Test Preparation and the Use of Calculators

Sol E. Sigurdson

A recent decision by Alberta Education to use calculators in their Grade 9 Mathematics Achievement Test poses the question of whether students who have been trained to use calculators in tests would be at an advantage. Calculators are here to stay. It remains for us to determine their wise use. Teachers have major concerns over their role in instruction, but their role in testing is also cause for concern (Heid 1988). Although the curriculum calls for the general use of calculators in junior high school mathematics and students should know how to use calculators, the issue in testing is whether students who have had special preparation in the use of calculators in tests would have an unfair advantage. Evaluation experts in Alberta Education have expressed an interest in the question. With their cooperation, a study was undertaken to examine the issue of preparation for the use of calculators in the multiple-choice provincial Grade 9 Mathematics Achievement Test 1987.

The use of calculators is part of the larger issue of general preparation for tests. What do teachers normally do in preparing for tests? Tests are meant to determine a student's level of mathematical knowledge. Is special preparation of any kind unjustified then? Teachers have long believed that preparation for tests is important. When the author was studying Grade 12 mathematics, 35 years ago, the course was complete by Easter and the remaining two-and-a-half months were spent going over old examinations. This seems a bit extreme—but it got good results on provincial examinations.

The Research Question

The general question is: In preparing students for the Provincial Achievement Test in Mathematics, what type of preparation would be most effective? To formulate this as a research question, four test preparation treatments were devised. The first addresses the question of knowledge of mathematics, the remaining three the matter of knowing about tests and testing procedures:

1. *General Review*, using questions from the textbook to ensure students have a full understanding of the mathematics in the particular units
2. *Specific Structured Review*, using question sheets containing typical multiple-choice questions
3. *Multiple-Choice Preparation*, using the Specific Structured Review questions but attending to the multiple-choice format and how it could be advantageous in developing alternative solutions to the questions
4. *Calculator-Use Preparation*, using a focus on multiple-choice format, with special emphasis on how the calculator could be used to advantage in answering multiple-choice questions

Each treatment builds upon the previous one so that the fourth treatment included the general review, the specific review, a focus on multiple-choice format, and calculator-use preparation.

Development of Treatments

An initial survey of teachers who were interested in participating in the study showed a considerable range of emphasis on test preparation. Some teachers claimed to give students more than 200 specific test review questions. Others spent two or three days reviewing. In developing our treatments, because some of them were to include a lot of activities, we opted for every treatment to be of 11 days' duration. The researcher felt that time spent on review would make a difference to test scores, but was interested in whether what the teacher did during review time made a difference. The daily topics for all groups were:

Day 1. Ratio and proportion
2. Number systems, operations
3. Exponents
4. Pythagorean theorem
5. Surface area, shaded area
6. Measurement and graphing
7. Algebra—solving equations
8. Algebra—operations, polynomials
9. Algebra—factoring
10. Algebra—problem solving
11. General test, with all types of questions

General Review. This treatment consisted of reviewing, using only the textbook, the *mathematics* skills and concepts in each topic. The content was divided into 10 sections covering the Grade 9 course, leaving the last day for an overview. Students could use calculators during this review and be familiarized with multiple-choice questions.

Specific Structured Review. For this treatment 11 single-page handouts containing multiple-choice questions were used, one being assigned each day. Furthermore, teachers were to structure the class period as follows:

10 minutes: review previous day's work
15 minutes: teacher presentations of skills and concepts relating to the topic
15 minutes: allow students to work on a new handout
Homework: any work not done in class must be done at home

Students were told that the test was multiple choice and that calculators could be used.

Multiple-Choice Preparation. In addition to following the format of the Specific Structured Review, teachers were asked to emphasize the guidelines in *Guidelines for Answering Multiple-Choice Test Items* (see appendix) in this treatment. Teachers were asked to spend 10 to 15 minutes each day showing students these typical multiple-choice questions and encouraging them to use these ideas as they did the sample questions on their handouts.

Calculator-Use Preparation. Teachers in this treatment were asked to stress the points in *Guidelines for Using Calculators on Multiple-Choice Tests* as they went over the typical test questions, and to make use of the ideas suggested in the *Guidelines for Answering Multiple-Choice Test Items.*

Design of the Study

Twelve volunteer teachers, each with two Grade 9 classes, were recruited for the study. Each teacher was inserviced in two of the treatments. They were randomly assigned to offer one teatment to one class and the second to the other class. Thus three teachers offered the General Review and the Specific Structured Review to two different classes. Four comparisons were made, each involving three teachers (and six classes):

1. General Review vs. Specific Structured Review
2. Specific Structured Review vs. Multiple-Choice Preparation
3. Multiple-Choice Preparation vs. Calculator Use Preparation
4. General Review vs. Calculator Use Preparation

For these analyses, the student's mark on the provincial Grade 9 Mathematics Achievement Test was used as the dependent variable and the third report card mark of the student was used as the covariate. The advantage of this design was that comparisons were made only between classes that had the same teacher.

Results of the Analysis

For several reasons, including that some data were not available for the covariate (the student's third report card mark), four teachers had to be omitted from the data analysis, which meant that the numbers in each comparison were lower than was desirable. An analysis of covariance, using the student's *raw score* out of 75 and the student as a unit, yielded the means (adjusted by the covariate), given in the four tables following. Examining these tables reveals no statistical differences between any of the treatment comparisons. This means that the different test preparations made no difference and, in particular, that preparing students to use the calculator on multiple-choice tests does not lead to higher test scores. However, the great differences between classes in different comparisons (from 63.7 to 46.2 [raw score]), that is, between classes with different teachers, is noteworthy.

This latter observation could signify that the *teacher* is the major factor in differences between comparisons, caused by some teachers taking the Achievement Test seriously and others not. This interpretation justifies the design of the study (comparing two classes of the same teacher), and helps explain why no differences resulted, because, regardless of which treatments they had been assigned, some teachers made sure that both classes were well prepared for the test. This interpretation suggests that

Table 1. Comparison between General Review and Specific Structured Review Groups on Adjusted Means of Provincial Mathematics Achievement Tests

	Number of Students	Raw Score out of 75 Adjusted Means	Statistical Significance
General Review	73	52.9	
Specific Structured Review	66	51.6	No Difference

Table 2. Comparison between Specific Structured Review and A Focus on Multiple-Choice Format on Adjusted Means of Provincial Mathematics Achievement Tests

	Number of Students	Raw Score out of 75 Adjusted Means	Statistical Significance
Specific Structured Review	28	63.7	
Multiple-Choice Format	28	62.4	No Difference

Table 3. Comparison between Multiple-Choice Preparation and Calculator-Use Preparation on Adjusted Means of Provincial Mathematics Achievement Tests

	Number of Students	Raw Score out of 75 Adjusted Means	Statistical Significance
Multiple-Choice Preparation	43	46.2	
Calculator-Use Preparation	44	46.9	No Difference

Table 4. Comparison between General Review and Calculator-Use Preparation on Adjusted Means of Provincial Mathematics Achievement Tests

	Number of Students	Raw Score out of 75 Adjusted Means	Statistical Significance
General Review	41	50.0	
Calculator-Use Preparation	66	52.5	No Difference

the general preparedness of the class, not only mathematically but also psychologically, could be a more important factor in determining test scores than any particular test preparation. The choice of covariate, the third report card mark, is of little help in sorting out the teacher effects because it is dependent upon the teacher. This interpretation, which the present study was not designed to assess, sees the teacher playing the role of the coach getting his players "up for the game." It might warrant further study.

Discussion

What have we learned from this study? First of all, basing the study on the Provincial Achievement Tests was problematic in that these tests are taken *very seriously* by some teachers making any form of experimentation impossible. An informal survey taken at the beginning of the study showed that some teachers had planned extensive reviews (test preparations). In fact, during the course of the study, it became clear that several teachers participated in the study precisely because they viewed test preparation as an important matter. In the study, some teachers thought that spending only 11 days on the review was inadequate.

Second, the analysis of the multiple-choice format and the use of calculators on tests was probably too sophisticated for Grade 9 students, especially as they were to use this knowledge in a test situation. That is, it would take a fairly confident and sophisticated student who, in the middle of this important test, would consider the various options to answering a particular test item. For Calculator-Use Preparation, students were given some 20 rules over the 11-day period. Pressure on the student is another reason why using the Provincial Achievement Test as the dependent variable in this study was a poor decision. In any case, if test preparation, including the use of calculators, is to be advantageous, it probably has to be carefully planned and take place throughout the year.

Third, although this study did not show it, one has to believe that test preparation in general is helpful. Students writing multiple-choice tests should be aware of the guidelines for answering multiple-choice tests and using calculators on multiple-choice tests developed in this study. Other factors such as the enthusiasm of the teacher for the test, the importance the teacher places on the test, and indeed the mathematical knowledge of the student, are also important.

Recommendations

Although the study shows no achievement differences resulting from different types of test preparation, the informal survey taken at the beginning of the study suggests that there are enormous differences between teachers' approaches to preparing for tests. In the study, teacher effects overruled the effects of the test preparations. This suggests that if the test scores are to represent students' knowledge of mathematics, rather than a knowledge of how to take tests, some guidelines be given to teachers on what constitutes reasonable preparation for the Provincial Achievement Tests. If comparable results are required on these tests, Alberta Education should provide these guidelines. As it stands, many teachers are ill-informed about possible alternatives in test preparation, and many are unsure about the ethics of specific test preparations. A starting point for guidelines could be those developed in this study. For example, an 11-day review seems reasonable. In the meantime, although this study was seriously flawed, it does suggest that specific test preparation does not dramatically raise test scores. However, reviewing some of the principles developed in this study and practicing the expected type of test questions should be helpful to all students writing multiple-choice mathematics tests.

Reference

Heid, M.K. "Calculators on Tests—One Giant Step for Mathematics Education." *Mathematics Teacher* (December 1988): 710-13.

Appendix

Guidelines for Answering Multiple-Choice Test Items

1. *Alternative answers* should be read as part of the question and the best alternative should be selected.

   e.g., 2^4 can be written as

   a) 2^{-4} b) 8 c) $\frac{1}{16}$ d) 16

2. Begin by eliminating (marking with x) those that are clearly wrong.

   e.g., The equivalent form of x^{-2} is

   a) $^{-}x^2$ b) $\frac{1}{^{-}x^2}$ c) x^2 d) $\frac{1}{x^2}$

3. If alternative choices are similar (additive inverses or reciprocals) be careful about answering. Alternatives always represent common mistakes. They are trying to fool you.

   e.g., $^{-}9 + {}^{+}43 =$

   a) $^{-}52$ b) $^{-}34$ c) $^{+}34$ d) $^{+}52$

4. Alternative choices that include multiple answers require each alternative to be worked out. You must keep track of your answers.

   e.g., The polygons with equal area are

   a) A, B and C
   b) A, B and D
   c) A, C and D
   d) B, C and D

5. Students should be taught to recognize common stems, such as evaluate, the value of, simplify, sum, product, round off, the TRUE statement, standard form, scientific notation, decimal numeral, express as a percent, typical diagrams (dot paper, shaded areas, 3-D drawings).

6. Although the questions ask for a certain operation, the answer may be achieved by using alternative choices and revising the process.

   e.g., The decimal numeral 0.00000281, written in scientific notation, is

   a) 2.81×10^{-3} b) 2.81×10^{-5} c) 2.81×10^{-6} d) 2.81×10^{-8}

   e.g., Express 4.3 as a fraction

   a) $4\frac{3}{10}$ b) $4\frac{1}{3}$ c) $4\frac{33}{100}$ d) $4\frac{2}{3}$

   e.g., Solve for $6x + 9 = 15$, $x =$

   a) 1 b) 2 c) 3 d) 4

7. In looking at multiple-choice questions, see what the common mistakes are. Common mistakes are given as alternative choices.

   e.g., $2^3 + 2^2 =$

   a) 10 b) 12 c) 32 d) 64

Guidelines for Using Calculators on Multiple-Choice Tests

1. Use the calculator for all activities for the 11 days of review.

2. Use a method of calculating with which you are least likely to make a mistake. Do not use memory functions and avoid use of the negative sign in calculations. Use pencil and paper to determine the correct sign. Use pencil and paper to record intermediate results. Do not use the "%" key, divide by 100 instead.

3. Avoid using calculators for simple numbers. Calculators should not be used for manipulating numerals in algebraic expressions such as

$$\frac{8x^4y^3}{2xy^6} =$$

4. Most calculators do not handle:

$5.6 \times 10^9 =$

5. Following are examples where calculators are useful:

1. $(0.1)^3 =$

a) .3 b) 0.001 c) 0.003 d)3.001

2. Evaluate 4^3

a) 4 b) 12 c) 64 d) 81

3. $4^3 + 4^2 =$

a) 20 b) 80 c) 1024 d) 4096

4. Which is the prime number?

a) 39 b) 4 c) 49 d) 53

5. $3\frac{2}{5}$ is the same as

a) 34 b) 0.34 c) 3.4 d) 52.3

6. $0.00523 \times 1000 =$

a) 0.0523 b) 0.5230 c) 5.23 d)52.3

7. 0.35 divided by 7000 expressed as scientific notation is

a) 5×10^{-1} b) 5×10^{-5} c) $\frac{1}{20\,000}$ d) 0.5

8. $\frac{7}{20}$ is equivalent to

a) 0.35 b) 0.72 c) 7.7 d) 20.7

6. Ratio problems can be solved by the unit method with a calculator.

e.g., A store is selling 5 bags of candy for 89 cents. If the regular price is 3 bags for 66 cents, how much is saved per bag by buying at the sale price?

a) 23 cents b) 17.8 cents c) 4.2 cents d) 4.6 cents

7. For all problems, first write down the equation before you use your calculator to calculate the answer.

e.g., A merchant buys a product for $200 and adds 25% to cover overhead and profit. The selling price is

a) $150 b) $225 c) $250 d) $300

e.g., Bill's commission for selling a $1200 car was $60. His rate of commission was

a) 5% b) 7.2% c) 12% d) 20%

8. Practice using the calculator in evaluating formulas.

e.g., $V = \pi r^2 h$ $r = 3$ cm, $h = 7$ cm

$V = l \times w \times h$ $l = 17$ cm, $w = 5$ cm, $h = 34$ cm

$V = \frac{4}{3}\pi r^3$ $r = 1.4$ m (Note: Divide by 3 at the end of the calculation.)

9. The effect of altering elements in a formula can be tested by calculating.

e.g., $V = \frac{1}{3}\pi r^2 h$. If the radius is doubled and the height is halved, its volume will

a) remain the same
b) be doubled
c) be four times as large
d) be eight times as large

10. In evaluating algebraic expressions, great care must be taken with negatives.

e.g., $x^2 - 5x + 4 =$ when $x = 3$

a) -5 b) -2 c) 2 d) 5

11. In using a calculator always try to estimate your answers.

12. The calculator can be used to check answers arrived at in other ways.

e.g., Solve $3x + 5 = 14$

(Solve as usual, then test your answer with a calculator.)