The Potential of Spreadsheets in the Learning of Algebra

Teresa Rojano
Centro de Investigacion y de Estudios Avanzados

Introduction

Algebra remains one of the most important secondary school curricular contents in many countries. Nevertheless, the shape of algebra content as well as the algebra teaching approaches suggested in documents of recent educational reforms have been subject to big changes. For example, as Sutherland (2001) points out, in the United Kingdom there is now less emphasis on the role of symbols and more emphasis on relating algebra to pupils' informal methods. In the same way, the 1993 educational reform in Mexico gives more importance to the development of pupils' abilities to solve problems and has removed a large piece of content related to algebra syntactic (symbolic) skills (SEP, 1993).

Research work developed during the last two decades has contributed (among other factors) to conceive new approaches to the teaching and learning of algebra (Bednarz, Kieran & Lee, 1996) some of which have partly inspired curricular changes such as those mentioned before. This is the case of the so-called (1) *functional,* (2) *problem solving*, (3) *modelling* and (4) *generalisation approaches to algebra*. Incorporation of

Address all correspondence to: Teresa Rojano, Jefatura del Departamento de Matematica Educativa, Centro de Investagacion y de Estudios Avanzados, Avenida Instituto Politecnico Nacional 2508, San Pedro Zacatenaco, Deleg. Gustavo A. Madero, C.P. 07360, D.F. Mexico.

new technologies, such as computing environments as learning tools has been crucial for implementing some of the new algebra approaches in the classroom. Spreadsheets is one of the technology pieces which has proved to have a great potential both to emphasise the role of algebra as a modelling tool in problem solving and to promote the use of algebra in generalisation tasks. In this paper we discuss issues from an Anglo/Mexican collaborative project, which are related to the feasibility of switching pupils' informal strategies to algebraic school methods of solving word problems by using a spreadsheet. A theoretical tool adapted from the *mathematical analysis and synthesis process* is used to probe the nature of pupils' productions when solving word problems.

The Anglo/Mexican Project

Expressing the elements of a problem statement as an equation, and solving the equation to find the numerical value of the unknown is considered an algebraic method. Students' use of algebraic methods has been for many years one of the main goals of secondary school. Nevertheless, a number of studies indicate that pupils at this school level are more likely to use non-algebraic methods when solving word problems (Bednarz *et al.*, 1992; Lins, 1992). This has led in many cases to focus the research work on the analysis of pupils' strategies with the aim of probing the nature of these informal approaches.

Although it is necessary that students experience a detachment from their informal methods in order to acquire algebraic ones, results from one of the studies of the *Anglo / Mexican Spreadsheets Algebra Project* suggest that pupils' informal processes can be used as a basis to build up "more algebraic" methods of solving problems when working in a spreadsheet environment (Rojano, 1996; Sutherland & Rojano, 1993; Rojano & Sutherland, 1992). This collaborative project was developed to help students bridge the gap between arithmetic and algebraic thinking alongside two evolution lines: (1) basic algebra concepts and (2) problem solving methods. The main aims of this project were to:

- Investigate the way in which pupils use a spreadsheet environment to represent and solve algebra problems relating this to their previous arithmetical experiences and their evolving use of a symbolic algebra-like language.

- Characterise pupils' problem solving processes alongside the dimension arithmetic/algebraic as they evolve through working in a spreadsheet environment.

The project consisted of two phases. The first phase was carried out with two groups (one in Mexico and one in Britain) of eight pre-algebra pupils (aged 10 to 11 years). Whereas in the second phase we worked with two groups of eight 14-15 year olds (one in Mexico and one in Britain) who had had a history of being unsuccessful with school mathematics. All these pupils were involved in spreadsheet activities, which focused on the notion of function and inverse function, equivalent algebraic expressions and the solution of algebra word problems. They used a spreadsheet cell to represent the unknown and then with the mouse or the arrow keys expressed algebraic relationships in terms of this cell. Dealing with the unknown, both in a symbolic and in a numeric way, allowed pupils to make a step in accepting the idea of operating with an unknown quantity, an idea that many secondary students find difficult (Filloy and Rojano, 1989) but which, in turn, constitutes the core of the Cartesian (algebraic) method for solving word problems.

Despite the school mathematics experience that Mexican and British pupils had been different, due to the different approaches to the teaching of algebra used in Mexico and Britain, results from the pre-interview did no reveal significant differences in pupils' pre-algebraic competencies. Therefore, a common set of activities was designed and used in the experimental work in both countries.

Results from the project emphasising the conceptual development of the pupils have been synthesised in previous papers (Sutherland & Rojano, 1993; Rojano & Sutherland, 1992, 1993 and 1994; and Rojano, 1996). In the present paper we focus on methodological aspects of the transition towards the algebraic realm. We specifically discuss issues related to the possibility of linking pupils' informal strategies to algebraic school methods of solving word problems, when using a spreadsheet to represent the relationships present in a problem statement.

Arithmetic Methods—Algebra Methods

When trying to characterise arithmetic as well as algebraic methods, there always exists the difficulty of referring at the same time to the sorts of problems that are being solved. Puig and Cerdán (1990) retake some of the questions posed by Kieran and Wagner (1989, p. 226) related to the nature of problems and solving methods, such as a) *Are there word problems that are intrinsically algebraic rather than arithmetic?* b) *What makes a method of solving a word problem algebraic rather than arithmetic?* In an attempt to answer these questions, Puig and Cerdán develop an analysis of the *translation processes* of the problem statement into an arithmetic or algebraic expression. These authors use as tools of