Research on Student Learning

Early reviews of the research (e.g., McLeod, 1992; Schoenfeld, 1992; Thompson, 1992) support continuing studies of beliefs, attitudes, and values about the nature of mathematics. For descriptions of international research programs, see the volume edited by Leder, Pehkonen, and Toerner (2002), and the special issue on affect published by Educational Studies in Mathematics (e.g., Zan, Brown, Evans & Hannula, 2006). For a more comprehensive review of recent literature, with an emphasis on teacher beliefs, see Philipp (in press). Data on student beliefs and attitudes are also a component of large-scale studies, such as the National Assessment of Educational Progress and the Third International Mathematics and Science Study (see, e.g., Silver & Kenney, 2000). Investigations of students' beliefs about the nature of mathematics are illuminated by Schoenfeld (1992) and summarized in a report from the National Research Council (Kilpatrick, Swafford, & Findell, 2001). These studies examined difficulties arising from students' beliefs about the nature of mathematical problem solving and from their perceptions of the role of memorization in learning mathematics and of mathematics as rule-oriented versus process-oriented or as a static versus a dynamic discipline. There has been less emphasis on students' understanding of the relationships between mathematics, science, and technology or to the nature of mathematical inquiry as a modeling process. [1]

Research on student understanding of early algebra ideas, such as patterns and relationships, has received increased attention. Early studies suggested students have difficulty connecting mathematical expressions, sentences, and sequences that share common structural patterns, often focusing instead on incidental similarities or differences. [2] Evidence suggests that these difficulties can be ameliorated by introducing early algebra ideas in the elementary grades. [3]

Research on the integration of new technologies into mathematics instruction continues to advance and is summarized in a National Research Council report (Kilpatrick, Swafford, & Findell, 2001). Kieran and Sfard (1999) discuss how students develop stronger conceptual knowledge of equations through graphing, and there is evidence that students can use technological tools to improve problem-solving even when their algebraic skills are limited. [4] Survey data suggest that middle- and high-school students think that mathematics has practical, everyday uses and that mathematics is more important for society than for them personally. [5]

Student beliefs about mathematical inquiry limit students' mathematical behavior. [6] Typical student beliefs about mathematical inquiry that limit students' mathematical behavior include the following: There is only one correct way to solve any mathematics problem and only one correct answer; mathematics is done by individuals in isolation; mathematical problems can be solved quickly or not at all and their solutions do not have to make sense; and formal proof is irrelevant to processes of discovery and invention. [7]

Research is needed to assess when and how students can understand that mathematical inquiry is a cycle in which ideas are represented abstractly, abstractions are manipulated, and results are tested against the original ideas. We must also learn at what age students can begin to represent something by a symbol or expression, and what standards students use to judge when solutions to mathematical problems are useful or adequate. [8]

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