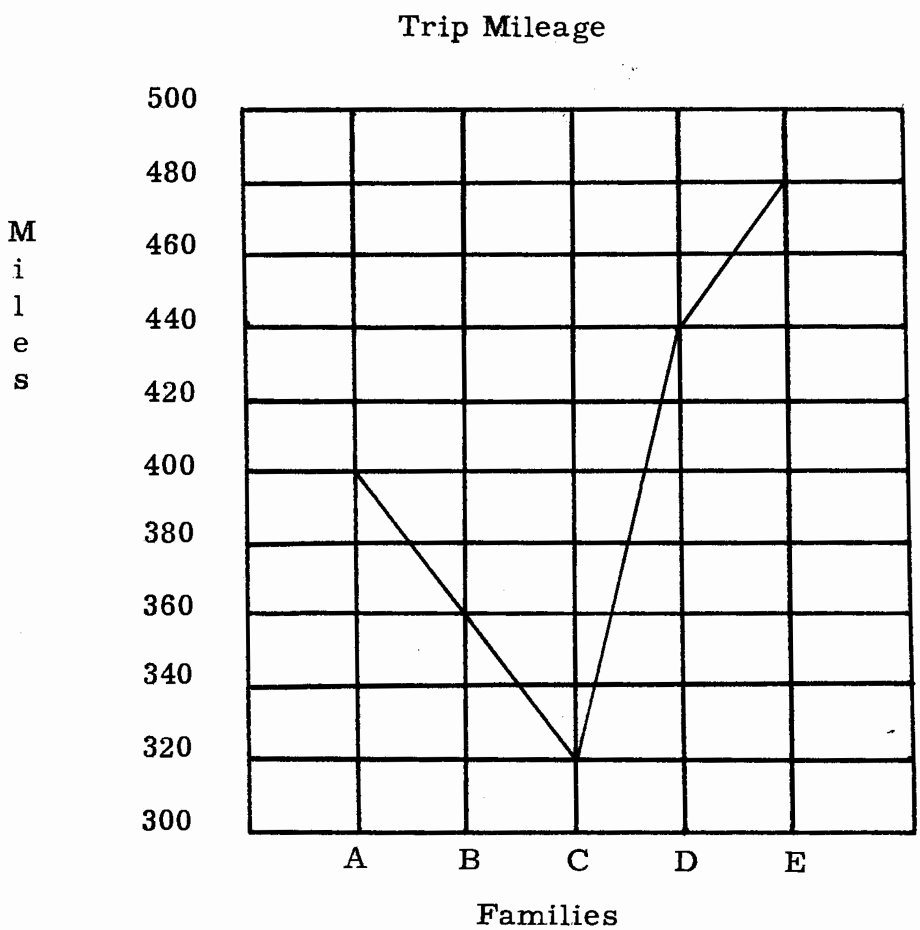
11. When you are sure the class has the correct place, let them put a dot at that intersection. Repeat this process until all the distances are plotted on each child's graph.

12. After the connecting lines have been drawn, tell the class to answer the questions on the bottom of the graph.

13. Check each child's graph during this period to see that he has the graph on his desk drawn correctly.

End of Lesson

Dittoed Graph #2



1. What is the farthest distance traveled shown on the graph?

2. How much farther did D go than B?

3. What is the shortest distance traveled shown on the graph?

4. The highest point on the graph is for which family?

5. How far did the slowest and fastest families travel altogether?

6. How much farther did family A go than family B?

7. How much farther would family D travel to go 500 miles?

8. What do the numbers on the left side of the graph tell us?

Lesson Plan #4
Thursday, February 10, 1955
Arithmetic

Materials: Wall graph #3 and dittoed graph #3.

Procedure:

1. Review with the class the reasons for having titles and sub-titles on graphs.

2. Tack wall graph #3 on the board and review the procedure for locating information on a line graph.

3. Read the title of the graph, making sure the children understand its meaning by asking several of the students to put the idea into their own words.

4. Let someone in the class go to the graph and locate the sub-title that tells the names of the trucks and also the sub-title that tells how much gasoline was used.

5. Ask the class how they would find out how many miles one of the trucks travelled during the week if he got 10 miles to the gallon of gasoline. (Locate the number of gallons used and multiply it by 10.)

6. Explain that they first look on the graph to find how many gallons of gasoline the truck used during the week. Then they multiply that number by the number of miles per gallon the truck got.

7. Let the class work several examples of this type, but not using trucks B or D.

8. Illustrate with the examples how to compare miles travelled by trucks using different quantities of gasoline and getting different numbers of miles to the gallon of fuel.

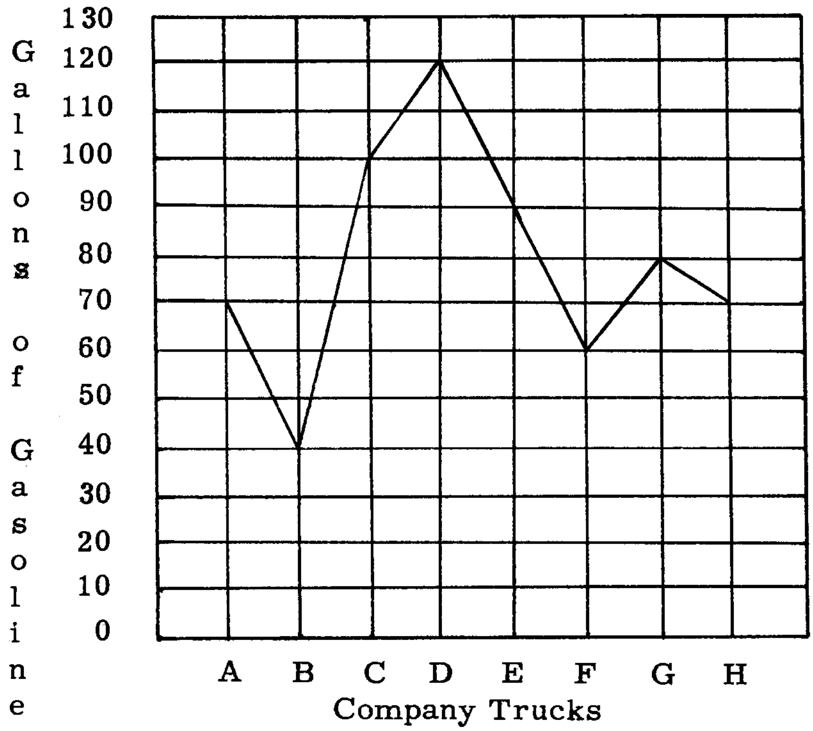
9. Illustrate (1) they must first find how many gallons of gasoline were used by each truck and (2) multiply that number of gallons by the miles per gallon figure.

10. Pass out dittoed graph #3 and instruct the class to work the problems at the bottom of the page.

End of Lesson

Dittoed Graph #3

Gasoline Used By Company Trucks
Between January 3 and January 10



1. How much more gasoline did truck G use than truck B?

2. How much gasoline was used by all 8 trucks during the week?

3. How many miles did truck B go if it got 20 miles on every gallon of gasoline?

4. How far did truck D go if it got 15 miles on every gallon of gasoline?

5. If truck D and truck E both went the same number of miles on a gallon of gasoline, which truck traveled farther?

Major Aims of Instruction for Graph Lessons 5 Through 8

Bar Graphs

1. To teach the ability to read amounts from the scales on a bar graph.

2. To teach the ability to grasp outstanding facts portrayed by a bar graph.

3. To teach the ability to determine trends as shown by a bar graph.

4. To teach the ability to determine rank from an unordered bar graph.

5. To teach the ability to compare two or more values read from a bar graph.

Lesson Plan #5
Tuesday, February 15, 1955
Reading

Materials: Wall graphs #1, #2, and #3, and dittoed graph #4

Procedure:

1. Review with the children the method of reading a line graph by following the line in relation to the meanings of the grid lines and row or column headings.

2. Show graph #1 and graph #2 to the class. Explain that #1 and #2 are line graphs. Review the use of the line on the graph to show or indicate information.

3. Take out wall graph #4 and explain that this is called a bar graph because each column uses a bar to show amounts instead of a line.

4. Ask the class if they can tell what the graph will be about by reading the title and sub-titles.

5. Using graph #2, review how to read amounts. Next use graph #4 and let a volunteer illustrate how to read amounts from a bar graph. Then re-illustrate for the class by two or three examples.

6. Ask the pupils such questions as follows and let them find the answers on the graphs:

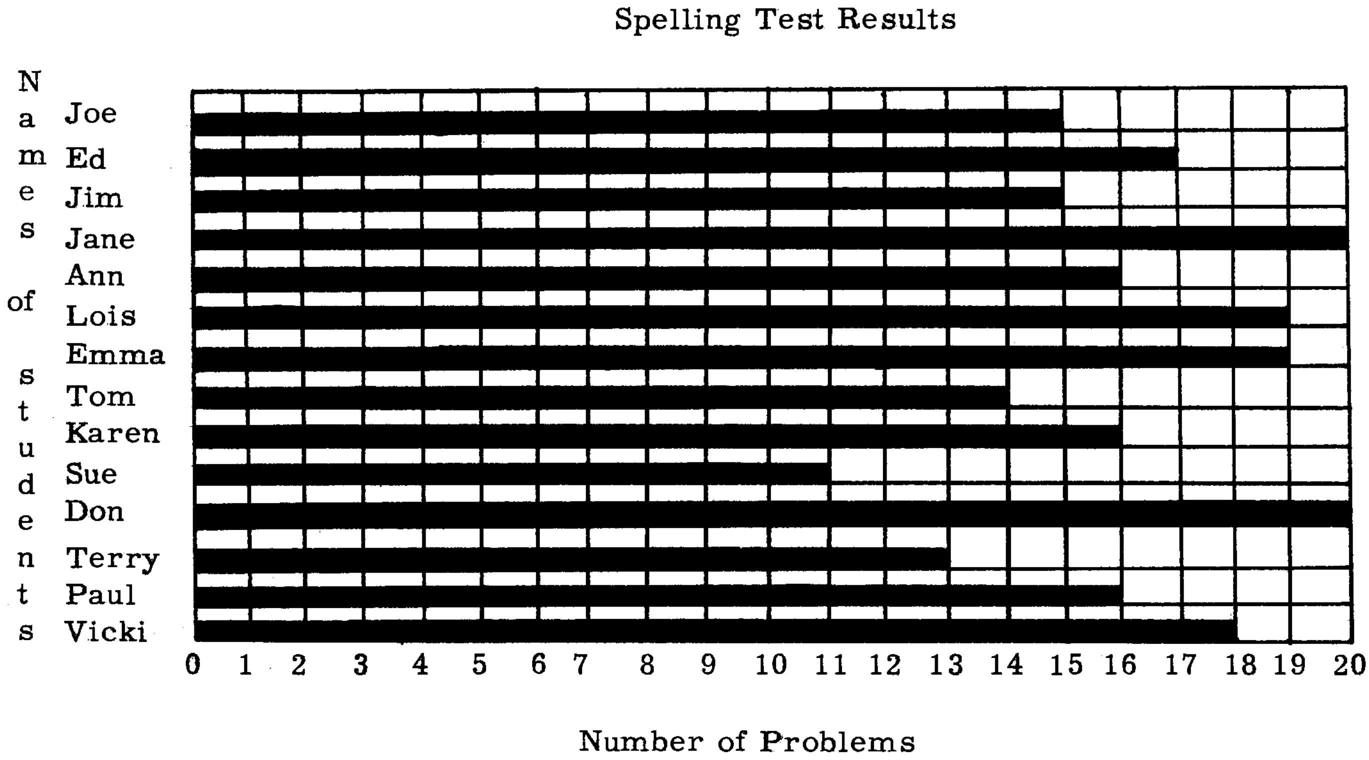
a. How many words were in the spelling test?
b. Who spelled the most words correctly?
c. How many pupils took the test?

7. After you are satisfied the class understands the procedure of locating information on the graph, pass out dittoed graph #4.

8. Direct the pupils to read the titles and sub-titles on the graph, study the graph briefly, and then answer the questions below the graph.

End of Lesson

Dittoed Graph #4



1. Did more boys or more girls spell more than 15 of the words correctly?

2. How many words did Karen miss?

3. Did Sue or Tom miss the most words?

4. Did any pupil miss more than 1/2 of the words?

5. How many pupils spelled more than 15 words correctly?

6. Between which two students is there the greatest increase in the number of words spelled correctly?

7. Name the students who had exactly 16 words correct.

8. How many words must Jim spell correctly to have the same score as Lois?

Lesson Plan #6
Thursday, February 17, 1955
Reading

Materials: Days and Deeds, wall graph #5, red strips of construction paper, paste, and the set of lamp drawings.

Procedure:

1. Review with the class the story "Rules or No Rules" on page 61. Bring out that this story is not of modern times, but of years gone by.

2. From the photos of the story and the text bring out some of the factors which distinguish this period from our present modern way of life. (Cooking equipment, type of clothing, type of furniture, source of light, etc.)

3. Discuss some of the different types of lights that have been or are now being used. (Candles, kerosene lamps, gas burners, tungsten lamps, etc.) Write the types of lights the children discuss on the board.

4. Discuss the concept that different types of lights give off varying amounts of light. Point out the differences in the amount of light from a candle and your overhead lights.

5. Build up the idea that down through history we have been able to use the knowledge constantly gained to continually build better types of lights.

6. On the board write these types of lamps and their candle power. Show each corresponding poster of the type of lamp being recorded.

Roman lamp	4 cp*
Betty lamp	5 cp
kerosene lamp	7 cp
gas burner	10 cp
Welsback Mantle	50 cp
tungsten lamp (60 w)	60 cp

* candle power

7. Take out wall graph #5 and attached envelope.

8. The red bars are marked to correspond with the number of candle power given off by each type of light. Paste them to the wall graph as you explain or illustrate the relative amounts of light given off by each type.

9. When all the strips are pasted on the graph, conduct an oral question-and-answer period about the graph. Some questions to ask are:

a. What do the numbers at the bottom of the graph represent?

b. Which bar represents the number of candle power of the Roman lamp? (The first)

c. How many candle power has the Welsback Mantle? (50)

d. How many times brighter is the tungsten lamp than the Betty lamp? (12)

e. What is the total candle power of all the lamps shown on this graph? (139)

f. What is the outstanding trend shown by the graph?

g. The Betty lamp is about (1) twice as bright, (2) one-half as bright, or (3) the same brightness as a gas burner?

h. Between which two lamps on this graph is there the greatest difference in brightness? (Roman lamp and tungsten lamp)

i. Would all the power of the first four lamps shown on the graph equal the candle power of one Welsback Mantle? (No)

j. Between which two types of light is there the greatest increase in brightness? (Gas burner and Welsback Mantle)

Lesson Plan #7
Thursday, February 24, 1955
Reading

Materials: Wall graph #6, Days and Deeds, chalk, chalkboard, paste, 1-inch strips of construction paper, and scissors.

Procedure:

1. Browse through the story "The Mail Must Go Through" on page 87 to find out some of the methods which have been employed to transport mail.

2. List the types brought out by discussion on the board noting especially the five to be used in this lesson--Pony Express, stage coach, truck, train, and airplane.

3. Discuss the relative speeds of the various modes of mail carrying noted. Determine a reasonable accurate speed for each type by the process of group discussion. (Note: top speed of the airplane cannot be greater than 300 mph, the highest speed on the graph.)

4. Take out wall graph #6.

5. Have the group isolate the two types of information needed to fill in the graph from the list on the board. (1) The method of carrying mail and (2) the relative speeds of these methods.

6. Before writing the sub-titles on the graph the children should be led to see that the names of the methods of transportation should be best suited to go along the left-hand side; similarly, the speed scale is best go along the bottom of the graph.

7. Place the names of the methods of carrying mail on the left column in order of increasing rates of speed. Start at the top and work toward the bottom. (Airplane is on the bottom)

8. Along the base line the number of miles per hour starting with the left most grid line for 0 miles and increasing the speed 20 mph for each grid line (0 20 40 etc.)

9. Take out the strips of construction paper and cut them to fit the indicated speed of the types of transportation as determined by the group. Paste them to the graph beside the mode of transportation appropriate.

10. Follow up the 9th step with an oral discussion of the graph using the following questions as a guide:

a. What does the left hand vertical column represent?
b. What do the horizontal figures represent?
c. What does the title tell us about this graph?
d. About how many times faster does a train carry mail than the stagecoach?
e. About how long will it take a train to travel as far as an airplane can travel in one hour?
f. Improved methods of transportation have a tendency to do what to the speed of transportation?
g. How does the speed of the stagecoach compare with the speed of the pony express?
h. How does the speed of the truck compare with the speed of the train?
i. Between which two types of transportation is there the greatest increase in speed?
j. What effect might jet airplanes have upon this graph?
k. What are some advantages of increased speed of mail transportation?

Lesson Plan #8
Tuesday, March 1, 1955
Reading

Materials: Wall graph #6 and dittoed graph #5

Procedure:

1. Bring out the graph the class made for Lesson #7.

2. Ask the class the meaning of the names in the left-hand column.

3. Ask what the numbers at the top of the graph indicate.

4. Let a child go to the board and show the class how to find the number of miles per hour the truck traveled. Do the same for the airplane.

5. Explain to the group that they will be given a graph similar to the bar graphs they have been working with. This is to be a review of the things they have learned to do with bar graphs during the last three lessons.

6. Pass out dittoed graph #5.

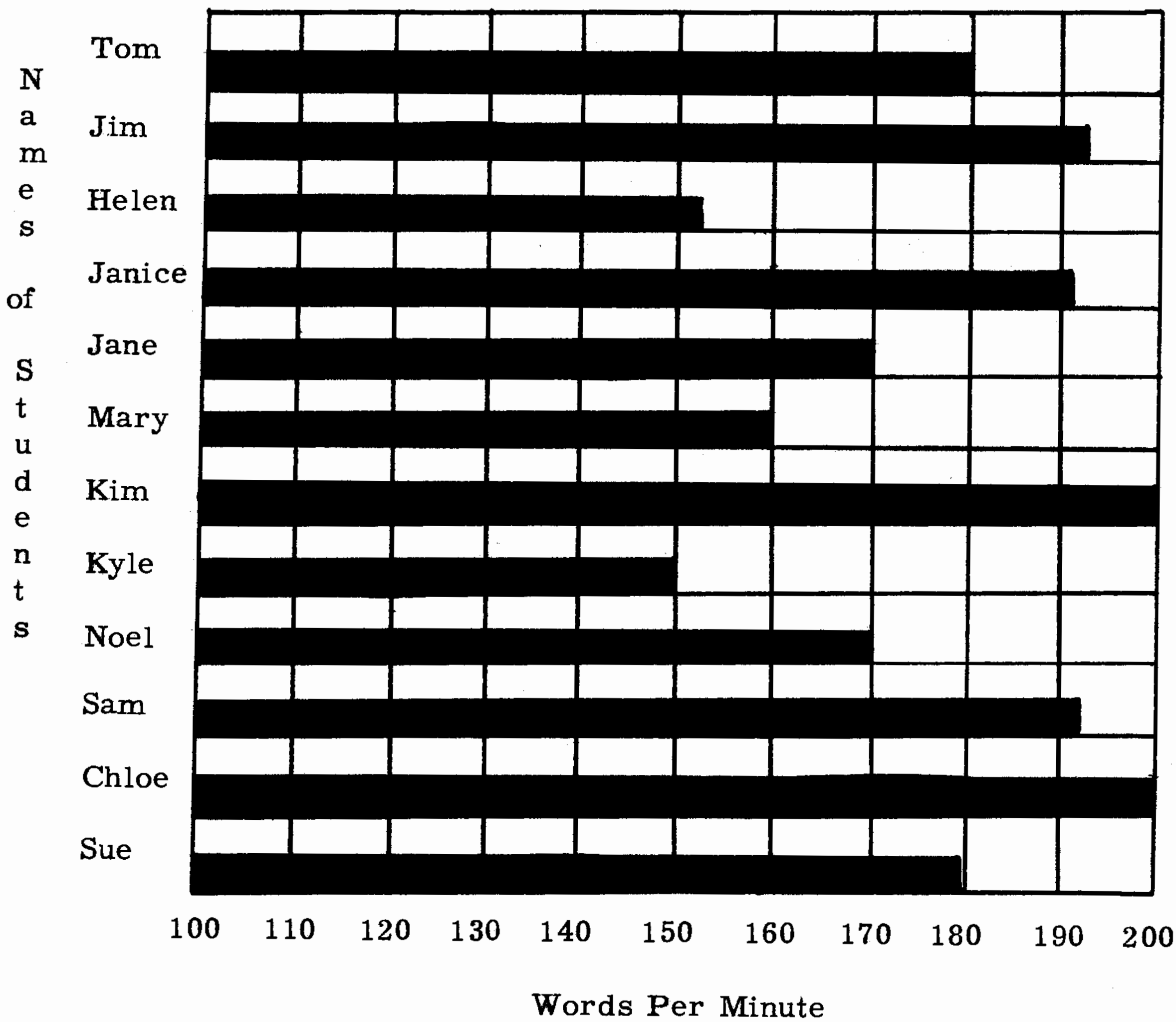
7. Give directions to the class to read the title, sub-titles, and briefly study the graph. The questions below the graph and on the following page are to be answered from their graphs. Answers are to be placed on the line following each question.

8. Be sure the class understands the procedure they are to follow, then let them commence.

End of Lesson

Dittoed Graph #5

Speed Reading Test Results



1. How many pupils took this test?

2. What is the highest number of words per minute shown on the graph?

3. Did most of the children read more or less than 150 words per minute?

4. How many pupils read at least 110 words per minute?

5. Which student read the fewest words per minute?

6. Name the students who read 200 words per minute.

7. Which student read more words per minute -- Noel or Janice?

8. How many more words per minute would Jane have to read if she wishes to read 200 words per minute?

9. Did Mary read (10 20 30) words fewer than Tom?

10. About how many words per minute did Helen read?

11. Did more boys or more girls read more than 170 words per minute?

12. How many words did Kim, Chloe, and Jane read altogether?

13. The fastest boy read how many words a minute more than the slowest girl?

Major Aims of Instruction for Graph Lessons 9 Through 12

Circle Graphs

1. To teach that percentages and fractional parts of a graph need not represent exact amounts.

2. To teach the ability to read amounts by interpreting sectors of a circle graph.

3. To teach the ability to determine rank from an unordered list.

4. To teach the skill of comprehension from titles and sub-titles.

5. To teach the ability to grasp outstanding facts as shown on a circle graph.

6. To teach the ability to determine amounts by use of a key.

Lesson Plan #9
Thursday, March 3, 1955
Geography

Materials: The American Nations, chalk, chalkboard, wall graph #7, tacks, and paper "pie" sections.

Procedure:

1. Using the map on pages 18-19 in the text The American Nations, have the students locate the five Great Lakes.

2. Ask the students to arrange the lakes in the order of their apparent sizes. List them on the board in the order the class suggests.

3. When this has been done, fill in the area in square miles after each lake:

Superior, 31,820; Huron, 23,010; Michigan, 22,400; Erie, 9,940; and Ontario, 7,540.

4. Draw a large circle on the board and tell the students that the circle represents all the lakes if their waters are put together into one big lake.

5. Ask the class to add up the square miles of all the lakes to see how many square miles there are altogether. Round off the figures for the lakes before the lakes are added together.

Superior	31,820	to	32,000
Michigan	22,400	to	22,000
Ontario	7,540	to	8,000
Huron	23,010	to	23,000
Erie	9,940	to	10,000

Total number of square miles after rounding off is 95,000.

6. Write the total in the circle on the board to represent the total number of square miles the graph represents.

7. On the board have the class help you estimate the fractional part which each lake is to the whole.

Superior	$\frac{32,000}{95,000} = \frac{1}{3}$
Michigan	$\frac{22,000}{95,000} = \frac{1}{4}$
Ontario	$\frac{8,000}{95,000} = \frac{1}{12}$
Huron	$\frac{23,000}{95,000} = \frac{1}{4}$
Erie	$\frac{10,000}{95,000} = \frac{1}{9}$

8. Be certain the class understands that these are only estimations and not exact figures.

9. Take out wall graph #7 and tack it to the board.

10. Take out the paper "pie" sections attached to the graph.

11. Relate the size of each of the pieces to the fractional part of the whole graph that each of the lakes represents. After each section has been related to its fractional part, place that part on the wall graph with paste.

12. Lead the children into an oral discussion period about the graph whith the following questions.

a. Which of the two lakes are most nearly equal in size?
b. Which is the smallest of the lakes?
c. Which is the largest of the lakes?
d. Which is the second largest of the lakes?
e. Lake Superior is about (2 times, 3 times, or 4 times) as large as Lake Ontario.
f. Lake Erie is about (1/3, 1/2, or 1/4) as large as Lake Michigan.

g. Which two lakes, when added together, equal the size, or nearly equal the size, of Lake Superior?

h. Would the smallest two lakes added together equal the size of Lake Huron?

i. The largest amount of water in the circle graph for one lake is how many square miles?

j. Each section of this graph represents: (1) the length of each lake, or (2) the size of each lake in square miles?

k. The total area covered on the graph by Lakes Huron and Michigan together is about (1/2, 1/3, or 1/4) of the entire graph?

End of Lesson

Lesson Plan #10
Tuesday, March 8, 1955
Geography

Materials: Map of U. S. A., wall graph #8, chalkboard, chalk, and tacks.

Procedure:

1. The material for this graph was taken from the trade magazine, Fuel Oil and Oil Heat.[1]

2. This graph is introduced by a review of the types of fuels used to heat homes, and where such fuels are found in this country.

3. Bring out the points as the fuel used by the early settlers such as wood and buffalo chips.

4. Lead into the changing fuels used today as a result of the discovery of coal in such places as Pennsylvania, Kentucky, West Virginia, and Washington; oil in such states as Texas, Oklahoma, and California; and natural gas in such places as Texas and Louisiana.

5. Locate these areas on your map of the U. S. A.

6. List the 3 types of fuel for heating American homes, as listed in point 3, on the board.

7. Lead the children into a discussion about this graph by using the following guide questions.

a. Where is the title on this graph? What does the tell us about the graph?

b. What does the largest space on this graph represent?

c. The smallest space is for which fuel?

d. The second largest space is for which fuel?

e. Do more homes in each 100 use coal heat than the other two types combined?

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[1]"Oilheating Users Reach 7,606,114," Fuel Oil and Oil Heat, XIV (January, 1955), 89-98.

f. Which type of fuel is most widely used?

g. How many more people out of every 100 use oil than gas?

h. The number of homes using coal is about (1/5, 1/8, or 1/2) the number using gas?

i. The 49 in the section for oil means: (1) 49 homes in America use oil heat, (2) 49 more homes use oil than coal, or (3) 49 homes in every 100 use oil?

Lesson Plan #11
Thursday, March 10, 1955
Geography

Materials: Wall graph #9, chalkboard, chalk, and dittoed graph #6

Procedure:

1. The material for this graph was taken from The Reader's Digest.[2]

2. Introduce the circle graph by asking the members of the class how many of them rode to school in a car this morning. Ask them, also, what the make of the car was that brought them. List the various makes mentioned on the board.

3. Discuss where cars are manufactured and why Detroit has become the center for this industry. (Central location, cheap and rapid transportation, location of sources of supply, etc.)

4. Locate this area on a map and relate the points mentioned above and those noted by the class to the geographical features of this area.

5. List on the board all the cars being manufactured now which the class can name.

6. From this list group the cars with the name of the company by which they are made.

Ford Motor Company	Chrysler Corporation
Ford	Plymouth
Mercury	Dodge
Lincoln	DeSoto
	Chrysler

General Motors Corp.	All Independents
Chevrolet	Studebaker
Pontiac	Packard
Buick	Hudson
Oldsmobile	Nash
Cadillac	etc.

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[2]Don Wharton, "1955: The Automobile World's Year of Decision," The Reader's Digest, LXVI (January, 1955), 69-72.

7. Explain that the 3 big companies manufacture 91 out of every 100 automobiles manufactured in the United States.

8. Explain that all the other cars manufactured equal the remaining 9 out of every 100 cars manufactured and that all these other companies are classified as "Independents."

9. Bring out wall graph #9.

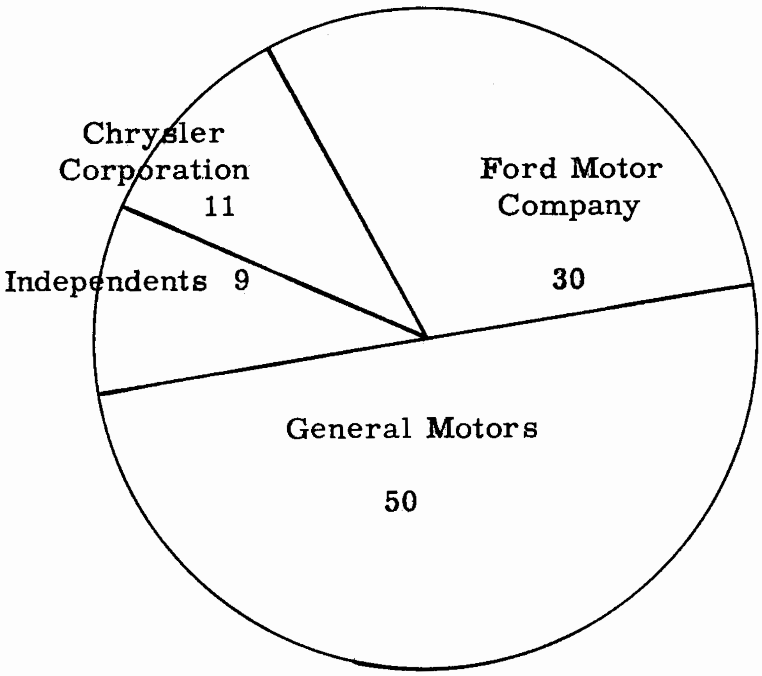
10. Discuss the titles on the graph and what they indicate.

11. Pass out the dittoed graph with the directions that the class is to answer the questions on the sheet from the graph at the top of the paper. In questions, 3, 4, and 5, the students are to underline the correct response. All other answers are to be placed on the line after each question.

End of Lesson

Dittoed Graph #6

Automobile Production of 1954



Number of Cars in Each 100 Produced by
Each Company

1. Which company has the largest space on the graph?

2. Which company has the third largest space on the graph?

3. General Motors produces:
   a. Twice as many cars as all the others combined.
   b. As many cars as all the others combined.
   c. Half as many as all the others combined.

4. The space for the independent companies is nearly (1/2, 1/3, of 1/4) as large as the space for Ford Motor Company.

5. The number for General Motors is 50. This means that

   a. General Motors makes 50 times as many cars as Ford.
   b. General Motors makes 50 cars a year.
   c. General Motors makes 50 out of every 100 cars produced.

6. Which two of the spaces are most nearly equal in size?

7. How many more cars out of every 100 produced does General Motors make than the Chrysler Corporation makes?

8. Out of every 100 cars produced, how many are made by Ford Motor Compan y and Chrysler Corporation?

Lesson Plan #12
Tuesday, March 15, 1955
Geography

Materials: Wall graphs #9 and #10, dittoed graph #7

Procedure:

1. Bring out the wall graph marked #9 and briefly review the information it tells.

2. Bring out the circle graph #10.

3. Relate this graph to graph #9 by showing that #9 illustrates the number of cars produced by each company per 100. Graph #10 shows the number of companies making automobiles from 1916 to 1955.

4. Review with the class the following items:

   a. We compare the sizes of the parts of a circle with one another. (Illustrate)

   b. We must read the titles to tell what type of information the graph represents.

   c. The key tells us the meaning of the different types of markings shown on a graph and what they mean.

5. Ask a child in the class to read the title and tell the class what the graph will be about. (Graph #10)

6. Locate the key and ask the class to explain what each of the two colors indicates. Go no farther until all the students clearly understand the key.

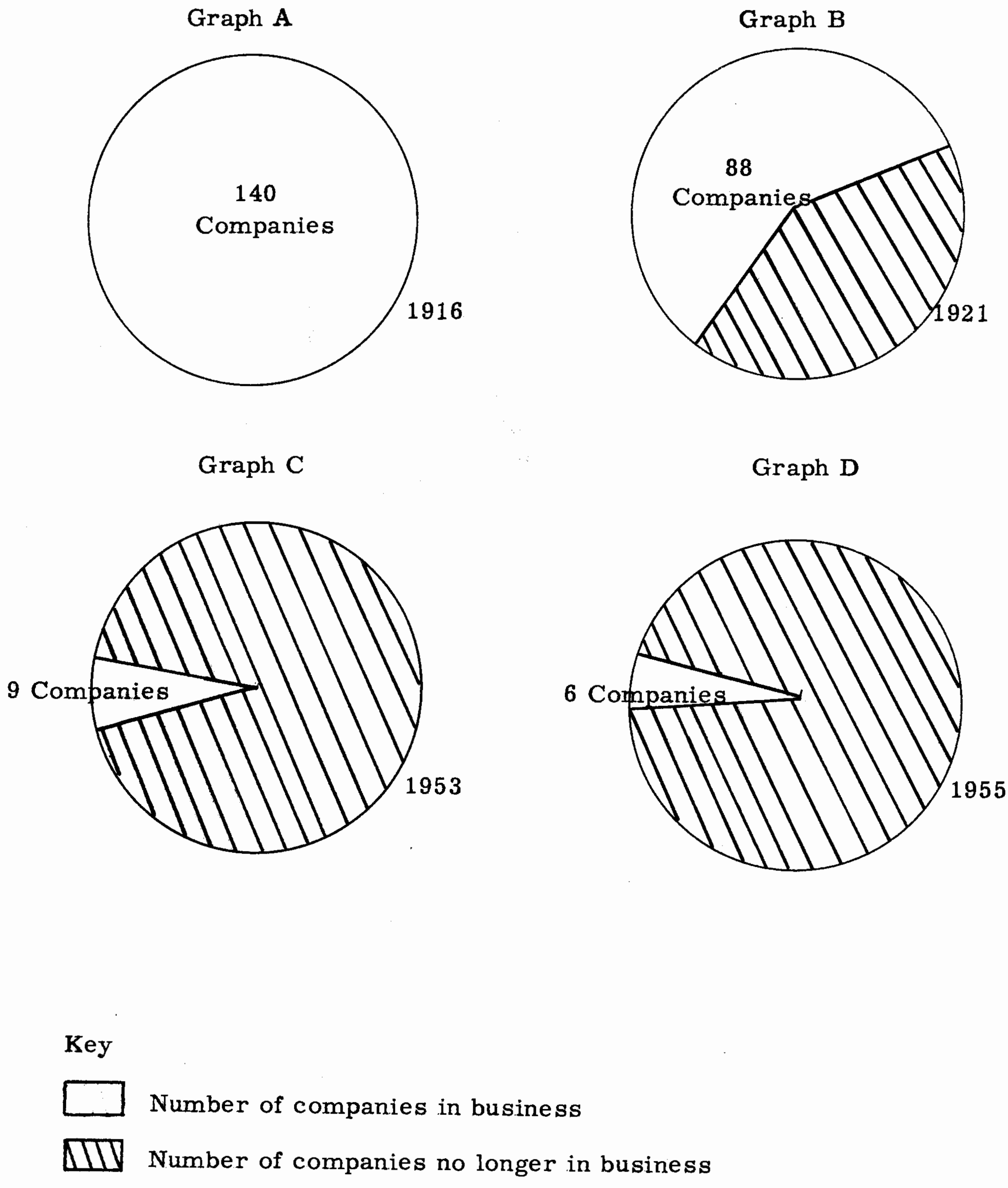
7. Pass out dittoed graph #7 and instruct the class to answer the questions by either underlining their response (questions 5, 9, and 11) or by placing their answer in the space after each question.

End of Lesson

Dittoed Graph #7

Decline of the Number of Automobile Companies

in the United States



1. What is the earliest date shown on these graphs?

2. How many companies were building cars in 1921?

3. How many years separate graph B from graph C?

4. How many companies went out of business during those years?

5. Between which two groups of years did more companies go out of business, 1916 to 1921, or 1921 to 1953? (Underline your answer)

6. How many automobile companies are there today?

7. Is this more or less than the number of companies 5 years ago?

8. Which graph has the most black space?

9. Graph B tells us that in 1921:

   a. 88 companies went out of business
   b. 88 companies were in business
   c. 88 companies started business that year

10. Are companies that make automobiles increasing or decreasing in number?

11. There is no shaded area in graph A because:

    a. There were no companies in 1916
    b. All the companies stopped making cars that year
    c. All the companies stayed in business that year

Major Aims of Instruction for Graph

Lessons 13 Through 16

Tables

1. To teach the ability to determine rank from unordered lists.

2. To teach the ability to read amounts in a graph by reading across in a table.

3. To determine how many times greater one amount is than another.

4. To teach the ability of interpreting from sub-titles what is shown by each part of a graph.

5. To determine trends as shown on a graph.

Lesson Plan #13
Thursday, March 17, 1955
Science

Materials: Temperature chart, tacks, chalk, chalkboard, dittoed graph #8

Procedure:

1. Introduce the lesson by asking the children how they are able to tell how cold the weather may be.

2. Then unroll the thermometer chart and tack it to the board.

3. Explain that the degrees on the thermometer are consecutive beginning at the zero and that the numbers grow larger as they go toward the top. Also that the numbers below the zero grow larger as they go toward the bottom. The class may become confused when two consecutive hours have the same temperature so be sure they understand that each degree on a thermometer appears only once above and once below the zero.

4. Arrange on the board in random order about 10 numbers which represent the degrees on a thermometer. Let two of the numbers be the same. (Ex. 52 54 55 58 59 60 60 57 56 53)

5. Ask the class to arrange the numbers as they would appear on a real thermometer. Be certain that they do not put 60 down twice as it appears only one time on the thermometer above zero.

6. Arrange the numbers of a clock face on the board from 7 a.m. to 4 p.m. (7 8 9 10 11 12 1 2 3 4). Be sure the class knows these numbers are not arranged starting with 1 p.m. but as they actually occur during the day.

7. Pass out blank graph #8 and have the class label the horizontal lines Temperature and the vertical lines Hours.

8. Illustrate on the board the correct manner in which to fill in the temperatures and the hours for this graph. Write in the

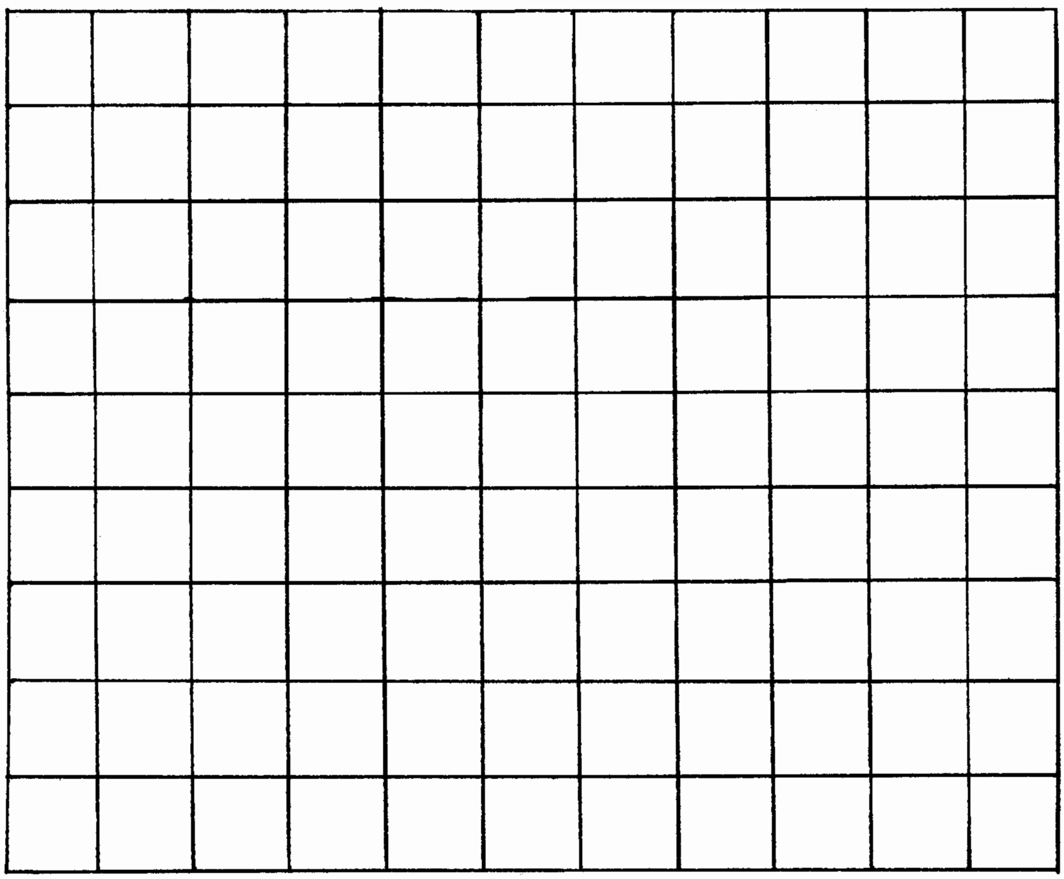
first 2 or 3 temperatures and the first 2 or 3 hours and let the class finish the job by themselves. (Use the hours and temperatures given in steps 6 and 4 of this lesson.)

9. Explain to the class they have prepared a grid on which they will record some temperatures on the next lesson. Have the children put their names on their papers and collect them.

End of Lesson

Dittoed Graph #8

Temperature Chart



Lesson Plan #14
Tuesday, March 22, 1955
Science

Materials: Dittoed graph #8, scotch tape, chalk, and chalkboard.

Procedure:

1. Place the following table on the board and let a member of the class arrange the degree numbers in their proper sequence on the board along a vertical axis.

Temperature	50	52	53	55	57	58	58	56	54
Hour	8	9	10	11	12	1	2	3	4

2. Next let a child place the hour numbers in their proper sequence along the horizontal axis.

etc.

51

50

7 8 etc.

3. A third child may draw in the grid lines.

4. When this is finished, ask a child to place a dot to show the temperatures indicated on the table.

5. Connect the dots with straight lines to complete the graph.

6. Return the graph used on Thursday to the class.

7. Place the following table on the board and instruct the class to fill in their line graphs from the table.

Temperature	52	54	55	58	59	60	60	57	56	53
Hour	7	8	9	10	11	12	1	2	3	4

8. When the graphs are completed, collect them and place them in the folder.

End of Lesson

Lesson Plan #15
Thursday, March 24, 1955
Science

Materials: Chalk, chalkboard, dittoed tables #1 and #2, and dittoed graph #9

Procedure:

1. Review with the class Lessons 13 and 14 on transferring tables to graphs. Illustrate on the chalkboard. Note the following points:

   a. Placement of the row and column headings
   b. Correct placement of information in the rows or columns
   c. Correct placement of the line upon the graph

2. Pass out 2 dittoed graphs to each child and explain that the class will use them to make some graphs from two tables they will receive after the graphs have been passed out.

3. Explain to the class that Table #1 is to be used on Graph 1 and Table #2 on graph 2.

4. Check each paper to see that each child fills in the temperature and hour numbers correctly before they proceed to record the tables on their graphs.

End of Lesson

Dittoed Tables

Table 1

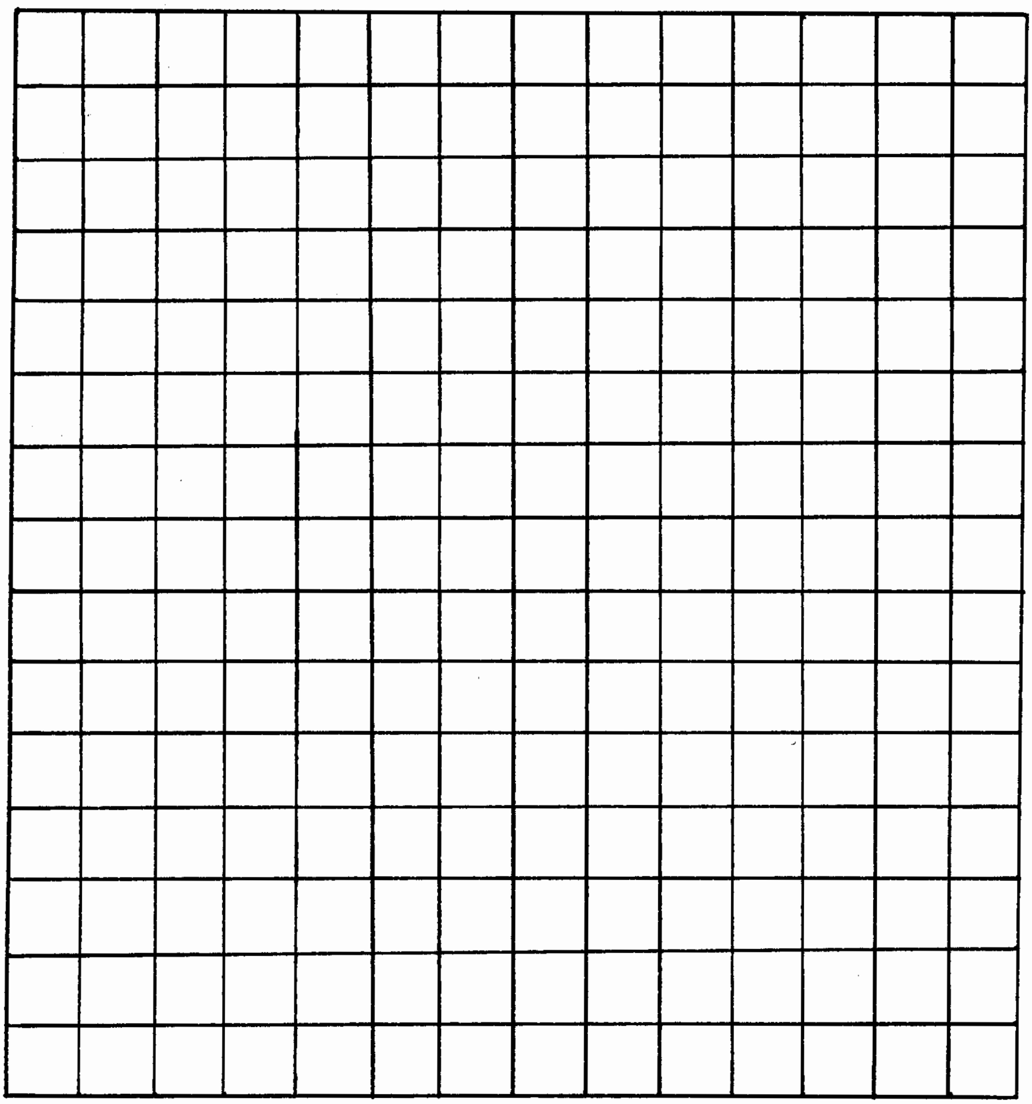
Hour	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00
Temperature	54	55	57	60	61	63	62	56	55	53

Table 2

Hour	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00
Temperature	48	49	52	55	57	61	63	63	60	58

Dittoed Graph #9

Daily Temperature



Lesson Plan #16
Tuesday, March 29, 1955
Science

Materials: Dittoed tables #3 and #4, and dittoed graphs #10 and #11.

Procedure:

1. The concluding lesson translates two tables into bar graphs.

2. Illustrate once again how to fill in the lines on a graph as done in Lessons 14 and 15.

3. Explain to the class that they will be given two tables and two graph grids. They are to translate the information Table #1 to Graph #9 and Table #2 to Graph #10.

4. Instruct the class to use pencils instead of ink for easy erasing if any errors are made.

5. When the graphs are finished, collect them and place them in the folder.

End of Lesson

Dittoed Graph #10

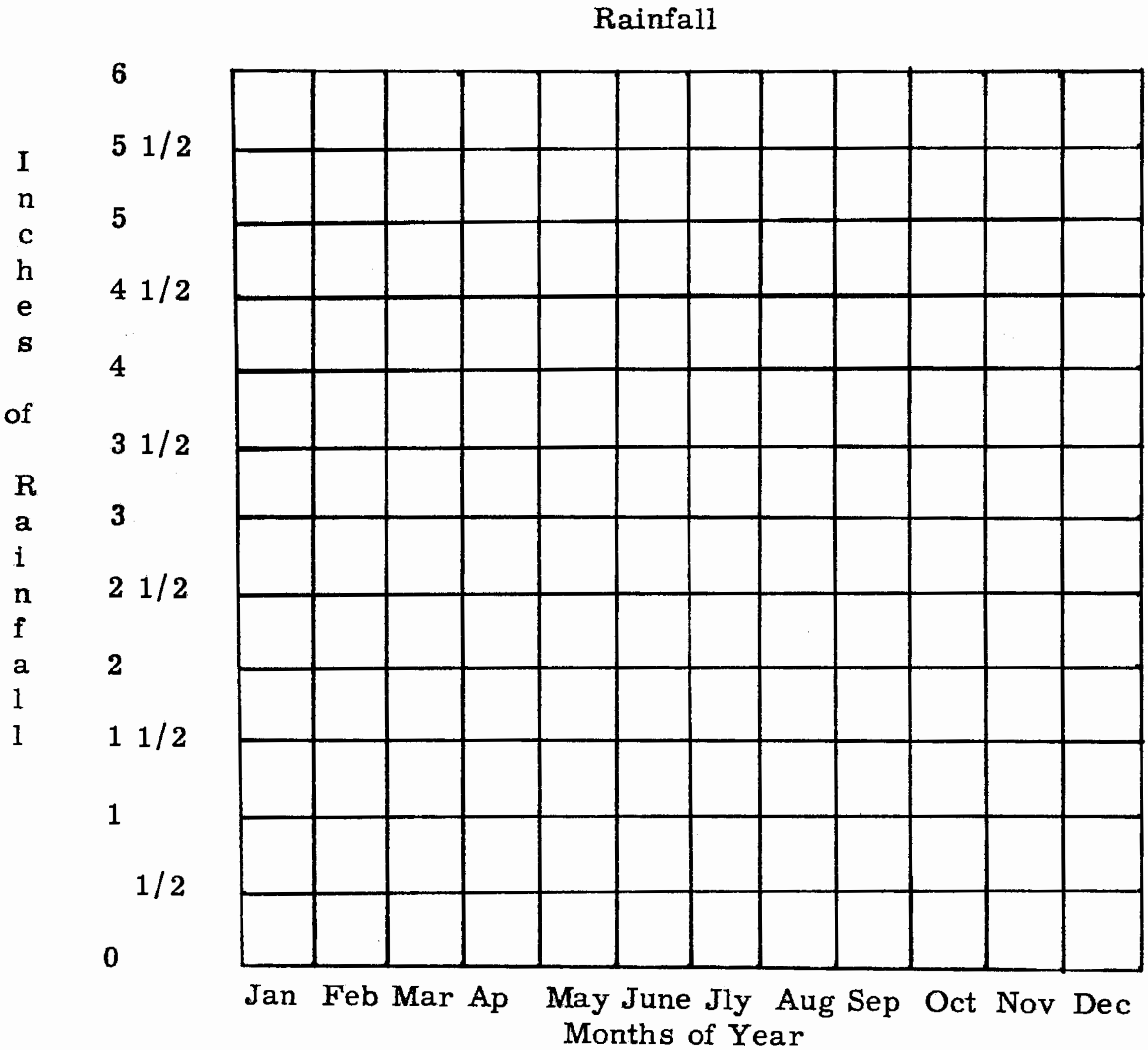


Table 3

Month	Jan	Feb	Mar	Ap	May	June	Jly	Aug	Sep	Oct	Nov	Dec
Rainfall	3 1/2	3	3 1/2	4	4 1/2	3	2 1/2	1 1/2	3	3 1/2	3 1/2	4

Dittoed Graph #11

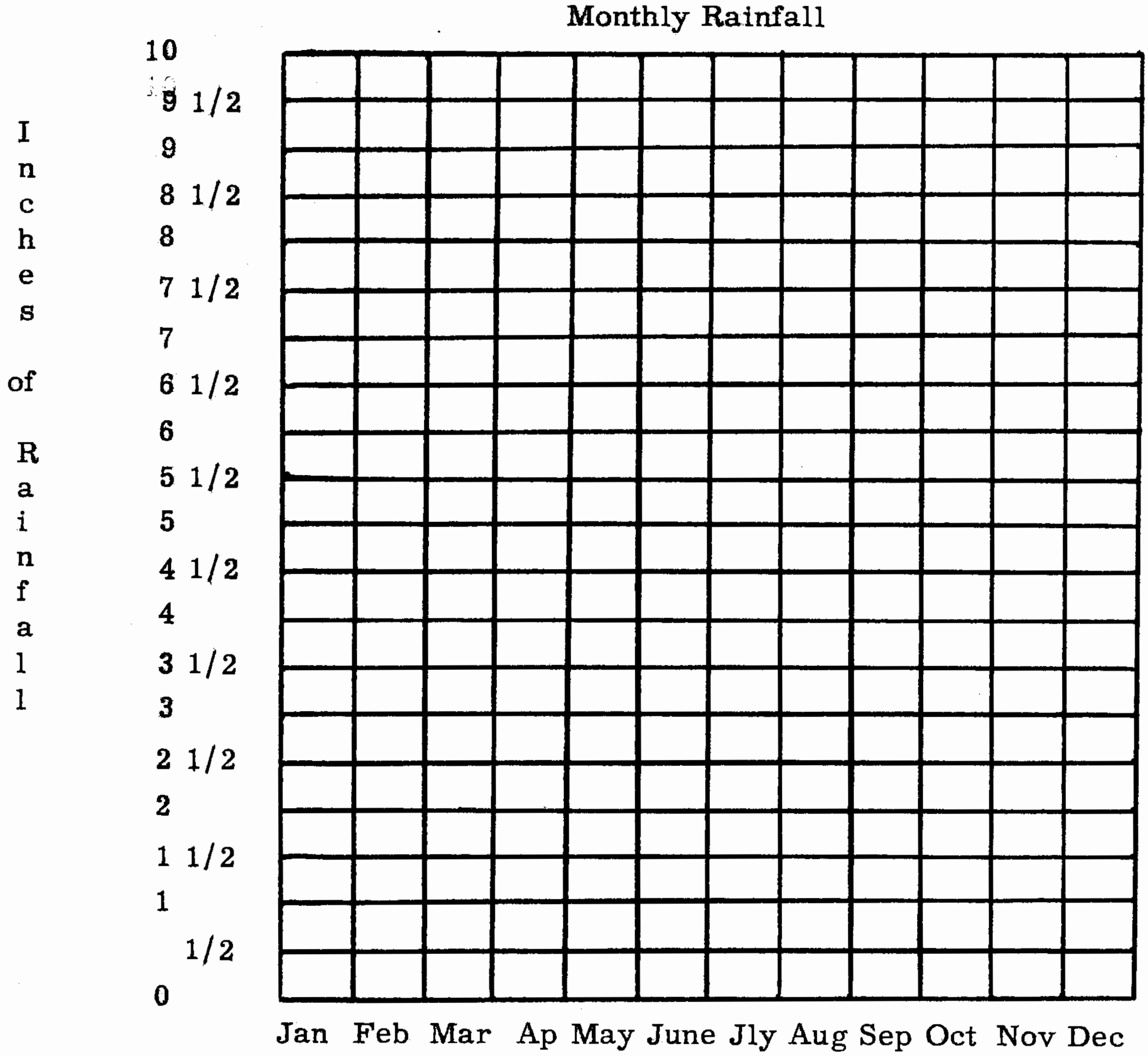


Table 4

Month	Jan	Feb	Mar	Ap	May	June	Jly	Aug	Sep	Oct	Nov	Dec
Rainfall	5	4 1/2	3 1/2	5 1/2	3 1/2	0	0	0	9	8	7	6 1/2

APPENDIX B

Sample Statistical Test

STATISTICAL TEST USED IN THE ANALYSIS OF THE DATA

TEST OF SIGNIFICANCE USING SMALL SAMPLES

The formula used for the significance ratio (t) for the difference in the means of two small samples is

$$t = \frac{M_1 - M_2}{\sigma md}$$

in which M_1 and M_2 are the obtained means and σmd is the standard error of the mean difference. The formula for the number of degrees of freedom is $(N_1 + N_2 - 2)$. An example of the above t-test follows:

$$M_1 = 6.29, \quad M_2 = 5.73, \quad \sigma md = .18$$

$$t = \frac{6.29 - 5.73}{.18}$$

$$t = \frac{.56}{.18}$$

$$t = 3.11 \quad (df = 228)$$

The table value of $t_{.01}$ $(df = \infty)$ is 2.5758; therefore, the t score is significant beyond the one percent level of confidence.[1]

[1]Allen L. Edwards, Experimental Design in Psychological Research (New York: Rinehart and Company, Inc., 1951), p. 407.