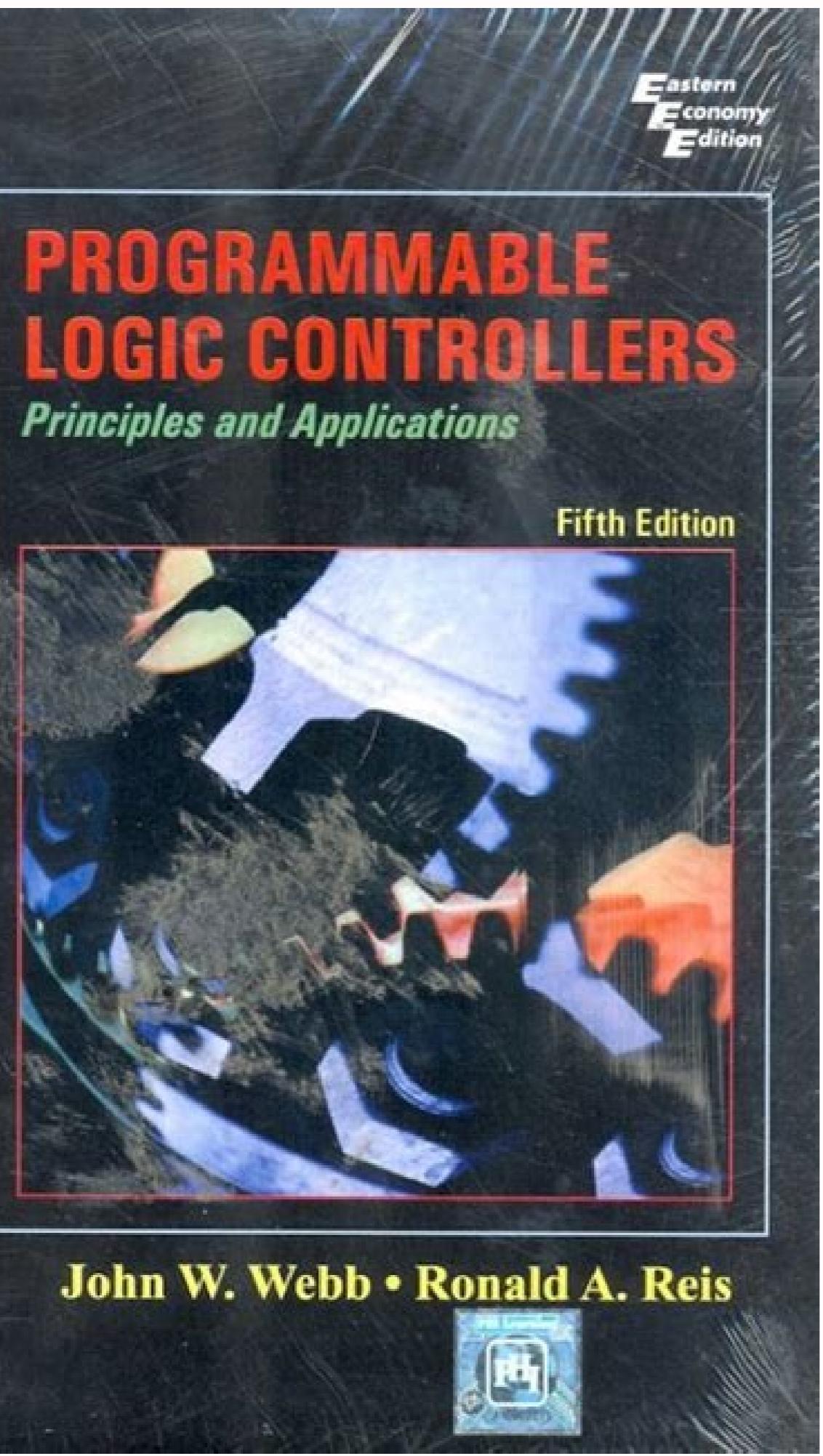


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**What Makes Mathematics Manipulatives Effective? Lessons From Cognitive Science and Montessori Education**

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**Abstract**  
Manipulatives are ubiquitous in early childhood classrooms, yet findings regarding their efficacy for learning mathematics remain inconclusive. In this article, we present four general principles that have emerged from cognitive science about ways to ensure that manipulatives promote learning when used with young children. We also describe how Montessori manipulatives can support learning when used in preschool and primary school settings. We find that manipulatives are associated with higher levels of mathematics achievement among children who attend Montessori programs during early childhood. The general principles we present have important implications for early education. We conclude that effective math programs maximize the benefits of using manipulatives for developmentally appropriate mathematics instruction.

**Keywords**  
manipulatives, Montessori, mathematics, research, cognitive science

We look into any early childhood classroom and you are sure to see manipulatives in use. Manipulatives are physical objects or materials (e.g., blocks, tiles) used to demonstrate a mathematical concept or procedure. They have been an integral part of mathematics instruction since the days of Euclid (e.g., Cohen, 1980; Greene, 1990; Hart & Cockburn, 1994). O'Donnell and Fick (2010) in a study of two school districts, found that 91% of teachers reported using manipulatives nearly every day (Orbe-Perez & Wilkins, 2010). Research on the use of manipulatives has been extensive. Despite manipulatives' popularity, it is concerning that some studies find they hinder learning (e.g., Williams, 1997). Some studies find that manipulatives can benefit learning, but only under certain conditions (e.g., for teaching fractions) or for some students (e.g., those more advanced for learning about fractions). That for learning about fractions, learning about fractions with manipulatives was least effective for children learning about fractions for the first time, but at least three times superior for those who had learned about fractions previously. These findings suggest that the effectiveness of manipulatives depends on the instructional conditions under which they are used.

Given the concerns about the potential negative uses of manipulatives, should they be used to teach mathematics in

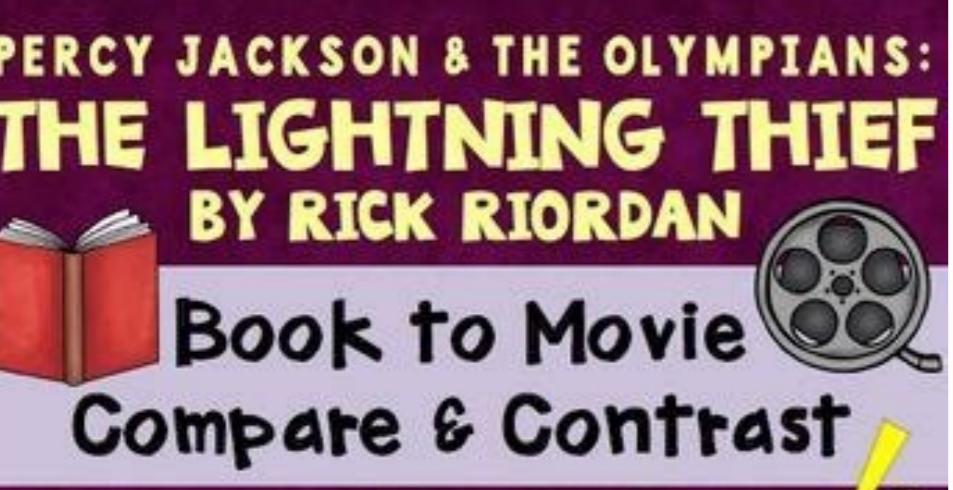
early childhood? We believe the answer is yes—if careful consideration is given to what manipulatives are used and the conditions under which manipulatives are likely to be most effective. This article presents four general principles for using manipulatives that will increase their likelihood of being used effectively. In addition, we provide supporting research evidence and include a brief discussion of the knowledge necessary for success, as described in National Council of Teachers of Mathematics (NCTM), National Council of Chief State School Officers (NCCSO), and the Council of the Great City Schools' (CGCS) Best Practices. Council of Chief State School Officers, NCCSO, CGCS, & NCTM (2006). Finally, we summarize, in tables, the findings from cognitive science relevant to best practices for using manipulatives. We end by summarizing and synthesizing them into four principles for maximizing the effective use of mathematics manipulatives.

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Tabela 5. Comparação do Físico-Accidental-Entre os Grupos de Sessões

Função	Iniciantes	Médios	Concluintes	Total	Significância
Auxiliar	N %	N %	N %		
Intuição	28 29,17	11 27,50	18 28,13	57	
Pensamento	8 8,33	7 17,50	7 10,94	22	X <sup>2</sup> = 8,38
Sensação	35 36,46	7 17,50	25 39,06	67	p = 0,212
Sentimento	25 26,04	15 37,50	14 21,88	54	
Total	96	40	64	200	



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