

# Using technology linear equation

## Introduction

For the last three years I have been teaching mathematics to a group of students at Year 9 level who have rarely had success in mathematics, particularly in the area of algebra. Most of these students struggle with algebraic concepts and processes and generally have poor retention of any acquired knowledge. For the two years prior to this year the students in this class have struggled with the topic of solving linear equations, using incorrect operations to solve the equations, as well as not recognising the correct order to use the operations. The problems were most evident when students tried to solve equations where the pronumerals appeared on both sides of the equation. I needed a new way of teaching this topic so that these students could be successful in solving all types of linear equations. According to Stacey, Kendal and Pierce (2002) students using computer algebra systems (CAS) have the opportunity to fulfil their mathematical potential with less computational skill. The technology can be used to support learning and teaching of many different styles, including both teaching emphasising routine procedures, and teaching emphasising understanding.

Stephens and Konvalina (1999) report on an experiment in which groups of students were compared with respect to use/non-use of computer algebra software in the courses. They found that the students using the software outperformed the students not using the software on a common final exam and that these students expressed very positive feelings about the use of the software in the course.

I decided to use CAS as a pedagogical tool to facilitate learning about the process of solving linear equations. At the end of the topic the students were required to complete a

test without the use of CAS. This decision was based on my school requirements. The types of assessment tasks are set by the subject coordinator and individual teachers are not allowed to deviate from these due to the reporting system. At the end of the semester, my students are required to sit an examination for which a CAS calculator would not be allowed. Therefore it was important that my students were able to solve linear equations without the use of technology by the end of the unit.

When teaching these students it is deemed important to cover the same topics as all the other Year 9 students but at a slower pace, which means that some of the content of each topic is deleted. The decisions of what content to include in this topic were based on my students' abilities and the amount of time available to complete the unit.

The intention of this unit was to use CAS:

- to teach the students how to solve linear equations by paper and pencil; and
- to develop understanding of the processes needed to solve linear equations.

A series of worksheets was developed and trialled with the class. These worksheets included instructions related to use of the technology and also questions to develop students' ability to solve linear equations.

## The ways of using CAS

It was believed that CAS might be used

- as 'trainer wheels' to compensate for weakness in algebraic simplification and to support students' equation solving; and
- as a teacher of correct mathematical language.

# to introduce solving at Year 9



## CAS as 'trainer wheels'

'Trainer wheels' studies are designed around the theory that CAS use can support learners as they learn to carry out mathematical procedures for themselves. This can reduce the cognitive load and enable students to recover from errors within an attempted solution (Stacey, Asp & McCrae, 2000). Tynan and Asp (1998) worked with younger students beginning algebra (Year 9). In this study they used CAS as 'trainer wheels' when students were learning to solve equations by the 'do the same to both sides' method. Students could use the CAS to test the effect of actions, to check each line of their work and to recover when they had made mistakes. My students were required to use the CAS to see how the equations could be solved and then use this information to solve the equations without the use of CAS. Students can learn which procedures to perform without always being required to perform those procedures by hand (Heid, 2002). While using CAS, my students did choose incorrect operations and the CAS produced an unexpected result. This enabled the students to readily see the error they had made and then enabled them to correct the error by using another transformation. This gave the students more practice at inverse operations.

## CAS as a teacher of correct mathematical language

A CAS is a syntax-sensitive device that can help students think about each symbol that they enter. This sensitivity should help promote focussed and deliberate use of symbols instead of casual and careless use (Jakucyn & Kerr, 2002).

Before being able to use the CAS to solve an

equation, the equation needs to be entered into the calculator. To enter the equation the student needs to understand how the equation is formed and what operations were performed on the pronumeral and in what order. This makes the students think more about the set up of the equations. For example to type the equation  $2x + 1 = 5$ , the students need to enter  $2 \times x + 1 = 5$ ,  $x$ . They become more aware that  $2x$  means  $2 \times x$  and at the same time that they will need to divide by 2 in order to inverse this operation. This was particularly important when solving equations of the form .

$$\frac{ax + c}{b} = d$$

In order to enter this equation correctly, parentheses are required around the numerator. That is, the students needed to type:  $(a \times x + c) \div b = d$ ,  $x$ . This helped the students to see that the division by  $b$  was the last operation and hence the first transformation required was to multiply both sides by  $b$ .

The students also need to tell the calculator which variable they are solving for. Doing this helps the student to focus on the purpose.

## Why use Symbolic Math Guide (SMG)

The TI-89 can be used in three ways to solve linear equations. Firstly students can use the 'solve' command directly. Using this command requires the student to type in the equation and indicate which variable needs to be solved, then a solution is produced without any intermediate steps. The output produced by the calculator is shown in Figure 1.

The student does not require any understanding of the process used to solve the equation. The aim of my unit of work was for students to understand and use correct proce-

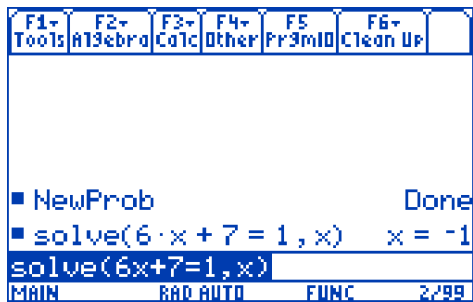


Figure 1

dures to solve linear equations, not just to get correct answers.

The use of technology in mathematics teaching is not for the purpose of teaching about technology, but for the purpose of enhancing mathematics teaching and learning with technology. Indeed, the use of technology in mathematics teaching should support and facilitate conceptual development, exploration, reasoning, and problem solving. Technology should not be used to carry out procedures without appropriate mathematical understanding (Lederman & Niess, 2000).

Secondly, an equation can be solved by typing in the equation and then manually using inverse operations to solve the equation step by step. This process produces steps in a form not familiar to my students. Figure 2 shows the output produced by the calculator when using this process.

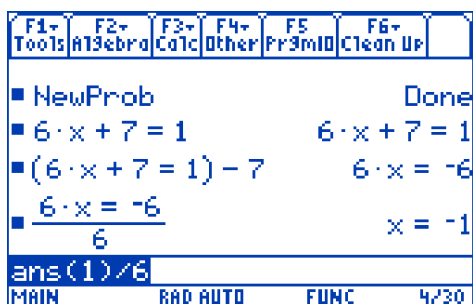


Figure 2

When subtracting 7 from both sides the calculator places parentheses around the whole equation and for the division by 6 the whole equation is placed over 6. It does not clearly show that the operation is being performed on both sides. The students in my class have difficulty coping with multiple new concepts and I believed that introducing a new way of showing 'applying an operation to both sides of an equation' could confuse many of the students in this class.

Lastly, the application Symbolic Math Guide (SMG), can be downloaded to a TI-89 from the Texas Instruments website (www.ti.com). The SMG program uses a more conventional notation for 'applying an operation to both sides of an equation' and also gives the student a menu of transformations to choose from. After choosing the transformation the student then needs to enter a value, as shown in Figures 3-4.

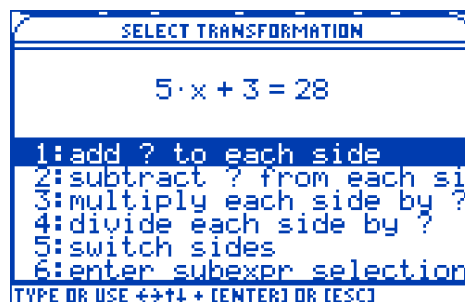


Figure 3

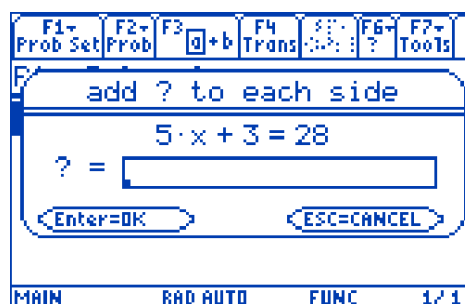


Figure 4

After entering the value, the student then needs to tell the calculator to do the operation and then tell the calculator to perform the operation by simplifying. Figure 5 is an example that shows the output produced by the calculator when using SMG.

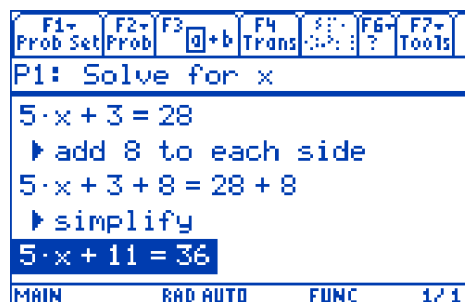


Figure 4

Using the notation  $5x + 3 + 8 = 28 + 8$  clearly shows the student that 8 has been added to both sides of the equation, unlike the second method illustrated above. This notation is more conventional and more familiar to the students. In the second method the calculator automatically simplified the equation whereas using SMG required the student to tell the calculator to simplify. Solving an equation by paper and pencil requires the students to do the simplification by themselves, so using SMG reinforces the requirement of this step in order to solve the equation.

According to Klein and Kertay (2002), the SMG application can be used to bridge the gap between using no calculator and using the calculator to explore processes or perform all the 'work' of solving an equation. The CAS and the SMG application actively engage students in the process of manipulating variables and solving equations. The students learn by doing and can concentrate on the solution process without worrying about making careless arithmetic or algebraic mistakes. The process also allows students to make poor 'solution' choices and learn from them.

## A problem encountered while using CAS with one Year 9 class

Ruthven (1996), makes the following statement in regards to the use of technology in mathematics

Ready availability is an important factor in generating the motivation to make a personal investment in learning to use a technology. Under such circumstances, too, learning can take place more informally and privately, and this can be an important factor in building confidence of those who may have a relatively weak affinity to technology. Equally, regular use helps to maintain technical skills, so that students are not confronted with the need to, in effect, relearn basic operating procedures each time that they use the technology.

In contrast, the students in my class had no experience in using CAS prior to this curriculum unit and they were not allowed to take the calculator home, hence each lesson the students were confronted with the need to

relearn basic operating procedures. This distracted some students from the real task of learning how to solve linear equations. Some students could not move past the operating procedures of the technology and hence, concluded that solving linear equations was difficult.

Making extensive use of technology appears to be a way to enable students to use technology as a tool for doing mathematics, as opposed to a one-off experience done for the sake of covering technology. But making regular use of technology in mathematics teaching is a difficult and time consuming job (Lumb, Monaghan & Mulligan, 2000).

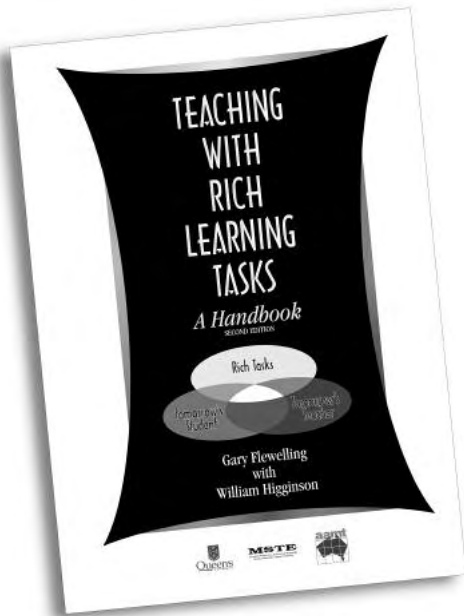
## Conclusion

Throughout this unit of work I tried to use CAS as a tool for investigation, to delve deeper into the structure of linear equations, to keep the students focussed on the transformations required to solve the equations, and to help students develop a deeper understanding of symbolic manipulation.

The use of CAS helped many of my students to develop a deeper understanding of equations and how to solve them. The students were able to apply correct transformations to both sides of the equations and then simplify the result. Most students needed their scientific calculator to perform the simplifications.

At the completion of this unit of work the students were required to complete a test that comprised of a variety of elementary linear equations to solve (CAS use was not allowed). Due to time restraints there was no time left in the unit to advance to 'word problems'. However, the main purpose of this unit of work was for the students to be able to solve linear equations by paper and pencil and this appeared to be achieved on most counts. An analysis of the class results show that approximately three quarters of the class obtained a pass grade (40% is a pass grade at my school), with half of the students achieving 80% or above. These results indicate that using SMG to teach linear equation solving was successful for the majority of my students. However, there were five students who obtained a test result below 40%. Of these students two have been diagnosed with learning difficulties and

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were often missing from lessons. These students had difficulty with the technology and tended to become frustrated with the calculator and hence with the topic. Each lesson they needed to relearn how to get to the SMG application and then how to operate it. This distracted them from the actual task of solving equations. Maybe if these students had more regular use of the calculator they may have been more successful.

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