

Constructing Graphs with Minority Students:

Computer-Assisted Tool-Based Learning

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In the Edgewood Independent School District, San Antonio, Texas, a revolution is underway. It is a revolution that is changing the way teachers teach, and the way teachers think children learn. Technology has facilitated the changes now underway. All has been in response--at the district level--to the Texas Education Agency's expectations. How teachers teach--from kindergarten to high school--will determine how well students do on the TAAS test. The Texas Education Agency's expectations have been clearly articulated and are outlined below:

The broadened scope of the new assessment program will also allow for a different focus, one which better addresses the academic requirements of the 1990s. Those skill areas which demand little more than rote memorization will be de-emphasized while those areas which improve a student's ability to think independently, read critically, write clearly, and solve problems logically will receive increased emphasis (TAAS Instructional Targets, 1993).

PROBLEM STATEMENT

The question investigated in the research was, "Would students' receptivity be higher if they used computers to make graphs rather than traditional paper and pencil?" The question was investigated using ethnographic techniques, employing both participant and non-participant observation. Data collection was accomplished by note-taking, administering questionnaires (Appendix A), eliciting personal opinions, video-taping teacher and students, students' rating on oral assessment (Ellis, 1990). The natural settings of a kindergarten class in two similar school district (poor socio-economic background), as well as a third and fourth grade class in one district.

Methods included detailed classroom observation, informal interview of students and teachers, and examination of student assignments (oral and written). Selections of participants was based on the teacher-researchers having access to them.

Purpose

The purpose of this study was to investigate what effect the use of computers as tools had on students' understanding of graphs and the relationship between data and graphs. Also important is how well students received instruction pertaining to graphs.

The role and value of graphic representations of knowledge is an important issue in classroom instruction, especially for special populations. Students are exposed to, interact with a variety of graphics in the classroom. However, whether these graphics facilitated learning depended on teacher guidance. Graphics are used to represent knowledge and serve as an alternative way of communicating knowledge (Tang, 1991). The use of technology across subject areas—with its powerful graphics creating capabilities—and how graphics are used was too broad an area to study in the time allotted. Thus, this study limited itself to how graphics are used to represent knowledge in mathematics and issues related to receptivity. In the public school system, much emphasis has recently been placed on teaching higher-order thinking skills (HOTS). Combining technology as a tool for creating graphics and the study of mathematical relationships in lower grades allowed the researchers a specific area to focus on.

Review of the Literature

A search for literature in reference to computer-assisted mathematics instruction in the lower grades (kindergarten through fourth) yielded few results in math journals. Mathematic journals aimed at teachers focused on junior high and secondary math instruction. The closest one mathematics journal came to computer-assisted instruction was a calculator. While a calculator can be invaluable in mathematics, helping students recognize the relationship between quantifiable real life events and graphs requires a computer. According to Art Bardige, cited in Hill (1993), while a calculator can make a first grader as good at computations as anyone in history, since math requires us to think spatially, a computer is necessary.

According to Hamilton and Lathrop (1993), more software is developed for math than for other subject areas. Even English as a Second Language journals--such as TESOL Journal--focus more on language software than math software. Failure to recognize the potential for language development centered around mathematics instruction is a serious concern. Most journals are focusing on other concerns and express opinions such as:

Most...software focused on typical vocabulary or grammar

drill and practice. Many titles were designed as instructional

management systems with a predetermined set of skills for

students to master in sequence...the very nature of drill and

practice software runs counter to the natural acquisition

approach for L2 instruction because it tends to present

isolated, noncontextualized exercises that focus on accuracy

rather than fluency (Hunt, 1993).

These drill-and-practice have little value except to make "good" students better. Well-designed software offers children a context in which to solve problems, while teachers provide the information and support that ultimately allow children to work with minimal teacher involvement (Burns, Goin, Donlon, 1990).

This scaffolded instructional allows teachers to teach higher level thinking strategies using well-designed software. The use of scaffolds are useful only within the student's zone of proximal development (Vygotsky, 1978). That is, the area where the students cannot proceed alone, but can proceed when guided by a teacher using scaffolds. Since scaffolds can be applied to the teaching of well-structured skills, as well as higher-order thinking strategies, some suggest that instead of a dichotomy, there is a continuum from well-structured explicit skills to cognitive strategies (Rosenshine, Meister, 1992). Thus, there must be a change in focus from developing software that is drill and practice to that which is tools-based. Some believe that tool-based software will play an important role in the "next stage in the evolution of math software" (Hill, 1993).

The National Council of Mathematics advocates a "shift toward mathematical reasoning

and away from memorization of procedures; a shift toward conjecturing, inventing, and problem solving and away from merely emphasizing finding the correct answer." Years of cognitive science research at Vanderbilt University's Learning Technology Center headed by Dean James Pellegrino provided insights into how children can learn to solve complex math problems. Cited in McCarthy (1992), Pellegrino says the following:

One thing we learned is that children relate well to inviting

video images. We also learned that relating math problems

to real world situations greatly increased student interest in

math.

This information has resulted in a variety of software and video that takes advantage of these insights. Computers allow students to experiment with concepts and ideas and the process of problem-solving--rather than with simple calculations (McCarthy, 1992).

What it all boils down to is this: Math is coming to be seen as a science where students use tools--technology--to investigate and explore the mathematical components and their relationship to the real world. In developing curriculum--which addresses the questions of what and how to teach--educators are turning away from the past, the behavioristic paradigms, to cognitive theories of learning. The Constructivist Learning Model is such a theory.

The Constructivist Learning Model (CLM) focuses more on students than teachers. Thus, learning outcomes do not depend on what the teacher presents so much as how students interact with and process information. CLM is based on the ideas that date back to 1710, to the work of Giambattista Vico. "To know" means "to know how to make." Cited in Yaeger (1991), Vico substantiates this notion by arguing that one knows a thing only when one can explain it. This means that we can only know what we have constructed ourselves, and such learning invariably takes place in a social context.

Teaching math using a constructivist model involves making the shift from simple computation to higher-order thinking skills. Technology-based scaffolds, encouraging students to construct their own understanding of the mathematical relationships in the real world, will have, according to research, a more positive impact than continuing to focus on lower-order thinking skills (LOTS).

Selecting and Evaluating Math Software

Evaluating math software is important. In the past, much of the math software available has focused on drill and practice. Recently, new mathematics programs are being

evaluated according to a strict criteria, as expressed in the California Math Framework cited in Hamilton and Lathrop (1993) (refer to Appendix B). The Texas Education Agency (1993) has outlined computer-based technology assessment draft objectives. One of these objectives is that students will demonstrate an understanding and use of electronic spreadsheet software. Students will be expected to save and retrieve a spreadsheet file, operate a spreadsheet program, and use basic features to enter and organize data, forecast through spreadsheet data manipulation, and produce printed output from a spreadsheet program. In the TAAS math instructional targets published by the Texas Education Agency, under objective five--The student will demonstrate an understanding of probability and statistics--students are expected to analyze data and interpret graphs (including line graphs).

Under the problem solving domain, objective 12--The student will express or solve problems using mathematical representation--students will need to be able to interpret charts, pictures and bar graphs and use the information derived to solve problems.

In the Spring of 1994, computer-based technology assessment will be given at the middle-school level (Computer Based Technology Assessment Objectives, 1993). Districts are now focusing on preparing their teachers and students to pass technology assessments. However, most of the attention has focused on grades three through six, leaving the lower grades unprepared. In one district surveyed (District B), teachers are scrambling to learn and use spreadsheet programs with their children. However, the neat rows and columns of a spreadsheet on a computer screen are daunting to many students, regardless of age.

To eradicate this fear of using the computer as a tool, of what spreadsheets can do, teachers must start working with students in the lower grades (kinder through second grade). A computer software program developed specifically for grades K-4 allows students to develop the ability to read and interpret graphs, use graphs to communicate information, answer questions, and solve problems. The Graph Club with Fizz and Martina assists children in making the transition from graphing with manipulatives to graphing in the abstract and help them understand the relationship between different representations of the same data (for example, picture graphs, bar graphs, line graphs, circle graphs, and table graphs). It has been designed to support NCTM standards and encourage cooperative learning, problem solving, and cross-curricular integration (Stearns, 1993). The Graph Club is the software employed in this study and it was evaluated using California Department of Education Standards (Appendix C).

Data Analysis

Two classrooms were observed, both kindergarten classes. While the classes were considered monolingual by the Districts involved, according to students' Home Language survey, informal questioning revealed that almost one-hundred percent of the student populations were bilingual. While this raises another issue for research, one must question the validity of the current tracking of bilingual students. The traditional class was taught by Monica Guhlin, and the computer assisted by Miguel Guhlin, in districts A and B, respectively.

Traditional

One kindergarten class was taught graphs using traditional methods, that is, crayons and paper. The teacher used the chalkboard, different colored blocks. The teacher discussed bar graphs, circle graphs, and picture graphs. The first lesson focused on bar graphs where the students chose their favorite drink for lunch. The students and the teacher then drew and colored the bar graph on chart paper and used different color for each bar graph. The students then used colored blocks to show the bar graphs that the class had made. The teacher had a handful of students who were able to understand how to make the bar graphs with the blocks but the rest of the students needed the lesson retaught. These students could not understand the representation of the bar graphs. The students also seemed to be less attentive and were impatient during the lessons, as evidenced by misbehavior (talking during direct teach, playing with other students).

The second lesson focused on circle graphs. The materials used were chalkboard, colored chalk, and chart paper. The students listened and were attentive in the beginning of the lesson but towards the end of the lesson, their minds wandered off and the teacher had to keep reinforcing the lesson. The teacher first wrote how many students enjoyed the housekeeping center the building center and the art center. Then, the teacher made a circle and colored in the distribution for each area. Most of the students enjoyed the art center, then came the building center, and lastly, the house-keeping center. By this time, the teacher explained to the students that they were going to make their own circle graph based on a vote of their favorite food to eat (i.e. pizza, hamburgers, and tacos). Again, a handful of students were able to make a circle graph and shade in the color representations where the rest had difficulty with the entire process so the teacher had to reteach that group who had difficulty.

The last lesson was a lesson on picture graphs. The students were a bit more attentive to this lesson because the students were able to draw stick figures for representing the amount of people who had black hair, blonde hair, and brown hair. The students seemed to grasp the lesson far better than previous lessons

