What About Research?

The most extensive review and synthesis of research on the use of physical/pictorial models in grades K-8 was conducted by Suydam & Higgins (1977). In analyzing the results of their review they assert that research provides scant information on the effective use of manipulatives. They state: "If every research study concluded that every use of every manipulative material increased student achievement, there would be little need to worry about the details of that use. We could conclude that the mere presence of manipulative materials in a mathematics program would be beneficial. In fact, research results show us to be as far away from this comfortable conclusion as possible."

Post (1980) maintains that one factor related to the effective use of manipulatives is how different instructional modalities might be sequenced to affect learning. He writes: ". . . the intellectual mechanisms used in the transition from one mode to another are of great interest to the researcher and of equal significance to the classroom teacher. At this time, the general nature of these mechanisms is not known. It is known, however, that experience and understanding at one level do not necessarily imply the ability to function at a more sophisticated level. For this reason the translation processes both within modes (multiple embodiments) and between modes need conscious attention."

According to Post understanding at the concrete level should not be interpreted as understanding at the symbolic level. He cautions: "Under normal conditions, children are given materials during an instructional sequence wherein concepts are introduced and developed. In general, insufficient attention is paid to the way in which this enactive (concrete) experience is related to the symbolic representation of that experience.

If appropriate connections are not made, Bright (1986) warns that students will think that their are two mathematical worlds, one for manipulatives and the other for symbols, each having different rules. Instead of building mathematical insights such misuse interferes with mathematical understanding. He contends: "It should be recognized that proper mathematical understanding simply does not exist when students do not see the need for accurate connections between the two worlds. Indeed, the main emphasis that needs to be made in teaching with manipulatives is that symbols and manipulatives must always reflect the same concept. Students don't automatically grasp this connection . . . . Unless the connection between the two settings is carefully articulated, however, counterproductive tension may be created between them."

After being out of "educational vogue" since the early 1970's, manipulatives are once again one of the most current instructional fads in mathematics education. Although research recommends the effective use of manipulatives, misuse of manipulatives is a dangerous instructional practice. Perhaps the greatest misuse of manipulatives occurs when physical/pictorial models are not directly linked to corresponding symbolic representations. While teachers may assume that students will develop the appropriate associations on their own, this rarely occurs. Such assumptions result in confusion as well as poor performance when students are only assessed in the symbolic mode.

One of the authors, Gilfeather (1989), conducted a year-long study with a classroom of fourth and fifth grade students to describe and analyze how MEBA™ affected students' thought processes with respect to several research questions. Analysis of the data shed light on these questions and resulted in several conclusions. First, systematic use of manipulatives promotes conceptual understanding, proficiency with symbolic algorithms, and an ability to articulate mathematics concepts and relationships. In this study the development of these abilities was related to the Sequenced Instructional Modes (SIMs™) framework that revealed four salient aspects of teaching. First, there are important subtleties in the use of concrete and pictorial models. If students are to experience the concrete mode, they need to directly manipulate the material. If this does not occur, students may encounter gaps in their understanding as they progress to more abstract modes. Second, students need direct guidance in connecting concrete, pictorial, and symbolic representations of mathematical ideas. Relationships that may be obvious to educators may not be obvious to learners. Third, systematic experiences with the pictorial mode may promote the development of spatial imagery. Finally, rote learning may interfere with conceptual understanding. Such prior learning may complicate or lengthen a teacher's task of teaching mathematics conceptually.

A second conclusion is that students' computational reasoning is augmented by understanding related spatial relationships. Another conclusion is that students' self-confidence is enhanced through their conceptual understanding of mathematical ideas and relationships. Finally, bridging the world of manipulatives and symbols is a complex task involving many interrelated factors.

The authors suggest that the SIMs™ framework be used to organize conceptually-based instruction. Furthermore, they propose that this framework be used to classify and identify the instructional modes of future research studies concerning the effective use of manipulatives. Such studies must clearly indicate which type of mode is being researched as well as how this relates to making a deliberate and sequential instructional progression from concrete to pictorial to symbolic. Unless such steps are taken, how can educators make coherent sense of research data and results?