The effect of calculator use on standardized test scores of eighth grade mathematics students

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Abstract

The effects of calculator usage on the scores of students taking the Iowa Tests of Basic Skills math battery were investigated. Two hundred seventy 8th grade students from Ames Middle School were included in the study. All students took the three mathematics subtests, Mathematical Concepts, Mathematical Problem Solving and Mathematical Computations, included in Iowa Tests of Basic Skills. Half of the randomly selected class groups were supplied with, and allowed to use, calculators on all three sections of the mathematics tests, the other half of the students were not allowed to use calculators. The results indicated that both groups of students did equally well on the Mathematical Concepts portion of the test. The calculator group scored slightly above the non-calculator group on Mathematical Problem Solving subtest and scored significantly (p<.01) better on the Mathematical Computation portion of the test. The continuous increase in the use of calculators in the mathematics curriculum implies a need for educators to examine the effects of calculator use on standardized test scores in an attempt to seek out alternative methods of evaluation.

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THE EFFECT OF CALCULATOR USE ON STANDARDIZED
TEST SCORES OF EIGHTH GRADE MATHEMATICS STUDENTS

A Graduate Project
Submitted to the

Department of Curriculum and Instruction
In Partial Fulfillment
of the Requirements for the Degree
Master of Arts in Education
UNIVERSITY OF NORTHERN IOWA

by

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July 19, 1990
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Entitled: The Effect of Calculator Use on Standardized Test Scores of Eighth Grade Mathematics Students

has been approved as meeting the research paper requirement for the Degree of Master of Arts in Education.

July 20, 1990
Date Approved

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Abstract

The effects of calculator usage on the scores of students taking the Iowa Tests of Basic Skills math battery were investigated. Two hundred seventy 8th grade students from Ames Middle School were included in the study. All students took the three mathematics subtests, Mathematical Concepts, Mathematical Problem Solving and Mathematical Computations, included in Iowa Tests of Basic Skills. Half of the randomly selected class groups were supplied with, and allowed to use, calculators on all three sections of the mathematics tests, the other half of the students were not allowed to use calculators. The results indicated that both groups of students did equally well on the Mathematical Concepts portion of the test. The calculator group scored slightly above the non-calculator group on Mathematical Problem Solving subtest and scored significantly (p<.01) better on the Mathematical Computation portion of the test. The continuous increase in the use of calculators in the mathematics curriculum implies a need for educators to examine the effects of calculator use on standardized test scores in an attempt to seek out alternative methods of evaluation.
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Calculators have been in schools since the mid 1970s. Educators are still philosophically split as to when and to what extent calculators should be used in the mathematics curriculum, especially in the evaluation of student achievement. The positive and negative effects of calculator usage in mathematics education has been and still is a topic of much debate and research. The National Council of Teachers of Mathematics (NCTM), however, recommends calculators be used in all aspects of school mathematics, including evaluation (NCTM, 1986).

A large body of research has been conducted concerning the use of calculators in mathematics instruction. Little research has investigated the effects of calculator utilization on the validity and reliability of standardized test results. A study of fourth graders indicated little difference between test scores of students using calculators and those not using calculators, in overall performance on the Mathematics Concepts and Problem Solving subtests of the Iowa Tests of Basic Skills (ITBS) (Hoover and Perlman, 1989). In another study using equivalent forms of ITBS
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eighth grade students performed slightly better when using the calculator on the Concepts and Problem Solving subtests, and dramatically better on the Computation subtest (Lewis and Hoover, 1981). An investigation, by Ansley, Spratt, and Forsyth (1987) of students in Grades 10-12 found little or no effect on student performance due to calculator use on the Quantitative Reasoning subtest of the Iowa Tests of Educational Development. While many researchers agree that calculators are and will be an integral part of a mathematics curriculum, how, and to what extent they should be used in evaluation, particularly in regard to standardized tests, is yet to be determined.

The National Council of Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards for School Mathematics (1989), repeatedly emphasizes increased attention to using appropriate technology for computation and exploration; use of calculators for complex computation; use of calculators, computers and manipulatives in assessment; and decreased attention to complex paper and pencil computations, at all levels of education. "It is the goal of NCTM to promote full implementation of the standards by the year 2000" (B. H. Litwiller, personal communication, June 21, 1990).

The age of technology is at hand. The availability
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of low-cost calculators and computers has changed the focus of today's school mathematics curriculum. Preparing students to adapt to an electronic society and function in a technologically oriented world is a major challenge facing schools. Heid (1988) argues that the mathematics curriculum is driven by the non-calculator methods of testing. She notes, that until the current methods of evaluation change, neither will the mathematics curriculum. Adapting to these changes presents a need for new instruments as a means of evaluation. The focus of this study was to provide insight into the effects of calculator usage on standardized mathematics test scores.

Definition of Terms

ITBS: The Iowa Tests of Basic Skills which is regularly utilized hand held calculators during assessment.

calculator group: This term identifies the experimental group which was composed of randomly selected eighth grade groups of heterogeneous students who utilized hand held calculators during assessment.

non-calculator group: This term identifies the control group which was composed of randomly selected eighth grade groups of heterogeneous students who did not utilize hand held calculators during assessment.

The following terms are used in reporting the results of this investigation.
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administered to students in the participating school for the purpose of assessing achievement.

equated scores: A method for scoring results of student who use calculators on present standardized test.

NCTM: The National Council of Teachers of Mathematics is a professional organization which serves as the body representing the views of educators in the mathematics subject area.

Team 1, Team 2: These terms identify the groups which were composed of randomly selected eighth grade students for the purpose of middle school organization and interdisciplinary teaming at Ames Middle School.

Statement of the Problem

The major research question was: Does the use of hand held calculators alter the results of scores on three subtests of the mathematics section of the Iowa Tests of Basic Skills?

The results of the investigation can provide direction to teachers, administrators, and test developers as they establish policies for achievement test administration.

Limitations

The sample was small and limited to intact classroom groups in a Midwestern community. The results, therefore, may not be able to be generalized to other grade levels.
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or different geographical areas.

Assumptions

The following assumptions were made regarding this study:
- It was assumed that all students possessed adequate manual dexterity to complete the tasks expeditiously.
- It was assumed that instructions were clearly understood since the instrument was administered by the regular classroom teachers.
- It was assumed that each subject conscientiously completed the test items.
- It was assumed that the sample was representative of the general population of eighth grade students.
- It was assumed that the time of administration, in late spring did not distort the results.
- It was assumed that the Hawthorne Effect that could occur between the experimental and control groups was not an influencing factor in this study.

Method

Subjects

Two hundred seventy eighth grade students at Ames Middle School participated in the study. The students at Ames Middle School are drawn from a middle class community, with a majority of Anglo and a minority of various other ethnic groups represented. The non-calculator (control) group
of 127 students was composed of 58 males and 69 females of which 63 were Team 1 students and 64 were Team 2 students. The calculator (experimental) group of 143 students was composed of 66 males and 77 females of which 72 were Team 1 students and 71 were Team 2 students. Approximately 30 students, who did not complete all three sections of the test, were excluded from the results in order to avoid skewing the comparison between the various subtests.

Instrumentation

Three mathematics subtests, Concepts, Problem Solving, and Computation, of the Iowa Tests of Basic Skills, Form G, Level 14, (University of Iowa, 1986) were used in the study. Accompanying administration manuals and answer forms were used in testing. Classroom sets of calculators were used by the treatment group. The test was the one which was regularly administered to eighth grade students in the participating school district. The three subtests were administered in order to enable the researcher to compare and contrast the effects of calculators in the specific areas of emphasis in mathematics curriculum.

Procedure

Testing occurred during regularly scheduled mathematics classes at Ames Middle School, Ames, Iowa in May 1990. Students were instructed in calculator use as part of the
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math curriculum and provided calculators for daily use during instructional lessons throughout the school year. Students selected for the study were randomly matched on the attribute of academic ability into two teams, Team 1 or Team 2, this was done prior to the beginning of the academic school year. Each of the two eighth grade mathematics teachers were assigned to teach one of the teams of students; these were further divided into six appropriate class periods. The corresponding mathematics periods were alternately assigned to either the calculator or non-calculator group, resulting in one calculator and one non-calculator group during each of the six class periods.

The regular classroom teacher administered the three subtests: Concepts, Problem Solving, and Computation, in the manner prescribed in the manual. Students were timed, according to ITBS instructions, on each of the three subtests.

Results

The mean raw scores, standard deviations, t-values, and number of students for each subtest are shown in Table 1, Table 2, and Table 3. There was no significant difference in the mean scores of the calculator and non-calculator groups on the Mathematics Concepts subtest (Table 1). The scores of the students in the calculator group on the Mathematics Problem Solving subtest indicated that the use
of calculators did slightly improve student performance on this subtest (Table 2).

The most significant effect of calculator usage was evident, however, in the students' performance on the Mathematics Computation subtest. Students in the calculator group recorded a mean score of 37.20 compared to a mean score of 27.36 for the non-calculator group (Table 3). The t-value calculated indicates that the use of calculators had a significant effect on scores of the Computation subtest (p<.01).

Students in both groups had high item completion rates for the Concepts subtest, 100% for the calculator group and 99% for the non-calculator group. The item completion rate on the Problem Solving subtest indicated 99% of those using calculators completed the test while only 89% of those not using calculators completed the test. The completion rate for the calculator group was most dramatically different on the Computation test with 86% of the calculator group completing all questions, while only 38% of the non-calculator group completed all of the questions. In both calculator and non-calculator groups, males scored better than females on all three subtests; the differences, however, were minimal (Table 4).
Discussion

The results of this study indicate that the use of calculators had little effect on a student's performance on the Mathematics Concepts subtest. The nature of the achievement test was such that the use of a calculator appeared to have minimal influence on item response. The results also indicate that the use of the calculator on the Problem Solving subtest did slightly improve student's scores. It can be noted that the use of calculators enables students to focus on the elements of the scenario and the procedure for reaching a solution. The nature of the problem solving questions was such that once students have determined the correct algorithm or strategy to apply, the manipulation of the numbers poses little difficulty for most students. The effect of calculator use was most significant on the computation subtest \( (p<.01) \). This indicated that the use of a calculator resulted in greater accuracy and provided an advantage to the experimental group. This can be attributed to the nature of the test which is specifically designed to test the student's ability to understand symbolic representation and to manipulate numbers in the four basic functions of arithmetic.

Some discrepancies are apparent in the completion rates of the treatment groups. A study of fourth and eighth
graders by Lewis & Hoover, (1981) and a study of fourth graders by Hoover & Perlman, (1989) both indicated lower completion rates for those using calculators than those not using a calculator on the Problem Solving and Computation subtests. The research presented in this paper showed the calculator group had a higher percentage of students completing all test items than the non-calculator group.

Students at Ames Middle School may have a high level of proficiency in calculator use due to the instruction they receive and the frequent use of calculators in daily lessons. This may also be a factor in the calculator group high rate of item completion on the computation test. Students at Ames Middle School are encouraged to use calculators on daily lessons, therefore, the lack of a calculator for completing a test may have been a factor in the non-calculator students' test taking speed. It should also be noted that the test was taken at a time in the curriculum when students are dealing with more complex numbers and ideas and the use of the calculator is highly encouraged. All students may be, therefore, less comfortable with paper and pencil computations.

In preparing students to meet the demands of a technological world, NCTM stresses the use of calculators and various manipulatives in instruction and assessment.
A challenge facing the educator is in attempting to implement the Curriculum and Evaluation Standards (NCTM, 1989) while using standardized tests for assessing student performance and program outcomes (Williams, 1987). The challenge is for developers and users of standardized tests to find new means of assessment. One suggested method of evaluating performance of students who use calculators on existing standardized tests is the use of equated scores. The report by Hoover and Perlman (1989), in regard to equated scores, states:

This would seem appropriate for concepts and problem solving tests, but not for computation tests. If the purpose of a computation test is to evaluate a student's facility with the four basic operations on whole numbers, fractions, and decimals, it would seem obvious that the availability of a calculator would make such an evaluation meaningless. (Hoover & Perlman, 1989, p. 2)

The use of calculators did dramatically affect performance on computation tests in this study, but appeared to have little or no effect on tests of concepts and problem solving. The findings are congruent with previous studies examined in this research, reinforcing the need to continue examining calculator usage on standardized tests and the
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need to seek new methods of evaluation. More research is needed at other grade levels involving larger populations. Mathematics teachers need to assess the precision of present testing methods and to develop new means of evaluation that will meet the needs of today's changing curriculum and technology.
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References


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### Table 1
Summary Statistics (Raw Scores)

**Mathematics Concepts**
42 Questions

<table>
<thead>
<tr>
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<th>Non-Calculator</th>
<th>Difference</th>
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<tr>
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### Table 2
Mathematics Problem Solving
32 Questions

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### Table 3
Mathematics Computation
43 Questions

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<tbody>
<tr>
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<td>37.20</td>
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<tr>
<td>SD</td>
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\[ p < .01 \quad \text{df=268} \]
Table 4
Comparison of Scores of Males and Females
Raw Scores

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<th>Difference</th>
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p<.01  df=141

<table>
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<th>Females</th>
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