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ABSTRACT

This pilot study tested the hypothesis that the logical thinking skills of middle-grades students are enhanced by teaching them computer programming using the BASIC programming language. A quasi-experimental design was used with 36 students randomly selected and assigned to one of two treatment groups: 18 students received no instruction in programming (the comparison group) and 18 students received programming instruction for 10 weeks (the experimental group). The Test of Logical Thinking (TOLT) was used as a pretest and posttest measure of logical thinking skills. The posttest scores were analyzed using analysis of covariance procedures with the pretest TOLT scores as the covariate. The results indicate no significant differences in level of logical thought at the .10 level of significance ($F=2.52$; $p=.12$), suggesting that instruction in computer programming does not significantly enhance growth in logical thinking skills. However, this conclusion must be considered as tentative due to the small sample size and limited scope of the study. In addition, 10 weeks may be too short a time period to expect much growth in logical thinking skills. (Author/JN)

Learning Outcomes of Computer Programming Instruction for Middle-Grades Students: A Pilot Study

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Learning Outcomes of Computer Programming Instruction

for Middle-Grades Students: A Pilot Study

<u>Purpose of the Study</u>

Educators and computer specialists are trumpeting the microcomputer as the most significant educational resource yet developed. The educational and popular literature is swamped with cla[illegible]es of the introduction of the small computer into the educational setting. The early 1980's saw an immense literature develop which touted the microcomputer panacea. Some even saw schools facing an "Apple-gap" (Goens, 1983). More recently, the issues of cost and quality of educational software have led to more cautionary statements (Bork, 1984).

Yet, some authors see the potential as so great that they fear that schools will fall out-of-step with our technological society if they do not effectively incorporate microcomputers.

> And the schools, still relying primarily paper-and-pencil exercises, will have little choice but to serve as holding tanks for youngsters who are receiving the profoundest aspect of their education in other quarters (Wagschal, 1984, p.254).

However, careful analysis of these claims reveals that there is not a well-developed empirical base for most of these statements.

Though the microcomputer has many applications in the school setting, the major ones involve computer assisted instruction (CAI), word processing, and the teaching of students to program the machines. This pilot project examined one of these applications of microcomputers in the elementary and secondary classroom -- instruction in computer programming. In our region, programming instruction, while being introduced at a variety of grade levels including the middle grades (4-6), is generally done via the language of BASIC. Our interest was not whether this age child can master the programming of a microcomputer in BASIC, but rather whether there are any corollary benefits such as improvement of the child's skills in problem solving and logical thinking.

Rationale

To write a computer program that solves a problem requires the programmer to be able to formulate a tentative solution to the problem, identify variables, construct logical relationships between the procedural steps in the program, test the possible solution (the program), and make modifications in the program as necessary. Learning to program computers appears to demand much use of the logical thinking skills described by Inhelder and Piaget (1958) as being characteristic of formal operational thought. The middle-grade student age coincides with the early transition between the Piagetian stages of concrete and formal operations. Other research (Padilla et al., 1983) has shown a significant relationship between level of formal thinking ability and science process skill ability. The thought processes required in programming are similar to the thought processes inherent in the integrated science process skills. Thus, there seems to be a logical relationship between learning to program and logical thinking skills.

Our experience with the literature on microcomputers in education has revealed numerous articles that looked at various methods of teaching programming to students, that assessed attitudes of students toward the learning of programming, or stated opinions which advocated that schools either should or should not provide instruction in programming. However, no studies were found that attempted to address the particular question in this study - does instruction in computer programming enhance the development of logical thinking skills?

Procedure

This pilot study used a quasi-experimental design to test the hypothesis that the logical thinking skills of middle grades students are enhanced by teaching them computer programming. The student population of grades 4-6 of a local elementary school which serves the University neighborhood was used in this study. This target population was selected because the study was to be conducted outside the school day (8:00 - 8:50 a.m.). Geographic proximity to the microcomputer laboratory at the University was important because students would have to walk to school at the conclusion of the programming lessons. Additionally, the student population of this particular school is quite representative of the midwestern, industrial city in which the university is located.

A letter which explained the study and invited the children to apply for participation in the project was sent to parents of all 108 fourth, fifth, and sixth grade students at the school. Seventy-two students applied for inclusion in the project.

Though the researchers were not able to ascertain why the remainder did not apply, they did not appear to differ from the total group on any demographic variable such as grade level, race, gender, or socioeconomic status. The pool of 72 students applying represented the full range of academic ability.

From the pool of applicants, two stratified random sample of 18 students each were selected to serve as the experimental and comparison groups. The samples were stratified according to grade level (six students per grade level). The subjects were randomly assigned to either the experimental or comparison group.

Prior to beginning the programming instruction, both groups were pretested on logical thinking ability using the Test of Logical Thinking (Tobin & Capie, 1981). This test is a 10-item test scored on a scale of 0 to 10. Reliability of the Test of Logical Thinking is .85 (coefficient α).

The experimental group received ten weeks of instruction in BASIC programming on Apple microcomputers. The group meet four days per week (Monday - Thursday) for fifty minutes each morning before school. The Creative Programming (1983) materials were used as the basis of the instruction. At the conclusion of the instruction phase of the study, both groups were again tested with the Test of Logical Thinking (TOLT).

The study experienced some experimental mortality. One student from the experimental group moved out of the district and another student quit attending the programming classes and did not take the posttest. Three students from the comparison group were not available for the posttest at the conclusion of the study. There did not appear to be any systematic bias on any variable that would influence the results among these students.

Results

Since this project was an exploratory pilot study, the level of significance was established at $p = .10$ for all analyses. The pretest TOLT scores were analyzed using a *t*-test to determine if there were any differences in logical thinking skills between the two groups at the outset of the study. No significant differences were found on the pretest TOLT results, $t = .72$ ($p = .48$).

Analysis of covariance (ANCOVA) procedures on the TOLT posttest scores with the TOLT pretest scores as a covariate were used to test the hypothesis that programming instruction would result in enhancement of logical thinking skills of middle grades students. These procedures indicated that no significant difference existed between the two groups on the TOLT posttest, $F = 2.52$ ($p = .12$). Table 1 gives the results of the ANCOVA.

Insert Table 1 about here

Table 2 gives the posttest adjusted mean scores of the experimental and comparison groups.

Conclusions and Implications

The results of this study would seem to suggest that instruction in computer programming does not significantly enhance growth in logical thinking skills. However, this conclusion must be considered as tentative due to the sample size and limited scope of this study. Additionally, ten weeks may be too short a time period to expect much growth in logical thinking skills.

Claims that the microcomputer is one of the most significant educational resources to be developed may be exaggerated. Educators have not developed a strong empirical base for any particular use (computer assisted instruction, programming, etc.) of the microcomputer. Yet, schools are rapidly purchasing computers in increasing numbers without much thought given to how this technology is to be used. There may be sound, compelling reasons for teaching programming to students, but this study suggests that enhancement of logical thinking skills is not one of these reasons. Perhaps BASIC is not the appropriate language to use with middle grades students. LOGO may be a more appropriate language. Continued cooperative efforts between researchers and schools are needed to explore the potential outcomes of use of computers and to develop the needed empirical base for use of computers in schools.

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Table 1

ANCOVA of TOLT Posttest Scores with TOLT Pretest Scores

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F	Probability of F
Main Effects	1	4.92	4.92	2.52	0.12
Residual	30	58.67	5.70		

Table 2

Group Size and Adjusted Mean Scores on TOLT Posttest

Group	n	$\bar{x}$
Experimental	16	0.94
Comparison	15	1.70