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ABSTRACT

The National Council of Teachers of Mathematics encourages the use of calculators in the classroom as a teaching and learning tool, as well as a computational tool. This paper evaluates the impact on teachers' approaches to teaching mathematics and students' attitudes toward mathematics as the result of participation in an in-service program designed to help third and fourth-grade teachers incorporate calculators into their instruction. Forty-two teachers from 14 rural Missouri school districts were invited to participate in three 1-day workshops held in the 1991-92 school year. The teachers were taught to use Texas Instrument Explorer calculators, encouraged to explore numbers and number relationships with the calculators, and asked to design five higher-level lessons to utilize the calculator. Results of a questionnaire used to assess changes in the teachers' (n=29) instructional approaches indicated no significant differences materialized in the teachers' teaching approaches and teachers hold misconceptions about such concepts such as division by zero. Pretest and posttest analysis of the students' (n=412) attitudes toward mathematics indicated that students developed a more positive attitude on scales dealing with value of division, willingness to do division, enjoyment of division, calculator use, and overall perception of mathematics. (MDH)

The Impact of a Calculator-Based Mathematics-Teaching In-Service Program for Elementary School Teachers

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The Impact of a Calculator-Based Mathematics-Teaching In-Service Program for Elementary School Teachers

The National Council of Teachers of Mathematics' (NCTM) Curriculum and Evaluation Standards for School Mathematics (1989) and Professional Standards for Teaching Mathematics (1991) emphasize conceptualization, real-world problem-solving, connections among mathematical topics, communications about mathematics, and applications of technology. These standards promote the use of calculators in the classroom as a teaching/learning, as well as a computational tool. Although the standards have receive widespread publicity, the practice of most elementary school teachers does not appear to be consistent with Standards-based recommendations (Allen, 1992). Many elementary teachers do not have the conceptual understanding of mathematics needed to teach their students in the recommended manner (Ball, 1988a) and perceive themselves to be inadequately prepared to teach mathematics (Struyk, 1992). Typically, they emphasize rote memorization of rules and algorithms with virtually no attention on conceptualization or real-world problem solving (Cangelosi, 1992, pp. 29-31). Paper and pencil calculations continue to be stressed, thus, rendering applications of mathematics to real-world problem-solving impractical.

Although years of research findings indicate "that heavy use of calculators in early grades as part of instruction and assessment does not harm computational ability and frequently enhances problem-solving skill and concept development" (Kaput, 1992, p. 534) and can enhance mathematical creativity (Meissner, 1987), there is still widespread belief among elementary teachers that calculator-use will interfere with students learning basic facts and processes (Struyk, 1992). The practice of requiring paper and pencil calculations even for multi-step problem-solving contributes to the deterioration of students' attitudes about mathematics as they advance from primary grades through high school (Cangelosi, 1992, p. 30).

Fortunately, some elementary teachers do understand the need to challenge their students to explore mathematics and to solve real-world problems. They recognize the value of calculators in their classrooms, but all may not be able to fully incorporate calculators in their teaching because their supply of machines is inadequate (Dossey, et al, 1988, pp. 79-82) or they have not yet learned to apply the Standards-based recommendations.

With the support from an Eisenhower grant, these problems were addressed in central Missouri through an in-service program designed to (a) provide third and fourth grade teachers with enough TI-Explorer calculators for each of their students and (b) deliver in-service instruction to help those teachers incorporate the calculators in their instruction in a manner consistent with Standards-based recommendations. Furthermore, a study was conducted to assess the effects of that program on two variables: (a) students' attitudes about mathematics and (b) teachers' approaches to teaching mathematics.

Methodology

Forty-two third- and fourth-grade elementary teachers from 14 rural Missouri school districts were invited to participate in the in-service program. The program consisted of three one-day workshops held in the Fall, Winter, and Spring of the 1991-92 school year along with the classroom set of calculators for each participating teacher. Only a few of the teachers had ever used a TI-Explorer prior to the Fall workshop.

Workshops. The focus of the Fall workshop was to familiarize the teachers with the TI-Explore calculator, influence their attitudes about calculators, and introduce them to the NCTM Curriculum and Evaluation Standards. They were taught the basic operations of the machine and participated in both expository and cooperative group activities demonstrating ways of using the calculators with their students in ways consistent with Standards-based instruction. In order for the teachers to obtain the TI-Explorer calculators, they were required to attend the first workshop which was conducted by a mathematics education specialist. For those who could not attend, a repeat workshop was conducted by the project director. During the Winter workshop teachers concentrated on hands-on, calculator-based activities that focused on using the calculator to explore numbers and relationships rather than for calculating processes. Teachers were also encouraged to use the calculators to explore questions that students might bring up.

The Spring workshop was devoted to idea-sharing among the teachers and completing the post-assessments. Teachers were asked to bring five higher level lessons they had designed utilizing the TI-Explorer calculator.

Results

Teachers Questionnaires. To assess changes in teachers' instructional approaches, two forms of a questionnaire/test were administered to a sample of 29 teacher-participants just prior to the Fall and just after the Spring workshop. The 29 teacher-participants were selected because they had attended the Fall workshop conducted by the mathematics education specialist. Three of the 29 teacher-participants did not return the second questionnaire/test resulting in a sample of 26 teacher-participants. The test portion of the instrument consisted of items in which the teachers must complete tasks which are not commonly found on questionnaires and tests (Cangelosi, 1988). For example, they were directed to critique and compare three test questions to measure their students' achievement which emphasized different learning levels. Another item required the teachers to relate how they would respond to a student who asks, "Seven divided by zero is zero. Right?" A correlated *t*- test was computed on their pre and post test scores. Results of the correlated *t*-test ($t = 0.4177$, $p = .3100$) were not statistically significant providing no evidence to support a shift in the instructional approaches of the teachers toward Standards-based strategies. Unfortunately, what the questionnaire/test did reveal was serious misconception about mathematics. For example, only one of the 26 teachers, indicated any understanding of why $7 \div 0 \neq 0$. The vast majority either thought $7 \div 0 = 0$ or provided a response to the student that would lead to further misconceptions (e.g., "If you had seven objects and didn't divide them at all, how many objects would you be left with?" -- leading the student to believe that either $7 \div 0 = 7$ or $7 \div 0 = 1$). Other misconceptions were apparent regarding even more elementary mathematical ideas (e.g., why the sum of two odd numbers is even). The prevalence of mathematical misconceptions among teachers is pointed out elsewhere in the literature (e.g., Ball, 1988b).

Student Attitude Questionnaire. To assess changes in students' attitudes, a pre-posttest survey was administered to a sample of 412 third and fourth graders. The instrument included 27 items convertible to 10 scales related to enjoyment of mathematics, willingness to do mathematics, use of calculators, and the applications of mathematics to students own real-worlds (see Figure 1.). Data were analyzed using the Wilcoxon Matched Pairs Test. Results of the data analysis are summarized in Table A.

Evidence of changes in attitude is indicated with an asteria. A plus sign (+) indicates that students developed a more positive attitude towards that particular activity and a minus sign (-) indicates a more negative attitude towards a particular activity. Wilcoxon Matched-Pairs tests indicated statistically-significant ($p < .01$) positive changes from pre- to post-test responses regarding the scales dealing with the (a) value of division, (b) willingness to do division, (c) enjoyment of division, (d) calculator use, and (e) overall perception of mathematics. Pre- to post-test differences were not significant relative to the other scales involving multiplication, subtraction, addition, fractions, and personal use of mathematics.

Insert Figure 1 about here

Insert Table A about here

Based on feedback questionnaires administered at the end of each workshop, virtually all of the participants praised the value of all three workshops, indicating that they acquired useful insights on how to improve their teaching. Every participant (a) related examples in which they applied techniques learned in the workshops and (b) testified to an increase use of calculators in their classrooms. Overwhelmingly, the teachers indicated a desire to participate in similar programs in the future.

However, results of the research study of the impact of the program on students' attitudes and teachers' instructional practices were somewhat disappointing, though providing interesting implications for the design of subsequent programs and research studies.

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Table A

Results of Student Attitudinal Survey

Item Number	Attitude Measured	Wilcoxon Matched Pairs Test (nonparametrics) prob. value
1	School (nonmath)	$z = -4.2744$ $p < 0.0000$*
2	School (nonmath)	$z = 0.1243$ $p < 0.9011$
3	School (math:money values)	$z = -0.1123$ $p < 0.9106$
4	Personal	$z = -2.9813$ $p < 0.0029$*
5	School (nonmath)	$z = -2.8388$ $p < 0.0015$*
6	School (math:division)	$z = 2.9240$ $p < 0.0035$*
7	Personal	$z = 0.4951$ $p < 0.6205$
8	School (nonmath)	$z = -3.1215$ $p < 0.0018$*
9	School (math:division)	$z = 4.3848$ $p < 0.0000$*
10	Personal	$z = -1.7381$ $p < 0.0822$
11	School (math:addition)	$z = -0.4818$ $p < 0.6300$
12	School (nonmath)	$z = -2.0131$ $p < 0.0441$*
13	School (nonmath)	$z = -3.0583$ $p < 0.0022$*
14	School (math:division)	$z = 2.6235$ $p < 0.0087$*
15	School (nonmath)	$z = -2.3400$ $p < 0.0193$*

16	School (nonmath)	z = -3.1683 p < 0.0015*-
17	School (math:calculator)	Z = 1.9910 p < 0.0465*+
18	Personal	z = -0.2980 p < 0.7726
19	School (math:Multiplication)	z = 4.7354 p < 0.0000*+
20	Personal	z = -1.0474 p < 0.2949
21	School (math:measurement)	z = -0.8401 p < 0.4010
22	School (nonmath)	z = -4.1265 p < 0.0000*-
23	Personal	z = -1.5080 p < 0.1316
24	School (math:fractions)	z = 0.9490 p < 0.3429
25	School (nonmath)	z = -3.2797 p < 0.0010*-
26	School (nonmath)	z = -2.7337 p < 0.0063*-
27	School (math:subtraction)	z = -0.4334 p < 0.6648

* = Significant at $p \leq 0.05$
\- = Negative attitude change
\+ = Positive attitude change

Name________________________

1. When I read, I feel
2. When I learn how plants grow, I feel
3. When I figure out how much money I have, I feel
4. When I help with supper dishes, I feel
5. When I go to school, I feel
6. When I do division, I feel
7. When I play basketball, I feel
8. When I learn to spell new words, I feel
9. When I do numbers like 4)23, I feel
10. When I watch T.V., I feel
11. When I do numbers like 231 + 5876, I feel
12. When I sing at school, I feel
13. When I eat lunch, I feel
14. When I work with numbers like 12)360, I feel
15. When I go to recess, I feel
16. When I write in school, I feel
17. When I use a calculator, I feel
18. When I am sick, I feel
19. When I do problems like 43 x 3, I feel
20. When I play computer games, I feel
21. When I measure my height, I feel
22. When I learn about eating the right foods, I feel
23. When I ride my bike, I feel
24. When I work with fractions, I feel
25. When I learn about the pioneers, I feel
26. When I learn how animals hide themselves, I feel
27. When I do problems like 7.52 - 4.73, I feel