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ABSTRACT

This study investigated the effect of teacher involvement in the development of calculator mathematics curriculum on the implementation of calculators in the classroom. Forty-five middle school mathematics teachers served as subjects. Findings revealed that teachers involved in curriculum development were observed significantly more often than those not involved in curriculum development to: explain the relationship between calculator and paper-and-pencil algorithm, stress the use of the calculator as a "time-saver," stress use of the calculator as a problem-solving tool, and initiate use of calculators in the classroom. Neither teacher attitude nor teacher involvement affected the overall quantity of student calculator use. In classrooms of teachers who were involved in curriculum development, students were observed more often than students in classes of other teachers to use calculators for exploration and induction activities, solving routine word problems, and self-checking and verifying answers. Findings indicate that classroom calculator implementation differences are not primarily the result of teacher attitude toward calculators. (Contains 17 references.) (JDD)

Effect of Teacher Involvement in Implementation of an Innovation

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Effect of Teacher Involvement in Implementation of an Innovation

Futrell (1988) noted that the teacher is the actual implementor of classroom change. Successful classroom innovation is dependent upon teacher support and commitment (Crandall, 1983). Several researchers have examined curriculum development and implementation and found that innovations may produce disappointing outcomes, not because of inadequacies of the innovative idea, but because of lack of teacher involvement in the development of the innovation (Berman & McLaughlin, 1976; Stein & Wang, 1988; Strathe & Hatcher, 1986). Fullan (1972) concluded that the teacher must experience some sense of meaning, practicality, and ownership early in the change process for implementation to gain momentum; otherwise teachers will abandon the efforts and the implementation will fail.

Participation in the development of curriculum offers teachers a role in shaping educational programs, a sense of involvement and responsibility in the implementation process, and a commitment to the success of the program (Morin, 1986; Rothman, 1988; Young, 1985). Berman and McLaughlin (1975) found that any lasting effect of change seemed related to the process of curriculum development rather than to the relative quality of materials developed. Authoritarian decision-makers can mandate "cosmetic" short-term changes, but participative structures are needed to promote lasting change (Fullan, 1982).

Reviews of educational reform involving technology provide scant evidence that curriculum and instructional transformations have occurred as a result of the availability of technology (Dede, 1990). The incorporation of technology into mathematics teaching, however, could play a powerful role in educational reform because technology could serve both as a catalyst for change and as a resource that could facilitate the transformation of teaching and learning (David, 1990). Effective methods for creating educational reform, particularly those involving technology, need to be determined and documented.

Once an innovation is adopted and in use, interest tends to shift toward the monitoring of outcomes. Evaluations of innovations often focus on student learning outcomes and omit an evaluation of the process of change, of the teachers' implementation behavior, and of the degree of implementation. Although student outcomes may be considered the ultimate indicator of the effectiveness of an innovation, use of such measurements are both premature and inappropriate without an examination of how the innovation was implemented (Berman & McLaughlin, 1976). Research summarized by Loucks-Horsley and Hergert (1985) indicates that it takes between three and five years for the change process to become totally incorporated into a teacher's instructional approach. Hence, sufficient time must be allowed for an innovation to be developed and incorporated and tested in "pieces" before an accurate assessment of its long-term effects on students can be determined (Ornstein & Hunkins, 1988). By examining the implementation process, one can determine whether and to what degree change has occurred.

Statement of Problem

No study to date has investigated whether involvement in curriculum development makes a difference when the innovation involves technology in addition to new instructional approaches. The purpose of the present study was to investigate the effect of teacher involvement in the development of calculator mathematics curriculum on the implementation of calculators in the classroom. The independent variable studied was level of teacher involvement in the development of new calculator materials while accounting for teachers' initial attitudes toward calculators. The dependent variables for the study included (a) teacher instruction with calculators, (b) frequency of student use of calculators, and (c) types of student activities which involved calculator use. Of particular interest, was whether teacher attitude toward calculators would be the overriding factor which affects the implementation process, or if other factors (i.e., teacher involvement in curriculum development) would also play important roles.

Methods

Subjects were selected from a large, urban/suburban school district that is located in a major metropolitan city in the south central region of the United States. Currently, the school district in conjunction with a leading university is involved in a three-year nationally funded mathematics project to create a model calculator curriculum for grades 6-8. During the first month of the project, each of the 60 middle school teachers received a minimum of 12 hours of inservice training on the use of calculators. Three months later, each of their middle school students (approximately 7,000 total in the district) was issued a calculator.

The selection of the subjects (45 middle school mathematics teachers) for this quasi-experimental study was based upon the teachers' scores on the Calculator Teachers Attitudes Scale (Bitter, 1980). It was anticipated that teachers' attitudes toward calculators might affect the implementation process. Hence, controls for teacher attitude were added to the research design so that differences (based on level of involvement in curriculum development) among groups might be examined. The investigation compared the implementation process of three groups: (a) teachers who had high attitudes toward calculators and were actively involved in the development of a calculator mathematics curriculum (group 1), (b) teachers who had high attitudes toward calculators, used calculators in their classroom, had access to the materials being developed, but were not actively involved in development of the curriculum (group 2), and (c) teachers who had low attitudes toward calculators, used calculators in their classroom, had access to the materials being developed, but were not actively involved in development of the curriculum (group 3). (No writers were found to have low attitudes toward calculators.)

The curriculum development group met for three hours each month from September through May with a university educator to create calculator activities for the mathematics curriculum. The writing meetings consisted of discussions about the technology, the NCTM Curriculum and Evaluation Standards, reports and goals set by national groups, calculator research results, questioning and problem-solving strategies, topics which need to be deleted or de-emphasized in the mathematics curriculum, new roles for classroom teachers, and suggestions for improving newly developed activities.

During the spring semester, the 60 teachers (including the 45 teachers for this study) were each observed four times by trained classroom observers. Observers were blind to the research questions, and the teachers had no indication as to when they would be observed. The observation Rating Scale for Calculator Implementation (ORSCI) (Williams, Waxman, & Copley, 1991) was used to assess the quantity and quality of calculator use for each of the three groups. The observation data was analyzed at the teacher level and then used to derive group means for each indicator. Analyses of variance were used to compare the three groups of teachers (while accounting for teacher initial attitude toward calculators) on the high-inference indicators. It was expected that teacher attitude toward calculators could affect the implementation process and the frequency of calculator use in classrooms. Hence, teacher attitude toward calculators was used as a controlling variable.

Data Sources

Teachers' initial attitudes toward calculators were measured using the Calculator Teacher Attitudes Scale (Bitter, 1980). The scores were used to separate the teachers into high attitude and low attitude groups. The 15 lowest scores identified the teachers for group 3. The five department chairpersons were eliminated because of their exceptionally high initial calculator attitude scores and strong leadership qualities. This was done to eliminate a possible bias factor for the group comparisons. The attitude scores for group 1 and 2 lay within the same range.

The Observation Rating Scale for Calculator Implementation (ORSCI) (Williams, Waxman, & Copley, 1990) was used to measure the amount of calculator use in each classroom, to assess the quality of the calculator instruction, and to identify the kinds of activities in which students were involved when they used calculators. Seventeen indicators measure the quantity and quality of calculator instruction and use. Observation data was analyzed at the teacher level. Group mean scale scores for each indicator from the high-inference classroom observation schedules were derived. Analyses of variance were used to compare the three groups of teachers (while controlling for teacher initial attitude toward calculators).

Results and Conclusions

The attitude scores for the 45 teachers selected for the study ranged between 58 and 97. Fifteen scores on the Calculator Teacher Attitudes Scale were less than or equal to 80. These 15 teachers were all non-writers and were identified as the low attitude toward calculators group (Group 3). (None of the 24 members of the writing team scored an 80 or below.) The remaining 30 teachers selected for the study (one-half writers and one-half non-writers) scored above 80. They were identified as having high attitudes toward calculators and assigned to the appropriate group: 15 writers, high attitude toward calculators group (Group 1) and 15 non-writers, high attitude toward calculators group (Group 2). The range of the scores on the Calculator Teacher Attitudes Scale and the mean score for each group were as follows: Group 1, range 81-96, mean 87.47; Group 2, range 82-97, mean 87.93; Group 3, range 58-80, mean 70.47. Listed in Table 1 are the score frequencies and percents for each group.

Once the three groups were identified, group means for the overall score and for each of the 20 items were determined. One-way analyses of variance were used to compare the three groups of teachers on the overall score and on each of the 20 items from the Calculator Teacher Attitudes Scale. Due to the large number of comparisons tested, the level of significance chosen for this portion of the study was 0.01. Significant differences among groups were found for the overall score and for 13 of the 20 items. In each of these 14 cases, no significant differences were identified between Groups 1 and 2 (high attitude groups), but Groups 1 and 2 scored significantly higher than Group 3 (low attitude group) on positive items or significantly lower than Group 3 on negative items. Large standard deviations for several of the items indicated that there are several issues regarding calculator use which are still unresolved for teachers. The items in question include: (a) students shouldn't use calculators while taking math tests, (b) calculators will cause students to not learn basic computation skills, (c) calculators should be available for students in all grades, (d) calculator use is causing students to lose the chance to do mental computations in school, and (e) calculators do not allow students to do simple math on paper. Listed in Table 2 is a summary of the findings which includes group means and standard deviations for each item, F and p values from each ANOVA, and post hoc results.

Nine indicators from the Observation Rating Scale for Calculator Implementation (ORSCI) (Williams, Waxman, & Copley, 1990) were used to assess classroom instruction with calculators for each of the 45 teachers. The group mean scores of the nine classroom instruction indicators were analyzed using one-way analyses of variance. Overall, four of the nine findings revealed significant differences among the three groups of teachers. Teachers involved in curriculum development were observed significantly more often than those teachers not involved in curriculum development to (a) explain the relationship between calculator and paper-and-pencil algorithm, (b) stress use of the calculator as a "time-saver", (c) stress use of the calculator as a "problem-solving" tool, and (d) initiate use of calculators in the classroom. No significant differences between the two non-writing groups were found. These findings indicate that classroom calculator implementation differences are not primarily the result of teacher attitude toward calculators. Table 3 which summarizes these findings includes group means for each indicator, F and p values from each ANOVA, and post hoc results from Duncan's Multiple Range Test when significant differences were found.

Although each middle school student was issued a calculator, there was no guarantee that students would bring the calculators to class each day nor that the teachers would provide opportunities for the students to use them. Two indicators were used to estimate the amount of calculator use in the classroom for each of the 45 teachers. Neither finding revealed significant differences among the three groups of teachers. Students of Group 1 teachers were observed with their calculators in class approximately 75% of the time; 61% for Group 2 and 63% for Group 3. Calculators were observed in use in Group 1 classes nearly 50% of the time; Groups 2 and 3 nearly 40% of the time. For these three groups, within the school context of issuing calculators to all students, it appears that neither teacher attitude nor teacher involvement affect the quantity of student calculator use. The findings are summarized in Table 4 which includes group means for each indicator and F and p values from both ANOVAs.

Six indicators were used to identify types of calculator activities that were employed in classrooms for each of the 45 teachers. The group mean scores of the six classroom calculator activity indicators were analyzed using one-way analyses of variance. One-half of the findings revealed significant differences among the three groups. In classrooms of teachers who were involved in curriculum development (Group 1), students were observed significantly more often than those in classes of teachers not involved in curriculum development (Groups 2 and 3)to use calculators for (a) exploration and induction activities, (b) solving routine word problems, and (c) self-checking and verifying answers. No significant differences between the two non-writing groups (Groups 2 and 3) were found for any of the six indicators. These findings indicate that active teacher participation in curriculum reform involving technology rather than teacher attitude toward calculators may be a more significant factor affecting teacher selection of student activities. Table 5 which summarizes these findings includes group means for each indicator, F and p values from each ANOVA, and post hoc results from Duncan's Multiple Range Test when significant differences were found.

Educational Significance of Study

The public's concerns about the effects of calculator use in schools has forced researchers to direct their attention toward student outcomes. It was necessary for them to show that calculator use would not negatively affect student achievement. It is possible, however, that the ensuing emphasis on the calculator as the change agent rather than an emphasis on curriculum and instructional changes needed when technology is present has slowed the process of change.

The present study has investigated a piece of the change process and has determined that teacher involvement in curriculum development and implementation of an innovation (even more than a positive attitude toward the innovative tool) can affect certain aspects of teacher instruction with calculators, frequency of student use of calculators, and types of activities students engage in when calculators are present. More than the purchase of technology and two-day workshops on the operation of the tool are needed for successful incorporation of technology into a mathematics curriculum. The importance of teacher involvement in curriculum development must be recognized and incorporated into calculator reform movements.

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Table 1

Frequency Distribution of Attitude Scores by Groups

Score	Group 1 writers high attitude (n = 15) f	%	Group 2 non-writers high attitude (n = 15) f	%	Group 3 non-writers low attitude (n = 15) f	%
58					1	6.7
63					2	13.3
64					1	6.7
65					1	6.7
70					3	20.0
72					1	6.7
75					2	13.3
76					1	6.7
78					2	13.3
80					1	6.7
81	2	13.3				
82	1	6.7	2	13.3		
83	1	6.7	1	6.7		
84			1	6.7		
85	2	13.3	2	13.3		
87			2	13.3		
88	3	20.0	1	6.7		
89	1	6.7	1	6.7		
90	2	13.3				
91			2	13.3		
92	1	6.7				
93			1	6.7		
94	1	6.7				
95			1	6.7		
96	1	6.7				
97			1	6.7		

Table 3

Summary of One-Way ANOVAs on Classroom Instruction with Calculators

Item	Group 1 n = 15 M	SD	Group 2 n = 15 M	SD	Group 3 n = 15 M	SD	F	p	Duncan Post Hoc
Teacher allows students to determine appropriate use of calculator.	.47	.21	.37	.21	.30	.22	2.37	.105	
Teacher emphasizes importance of estimation to determine reasonableness of calculator answer.	.13	.21	.03	.09	.05	.10	2.09	.137	
Teacher explains relationship between calculator and paper-and-pencil algorithm.	.25	.16	.07	.11	.07	.11	9.52	.000	1>2,3
Teacher stresses use of calculator as a "time-saver".	.25	.16	.13	.13	.12	.16	3.44	.041	1>2,3
Teacher stresses use of calculator as a "problem-solving tool".	.22	.16	.10	.13	.07	.11	5.10	.010	1>2,3
Teacher demonstrates use of calculator.	.27	.24	.13	.19	.12	.16	2.58	.088	
Students use calculators during teacher demonstration.	.28	.28	.20	.17	.15	.18	1.44	.248	
Students initiate use of calculators.	.35	.16	.30	.29	.30	.17	0.28	.760	
Teacher initiates use of calculators.	.45	.24	.27	.26	.23	.18	4.00	.026	1>2,3

Note. df for all items = 2, 42

Table 2

Summary of One-Way ANOVAs on Teachers Attitudes Toward Calculators

Item	Group 1 n = 15		Group 2 n = 15		Group 3 n = 15		F	p	Duncan Post Hoc
	M	SD	M	SD	M	SD			
Calculators should be an integral part of the curriculum.	4.5	.64	4.9	.35	3.7	.72	15.89	.000	1,2>3
I get no satisfaction from using calculators.	1.2	.41	1.4	.63	2.1	.46	11.87	.000	1,2>3
I want calculators for all students.	4.9	.26	5.0	.00	4.1	.80	17.31	.000	1,2>3
Calculators are too expensive for classroom use.	1.5	.83	1.1	.35	2.1	.92	6.88	.003	1,2>3
Calculators are neat.	4.7	.62	4.7	.46	3.8	.68	11.65	.000	1,2>3
The use of calculators for games and fun should be encouraged.	4.8	.41	4.8	.41	3.6	1.12	13.50	.000	1,2>3
Students shouldn't use calculators while taking math tests.	2.3	1.40	2.1	1.33	3.2	1.08	3.15	.053	
My appreciation for calculators has grown from understanding their application to school curriculum.	4.4	.83	4.6	.51	3.6	.83	7.74	.001	1,2>3
I have never liked calculators.	1.1	.35	1.3	1.03	1.8	.56	3.72	.033	
Working with calculators is fun.	4.6	.51	4.6	.63	3.8	.41	11.59	.000	1,2>3
I am afraid to work with calculators or to use them with students.	1.4	.74	1.6	.83	2.4	1.06	5.38	.008	1,2>3
Calculators will cause students to not learn basic computation skills.	2.2	1.21	1.9	1.22	3.1	1.03	3.93	.027	
Calculators should be available for students in all grades.	4.5	1.06	4.6	.63	3.1	1.16	11.75	.000	1,2>3
I don't feel calculators should be allowed in the schools.	1.1	.26	1.2	.41	1.9	.52	16.38	.000	1,2>3
Most schools will have calculators for all students by 1990.	2.9	1.46	2.8	1.08	2.6	.63	0.23	.792	
Working with calculators is boring.	1.4	.63	1.3	.46	2.0	.53	7.67	.001	1,2>3
Calculator use is causing students to lose the chance to do mental computations in school.	2.3	.90	2.5	1.06	3.1	.92	2.98	.062	
Calculators can stimulate a child to study mathematics.	4.3	1.05	4.4	.74	3.6	.63	4.35	.019	
Calculators do not allow students to do simple math on paper.	2.3	1.11	2.5	1.41	3.1	1.03	1.51	.233	
Calculators make mathematics fun.	4.7	.46	4.7	.62	3.4	.83	19.90	.000	1,2>3
TOTAL SCORE	87.4	4.72	87.9	4.68	70.5	6.64	50.29	.000	1,2>3

Note. df for all items = 2, 42.

Table 4

Summary of One-Way ANOVAs on Calculator Use

Item	Group 1 n = 15 M	Group 1 n = 15 SD	Group 2 n = 15 M	Group 2 n = 15 SD	Group 3 n = 15 M	Group 3 n = 15 SD	F	p
Percentage of students who have calculators at their desks/tables.	.74	.14	.61	.20	.63	.12	3.08	.057
Percentage of time students (who have calculators) use them.	.46	.15	.38	.21	.38	.17	0.86	.431

Note. df for all items = 2, 42.

Table 5

Summary of One-Way ANOVAs on Student Calculator Activities

Item	Group 1 n = 15 M	Group 1 n = 15 SD	Group 2 n = 15 M	Group 2 n = 15 SD	Group 3 n = 15 M	Group 3 n = 15 SD	F	p	Duncan Post Hoc
Students use calculators for computation.	.63	.23	.47	.28	.45	.24	2.47	.096	
Students use calculators for exploration/induction activities.	.20	.17	.05	.10	.05	.10	6.75	.003	1>2,3
Students use calculators for solving routine word problems.	.27	.20	.13	.19	.07	.15	4.84	.013	1>2,3
Students use calculators for solving non-routine word problems.	.12	.13	.03	.09	.05	.10	2.49	.095	
Students use calculators for self-checking/verifying answers.	.40	.16	.27	.22	.17	.18	5.79	.006	1> 2,3
Students use calculators for games.	.05	.10	.02	.06	.00	.00	1.96	.154	

Note. df for all items = 2, 42.