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ABSTRACT

Clinical interviews were conducted with 25 seventh- and eighth-grade students to determine: (1) the extent to which they could produce correct graphical representations of familiar situations; (2) to what extent they could infer relationships from graphs; (3) what are the most commonly held graphing misconceptions and how stable they are; and (4) how consistent are students' graphing skills across different content areas and types of problems. Notes taken during and tape-recordings of the interviews were used to identify the following types of misconceptions, namely, graph as picture, slope/height confusion, centering on one variable only, linearity of scale, initial positioning at the zero point on the axis, and a static (rather than dynamic) conception of graphs. Two major misconceptions, both of which have been observed with college populations, were documented in the preliminary analysis of three items. The first misconception (graph as picture) was strongly exhibited in a bicycle problem (dealing with elevations and speed). For example, subjects drew a picture when asked to make a graph, and when presented a graph, they read it as a picture. The second misconception (slope/height confusion) was found in a problem dealing with graphs of temperature versus time of day. (JN)

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ADOLESCENTS' GRAPHING SKILLS:

A DESCRIPTIVE ANALYSIS

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ADOLESCENTS' GRAPHING SKILLS: A DESCRIPTIVE ANALYSIS

Objectives

The major objective of this study was to provide an in-depth examination of middle school children's graphing skills and misconceptions. While past research based on standardized tests has identified the graphing conventions which students have mastered (Bestgen, 1984), there have been few attempts to illuminate the cognitive processes underlying adolescents' ability to produce and interpret graphs. Our intensive interview study of adolescents' graphing skills addresses this issue by asking the following questions:

- To what extent can 7th and 8th graders produce correct graphical representations of familiar situations?

- To what extent can they infer relationships from graphs?

- What are the most commonly held graphing misconceptions and how stable are these misconceptions?

- How consistent are students' graphing skills across different content areas and types of problems?

Recent research (Clement, 1985, McDermott, et. al., 1983) shows that college students exhibit major misconceptions in interpreting graphs of physical phenomena (e.g., velocity). There is a strong tendency among students to view graphs as pictures rather than as symbolic representations, and a tendency to incorrectly superimpose existing knowledge about a physical phenomenon upon the graphing problem. It is important for researchers and educators alike to identify the early developmental patterns of these misconceptions. Equally important, we need to know more about the development of graphing competencies. While teachers often assume that students can employ graphs as symbolic representations, this assumption is not based on solid research. More knowledge about the development of the ability to produce and interpret graphs might lead to the improved pedagogical approaches to math and science.

Approach and Method

In order to better understand children's graphing skills, clinical interviews (Piaget, 1954) were conducted with twenty-five 7th and 8th grade students. A carefully constructed set of graphing problems, some involving graph interpretation and others graph production, was administered in individual interviews. The items included problems from different content areas, balanced to minimize confounding of graphing skill with knowledge of a specific content area. Most of the subject matter in these problems was scientific in nature, but within the realm of students' experience (e.g., graphs of the speed of a bicycle as it goes up and down hill, of the number

of calories needed by boys vs. girls, of the temperature rise and fall on sunny vs. cloudy days). On the basis of a pilot test, items were revised to ensure appropriateness in terms of language, difficulty level, and coverage of various types of problems.

The interviews consisted of six graphing items (from two sets of comparable items) and lasted from 20-40 minutes. The interviewer asked the child to read the problem aloud and to "think aloud" while s/he solved the problem and answered a series of questions about the graph. The strength of the child's answer was assessed by having the interviewer make countersuggestions, and asking for the child's response.

Analysis

Notes from the interviews, as well as tape-recordings of them, were the basis for the first stage analysis: e.g., identification of correct responses and major types of misconceptions. A protocol summary was then completed for each student's performance on each item. Based on these protocols and on pilot work, graphing misconceptions were classified. The following types of misconceptions were identified: graph as picture, slope/height confusion, centering on one variable only, linearity of scale, initial positioning at the zero point on the axis, and a static (rather than dynamic) conception of graphs. For each misconception, a record was made of the type of misconception, nature of the difficulty the student encountered, and evidence from the protocol to support the classification.

Results

Two major misconceptions, both of which have been observed with college populations, were documented in the preliminary analysis of three items: 1) slope-height confusion; and 2) graph as picture. The notion of graph as picture was strongly exhibited in two problems discussed below (Bicycle and Stage problems), while the slope-height confusion appeared in subjects' responses to one problem (Sunny Days).

In the Bicycle Problem, subjects were shown an elevation view of a bicycle path with uphills, downhills, and level stretches, together with a word description of one cyclist's speed along each segment of the path. Subjects were asked to draw a graph of speed vs. position along the path and to relate their graph to the given description. Seven of the fourteen subjects who answered this problem incorrectly drew graphs that were more or less faithful copies of the drawing of the path given in the problem. Countersuggestions by the experimenter, including the drawing of the correct graph, were typically rebuffed with comments which confirmed that these subjects interpreted the graphs as pictures rather than as speed graphs. When asked to make a graph, they instead drew a picture, and when presented a graph, they read it as a picture. Two other subjects initially drew pictures, but changed their minds when presented with the correct graph.

In the second problem, (the Stage Problem), subjects were presented a graph of a person's position on a theater stage vs. time. They were asked to identify the time intervals, when the person was moving "to the right" or "from left to right" on the stage. Eight of the fourteen subjects gave incorrect responses which again indicated that they viewed the graph as a pictorial representation of the stage. Four others gave correct written responses on the multiple choice question, but indicated by their comments and by their embellishments of the graph that they also saw the graph as a picture at least part of the time.

A third problem, the Sunny Day's Problem, tapped slope/height confusion. From a pair of graphs of the temperature vs. time of day (drawn on the same coordinate axis), subjects were asked to identify the day and time of certain points, e.g., where the temperature was rising most rapidly. Only three of fourteen subjects correctly answered the questions of this problem. Of the other eleven, five confused greatest rise or fall with highest or lowest point on the graph, while the other six identified the perceived initial point of change (which is in fact arbitrary on a smoothly varying curve) or another aspect of one of the curves.

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