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ABSTRACT

Sixth-grade middle school students (N=91) in four mathematics classes served as subjects in a study designed to: (1) determine if the use of computers as an integral part of instruction would increase mathematics achievement; and (2) explore the impact of computers as an integral part of instruction on other factors (such as student attitudes, attendance, and discipline). Students in experimental classes (computer immersion project) spent approximately 40 minutes of each class period engaged in computer assisted instruction while a teacher directed, group centered instructional mode was used in control classes. When decisions regarding implementation of a new program which is as expensive to replicate as the computer immersion project must be made, both statistical and practical significance must be weighed. Although statistically significant differences were found, the practical magnitude of these differences was small, and this, coupled with other methodological problems, resulted in the conclusion that the computer immersion project did not demonstrate an impact of computers, even when time is maximized, on any of the variables studied. School district officials concurred with this conclusion and the computer immersion model was dropped and the computers put to other uses. (JN)

Computer Immersion Project: Evaluating the Impact of Computers on Learning

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Running head: Computer Immersion

In examining the impact of computers in the classroom, much of the enthusiasm for using this tool as a learning aide is based on reports by principals and teachers that computers produce achievement gains and that a child's enthusiasm for learning is increased when computers are used. There have been a large number of studies which have empirically investigated these claims. Dating back to the early 1970's, researchers have provided reviews of the effectiveness of Computer Aided Instruction (CAI) on achievement as well as other factors (Vinsonhaler & Bass, 1974; Jamison, Suppes & Wells, 1974; Edwards et al., 1975).

Kulik, Bangert and Williams (1983) applied meta-analysis to study the effects of CAI on students in grades 6 - 12. Unlike some of the previous reviews, their analysis included only studies in which both a CAI and a control class were used. The 51 studies included looked at effects in final examination performance, attitude toward subject matter, and attitude toward instruction. Results showed increased achievement for CAI in 39 of 48 studies, particularly for studies of short duration, more positive attitudes toward the subject in 8 out of 10 studies, and 4 studies which reported more favorable attitudes toward instruction. While effect on final exam performance seemed to be substantial, effect on attitudes was somewhat weaker; only 3 of the 10 studies relating to attitude toward the subject reported statistically significant findings, and none of the attitude toward instruction studies reported significant differences.

In a meta-analysis of the relationship between CAI and mathematics achievement, Burns and Bozeman (1981) looked at studies in which CAI was used as drill/practice or tutorial as a supplement and its effect on student achievement. Results indicated that CAI was "significantly more effective in fostering student achievement than a program utilizing only traditional instructional methods (p. 37)."

Other attempts to summarize the effectiveness of CAI have come up with general "rules-of-thumb." Fisher (1983) reviewed articles with relation to three factors, subject area, achievement range and use in the curriculum. He concluded that in terms of impact on achievement, CAI is most effective for science and foreign language when used with either high or low achievers as a supplement to the regular curriculum. It was found to be only moderately effective when used for mathematics and middle achievers. Fisher also reported positive changes in student attitude, improved attendance, increased motivation, and lengthened attention span.

For the most part, computers have been used in schools in a supplementary capacity, with the number of computers in a school limited and the time-per-pupil on computer as little as seven to ten minutes per day. Additionally, most of the studies which have been done to document the effectiveness of CAI have been of short duration. Kulik (1983) reported that only 18 of 32 studies in which the length of the study was given were longer than 8 weeks and the Effect Size, the difference between the means of the experimental and control group divided by the standard deviation of the control group, dropped with duration of the study.

It is difficult, therefore, to determine the impact of CAI on learning and related variables when time on computer is so small and duration of the studies so short. As early as 1970, Grayson summed up this methodological problem: "While many studies have been conducted, very few have dealt with large numbers of students over a long period of time, even in a loosely controlled situation. In many of them, the Hawthorne effect of novelty may be the overwhelming factor. (p. 3)"

The cost of computers is, of course, the reason for this. A large urban school district in the southwest reported that its computer-to-pupil ratio was 1:235 at the end of the 1982-83 school year, in spite of an expenditure of $2.5 million for computers that same year (HISD, 1983). In 1983-84, this district piloted a program designed to study the impact of computers on learning and the school environment if provided in quantity, and if the time on computer were maximized.

A middle school mathematics class was equipped with enough microcomputers for a 1:1 computer-to-pupil ratio. Two of a sixth grade mathematics teacher's classes were designated at random as "immersion" classes and two were used as controls. Students were "immersed" in an environment that would allow each to have access to a computer. The computer was then available as a major support system for the teacher, rather than a supplementary device.

Instruction in the experimental classes was comprised almost entirely of time spent on computers. Each student spent approximately forty minutes of each class period in CAI. SRA software, CDI Mathematics, levels B, C and D were used as core material during the pilot time period. The teacher worked with individual students or small groups of students when a common problem was identified. She only worked with the whole class when a new concept was introduced or when a problem affected a large number of students.

In the control classes, a teacher-directed, group-centered instructional mode was used. The model was tested at the end of the 1982-83 school year, and fully implemented during the entire 1983-84 school year.

Evaluation for this study was designed to:

1. determine if the use of computers as an integral part of instruction would increase mathematics achievement.

2. explore the impact of computers as an integral part of instruction on other factors, such as student attitude, attendance, discipline, etc.

Method

Subjects

The subjects for this study consisted of 91 sixth grade students in four mathematics classes at a middle school (grades 6 - 8) in a large urban school district in the southwest. The classes were regular classes, and students were, for the most part, scoring at or just below grade level in mathematics achievement as measured by the Iowa Tests of Basic Skills. The sample consisted of 46 girls and 45 boys, with an equal representation of boys and girls in both the experimental and control groups. The school was ethnically mixed, with a predominantly Hispanic population.

Procedure

The mathematics classroom was equipped with 26 Apple II computers, enough to provide a 1:1 computer-to-pupil ratio. From the beginning of the school year until the administration of the Iowa Tests of Basic Skills in early March, two classes used the computers as the primary means of instruction. These classes were selected at random from six classes being taught by the mathematics teacher who participated in the study. Two of her other classes were designated as control classes. There were 50 students in the two experimental classes and 41 students comprised the two control groups.

Instruction in the experimental classes consisted almost entirely of time spent on computers. Each student spent approximately forty minutes of each class period at a computer. The SRA software, CDI Math, Levels B, C and D, were used as core material. This material provided drill and practice as well as tutorial for the students.

Additional mathematics software was also utilized as supplementary material. SRA core materials were used 30-35 minutes each class period. Other materials, such as the DLM software were generally used for 5 to 10 minutes at the end of each class period for skill building and as a motivator.

Insert Table 1 about here.

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The only computer literacy provided to the student was that which was necessary to operate the software. Two days were spent on terminology and explaining how to use the diskettes.

During the time period in which the study took place a series of observational visits to the campus took place. Both experimental and control classes were visited. Classroom patterns were noted as was student time-on-task. The teacher was interview at the end of the school year. Data relating to the implementation of the program, problems encountered and general impressions of the experience were gathered.

Student data collected at the end of the school year included: 1984 raw scores for the Mathematics Skills subtest of the Iowa Tests of Basic Skills, Concepts, Computation and Problem Solving, number of days absent from school, number of times tardy to math class, number of discipline cards filed on each student, and scores on two measures of attitudes toward mathematics, Attitudes Toward Arithmetic (Dutton & Blum, 1986) and the Fennema-Sherman Mathematics Attitudes Teacher Scale (Fennema & Sherman, 1976).

Instrumentation

A measurement of achievement already in use by the district during 1983-84 was used. The Iowa Tests of Basic Skills, Level 12, Test M (Mathematics Skills) which comprised the regular testing program was utilized. This test yields scores for mathematics computation, concepts and problem solving. Raw score data were obtained.

Attitudes Toward Arithmetic

The Attitudes Toward Arithmetic scale (ATA) was developed in 1968 by Dutton and Blum (1968). It is a 25 item Likert-type scale designed to assess student's attitudes toward arithmetic. This scale was constructed by putting the strongest items from a previously constructed Thurstone-type scale into a Likert format. Half of the items were positive and half negative in connotation. Calculated Spearman-Brown test-retest reliability was 0.84.

Fennema-Sherman Mathematics Attitudes Teacher Scale

The Mathematics Attitudes Teacher Scale (MATS) was "designed to measure students' perceptions of their teacher's attitudes toward them as learners of mathematics. It includes the teacher's interest, encouragement and confidence in the student's ability (Fennema & Sherman, 1976, p. 4)."

The scale consists of six positively stated and six negatively stated Likert-type items with five response alternatives: strongly agree, agree, undecided, disagree, strongly disagree. The person's score on the scale is the cumulative total; the higher the score, the more positive the attitude. Split-half reliabilities were reported to be 0.88. A factor analytic technique was utilized to provide evidence of construct validity.

Data Analysis

Because the major focus of the evaluation was to document increased levels of achievement in the computer immersion classes, an analysis of covariance was done, using the 1983 mathematics raw score total from the ITBS as a covariate and the 1984 mathematics raw score total as a dependent variable. To explore the relationship of CAI to other factors, a two-group stepwise discriminant analysis was also conducted, using Wilks lambda as a selection criteria (Hair et al., 1979). Scores on both math attitude scales, the ATA and the MATS, number of times tardy to math class, number of days absent, number of discipline cards on file, and scores on each of the three mathematics subtests, computation, concepts and problem solving for each student were used as predictor variables. Because the sample size was not large enough to exclude some cases from the analysis, the discriminant function was calculated using all cases. The Statistical Package for the Social Sciences was used for all data analysis.

Results

The analysis of covariance yielded a significant main effect for group between the computer immersion students and the control group.

Insert Table 2 about here.

A significant discriminant function was found consisting of a reduced set of three variables, number of times tardy to math class, number of discipline cards filed and mathematics computation raw score. The canonical correlation squared, a measure of the proportion of variation in the discriminant function explained by the groups (Klecka, 1980) was .148. Box's M was significant.

Insert Tables 3 & 4 about here.

Classification of cases resulted in 68.13% of the cases correctly classified. A higher proportion of the computer group was correctly classified.

Insert Table 5 about here.

Discussion

The evaluation design employed in the computer immersion project had two foci: to determine if the project had an impact on students' mathematics achievement and to explore the project's effect on other variables. The raw score mathematics totals for the computer group and the control group yielded statistically significant differences. The discriminant analysis indentified the part of that overall score which was contributing to group differences to be computation scores. When the magnitude of these differences was examined, however, it was found that the mean raw score total for the computer immersion group differed from the control group by just over one item.

Insert Table 6 about here.

The discriminant analysis resulted in a reduced set of variables which comprised the function. The number of times tardy to mathematics class, number of discipline cards filed and the mathematics computation raw score significantly differentiated between the groups. Wilks lambda values for the three variables were high, however (Table 4). Wilks lambda is an inverse measure (Klecka, 1980). As lambda increases, there is less discrimination between the groups. Lambda values such as those obtained indicate low discrimination in spite of statistical significance. The canonical correlation squared indicated that less than 15% (14.8%) of the variance was accounted for by the groups.

An additional problem with the discriminant analysis was a significant Box's M. One of the assumptions of discriminant analysis is equality of the group covariance matrices, and this data violates that assumption. While some authors consider discriminant analysis to be a robust technique with respect to these violations (Lachenbruch, 1975), the amount of error this has introduced is unknown.

Interpretation of the data from this study, then, becomes very much a question of practical significance rather than statistical significance. The mean difference between the math computation raw scores for the two groups was less than two items (1.9). Similarly, a difference of only one time tardy to math class was found between the two groups and no difference was found in the avereage number of discipline cards filed. The fact that this variable was included in the discriminant function was accounted for by the fact that one student in the control group was responsible for 16 discipline cards.

When decisions regarding the implementation of a new program which is as expensive to replicate as the computer immersion project must be made, both statistical and practical significance must be weighed. The evaluation of the computer immersion project did yield statistically significant differences. The practical magnitude of these differences was small, however, and this, coupled with other methodological problems, resulted in the conclusion that the computer immersion project did not demonstrate an impact of computers even when time is maximized on any of the variables studied. School district officials concurred with this conclusion. The computer immersion model was dropped and the computers were put to other uses.

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Table 1

Supplementary Software

Publisher	Title
MECC	Volumes 8, 9, 10 (Geometry)
	Lemonade
DLM	Dragon Mix
	Demolition Division
	Meteor Multiplication
SRA	Estimation Tennis
	Beano
White	Time Multiplication Test
TABS Test	Fifth Grade Level
	Addition, Subtraction,
	Multiplication, Division,
	Linear & Solid Geometry,
	Identification of Polygons,
	Place Value
Teacher	"Pink Panther" (Linear
Developed	Geometry Terms)
	Review Program

Table 2

Analysis of Covariance: 1984 ITBS Math Skills Total Raw Score

Source	Adjusted df	Adjusted MS	F
Between Groups	1	43.184	5.357*
Within	83	8.061	
Total	84		

*$p < .05$

Table 3

Canonical Discriminant Function

Eigenvalue	Canonical Correlation	Wilks' Lambda	df	X^2
0.1743	0.3852	.8516	3	13.735*

*p >.01

Table 4

Standardized Discriminant Function Coefficients and Wilks' Lambda for Reduced Set of Variables

Variable	Standardized Coefficients	Wilks' Lambda
Tardies	-1.1371	0.9523
Discipline Cards	0.9707	0.8687
Computation Raw Score	0.3659	0.8516

Table 5

Classification Results

	N	Predicted Group Membership	
Actual Group		Computer	Control
Computer	50	42	8
		84.0%	16.0%
Control	41	21	20
		51.2%	48.8%

Percent of Cases Correctly Classified: 68.13%

Table 6

Group Means and Mean Differences, All Variables

	Computer N=48	Control N=40	Difference	Overall N=88
ATA	88.3	86.8	1.5	87.6
MATS	43.9	43.9	0.0	43.9
Days Absent	5.7	6.8	1.1	6.2
Tardies	.6	1.6	1.0	1.0
Disc. Cards	.6	.6	0.0	.6
Math Total	67.9	66.6	1.3	67.4
Computation	30.9	29.0	1.9	30.0
Concepts	22.9	21.6	1.3	22.3
Prob. Solving	16.1	15.8	0.3	16.0