The Use of Calculators for Problem Solving in the Elementary School

An Honors Thesis (ID 499)

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Introduction

We are faced with a variety of problems each day; whether in schoolwork, in our homes, or on the job. Problems are part of our lives and always will be. Problem solving, however, can be one of the most difficult and least popular skills educators and students must face. The hand-held calculator is a tool that can both motivate students and enhance problem-solving instruction.

Calculators, once quite expensive, are now quite common in our homes and workplaces. They come in all shapes and sizes. Calculators are constantly being improved and even made smaller to accommodate our changing society, a high-technological society. It is important that children are instructed how to use this technology to its fullest advantage.

Recent recommendations for mathematics also include a stronger emphasis on both problem solving and the use of calculators. Despite these recommendations, the use of calculators for problem solving has not happened all at once due to opposition and the lack of teacher training and curriculum materials. I hope to not only encourage and support the use of calculators for problem solving, but provide several ideas to introduce calculators into the elementary mathematics classroom and show how they can be used for problem solving.
Problem Solving

Of all the creatures on earth, human beings have the greatest ability to create and solve problems. A problem is a situation in which there is a difference between how things are and how one would like them to be. Problems come in all different shapes and sizes. Each of us are continually faced with problems, both big and small. The problem is an obstacle between us and something we want, and we must overcome or remove the obstacle.

Problem solving is a unifying theme in education. That is, much of education is directed toward understanding problems and learning how to solve them. "In good instruction, problem solving is always present, for problem solving is learning and learning is problem solving." (5,p.40)

There are many different types of problems. A good problem is open-ended and it can be interpreted in different ways. Several procedures for arriving at the solution are possible or more than one strategy may exist. A good problem provides for maximum involvement on the part of the pupils and minimum teacher direction. It leads to further problems and can be integrated into other areas of study. "Our goal as elementary teachers is to help children learn to solve a wide spectrum of problems: we help them to learn word attack and comprehension skills in reading, to use inquiry skills in science, to
analyze the reasons why events occurred in social studies, and to cope with social interactions. And in mathematics, we present story or word problems and applications. Knowledge, skills, and understandings are important elements of mathematical learning, but it is in problem solving that the child synthesizes these components in order to answer a question, make a decision, or achieve a goal." (18,p.22)

Unfortunately, tests indicate that students have serious deficiencies in problem-solving abilities, more than with computational skills. Some students who can perform the computational skills quite well, often cannot solve word problems that require the application of those same computational skills. "An examination of current mathematics texts and the results of classroom visitations reveal that problem solving is only a minor part of the mathematics instruction in both elementary and secondary schools." (13,p.41) It should not be surprising then that problem solving has been a concern for years. Renewed attention, however, was focused on it by two reports.

The first, prepared by the National Council of Supervisors of Mathematics (NCSM) in 1977, was a position paper on basic skills. Listed first of the ten skills was problem solving.

"Learning to solve problems is the principal reason for studying mathematics. Problem solving is the process of applying previously acquired knowledge to new and unfamiliar situations. Solving word problems in texts is one form of problem
solving, but students also should be faced with non-textbook problems. Problem-solving strategies involve posing questions, analyzing situations, translating results, illustrating results, drawing diagrams, and using trial and error. In solving problems, students need to be able to apply the rules of logic necessary to arrive at valid conclusions. They must be able to determine which facts are relevant. They should be unfearful of arriving at tentative conclusions, and they must be willing to subject these conclusions to scrutiny.” (18,p.7)

The second was issued by the National Council of Teachers of Mathematics (NCTM) in An Agenda for Action: Recommendations for School Mathematics of the 1980s. In this report, recommendation number one states "Problem solving must be the focus of school mathematics in the 1980s." (12,p.3) NCTM just recently published the Curriculum and Evaluation Standards for School Mathematics in March 1989. Problem solving shows itself in this report also. "The Standards emphasize that problem solving should be the focus of the mathematics curriculum. A problem-solving emphasis furnishes a context for the meaningful learning of concepts and skills and fosters the development of pupils' higher-level thinking processes. Further, the Standards emphasize the importance of establishing an inquiry-oriented, problem-solving classroom environment for all mathematics instruction." (23,p.17)

Although test results and studies show that children are lacking in the area of problem solving and national recommendations support an increase in problem-solving
instruction, it must be noted "Students are not nearly as excited about problem solving as are their teachers. Thus it is essential that we search for ways to motivate problem-solving instruction." (20,p.53)

Motivation is an ongoing need in all areas of education, not just with problem solving. If a child does not enjoy reading, educators find reading material that interests him or her and provides motivation to read. The same should be true for mathematics, especially for problem solving. The hand-held calculator may very well be that motivational tool.

Calculators

"The calculator will act as a motivational tool for many students. Successful use of a calculator by students will help them develop more confidence in their ability to solve problems, a quality that is missing all too often in many of today's students." (28,p.16) "The calculator is a tool that can make learning mathematical concepts more meaningful. It gives students new opportunities to apply concepts and new opportunities for discovery. And it motivates all students, even the most reluctant learners." (24,p.53) "Research claims that calculators do not hinder motivation for learning mathematics, nor do they act to negatively influence the development of positive attitudes toward mathematical
David Williams states that "The late 1970s and early 1980s witnessed many national reports and studies recommending substantive changes in the elementary school mathematics curriculum—all recommended the use of calculators." (26,p.8) He also states that in "The Mathematical Sciences Curriculum K-12: What Is Still Fundamental and What Is Not (Conference Board of Mathematical Sciences, 1975) it is recommended that existing mathematics courses be drastically changed and that calculators and computers be introduced into the mathematics curriculum at the earliest grade practicable." (26,p.8) The National Council of Teachers of Mathematics also issued its support for calculators. In An Agenda for Action, recommendation number three states "Mathematics programs must take full advantage of the power of calculators and computers at all grades." (12,p.8) This recommendation urges that students have access to calculators and that calculator use be integrated into the mathematics curriculum on a routine basis, not as a replacement for pencil-and-paper skills, but as an enhancement to the curriculum.

The following is NCTM's official position on calculators in the mathematics classroom as published in Arithmetic Teacher, February 1987.

"The National Council of Teachers of Mathematics recommends the integration of the calculator into the school mathematics program at all grade levels in classwork, homework, and evaluation. Although extensively used in society, calculators are used far less in
schools, where they could free large amounts of time that students currently spend practicing computation. The time gained should be spent helping students to understand mathematics, to develop reasoning and problem-solving strategies, and, in general, to use and apply mathematics.

At each grade level every student should be taught how and when to use the calculator. To use calculators effectively, students must be able to estimate and to judge the reasonableness of results. Consequently, an understanding of operations and a knowledge of basic facts are as important as ever. The evaluation of student understanding of mathematical concepts and their application, including standardized tests, should be designed to allow the use of the calculator.

The National Council of Teachers of Mathematics recommends that all students use calculators to:

* concentrate on the problem-solving process rather than on the calculations associated with problems;
* gain access to mathematics beyond the students' level of computational skills;
* explore, develop, and reinforce concepts including estimation, computation, approximation, and properties;
* experiment with mathematical ideas and discover patterns;
* perform those tedious computations that arise when working with real data in problem-solving situations." (14,p.61)

David Williams states that "Despite these recommendations, little has been done to integrate calculator use into our nation's elementary school classrooms." (26,pp.8-9) "If we are to implement fully the Agenda's recommendation then it is time to reaffirm the viable role of the calculator in the teaching and learning of mathematics. The calculator has the potential to influence mathematics instruction. Perhaps no other topic is more
timely for mathematics teachers at all levels. Each teacher of mathematics has an essential role to play in developing new materials and practices for the calculator." (8,p.2)

Calculator Support and Opposition

The use of calculators in the home and in business is quite common. From a simple calculator, the size of a credit card, used to balance a checkbook to a sophisticated cash register used in a department store, calculators are a part of today's society. The calculator is, however, slowly invading the elementary classroom and is not being used to its fullest advantage.

One reason for the slow integration of calculators into the elementary school curriculum stems from the confusion among educators and parents over the calculator's role and purpose in the mathematics curriculum. David Moursund states that "Some view the calculator as an innovative, instructional aid capable of enriching and extending present curriculum goals. Others fear the calculator to be capable of devastating the school curriculum, transforming students into nonthinking, blurry-eyed button pushers." (11,p.181)

"Opponents argue calculators (1) destroy all motivation for learning the basic facts, (2) discourage mathematical thinking, (3) cause a dependence on them for all
calculations, (4) are inappropriate for slow learners, (5) block the opportunity to fully understand algorithmic process, and (6) develop the notion that mathematics is nothing more than pressing buttons on a black box."

(11, pp.181-182)

Teachers have been afraid that calculator usage in the classroom would be detrimental to mathematics instruction. They have said that children would not memorize the basic facts or learn how to work with numbers. Just the opposite has occurred. If they are used properly, calculators can reinforce the mathematics curriculum. Proper use of the calculator requires knowledge of basic facts and strengthens number skills. Students must also develop estimation skills and be able to recognize any unreasonable answers.

Still others feel that calculators do not require thinking. Calculators do not think, however; they only follow the operator's instructions. "In fact, a very strong argument can be made that using calculators actually increases student thinking. More specifically, it frees students from tedious and laborious computation and allows them to dwell on the important problem-solving processes that generally precede the arithmetic computation." (18,p.11)

"The National Science Foundation (NSF) funded an investigation into the role of the calculator. The study was to identify the beliefs and reactions regarding calculator use in school as well as the arguments in support of
incorporating calculators within the school mathematics curriculum. Here are some of the most frequent reasons for using calculators.

(1) They aid in computation. They are practical, convenient, and efficient. They remove drudgery and save time on tedious calculation. They are less frustrating, especially for low achievers.

(2) They facilitate understanding and concept development.

(3) They lessen the need for memorization especially when used to reinforce basic facts and concepts with immediate feedback. They encourage estimation, approximation, and verification.

(4) They motivate. They encourage curiosity, positive attitudes, and independence.

(5) They aid in exploring, understanding, and learning algorithmic processes.

(6) They encourage discovery, exploration, and creativity.

(7) They help in problem solving. Problems can be more realistic, and the scope of problem solving can be enlarged.

(8) They exist. They are here to stay in the real world; so we cannot ignore them." (9, pp. 7-8)

In past years research shows that there are no measurable ill effects and that the calculator can be a powerful teaching and learning tool. (18, p. 11)

According to Joan Spiker and Ray Kurtz, "Calculators should not be thought of as a shortcut or a crutch or used in lieu of children's learning the basic facts." (21, p. 27) "Calculators cannot serve as a substitute for good teaching or for the use of concrete materials or manipulatives in the classroom." (9, p. 64) By using calculators, it is hoped
that children will be at ease with technology and be able to move into the computer age. The obvious functional uses of calculators and their perhaps not-so-obvious uses as instructional aids continue to be ignored by educators. Despite all of the "excuses", the only real obstacle to the use of calculators in the elementary mathematics curriculum is our attitudes and beliefs.

Introduction to Calculators

The hand-held calculator is a powerful, problem-solving tool. But like any tool, the calculator will not be useful or effective without a good operator. A construction worker is not expected to operate a power saw without first understanding how to use it. A seamstress does not use a sewing machine without proper instruction and understanding of the tool. The same is true for students and calculators.

"Students must have a good background in manipulative math experiences before they can understand the inputs and outputs of the calculator." (7, p. 48) They should understand the nature of the processes basic to mathematics. If students understand the reasons underlying the various operations, then they should be given a calculator to do them. According to Robert Reys, "The student must still be
able to determine how to solve a problem before he or she can use a calculator to attain the solution." (18,p.25) The National Council of Teachers of Mathematics also states that "Students must obtain a working knowledge of how to use them (calculators), including the ways in which one communicates with each and commands their services in problem solving." (12,p.8)

Whenever calculators are first introduced, students will be very excited. This initial excitement will subside, but both motivation and enthusiasm will continue. Mathematics instruction should take advantage of and build on this excitement. (Introductory topics and activities are given in the section Classroom Ideas for Teachers.)

Use of Calculators for Problem Solving

It can be agreed that the calculator has a place in the curriculum and, when used properly, the calculator is a valuable motivational and computational tool. "The fact of the matter is that the calculator can be used in a variety of ways and should be an indispensable part of mathematics instruction." (10,p.18) Since calculators are and will continue to be a dominant way of doing arithmetic in the home and at work, changes in our instruction of mathematics will be necessary.
Problem solving should pervade the mathematics curriculum. Children need many experiences with problems that they do not immediately know how to solve. Moreover, they should be taught to use a variety of problem-solving strategies, providing them with a repertoire from which they can draw. You will need to provide not only a large resource of good problems, but also enough time for problem solving. Your instruction must coordinate textbook materials with the use of calculators and other technology, as well as large-group, small-group, and individual work." (18,p.34)

Not only does the use of calculators motivate children for problem solving, but using calculators allows students to focus on problem-solving situations. Using the calculator avoids the rote memorization of rules to solve verbal problems. Calculator use also provides immediate feedback for students' results. Teacher correction is not immediately needed and the students can progress independently.

Finding the answer has generally been the only objective in problem solving. When the answer is stressed, students may learn to solve particular types of problems. If the process is stressed, however, children are more likely to be successful with other problems. Calculators help shift students' attention from the computational aspects of the problem to the relevant factors used to solve the problem. They can spend more time analyzing and interpreting the actual problem at hand.
When the drudgery of computation no longer stands in the way, students can also use more problem-solving strategies and consider more complex problems or problems with realistic data. The National Council of Teachers of Mathematics best summarized this when it said that "The calculator puts the emphasis on 'what to do' rather than on 'how to do it'. And most important, everyone can do it!" (15, p. 117)

When students study mathematics in school, their understanding of and enthusiasm for the subject is often limited by the artificial "real-life" applications they confront in their textbooks. Textbook problems, which propose situations that have little to do with elementary students' lives and usually come out evenly, rarely promote the idea that mathematics is a useful tool for solving problems important to everyday life. Since problem solving is the process of applying previously acquired knowledge to new and unfamiliar situations and real-world problems rarely occur in a form for which an answer is immediately known, it is important to provide students with the opportunity to practice these important problem-solving skills with real-life problems. The calculator allows the teacher and students to get away from the synthetic numbers and oversimplified situations and become involved in solving real-world problems outside the doors of the classroom. (11, pp. 106-107)
Real-world problems may show themselves in a variety of forms for use within the elementary school mathematics curriculum. Newspaper advertisements, supermarket coupons, and mail-order catalogs are just three examples of real-life data for problem solving. Everyday situations in the home or classroom may also provide students with real-life applications. It should be emphasized to students that the calculator is also a convenient tool for gathering information and data about themselves. Bernard Yvon gives several examples of this. "For instance, have them average their own grades, the capacity of their lungs, the average time they can run a certain distance, the area of the skin on their bodies, or their age in minutes or hours." (28,p.19) The possibilities go on and on. The student themselves may also create their own problems, problems not bound by paper-and-pencil computation. (Several problem-solving examples can be found in the following section, Classroom Ideas for Teachers.)

Whether students are concentrating on using the calculator for textbook problems, real-life problems, or their own creations, it is always important to examine the results for reasonableness. Calculators or other machines cannot always be counted on when needed, so students should possess the ability to estimate while using the calculator and check its accuracy. Opportunities should also be taken to emphasize occasions when the calculator might not be used. Some computations are much easier to complete without the
calculator. Over time students should be able to judge whether or not the calculator will be useful and effective for the task at hand.

It is important that students be shown the value of the calculator as a problem-solving tool. The following are calculator advantages as shared by Phares G. O'Daffer in *Arithmetic Teacher*:

"*Computational power is available to all students.*
*More practice can be offered in a shorter period of time.*
*Students using calculators may increase their willingness to take risks and become more creative problem solvers." (16,p. 45)

The calculator can contribute immensely to problem-solving instruction, changing "an elementary school mathematics curriculum dependent on paper and pencil to one that teaches our students to think and solve problems." (26,p.9)
Problem Solving

As was said earlier, there are many different types of problems. Mathematics problems can be solved using a four-stage model of problem solving proposed by George Polya.

"*First, understand the problem.  
*Second, devise a plan for solving it.  
*Third, carry out your plan.  
*Fourth, look back to examine the solution obtained." (18, p. 26)

Specific strategies are helpful to move through the problem-solving model. It is important for children to gain confidence in each because a variety of strategies may be possible or necessary for one problem. These strategies give children a starting point to attack a problem and provide alternatives when a particular strategy fails. The following are problem-solving strategies as given by Robert Reys:

"1. Act It Out  
2. Making a Drawing or Diagram  
3. Look for a Pattern  
4. Construct a Table  
5. Account Systematically for All Possibilities  
6. Guess and Check  
7. Work Backward  
8. Identify Wanted, Given, and Needed Information  
9. Write an Open Sentence  
10. Solve a Simpler or Similar Problem  
11. Change Your Point of View" (18, pp. 27-32)
Looking back and thinking about how the problem was solved is extremely important. Time should be spent discussing and reconsidering the thinking involved. Robert Reys states that this may be more important than any other strategy in helping children become better problem solvers. (18,p.32)

Another helpful method to teach problem solving to elementary school children is for the teacher to be a good role model. Teachers must encourage the enjoyment of problem solving. A positive attitude toward problem solving on the part of the teacher will inspire a similar attitude by the students. Here are some specific ideas that teachers can and should do in the classroom to promote problem solving.

"1. Create an atmosphere of success.
2. Provide an ample supply of challenging problems for problem-solving practice.
3. Help students develop the techniques to read problems analytically.
4. Require students to create their own problems.
5. Have students work together in pairs or small groups.
6. Encourage students to attempt alternate strategies.
7. Raise creative, constructive questions when leading a problem-solving discussion, as a model for students to emulate.
8. Require students to estimate their answers.
9. Use strategy games to develop the problem-solving process.
10. Have students make a flowchart of their own problem-solving procedures." (27,p.124)

A problem file, organized by mathematical content or strategies, will be a great asset to the classroom.
Students can go to this file for sources of problems during free time. It will be helpful if each problem is put on a card and then laminated so that they may be used over and over again by students. The following are examples of problems that may be excellent ideas for a problem file.

**Personalized Problems**

The first three problems below were donated by Jean M. Shaw, University of Mississippi, to Readers' Dialogue of Arithmetic Teacher.

1. "Take your pulse for three or four minutes. Find your average number of heart beats a minute. Now use your calculator to compute (a) the number of times your heart beats in an hour, (b) the number of times your heart beats in a day, and (c) the number of times your heart will beat between your birth and age forty.

2. Time your breathing for three or four minutes. Then figure your average number of breaths a minute. On the basis of your average, (a) how many breaths do you take in a day, (b) how many breaths have you taken so far in your life, and (c) how many breaths will you take between now and Christmas?

3. Measure your height in centimeters. Use your calculator to help you find (a) how many of your heights make 1 km, (b) how many of your heights would stretch from New York to Los Angeles (about 4460 km), and (c) how many of your heights would stretch from ___ to ___ (fill in some places)." (17, p. 5)

4. "How many times can you write your name in 1 minute? In an hour? How many hours would it take you to write your name 5000 times?" (16, p. 44)

5. "What is your age in years? In months? In hours? In seconds?"
6. Estimate the number of hours you watch television in a year.

7. Estimate the number of hours you spend eating in a year."

(11, pp. 150-151)

"Shopping with a Calculator"

The following real-life application was shared by Donnie Bain in Readers' Dialogue of Arithmetic Teacher, February 1987, page 6.

"This year give your students a $1000.00 shopping spree and at the same time practice with discounts and sales tax. All you need are some catalogs from mail-order houses or local retail stores and a recording sheet for purchases. Make sure the catalogs have a wide variety of items and prices that will interest your students.

The goal of this activity is to buy at least ten items of different prices and spend exactly $1000.00. It sounds easy so but here is the twist - different prices receive different rates of discount, and sales tax must be added to the discount price. I use the following table for discount rates:

If the item's cost is -

$0.00 - $24.99, the discount is 10%;
$25.00 - $74.99, the discount is 15%;
$75.00 - 149.99, the discount is 20%;
$150.00 or over, the discount is 25%

Sales tax is always 4 percent for each item.

I also give students a recording sheet like the one below to keep track of their purchases. To save space I have abbreviated the number of lines that normally fill a full page. Although the columns appear vertically here for publication purposes, use a horizontal treatment and include a spot for totaling the costs.
As you can imagine, buying the first eight or nine items is relatively easy, but finding the right items and prices to reach $1000.00 can be pretty challenging. All my students do this activity individually; I allow them to use their calculators. Each student will receive a grade according to how close they can get to $1000.00. The scale I use is as follows:

- Exactly $1000.00 - 100
- within $0.25 - 95
- within $0.40 - 85
- within $0.50 - 75
- within $1.00 - 70
- within $2.00 - 65

Allow four or five days for your students to complete this activity. Lively discussions occur, and interesting items are purchased to reach that $1000.00 mark. Some students enjoy trying to figure out an equation to give them the final price they need to spend $1000.00. An ideal time in the year to use this activity is just before your December holidays.

All in all this is an enjoyable activity that does not require much preparation and provides practice with both percents and problem solving." (17, pp. 6, 15)

The above problem is excellent for the upper grades, but for the primary grades, playing "store" using calculators as cash registers can be just as exciting. The "store" can consist of actual items with price tags, catalog pictures, or grocery ads.

### Problems with Large Numbers

The following problems from David Moursund, *Calculators in the Classroom*, pages 149 to 151, are designed to give students practice in solving problems with large numbers.
1. "Suppose there are 24 students in a class. Each school day each student brings a penny and gives it to the teacher. At the end of the 180-day school year how many pennies will the teacher have? Is this enough to buy a new car?

2. The distance across the United States is about 5,000 km. Suppose that a person can walk 3 km/hr and 8 hours per day. How many days would it take to walk across the country? Suppose a car is driven at 85 km/hr for 8 hours per day. How many days will it take for it to cross the country?

3. In a classic story a servant performs a good deed for the king. The king asks what reward the servant would like. The servant requests one grain of wheat for the first square on a chess board. Find approximate values for the number of grains the servant is requesting for the 64th square and for the total.

4. A factory worker is paid $7.85 per hour. If the worker works 8 hours per day, five days per week, 52 weeks per year, for 40 years, what will the total pay be?

5. A particular novel has about 12 words per line, 58 lines per page, and 375 pages. How long will it take to read this novel if one can read 260 words per minute?" (11,pp.149-151)

Calculators

Before actually using the calculator in the classroom, here is a possible checklist to follow as given by Robert Reys:

"*Show the children several types of calculators.
*Ask how many children have used a calculator.
*Ask how many own their own calculator.
*Discuss with children what they think a calculator is for.
*If possible, show the students the inside of a calculator." (18,p.12)
When calculators are first used, it is ideal to have a one-to-one ratio between students and calculators. The best introduction is to just allow the students to begin working with the calculator and exploring on their own. "Letting students experiment with their calculator (usually 3 to 5 minutes) will reduce the initial excitement to a manageable level. Most students will then be eager for guidance." (18, p.12) Of course, the time spent on activities will depend on the students' level, background, and interests.

After students explore on their own, a description of the keys and their functions should be given. Any special features (i.e. auto power-off, all clear, and memory keys) of the calculator model being used should be explained at this time. There are a few vocabulary words that should be introduced also: calculator, keyboard, display, and solar power.

Location exercises should be done with calculators. Children should locate each number, key it in, and clear. Practice should be given entering numbers as shown on the fingering chart (fig.1) as well as some basic addition and subtraction problems.

![Fingering Chart](image-url)
Location exercises may also be done using a large keyboard chart made from posterboard or using a large floor mat depicting the calculator keyboard as described by Charles Watson and Judy Trowell.

Materials: oil cloth or white sheet
            colored tape
            stick-on letters and numbers

Instructions: Using the oil cloth or sheet for a base, design the keyboard by using the colored tape to form the display and keys. Stick-on letters and numbers may be used to complete the keyboard according to the model being used.

When the "calculator" is completed, "each student is given an opportunity to hop from one location to another as directed by the teacher or another student to become more familiar with the location of the number and function keys. A floor mat is also used to help students learn the correct sequence for keying a problem into the calculator. For example, to enact the problem 2+4=6, a student begins by hopping to the 'on' key, then to the '2,' to the '+,' to the '4,' and finally to the '=' key. After this sequence the student states what was shown on the display, then hops to the 'clear' key. While one student is on the floor mat, others use their calculators to perform each step with the action on the mat." (24, pp. 51-52)

There are several books of calculator games and puzzles available today. Most of these were designed to entertain, but every calculator game has educational value even if it is just practice in working with the calculator. The following are examples of calculator games that will not only be entertaining and provide calculator practice, but will encourage
students to develop strategies for playing the game, and thus enhance problem-solving skills. Just as with problem-solving ideas, these calculators games may be great additions to any game file.

Calculator Games

The following calculator games from David Moursund, *Calculators in the Classroom*, are just a few examples of strategy games that may be played in pairs or small groups.

1. "Nim. Two players work together on one calculator. A target number such as 21 is selected. The calculator is cleared. Students take turns adding in 1, 2, or 3. The first person to reach or exceed the target number loses. Some variations:
   a. First person to reach or exceed the target wins.
   b. Use a larger target number and select the number to be added from the list 1, 4, 7.
   c. Start at a positive number and work backward by subtraction. The target is zero.

2. Single digit key. All of the digits on your calculator are broken except the 'four' key. Can you make the display show the number 17? What is the smallest number of keystrokes needed? Variations:
   a. Any target number (not just 17) may be selected.
   b. A single digit other than 4 may be used as the digit key that functions.
   c. If a calculator has a four-key memory, its use may be allowed.
   d. Allow two different digit keys to be functional.
   e. Have one of the operation keys, such as '+', also be broken.

3. Looking for One. This game is played by two students with one calculator. To begin the game, students agree upon numerical limits, say 1 and 100. One student, without the knowledge of the other selects a number within these limits, say 38, and keys it into the calculator followed by ' '/', then creating a division constant. (Be careful not to press 'C' at any time during a turn. Clearing the machine will wipe out this constant.) The second student attempts
to discover the 'mystery number' by keying numbers followed by '='. The number '1' will appear on the display screen when the 'mystery number' is discovered. Suppose the second student keys in '50' on the first try. This gives 1.3157894, indicating 50 is too large. Next, the student tries 35. This gives 0.9210526 - too small. After two more tries 38 gives '1.' Each attempt carries the score of one point. Thus, in this example, the second student scores four points. Students keep their own scores. After five turns each, scores are compared. The student with the least number of points wins the game. Variations:
a. For younger students, limit 'mystery numbers' to between 1 and 10.
b. For students with good estimation skills, use three- and four-digit 'mystery numbers.'

Instructor's Big Book of Absolutely Everything, page 111, also lists calculator games that are helpful in developing strategies.

1. "Find the number. Divide students into teams, then write a large number on the board, such as 1476383. The object of the game is to combine various numbers and operations that will result in this number. Start the teams off by giving them a simple problem like 3 x 9 to calculate, then let them devise their own calculations from there. First team to reach the number wins.

2. Calculator Lottery. Write numbers, fractions, or decimals in separate one-inch squares of cardboard. Place these in a large empty container. Have kids take turns picking two cards from the can and using their calculators to add, multiply, or divide both numbers to get the highest number possible with each turn. Player with the highest score wins." (1, p.111)

Calculator Selection

There are many different makes and models of calculators available today. When selecting calculators for elementary school children, Charles Watson and Judy Trowell suggest
1. Size of the calculator and its keys: The keyboard should be large enough to use accurately when pressing keys.
2. Sturdiness: The model should be sturdy enough to withstand heavy usage.
3. Readability of the display.
4. Power source: Solar-powered calculators are preferred, eliminating the need for constant replacement of batteries.
5. Number of functions: Too many functions may be distracting. A calculator with the four basic functions is best.
6. Type of logic: It is important to know the order in which the keys must be struck.

The most important guideline to follow when purchasing a calculator, however, is to buy one with all the needed features, but as simple as possible.

The following are addresses of three of the most popular calculator producers that may be able to offer additional information on what is available for elementary schools. Many educational materials companies also offer calculators and calculator materials.

Casio, Inc.
570 Mount Pleasant Avenue
P.O. Box 7000
Dover, New Jersey 07801

Sharp Electronics Corporation
Sharp Plaza
Mahwah, New Jersey 07430-2135

Texas Instruments Incorporated
P.O. Box 53
Lubbock, Texas 79408
Resource List


Summary and Conclusion

Research shows that problem solving and calculator usage are important aspects of the mathematics curriculum. Mathematics instruction should not only provide a variety of problem-solving strategies, but a large resource of good problems that are no longer bound by the limits of paper-and-pencil computations. The calculator removes this boundary and allows students to concentrate on the process used to solve a problem rather than on the answer. The calculator also provides motivation and encouragement to attempt further problems.

Teachers have the responsibility to show other teachers, parents, administrators, and students that the calculator can supplement and extend problem-solving instruction. It is important that students be properly introduced to calculators and once they understand how to use the calculator, the sky is the limit! Students will enjoy using the calculator to solve many real-life problems. I hope that I have provided several classroom ideas and resources for introductory activities, problem-solving activities, and calculator games that will motivate and encourage elementary students to think and solve problems which is the primary goal of education.
Bibliography


