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Microcomputer-Based Math Instruction with First-Grade Students

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Abstract — *Computer-assisted instruction (CAI) delivered by large computers has generally been found to be effective in improving academic skills, particularly in elementary schools. However, the effectiveness of microcomputer-assisted instruction (MCAI) has been relatively unexplored, even while the use of educational microcomputers expands at an accelerating rate. To assess the educational effectiveness of MCAI, 82 first-grade students were assigned to either a mathematics MCAI or placebo control reading MCAI group. After 6 months, posttest mathematics scores were gathered and covaried for initial group differences in mathematics and cognitive ability. Analysis revealed a significant difference in favor of the MCAI mathematics group. It was concluded that MCAI results were consistent with the existing literature on CAI, but that much remains to be explored in the educational application of microcomputers.*

Microcomputers have become ubiquitous in American schools. The installed base of microcomputers has more than doubled each year for the past three years, with the fastest growth occurring in elementary schools (TALMIS, 1984). This growth in microcomputer ownership has been paralleled by positive teacher attitudes toward educational computing (Ingersoll, Smith & Elliot, 1983).

Unfortunately, the phenomenal rise in microcomputer usage has not been accompanied by a great deal of evidence attesting to the pedagogical effectiveness of microcomputer-assisted instruction (MCAI) (Melmed, 1984). Kulik, Kulik and Bangert-Drowns (1985) reviewed 32 comparative studies on the effects of computer-based education in elementary schools and found that computer-assisted instruction (CAI) improved pupil achievement by .47 standard deviations, but they included only one microcomputer-assisted instruction (MCAI) study in their meta-analysis. Other comprehensive reviews of the computer-based instruction literature also have revealed robust effects for instruction delivered via mainframe or minicomputer (Burns & Bozeman, 1981; Jamison, Suppes & Wells, 1974), but few experimenters have assessed the effectiveness of microcomputer-based instruction (Spencer & Baskin, 1981). Although alike in many ways, CAI and MCAI typically are dissimilar along several dimensions, including type of display, interactive capability, response

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The microcomputer software used in the present research was written, copyrighted and published by the author. To facilitate research in this field, the author will accept research proposals involving free use of this software. Research proposals and requests for reprints should be addressed to Marley W. Watkins at PO Box 1870, Phoenix, AZ 85001.

speed, color, graphics, sound and music, etc. These differences suggest that the literature on CAI cannot be uncritically generalized to MCAI. Published MCAI studies have either been encouraging but with non-significant results (McDermott & Watkins, 1983; Taylor, Smith & Riley, 1984; Watkins & Abram, 1985), or lacking in experimental rigor (Jacobi, 1985; "Preschoolers," 1982).

The current situation is decidedly in need of research clarification. Schools will spend an estimated $1 billion on educational microcomputers and software by 1987 (Electronic Education, 1984). Given these massive expenditures, it is imperative that the educational effects of MCAI be determined more adequately. The present study was conducted to begin that clarification process by testing the effectiveness of MCAI drill and practice in math with first-grade students.

METHOD

Subjects

The complete first-grade class of a suburban southwestern elementary school (47 females and 56 males) served as subjects for this investigation. A "transition" class of 21 students was excluded from the study due to non-standard curriculum, history of academic difficulty, and age. This class received MCAI so as not to deprive them of a potentially beneficial treatment, but they were not subjected to standardized academic posttesting. The final experimental population was therefore composed of 82 students (40 females and 42 males). Average student age was 6.58 years, with a standard deviation of .42 years.

Materials

The educational software used to deliver MCAI drill and practice was *The Math Machine* (Watkins, 1981). This software contained a positive reinforcement system to enhance student motivation. Reinforcement was delivered by the software on a variable ratio schedule, individualized for each student, and consisted of approximately one minute's play of an arcade game of the student's choice (selected from a menu of six games). *The Math Machine* also included multiple skill levels that closely fit the school curriculum, and record keeping and management so teachers could monitor and direct student progress. Math problems were composed of large, colored graphics, numerals and figures. Students responded to problems by pressing numeric keys. The software provided students with personalized informational feedback to both correct and incorrect responses. Students were allowed as much time as they wanted to solve each problem and therefore they controlled the rate of presentation. Content was not under student control. Rather, instructional drill objectives were assigned to students by their teachers based upon individual performances.

Regular classroom instruction was conducted from the Holt mathematics series (Nichols, et al., 1981). Students were pretested with the Iowa Test of Basic Skills (Hieronymus, Lindquist & Hoover, 1982) mathematics subtest and the Cognitive Abilities Test (1982). Both tests served as covariates. Students were posttested with the California Achievement Test (1977) mathematics computation subtest, which served as the dependent variable. Iowa Test of Basic Skills and California Achievement Test raw scores were converted to normal curve equivalent scores ($M = 50$, $sd = 21$) prior to data analysis.

Procedure

Provision of MCAI began in October and continued for the remainder of the school year. Pretests were administered in September and posttesting was conducted in March and April of the same school year.

A computer laboratory was established at the target school. This lab contained 10 Apple II+ microcomputers, each with a color television monitor and a disk drive. While in the lab, students were supervised by a trained paraprofessional who entered teacher-assigned objectives onto software disks, maintained records, and ensured that all students were engaged in appropriate activities.

Children were assigned to the MCAI math treatment group and placebo control group via stratified random sampling where ability level (as measured by the Cognitive Abilities Test) and sex served as stratification variables. The MCAI math group received math computation drill and practice on microcomputers, while the placebo control group received reading drill and practice on microcomputers. Each child spent 45 minutes per week participating in MCAI (broken into three 15 minute sessions). MCAI was used to replace an equivalent amount of regular classroom instruction without a corresponding increase in total instructional time. That is, students received similar amounts of instruction in reading and math, with the placebo control group receiving a portion of their reading instruction via MCAI and the treatment group receiving a portion of their math instruction via MCAI. Thus, both groups were exposed to MCAI so as to remove any potential biasing effects and both groups received the same total quantity of math instruction.

Math instruction for all subjects followed district curriculum guidelines and occurred in classroom groups on a daily basis. Classroom teachers reviewed each student's progress once per week and assigned instructional drill objectives for the coming week. Pupils in the treatment group were drilled on assigned objectives in the computer laboratory via MCAI. Placebo control students received drill on assigned math objectives in their regular classrooms via teacher selected traditional methods (i.e., flash cards, drill sheets, work books, oral recitation, etc.). Thus, both groups were exposed to the same math curriculum for similar amounts of time with only the method of skill acquisition and consolidation varying between groups.

RESULTS

Data analysis was accomplished via analysis of covariance with treatment group (MCAI versus placebo control) serving as the independent variable, scores on the mathematics subtest of the Iowa Test of Basic Skills and the Cognitive Ability Test serving as covariates, and scores on the math computation subtest of the California Achievement Test serving as the dependent variable. A significant main effect for treatment group was obtained, $F(1, 78) = 6.91$, $p < .01$, in favor of the MCAI group (adjusted $M = 63.5$) over the placebo control group (adjusted $M = 54.9$). By subtracting the unadjusted mean of the placebo control group ($M = 53.0$) from the unadjusted mean of the MCAI group ($M = 65.5$)[1] and dividing by the standard deviation of the placebo control group (19.7), it was determined that the MCAI group achieved .63 standard deviations higher than the placebo control group.

DISCUSSION

In their meta-analysis of the computer-based education literature, Kulik, Kulik and Bangert-Drowns (1985) found an average effect size of .47, indicating that CAI has been found to raise student achievement scores from the 50th to the 68th percentile. The present study demonstrated that MCAI in math can raise student mathematics computation scores to a similar degree (effect size = .63). Thus, the present results are consonant with the existing literature on CAI.

Such results are encouraging, but much remains to be done in the investigation of MCAI effectiveness. As noted by Kulik, Kulik and Bangert-Drowns (1985), there are many ways to use microcomputers in education: drill and practice, tutorial, simulations, games, etc. The present positive results were obtained through drill and practice software. The educational effectiveness of other applications of microcomputers remains unexplored. Even within the drill and practice domain, the relative effectiveness of discrete components (i.e., feedback, reinforcement, pace, student control) is unclear, although the use of instructional design guidelines can provide a starting point (Alessi & Trollip, 1985).

Given the massive educational investment in microcomputers, it is apparent that they will be used by teachers. What is not apparent is that microcomputers will be used to improve student learning. Although teachers assert that pedagogical soundness is the major factor in their software selection (Ingersoll, Smith & Elliot, 1983), pragmatic analysis suggests that teachers are strongly influenced by graphics and less likely to consider underlying educational structure or objectives (Preece & Jones, 1985). This phenomenon is also manifested in the marketplace. A national survey of educational software usage in schools (TALMIS, 1984) revealed that word processing, problem solving, Logo, and simulation gaming programs have achieved overwhelming market penetration at the elementary school level, despite the lack of evidence regarding the educational effectiveness of such applications (Baker, Herman & Yeh, 1981; Cron, 1983; Dekkers & Donatti, 1981; Shaw & Okey, 1985).

As suggested by Kulik, Kulik and Bangert-Drowns (1985), it is imperative that researchers delve into the relative efficacy of a variety of educational applications of microcomputers and identify the educationally salient components of effective applications. Lack of such evidence will allow a squandering of precious educational resources and permit the development of a situation described by Ohles (1985), whereby "another highly useful (even if not miraculous) educational tool is misunderstood, over-bought, under-used, and eventually largely discarded" (p. 53).

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[1]Since the pretreatment group differences were not statistically significant ($t > .05$), the unadjusted posttreatment means and standard deviations were used to assess the relative gain of the MCAI versus the placebo control group.

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