DOCUMENT RESUME

ED 264 128 SE 046 290

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TITLE The Impact of Microcomputer-Based Science Labs on Children's Graphing Skills.
INSTITUTION Technical Education Research Center, Cambridge, Mass.
SPONS AGENCY National Science Foundation, Washington, D.C.
REPORT NO TERC-TR-85-3
PUB DATE Nov 85
GRANT NSF-DPE-8319155
NOTE 7p.; Paper submitted to the 1986 Annual Meeting of the National Association for Research in Science Teaching.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Comprehension; *Computer Oriented Programs; *Elementary School Science; Grade 6; *Graphs; Intermediate Grades; Mathematics Skills; *Microcomputers; Science Activities; Science Education; *Science Instruction; Skill Development; Teaching Methods
IDENTIFIERS *Graphing (Mathematics); National Science Foundation; Science Education Research

ABSTRACT

Microcomputer-based laboratories (MBL), the use of microcomputers for student-directed data acquisition and analysis, represents a promising new development in science laboratory instruction. This descriptive study determined the impact of MBLs on middle school students' understanding of graphs of distance and velocity. The study was based on the premise that understanding the use and interpretation of symbol systems such as graphs is a central developmental task for all children. Sixth-grade students received five MBL lessons on distance and velocity, where they were challenged to construct different kinds of graphs via their own movements and the movements of a toy cart. Results (based on classroom observations and a post-intervention quiz which required students to match graphs with written descriptions of these graphs) indicated that after experience with MBL, students could accurately match complex graphs of physical phenomena with written descriptions of these graphs. Children attained a mean accuracy level of 85 percent on the matching task which involved graphs of position and velocity (including negative velocity). Observations corroborated these findings, and showed that students' understanding of graphs was resistant to countersuggestion. By linking the concrete and the abstract, MBL may be providing a bridge that facilitates the development of formal operational thinking. (Author/JN)

TERC Technical Report 85-3
November, 1985

THE IMPACT OF MICROCOMPUTER-BASED SCIENCE LABS ON CHILDREN'S GRAPHING SKILLS

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Paper submitted to the 1986 annual meeting of the National Association for Research in Science Teaching.

This report was produced as part of NSF grant DPE-8319155. However, any opinions, findings, or recommendations expressed herein are those of the authors and do not necessarily reflect the views of the Foundation.

The Impact of Microcomputer-based Science Labs on Children's Graphing Skills

Abstract

Microcomputer-based Labs (MBL)--the use of microcomputers for student-directed data acquisition and analysis--represent a promising new development in science laboratory instruction. Students use probes that are connected to the computer to gather data on physical phenomena such as motion or temperature. These measurements are instantly graphed in real time on the computer screen. Because the tools link the concrete data-gathering experience with an instantaneous symbolic representation of that experience, they are a potentially powerful learning device for science laboratories.

The purpose of this descriptive study was to determine the impact of microcomputer-based labs on middle school students' understanding of graphs of distance and velocity. The study was based on the premise that understanding the use and interpretation of symbol systems such as graphs is a central developmental task for all children.

Sixth grade students received five MBL lessons on distance and velocity, where they were challenged to construct different kinds of graphs via their own movements and the movements of a toy cart. They used a sonic detector "probe" linked with the microcomputer, to produce and observe the graphs of these motions in real time. Classroom observations, consisting of narrative records of the behavior of lab groups, were conducted on all five days, using an event sampling process. A post-intervention quiz, which required students to match graphs with written descriptions of these graphs, was administered.

Results indicated that after experience with MBL, students could accurately match complex graphs of physical phenomena with written descriptions of these graphs. Children attained a mean accuracy level of 85% on the matching task which involved graphs of position and velocity (including negative velocity). Observations corroborated these findings, and showed that students' understanding of graphs was resistant to countersuggestion.

The power of the intervention stems partly from the fact that it reinforced many learning modalities. The kinesthetic experience of using one's own movements as "data" was linked with the visual experience of seeing graphs of these movements on the screen. By linking the concrete and the abstract, MBL may be providing a bridge that facilitates the development of formal operational thinking.

The Impact of Microcomputer-based Science Labs on Children's Graphing Skills

Microcomputer-based Labs (MBL)--the use of microcomputers for student-directed data acquisition and analysis--represent a promising new development in science laboratory instruction. Students use MBL probes to gather data on physical phenomena such as motion, sound, temperature, or response time. These measurements are instantly displayed and graphed in real time on the computer screen. Because the tools link a student's concrete data-gathering experience with an instantaneous symbolic representation of that experience, they are a potentially powerful genre of "thought-provoking software". (Dickson, 1985).

The major purpose of our research is to determine the impact of microcomputer-based labs on middle school students' understanding of symbolic representations involving graphs of temperature, sound, position, and velocity. The study reported below is an intensive observational examination of the ways in which students learn graphing skills via MBL.

The study is based on the premise that understanding the use and interpretation of symbol systems such as graphs is a central developmental task for all children. According to Gardner, "mastering of symbolic systems . . . might even be regarded as the principal mission of modern educational systems" (1983, p. 302). Graphing constitutes a key symbol system for science education because it enables us to follow change in physical phenomena across time and as an effect of various interventions. McKenzie and Padilla (1984) state that graphs are an important tool in enabling students to predict relationships between variables and to substantiate the nature of these relationships. They suggest that there is a link between students cognitive skills, particularly their ability to understand relationships, and their graphing skills. It has also been shown that lack of mastery of graphing skills is a major stumbling block in understanding important science concepts (Shaw, Padilla and McKenzie 1983).

Procedure

The study of students' graphing skills employed an MBL unit on "Motion" as the intervention. The goal of the unit is to teach middle school students to measure and plot position and velocity. The unit consisted of five days of activities that challenged students to construct different kinds of graphs via their own movements, along with "prediction" activities (e.g. "What kind of graph will you get if you push the cart up the ramp, then have it come back down to the start?") Using a sonar detector and software, students observed and saw graphed in real time the results of their own bodily motions or the motion of toy carts on a ramp.

Classroom observations were conducted on each of the five days. Observations consisted of narrative records of the behavior of students in lab groups as they proceeded through a given activity. Using an event sampling process, observers recorded students' interactions with each other, their use of the software and hardware tools, and their verbalizations as they completed lab worksheets. Observations were subjected to qualitative analysis (Patton, 1980). In addition to the observations, a quiz assessing mastery of distance and velocity graphs was administered on the final day of class. The quiz required students to match a verbal description of a graph with the appropriate graph (e.g., Which velocity graph shows an object turning around?) Descriptive statistics were computed on the quiz scores.

Results

The observations showed that students consistently devised their own choreography-like process for completing the graph reproduction exercises. Within each lab group of three students, the process often assumed this pattern: A student choreographer explained to the "dancer" what he should do in order to reproduce the graph that appeared on the activity sheet. Being an effective choreographer necessitated the translation of graphs into accurate verbal directions. The dancer then followed the choreographer's instructions by moving in the direction and at the speed that would result in the desired graph. The third student in the group was in charge of the computer, and typically offered advice from the sidelines. When the graph reproduction exercise had been completed, students examined the computer graph and critiqued their performance. (At this point, the dancer often begged for a chance to repeat the graph until he was satisfied with the results!)

The observational record provides many demonstrations of a solid understanding of distance and velocity graphs. The following observation, taken on Day 3, shows the strength of this understanding as evidenced by resistance to (unintentional) countersuggestion from a teacher:

> The girls made a velocity graph of a cart that was speeding up, and correctly demonstrated a positive slope. As they completed their worksheet questions, a teacher told them their graph was wrong. "No, it's not," replied one of the girls, "see how it gets faster, that's why the graph keeps going up." "It should be level," said the teacher. "No, it shouldn't!" insisted the girls. "Level would mean that it's going the same speed." The teacher shrugged and walked off. "We got it right," said one of the girls, and the others nodded knowingly.

Like the observations, the quiz scores indicated that after five days, students had developed solid graph interpretation skills. The quiz, which asked students to match written descriptions with actual graphs, tapped knowledge of graphs of position, positive, and negative velocity. Distractor graphs increased the level of challenge. The mean score on the 9 point quiz was 7.3, with a modal score of 8. Forty-seven percent of the students achieved either a perfect score or missed only one item.

Discussion

This descriptive study indicates that middle school students are quite capable of producing and explaining graphs of position and velocity. Building on this research, we will next undertake a controlled study of the effect of MBL on graphing skills. The second study, to begin in January, 1986, is a quasi-experimental investigation of the development of graphing skills over a three month period in an environment where children receive intensive exposure to microcomputer-based labs.

If our ongoing work substantiates that graphing skills are facilitated through MBL, what are the implications for science instruction? First, it seems that the power of the intervention stems partially from the fact that it reinforced many learning modalities. Students had the kinesthetic experience of using their own physical movements as "data". The physical experience was reinforced with the visual experience of seeing how physical phenomena change, and these experiences immediately were linked with symbolic visual representations on the screen. Perhaps one crucial element of effective science laboratory instruction is this multi-modal involvement.

The study also suggests that by linking the concrete and the abstract, the computer may serve as an important "carrier" of problem solving skills (diSessa, 1984). Viewed within Piagetian theory, the value of MBL may be as a bridge between concrete and formal operations. It is possible that intensive juxtaposition of these concrete and formal operations could facilitate the development of formal operational thinking.

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