THE UNIVERSITY OF MANITOBA

THE EFFECT OF THE USE OF THE CALCULATOR ON SCIENCE-RELATED OUTCOMES

BY

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ABSTRACT

The purpose of this study was to examine the effect of the use of the calculator on science-related outcomes. The outcomes consisted of the students performance in science, their attitude to some facets of science (four concepts), plus speed, accuracy and achievement in arithmetic.

In this investigation, 18 grade ten students were instructed with the aid of a calculator in two science units, both of which involved fundamental operations in arithmetic. These 18 students were then compared to another group of 18 students who were taught without the use of the calculator. Other factors which were also considered included the effect of calculator usage during testing and the effect of time of testing.

All students were tested prior to and after the instruction. The performance test in science was also given three weeks after the termination of instruction. The findings for attitude suggest that any changes in attitude due to the type of instruction were either parallel changes or non-existent for the two types of instruction.

The changes in arithmetic performance were similar to the changes in attitude. It did not seem to matter which one of the two instructional types were used, since student performance in arithmetic as measured by the facets speed and accuracy improved from pretest to posttest. This suggests that the type of instruction with or without the calculator has no significant effect on arithmetic performance.

There was, however, a significant effect in achievement in science due to instructional type (recalling that this was a post-retention test). The results favored the group using the calculator during instruction.

The implications of the study are that students of similar age and background will score higher on mathematical problem-oriented units in science, if they use a calculator during instruction. At the same time, there is very little difference in attitude between the two groups, and no loss in computational ability in arithmetic.

The results of the study also imply that when problem-oriented science tests are made up, keeping in mind that calculations are to be done manually, there is no effect due to the use of the calculator during testing.

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CHAPTER I

INTRODUCTION

We are living in an age of future shock, and nowhere is this more evident than in the field of pocket calculators. In the past two or three years, hand calculators have been increasing in number and decreasing in price. The microcircuit technology spin-off from the space industry has given the consumer a handy calculating tool. The full extent to which the availability of electronic calculators will affect the teaching of science and mathematics has yet to be determined.[1]

Background to the Study

There are conflicting views about the effect of the calculator on students. Opponents of calculators say that students will not know the basic paper-and-pencil algorithms

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[1]Deede Pendleton, "Calculators in the Classroom," Science News, 107, No. 11 (1975), 175.

for addition, subtraction, multiplication, and division, just as television-oriented students no longer seem to know the basics of grammar and spelling.[2] The device, critics contend, will eventually make paper-and-pencil mathematics obsolete.

However, instructors who are using calculators take the opposite stand. They say that calculators allow students to solve more relevant types of problems, therefore stretching their interest and increasing their motivation. Calculators, because of their speed and accuracy, lend themselves to complicated problems previously avoided by school teachers.[3]

These conflicting views together with the greater availability of the calculator have provided the stimulus for this investigation.

Statement of the Problem

The purpose of this investigation is to consider the following problem: What is the effect of the use of the calculator on science-related outcomes? The outcomes chosen

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[2]Richard J. Shumway, "Hand Calculators: Where Do You Stand?," Arithmetic Teacher, 23, No. 11 (1976), 571.

[3]Ibid., p. 570.

for this study are performance in science, attitude to some facets of science (four components), and performance in arithmetic operations.

The educational research and development in this field is relatively new. Furthermore, the possibility of supplying public schools with calculators will increase as the price decreases. The National Council of Teachers of Mathematics have formally endorsed the use of the calculator in the classroom.[4] Thus there is a need for research in this field.

The effect of the use of the calculator on performance in science courses that require some practical mathematics has been observed, but as far as the writer has ascertained, no research has been done in this area. Gerry Pankiewicz, a science teacher, observed that the use of calculators, with vocational students, improves motivation and the rate at which students can learn science concepts that involve mathematic operations. His rationale for this is that previous to the use of calculators, students became

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[4]The National Council of Teachers of Mathematics, Newsletter, The National Council of Teachers of Mathematics, No. 11 (1974), p. 3.

so bogged-down in arithmetic calculations, that they were unable to achieve their real objective.[5] Educational research has not been done to determine the effect of the calculator on science performance.

The effect of calculator usage during testing will also be studied in this investigation. This question was posed by Sosebee and Walsh: "Do students having a calculator while writing an exam have an unfair advantage over the students who cannot afford one? Or, on the contrary, is the student who has been using the tool and has it taken away from him at a disadvantage when writing an examination?"[6]

The question of performance in arithmetic operations was chosen because critics of the calculator contend that the calculator will make pencil-and-paper mathematics obsolete. Students will forget the basics and be unable to add if their calculator batteries die.[7] This study should indicate if the

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[5]Gerry Pankiewicz, "Science 203 Course used at Kildonan East" (paper presented to Dr. K. Slentz, University of Manitoba, 1975).

[6]Jackson Sosebee and Lola Walsh, "Pocket Calculators and Test Scores in Introductory Chemistry," Journal of College Science Teaching, 4, No. 5 (1975), 324.

[7]Pendleton, op. cit., pp. 175-181.

use of the calculator over an eight-week period has any effect on arithmetic operations.

This study will also consider the effect of the calculator on attitude because, instructors who have used the device, claim that student motivation is increased.[8] The four facets of attitude--"What I learned in this science course", "How I feel about this science course", "Science student", and "Science teacher"--may give some idea as to what causes this increased motivation.[9]

Jan L. Higgins, an associate professor of Math Education at the Ohio State University, wrote the following:

> "Teachers would be well-advised to begin experimental classwork with pocket calculators, focusing on their use as a basic tool in successful problem solving.
> Concurrently, school administrators and other decision makers should make funds available for the purchase of such equipment for classroom use, for the calculator must be viewed not as a technological curiosity but as an essential implement in the newest mathematics."[10]

Consideration to the above recommendation has been given in

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[8]Pendleton, loc. cit.

[9]Garth E. Martin, "An Evaluation of the Physical Science 201 and 301 Programs in Manitoba" (unpublished Masters dissertation, University of Manitoba, August 1975).

[10]Jan L. Higgins, "Mathematics Programs are Changing", N.A.S.S.P. Curriculum Reports, 40 (December 1974), 56-58.

this study.

The use of the term calculator in this paper implies that consideration is being given to the performance characteristics of the hand-held calculator. The calculators used in this study were able to add, subtract, multiply, and divide, plus perform chain and mixed calculations.

CHAPTER II

REVIEW OF LITERATURE

There were two basic problems in conducting the review of literature. Firstly, the early literature reviewed relates to the use of the desk calculator in the classroom, as opposed to the hand calculator. Secondly, much of the research that has been conducted refers to the use of the calculator in the mathematics classroom, not the science classroom. Although these studies do not relate directly to this particular study, the dependent variables relied on the use of the calculator. These studies were, therefore, considered relevant for this research.

Previous Studies

Studies were reported by Fehr, McMean and Sobel,[11]

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[11] H. F. Fehr, George McMean and Max Sobel, "Using Hand-Operated Computing Machines in Learning Arithmetic," The Arithmetic Teacher, 3, No. 10 (1956), 145-150.

Ellis and Corum;[12] and Keough and Burke,[13] suggesting that the calculator improves student performance in mathematical computation. In these studies, homogeneous groups not using calculators established control for the experiment. The length of time for these studies ranged from four months to a full school year with the sample size ranging from sixty-one to three hundred students. These results differ from those of Longstaff, who found that there was no difference in the level of achievement between grade nine and grade five students using the calculator in arithmetic and those not using it. However, Longstaff did observe that the low ability students, who used the calculator, displayed more positive attitudes towards mathematics than those low ability students who did not use the calculator.[14]

Another test which analyzed the effect of using desk

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[12]June Ellis and Al Corum, Functions of the Calculator in the Mathematics Laboratory for Low-Achievers, 1969, (ERIC ED 040 847).

[13]John J. Keough and Gerald W. Burke, Utilizing an Electronic Calculator to Facilitate Instruction in Mathematics in the Eleventh and Twelfth Grades, July 1969, (ERIC ED 037 345).

[14]F. R. Longstaff, Desk Calculators in the Mathematics Classroom, June 1968, (ERIC ED 029 498).

calculators on the attitudes and achievement of low achieving ninth graders, was conducted by Cech. Based on his analysis, Cech concluded that the use of calculators did not have a significant effect on student attitudes. Furthermore, he concluded that the use of the calculator did not result in any significant improvements of computational skills.[15]

The most extensive study conducted on hand calculators was that of Glasin. With treatment groups of ninth graders in general mathematics, ranging in number from 31 to 48 students, he compared the achievements and attitudes of students who use conventional based algorithms for operations on positive rational numbers, with students who use algorithms which were dependent on the use of the hand calculator.

Glasin's study is based on the instruction to three separate groups. One group performed operations on positive rational numbers according to the usual text approaches, while the second group used the conventional set of algorithms with the calculator. The third group used an alternative algorithmic procedure, where each fractional operand is converted

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[15]J. Cech, "The Effect of the Use of the Desk Calculator on Attitude and Achievement with Low-Achieving Ninth Graders", Mathematics Teacher, 65 (February 1972), 183-186.

to a decimal using the calculator, and the indicated operation is then performed on the calculator. The five units of instruction taught were addition, subtraction, multiplication, division, and operating on fractions. The students attitude towards mathematics was then measured. Upon completion of each unit, students were given a posttest, after which they began a two week retention period. At the end of the two week period, students completed a fractional retention test.

Using the .05 level of significance, the results of the investigation suggested that, when computational skill with rational numbers is the goal of instruction, the alternative algorithm set with the calculator appears to be a viable alternative to the conventional method of teaching fractions to low ability and low achieving students. When the goal is to develop computational skill with rational numbers, via the conventional methods, use of a calculator does not significantly and consistently affect performance. However, use of an alternative algorithm, which uses the electronic calculator, can produce success for slow learning children.[16]

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[16]William L. Glasin, "A Comparison of Achievement and Attitudes of Students Using Conventional or Calculator Based Algorithms for Operations on Positive Rational Numbers in Ninth Grade General Mathematics," Research in Mathematics Education, 6, No. 2 (March 1975), 95-108.