ABSTRACT. Recent years have seen increasing interest in the role of metacognition in mathematical problem solving, and in the use of small group work in classroom settings. However, little is known about the nature of secondary students' metacognitive strategy use, and how these strategies are applied when students work together on problems. The study described in this paper investigated the monitoring behaviour of a pair of senior secondary school students as they worked collaboratively on problems in applied mathematics. Analysis of verbal protocols from think aloud problem solving sessions showed that, although the students generally benefited from adopting complementary metacognitive roles, unhelpful social interactions sometimes impeded progress. The findings shed some light on the nature of individual and interactive metacognitive strategy use during collaborative activity.

1. INTRODUCTION

This paper reports a study of the collaborative problem solving activity of a pair of students taking a course in applied mathematics. Group and collaborative work has been used increasingly in programs involving mathematical modelling and applications (e.g. Galbraith and Clatworthy, 1990). However, while the outcomes of group learning in such programs have been encouraging, no attribution could be made in terms of the 'anatomy' of the collaborative activity. This paper focuses on the nature and quality of the interactions between students working collaboratively on application problems.

The design of the present study distinguishes it from earlier research on the role of metacognition in the performance of mathematical tasks. Much of the latter research has used either tertiary level or primary school students as the subjects (e.g. Kroll, 1988; Venezky and Bregar, 1988); and studies which have attempted to train metacognitive strategies have tended to do so within separate 'problem solving' courses (e.g. Lester et al., 1989; Schoenfeld, 1985a), rather than treat metacognition – and problem solving itself – as a thinking process common to all branches of mathematics.

The study reported here differs from such research in two ways: the two subjects were sixteen year old secondary school students; and the problems on which they worked in this study, although challenging and unfamiliar, were similar to those they were likely to meet every day in
their mathematics classroom. The aim of the study was to investigate the metacognitive strategies the two students used while solving these problems.

1.1. **Research Questions**

The aim of the study may be succinctly expressed through four questions:

1. Is there evidence of a characteristic structure in the subjects' problem solving attempts?
2. What metacognitive strategies does each subject use during problem solving?
3. How do the students respond to being stuck?
4. How does the presence, or absence, of metacognitive behaviour influence the outcome of problem solving?

2. **SELECTIVE REVIEW OF LITERATURE**

Metacognitive processes such as assessing one's knowledge, formulating a plan of attack, selecting strategies, and monitoring and evaluating progress play a central role in mathematical performance by enabling effective decisions to be made regarding the allocation of time, energy, and knowledge resources, as argued by Schoenfeld (1985a).

Various approaches to discovering factors which influence problem solving have included the expert versus novice concept (Bransford et al., 1986; Glaser, 1984; Silver, 1982); cognitive processes involving the interplay between linguistic and syntactic knowledge (Mayer, 1983; Thomas, 1988 (after Newell and Simon, 1972)); schema instantiation (Lewis, 1989; Silver, 1982; Thomas, 1988); and problem solving processes (Garofalo and Lester, 1985; Schoenfeld, 1987a).

Despite the difficulty of identifying critical factors precisely the studies have led to agreement that not only do competent problem solvers have more extensive and better organised knowledge than novices, but they also exercise better control over their problem solving behaviour. This new dimension goes beyond cognition to metacognition – thinking about thinking. While metacognition is sometimes considered an elusive concept, partly because of the difficulty in distinguishing between cognitive and metacognitive processes (Garofalo and Lester, 1985; Perkins et al., 1990) we believe that the distinction is clarified nicely in one of the earliest descriptions of metacognition (Flavell, 1976, p. 232):