The role of cognitive monitoring has been a dominant theme in cognitive strategy research in recent years. Cognitive monitoring can be defined as any activity aimed at evaluating or regulating one’s own cognitions (Flavell, 1979). Examples of cognitive monitoring include planning, checking, self-testing, assessing one's progress, and correcting one's errors. Researchers have come to recognize that cognitive monitoring plays a vital role in virtually any cognitive endeavor and thus has important implications for instructional intervention. Accordingly, cognitive monitoring has received a substantial amount of attention in the reading, communication, and memory literatures (e.g., Baker, 1985; Baker & Brown, 1984a, 1984b; Beal, this volume, chap. 8; Brown, 1978; Flavell, 1979; Markman, 1981).

Somewhat surprisingly, cognitive monitoring has received little attention in research on mathematical thinking and problem solving, despite the applicability of the construct to many important theoretical and practical issues. For example, the debate over the relationship between conceptual knowledge (e.g., knowledge of the base-ten system) and procedural knowledge (e.g., algorithms) is really an issue of whether conceptual standards can be used to judge the sense of procedural results (see Hiebert, 1986; Nesher, 1986; Resnick & Omanson, 1987). By examining this issue in light of current theorizing about cognitive monitoring, perhaps some progress can be made in understanding and closing the gap between children's use of procedures and their understanding of concepts. Research on cognitive monitoring would be valuable from a practical standpoint as well, given that cognitive monitoring is actually an explicit part of the mathematics curriculum. For example, teachers routinely tell their students to check their answers, and mathematics texts often present heuristics for answer checking. In addition, students are frequently taught specific ways to judge the sensibleness of answers, using procedures such as estimation.

In this chapter we establish the relevance of the concept of cognitive monitoring in mathematics, drawing parallels where appropriate to cognitive monitoring research in other domains. The relative paucity of empirical research on cognitive monitoring in mathematics necessitates that our discussion
involve a certain degree of theoretical speculation. We will begin by clarifying what it is we mean by cognitive monitoring in the domain of mathematics. We will then go on to review existing research and theory, focusing primarily on elementary-school children's work with word problems. We will discuss how children are taught to monitor their work in mathematics classes and some of the problems with current practices. We will present some of our own research which examines children's abilities to detect errors in word problems and will then sketch a model of cognitive monitoring in mathematics based on the research. Finally, we will discuss existing instructional interventions and will offer suggestions for designing curricula that are more apt to enhance students' monitoring skills.

What is Cognitive Monitoring in Mathematics?

We use the term cognitive monitoring in the domain of mathematics to refer to students' attempts to determine whether they have given a correct answer, chosen a correct strategy for solving a problem, or understood a problem or concept. We are particularly interested in children's judgments of their understanding, an aspect of cognitive monitoring known as comprehension monitoring (Baker & Brown, 1984a; Flavell, 1979). Like much of the work on comprehension monitoring in the domain of reading, we emphasize children's evaluation of their understanding rather than their regulation of understanding (Baker, 1985). That is, we focus on children's discoveries of incorrect or nonsensical aspects of word problems rather than on their resolution of their misunderstandings or errors. This focus in no way implies that regulation is less important than evaluation, nor does it imply that these are the only aspects of cognitive monitoring worthy of investigation. It is simply that the length constraints of the chapter require selectivity of coverage. (See Pressley, 1986, for discussion of other relevant aspects of the literature.)

Our theoretical orientation is that there are multiple levels at which cognition can be monitored in mathematics, just as there are multiple levels at which comprehension can be monitored in reading (Baker, 1985). We see at least three levels at which children need to evaluate their cognition in solving mathematics word problems. First, there is the need to evaluate the results of arithmetic procedures carried out to get an answer. Such monitoring could occur simply by checking the arithmetic involved (e.g., adding in the other direction, subtracting an addition result, dividing a multiplication result). Second, there is the need to evaluate whether the procedure one has chosen is correct. To do this, one would have to carry out some level of semantic analysis of the text, whether that involves rereading the entire text or simply finding a key word. Finally, there is the need to evaluate the sensibleness of the problem itself. Such an evaluation would involve looking at the semantic relationships expressed in the text and making a decision about whether those relationships make sense. Each of these three levels of analysis will be con-