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ABSTRACT

The issue of how to integrate information technology in the teaching/learning environment remains strongly associated with the use of the computer as a tool. While technology based tools such as Logo have been advocated for problem solvers at the elementary level, spreadsheets have a great deal of potential for use at both the junior and senior high school levels. In this paper, alternatives to the solution of a variety of math problems, ranging from story problems to finding the root of equations, are explored. Although not all problems lend themselves to the use of spreadsheets, such an approach does add a viable alternative to existing problem solving strategies. The greater the number of strategies available to students, the more likely it is that differences in learning styles can be accommodated. Seven figures depict solutions to the sample problems. (Author)

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Let's not let The Number of Warthogs be 'X'

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Abstract

The issue of how to integrate information technology into the teaching/learning environment remains strongly associated with the use of the computer as a tool. While technology based tools such as Logo have been advocated for problem solvers at the elementary level, spreadsheets have a great deal of potential for use at both the junior and senior high school levels. In this presentation, alternatives to the solution of a variety of math problems, ranging from story problems to finding the roots of equations, will be explored. Although not all problems lend themselves to the use of the spreadsheet, such an approach *does* add a viable alternative to existing problem solving strategies. The greater the number of strategies available to students, the more likely it is that differences in learning style can be accommodated.

Introduction

It is now approximately fifteen years since micrmputers appeared in the schools; many interesting phases have been witnessed since the inception. At first, in the 'euphoric phase', attention focussed on the issues of what type of computers to buy, how many there should be, and equality of access. Sheingold (1991) acknowledged this phase quite recently in remarking that "computer-based technology has been brought into schools during the past decade largely because the technology was seen as being important in and of itself". Attention next turned to "but what do we do with them" and in the absence of quality educational software, a widespread computer programming epidemic broke out thereby marking the 'dawn of reality' phase. Fortunately, during this period, productivity and general purpose software emerged. This eventuality marked a very significant downturn in the popularity of computer programming and gave rise to the 'exploitation phase' during which the computer could be employed as a general purpose tool by teachers and students alike. Despite the passage of time and rapid advances in information technology, the 'electronic education phase' that visionaries had predicted is still not a pervasive reality. The burning issue of how to integrate information technology into the teaching/learning environment thus remains strongly associated with the use of the computer as a tool. This presentation will describe and demonstrate a number of ways in which the spreadsheet can be exploited in the mathematics classroom and through them, examine the problem solving strategies available to students. An assumption is made that students have been introduced to spreadsheet basics.

Of Warthogs and Cockatoos

The first example presented represents the classic story problem an example of which is as follows:

> The total number of legs in a group of 14 animals is 38. The group contains only cockatoos, which have 2 legs each, and warthogs, which have 4 legs each. How many warthogs are there?

The traditional approach to solving a story problem of this type is to begin by saying "let the number of warthogs be X" then proceed to establish and solve a set of simultaneous equations. Such a rigorous, analytical strategy can be very appealing to the mathematically inclined but less so to those who are not. The less mathematically inclined might choose to make an inspired estimate of the number of animals of each animal type, determine how many legs are implied and then adjust their estimate until they zero in on the answer—the trial and error method. Both strategies are perfectly valid. The spreadsheet offers a number of middle-ground alternatives which serve to widen the spectrum of problem solving strategies available to students. Three potential strategies that students might employ in solving the warthogs and cockatoos problem are described below in order of increasing level of sophistication.

Strategy 1

One of the simplest anticipated solutions might contain three columns as shown in Figure 1. Column 'A' contains an increasing sequence of natural numbers from one to fourteen (corresponding to the potential number of cockatoos in the group of animals); the students may either enter these numbers directly or generate them using a simple formula as shown. Column 'B' contains the corresponding number of warthogs (fourteen minus the number of cockatoos); these numbers may also be entered directly or generated by a formula. Column 'C' uses a formula to calculate the total number of legs for the fourteen animals (two times the number of cockatoos plus four times the number of warthogs). While this formula could be entered into each cell, students should be expected to be familiar with the simpler concepts of copying formulas between cells.

	A	B	C
1	#COCKATOOS	# WARTHOGS	TOTAL LEGS
2	----------	----------	----------
3	1	13	54
4	2	12	32
5	3	11	50
6	4	10	48
7	5	9	46
8	6	8	44
9	7	7	42
10	8	6	40
11	9	5	38
12	10	4	36
13	11	3	34
14	12	2	32
15	13	1	30
16	14	0	28
17			

=A15+1 =14-A16

=(A16*2)+(B16*4)

Figure 1.
Warthogs and cockatoos—strategy 1

The answer to the problem is obtained by scanning down column 'B' to locate the cell where the total number of legs is 38 (row 11 in this example); the answer to the problem is then derived from the corresponding cell in columns 'A' i.e. there are 5 warthogs.

Strategy 2

The solution shown in Figure 2 reflects an entirely different way of thinking about the same problem. As with solution 1, column 'A' is filled with the natural numbers from one to fourteen to represent the number of animals. In column 'B', each animal is given two legs because each animal type represented in the group has at least two legs (thereby accounting for the first 28 legs). This column can be filled manually or using a simple incrementing formula. The "leftover legs" are next allocated two at a time in column 'C' thereby "creating" the four legged animals. Cell 'C17' contains a formula which calculates and displays the running total of the legs allocated. When this total equals thirty eight, one simply counts the number of animals which have an extra pair of legs—this will be the animal number read from column 'A' corresponding to the last entry in column 'C'.

	A	B	C
1	ANIMAL #	INIT. LEG ALLOCN	EXTRA LEGS
2	=======	============	========
3	1	2	2
4	2	2	2
5	3	2	2
6	4	2	2
7	5	2	2
8	6	2	
9	7	2	
10	8	2	
11	9	2	
12	10	2	
13	11	2	
14	12	2	
15	13	2	
16	14	2	
17		28	38

=Sum(B3:B16) =Sum(B3:C16)

Figure 2.
Warthogs and cockatoos—strategy 2

Strategy 3

The solution shown in Figure 3 is an automated version of solution 2 and is presented here to illustrate the potential variety of student approaches which might be anticipated. Column 'A' and column 'B' are filled in one of the ways described previously. The first entry in column 'C' contains the number "2". Cells 'C4' to 'C16' contain a formula which automatically allocates an extra pair of legs to the animals until all 38 legs have been assigned. The answer is read in the same manner as for solution 2.

	A	B	C
1	ANIMAL #	INIT. LEG ALLOCN.	EXTRA LEGS
2	=======	============	========
3	1	2	2
4	2	2	2
5	3	2	2
6	4	2	2
7	5	2	2
8	6	2	0
9	7	2	0
10	8	2	0
11	9	2	0
12	10	2	0
13	11	2	0
14	12	2	0
15	13	2	0
16	14	2	0
17		28	38

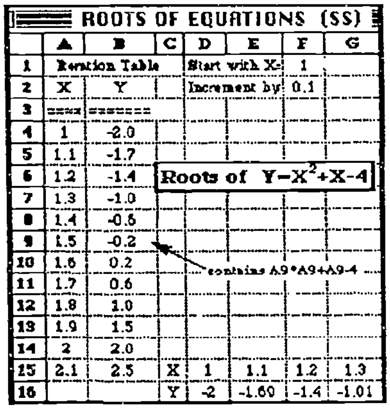
=If(B17+Sum(C3:C3)<38,2,0)

Figure 3.
Warthogs and cockatoos—strategy 3

This third solution is the most sophisticated of the three that have been presented. This solution entails the use of absolute cell references and the "logical if" function—it clearly requires a higher level of proficiency with the spreadsheet.

Finding the Roots of Equations

In mathematics, students are taught a variety of methods of "solving" (or finding the roots of) equations ranging from factoring to synthetic division to graphical analysis. Very often, however, equations do not have "nice roots" thereby lessening the convenience of algorithmic methods. In these instances, a simple spreadsheet (with or without plotting capability) can provide the learner with a viable tool for exploring the roots of equations by iteration. Figure 4 shows how this can be accomplished for a particular quadratic equation. As well, the approach described can provide the teacher with a very useful demonstration tool which allows for relatively quick and easy simulations.



ROOTS OF EQUATIONS (SS)

	A	B	C	D	E	F	G
1	Iteration Table			Start with X=		1	
2	X	Y		Increment by		0.1	
3	====	=======					
4	1	-2.0					
5	1.1	-1.7					
6	1.2	-1.4	Roots of Y=X^2+X-4				
7	1.3	-1.0					
8	1.4	-0.6					
9	1.5	-0.2					
10	1.6	0.2		contains A9*A9+A9-4			
11	1.7	0.6					
12	1.8	1.0					
13	1.9	1.5					
14	2	2.0					
15	2.1	2.5	X	1	1.1	1.2	1.3
16			Y	-2	-1.60	-1.4	-1.01

Figure 4.
Using a spreadsheet to estimate the roots of an equation

Using the graphical capability of the spreadsheet to plot the first iteration yields the graph shown in Figure 5. It is clear from the iteration table and reinforced by the graph that one root lies between "1" and "2" and the other lies between "-2" and "-3".

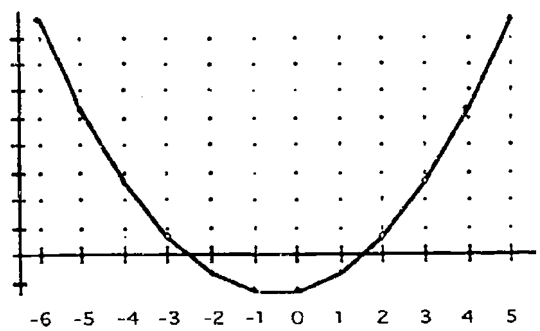


Figure 5.
Graph of $Y=X^2+X-4$, first iteration

From the graph of the first iteration, one of the roots is estimated to be x=1.5. If this root is required to further precision, a finer iteration can be carried out. The graph of such an iteration is shown in Figure 6—the start point and increment have been adjusted to zero in on the root.

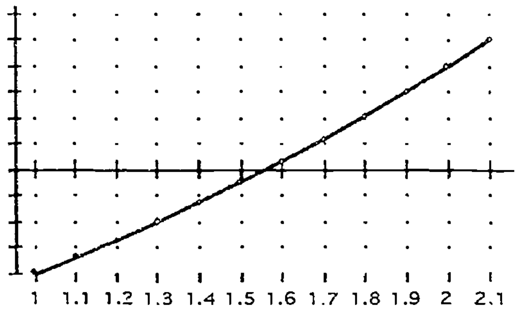


Figure 6.
Graph of $Y=X^2+X-4$, second iteration

From the second iteration, this root can now be estimated to two decimal places (x=1.56).

Towards Winning the State Lottery

This example, which is more broadly based than the previous two, has been descibed by Wright (1993). A student's desire to be successful in games of chance could be exploited to evoke an interest in random numbers. A general problem which might be assigned would be to develop an automated method of picking four natural numbers between one and ten. This problem, which lends itself well to a spreadsheet-based solution, can be approached with varying degrees of sophistication according to the extent to which the solutions address the question of repeated number selection. Figure 7 shows two potential solutions.

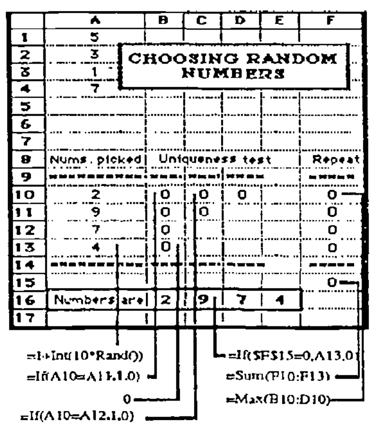


Figure 7.
Choosing four natural numbers between one and ten

The simpler of the two solutions is in cells 'A'1 to 'A4'. All this solution does is to employ the spreadsheet's random number generator to pick a number between one and ten—the prospect of selecting repeated numbers is not dealt with at all. The more sophisticated solution (in the block of cells 'A8' to 'G16') also does not avoid the selection of repeated numbers but it *does* check for their presence and will not print the selection in the dark-bordered box unless the four numbers *are* unique. Students may come up with one of many minor variations on the more sophisticated of the two solutions. An even more sophisticated solution might employ the use of macros to deal with repeated number selection.

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Discussion

This paper has described three diverse problem solving contexts within which the spreadsheet might be employed to considerable advantage—many others could have been presented. It could be argued that the degree of spreadsheet competency required in the case of strategy 3 for the warthogs and cockatoos problem supplants the complexity of the traditional, analytical approach. It could be argued, however, that the spreadsheet approach offers two benefits, notably: that it is more visual (less abstract) and therefore easier to relate to, and that it reflects an appropriate use of technology in an information technology age.

In the "roots of equations" example, the spreadsheet can also be employed to great advantage by the teacher to demonstrate various properties of equations. In so doing, the teacher is provided with a valuable opportunity to role model the effective use of information technology (Wright, 1993).

While technology based tools such as Logo have been advocated for problem solvers at the elementary level (e.g.Maddux, 1989), spreadsheets have a great deal of potential for use at both the junior and senior high school levels Alhough not all problems will lend themselves to the use of the spreadsheet, such an approach *does* add a viable alternative to existing problem solving strategies. The greater the number of strategies available, the more likely it is that differences in learning style can be accommodated.

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