Reading Horizons

Volume 22
Issue 2 *December 1981*

Article 2

12-1-1981

Graphing as a Reading Skill

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The science curriculum contains built-in opportunities for the teaching of reading skills. Using graphs is a skill that is necessary for children to gain information from their reading (Silvaroli and Wheelock, 1980). Science instruction can guide children to comprehend information from their reading by teaching them to read and infer from graphs. Lucas and Burlando (1975) stated that scientific experiences "are designed so that the student will be asked to define problems, locate information, organize data into graphic form, evaluate findings and draw conclusions.

The teacher should be systematic and methodical in creating and following procedures to reach specified goals in order to increase learning effectiveness (Okey, 1978). The goals of teaching graph skills appear to exist at two cognitively dichotomous levels. First, there is the productive goal of the ability to construct graphs; second, there is the receptive goal of being able to interpret existing graphs by the students. The goals are said to be cognitively dichotomous because mastery of one goal does not assure mastery of the other.

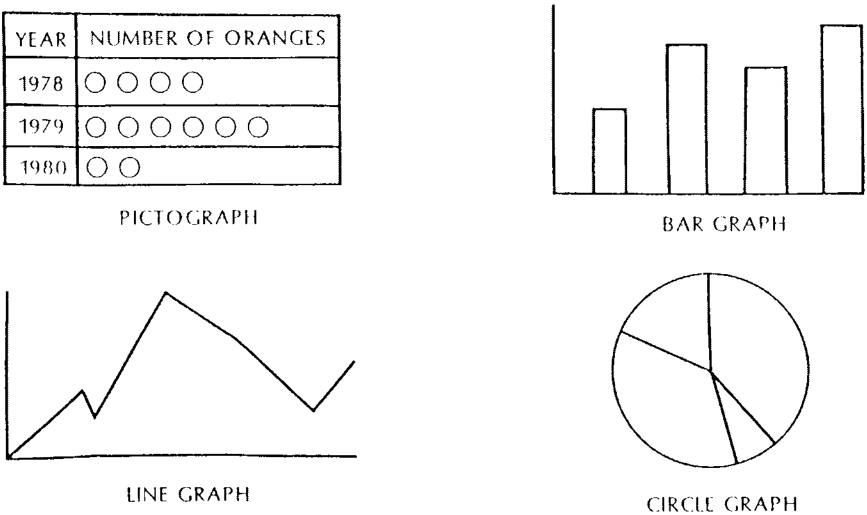


Figure 1. Examples of graph types.

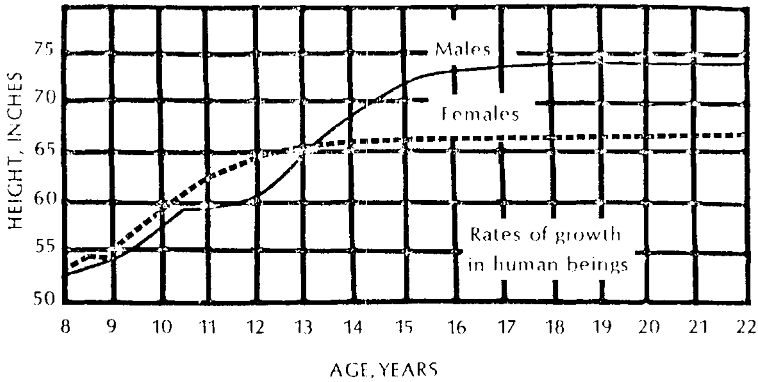
Toward the productive goal, children collect data or are given specific information from which they may construct a pictograph, bar graph, line graph, or a circle graph. Examples are shown above. The receptive goal implies that the students assimilate graphical date "in their head" and invent their own generalizations and facts based on the graphs presented to them.

Children performing activities leading up to an including graphing develop number concepts through visual experience. Smith (1979), using Piagetian theory, has formulated a number of classroom activities to enhance graphing abilities. These activities were based on four of the stages of cognitive development as stated by the Nuffield Foundation (1976). Stage one requires students to utilize concrete objects (such as themselves) and to make comparisons in a one-to-one correspondence. In stage two, children compare by making graphs using pictures of objects. The transition from a pictorial graph to a block graph occurs in stage three whereby students use square pieces of paper to construct their graphs. In stage four, children begin using large-squared graph paper in order to record data.

Graph construction activities can include comparisons of students' height, weight, and number of heartbeats or respirations per minute. Heartbeats and respirations can be measured before and after exercise. Plant growth under various conditions, animals and their habitats, and even the time records of animals or human fingers as they "run" a maze are also good bases for constructing graphs. Graphing accomplished by the learner may also provide an opportunity for the integration of other content within the science curriculum. Besides the incorporation of math skills, which can be basic (numbers) or advanced (slope and function), the teacher might have the children graph population studies (social studies), the amount of food produced by countries (global education), and the contemporary comparison of values (human development). Other graphing activities include: bar graphs of student progress in completing objectives, graphs composed from the results of games (Hirsch, 1976), the traditional teaching of graphing combined with workshops (IOWA, 1978), more games with graphathons (Dunagon, 1980), and birthdays (Sigas 1976). The many ideas for graph construction are unlimited.

Sigas suggested that students be initiated into graph construction activities as a class unit. The best assurance of mastery in the productive goal, however, would be the practical experience of a graph constructed by the individual student based on data collected from an independent science study. Graphs of simple observations may lead to more complex investigations involving the scientific method.

The necessity of having students achieve the receptive goal has acquired added dimensions. The ability to interpret graphs is required in some states, including Florida, beyond the third grade level. Furthermore, various assessment tests such as the SAT and the PSAT require mastery of the receptive goal.



Note. From Barron's College Entrance Examination SAT by S. C. Brownstein and M. Weiner, p. 327. Copyright 1980 by Barron's Educational Series, Inc. Reprinted by permission.

Figure 2. Sample of SAT type of graph interpretation exam question.

Methods formulated to enable children to meet the receptive goal demand systematic preparation also. A recent study (Kirk, et al, 1978) has suggested that students should first learn how to make and identify valid generalizations before continuing with complex predictions. This indicated that the learner should be made aware of similarities and differences in the construction of graphs for assimilation towards interpretation. There is a need here to teach common characteristics or specific critical attributes among graphs.

Vernon (1953) concluded that special training is needed in order to learn graphs. He believes that students understand diagrams better when they are supplemented by verbal explanation. Furthermore, there can be an increase in the interpretations of graphs through questioning. Of course, the difficulty of vocabulary would depend on the listening level of the children.

It appears that the more written information accompanying a graph, the more errors in interpretation may be expected. A threshold of cognitive overload may develop (Eggen,et al 1978). In fact, no matter what kind of graphic diagram is used, students are less likely to understand it if the concept or information is too complex or unfamiliar (Vernon, 1953). Thus, textual material relating to a graph should be limited or eliminated, at least in the initial instruction of graph interpretation.

In view of the above information, we propose a systematic strategy enabling children to reach the receptive goal based on a four-step process postulated from a historical study of instructional designs to teach concepts (Tennyson and Park,1980). Although the strategy applies to the receptive goal, it is suggested that the framework be incorporated within the activities leading to the productive goal. Care must be taken in presentation, however, to assure mastery of graph interpretation by the children.

First, the pupils should be made aware of the specific critical attributes among line, bar, and circle graphs. All three types of graphs have a title which gives an indication as to what the graph visually represents. All graphs are labeled. Bar and line graphs are usually labeled as: time vs. ———, some measurement or number vs. ———, distance vs. ———, cost vs. ———, etc. These specific critical attributes give the child a cue as to what relationships are being compared (labels) based on a specific instance (title of the graph). Circle graphs, which best illustrate the parts of a whole, usually label a proportion of something as compared to the entirety depicted by the title of the circle graph. Children should be directed to compare the specific critical attributes of graphs which are alike. That is, the childs' attention in the process of interpretation should be led, first, to the title and labels of the graph under study. The comparison can use graphic material such as that presented below.

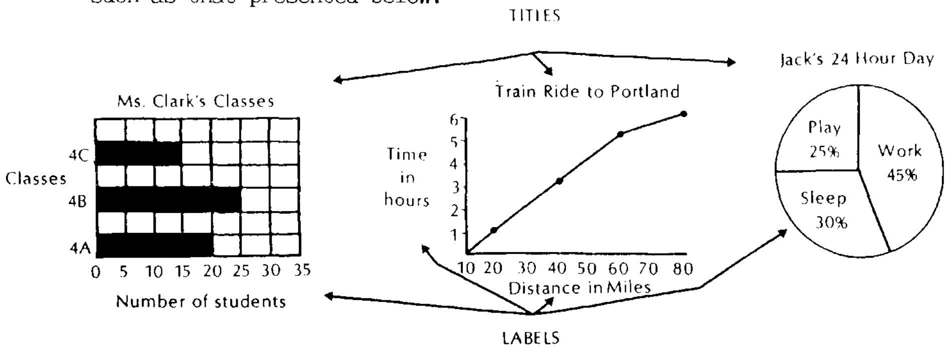
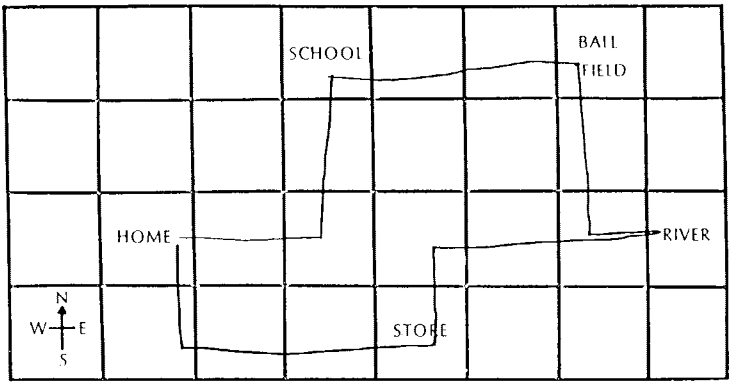


Figure 3. **Graphic interpretation through comparison of specific critical attributes.**

In the determination of a definition, appropriate terminology should be employed. The graph defined as a "picture with numbers to see how many more people like chocolate than vanilla ice-cream" might be more suitable for fourth graders than the more technical "a pictorial device used to disply relationships" for eighth graders.

Early graph interpretation should be promoted by the teacher in oral directions or questions consistent with the vocabulary level of the children. Reciting the names and counting the pictures from a pictograph may facilitate the importance of the specific critical attributes. Simple questions about the titles and labels should lead to questions about each item graphed. Phrases such as how much or how many can be used. Viewing the entire graph, the teacher may ask, "What does the picture mean?" Words such as most, least, longest, and shortest may soon be replaced by fewer and greater. After proper mathematical skills have been achieved by the learner, subtraction of measurements of two items on a graph is requested as a difference. Twice as many, half as much, increase and decrease are terms appropriate for advanced students.

Children can also be given graphing experiences related to early map reading skills and following directions. The student can be instructed to draw a line on a graph "two spaces East to a house, then four spaces North to the schoolhouse..." etc. An example of following these directions is shown below. This exercise initiates the learner to comprehend directions and to graph co-ordinates on the axes. Again, the teacher may ask, "Which building is farther South?"



Start at HOME.
Go two blocks east and two blocks north.
Go three blocks east.
Go two blocks south and one block east.
Go three blocks west and one block south.
Go three blocks west and one block north.
Where are you? HOME

Figure 4. Example of a student following mapping directions.

From a prototype, a bar graph for example, students should be given other similar bar graph samples from which to compare similarities of graph interpretation. Simultaneous presentation of two similar graphs can focus the learner's attention on differences. By comparing bar, line, and circle graphs which are not visually similar but contain the same information, the children may experience an increase in discriminate learning by ascertaining the likenesses and differences in the graphs. Tennyson and Park (1980) have concluded that the number of examples necessary to achieve the above objectives depends on the need and learning characteristics of the individual student.

Once children have learned to make simple generalizations, i.e., comparing similarities and differences within a graph, they can be directed to make predictions. This type of experience can provide an opportunity for the learner to make an educated guess. Predictions can be based on the weather, food costs or mathematical functions (Pereira-Mendoza, 1977).

Perhaps the most satisfying method to assure mastery of the receptive goal might be worksheets containing graph interpretation questions based on the learner's independent study suggested above. The questions should resemble the hierarchical teaching method described. For instance, the worksheet would begin by asking for the specific crtical attributes and a justification for the items compared in the particular type of graph. Oral questions may be substituted for written questions, such as "What is...the greatest...the least...the greatest difference... the smallest difference?" The learner may be requested to transpose his graph into another graph form; for example, a bar graph may be transposed into a line graph. Obviously, written questions should be attempted after the verbal experiences suggest an understanding of the receptive goal, to eliminate frustration.

Diagnostic testing and remediation, whether they are student controlled or teacher-directed, do not appear to assist students in the mastery of the productive and receptive goals of graphing (Okey, et al, 1972). This conclusion should not leave the imaginative teacher looking into an abyss. A later study determined that an individual's preference and not his ability is the determining factor as to what method he will select to solve a problem (Dunlap and Frazio, 1977). Thus, many examples presented in the systematic strategy described may provide the children with many suitable opportunities to experiment cognitively in order to reach the productive and receptive goals of graphing.

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