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Reducing intrinsic cognitive load in percentage change problems: The equation approach☆

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ABSTRACT

We compared the equation approach and unitary approach in helping students ($n = 59$) learn percentage change problems from a cognitive load perspective. The equation approach emphasized a two-part learning process. Part 1 revised prior knowledge of percentage quantity; Part 2 integrated the percentage quantity and the original amount in an equation for solution. Central to the unitary approach is the concept of unit percentage (1%). The unitary approach would expect to incur high element interactivity because of the intrinsic nature of its solution steps, and the need to search and integrate quantity and percentage in order to act as a point of reference for calculating the unit percentage. Test results and the instructional efficiency measure favored the equation approach. It was suggested that the equation approach reduced the intrinsic cognitive load associated with percentage change problems via sequencing and prior knowledge.

1. Introduction

There is evidence to indicate that instructional approaches depicted in mathematics textbooks may cultivate shallow mathematical reasoning and thinking skills (Vincent & Stacey, 2008). For example, there is little evidence of requiring students to solve geometry problems by setting up an equation such as, $(2\times - 6)^0 + 32^0 = 70^0$ in which they need to build on prior knowledge of algebraic expressions, $(2\times - 6)^0$. Thus, how can mathematics educators help middle school students understand and learn percentage change problems, such as "*Last semester Nikki scored 80 marks for a mathematics test. She has improved her mathematics marks by 10% this semester. Find Nikki's mathematics marks for this semester*" is an important issue. How do we know whether a particular instruction is effective in fostering understanding and learning percentage change problems?

Our ability to solve a range of real-life problems (e.g., *If 5 kg oranges cost $20, what is the cost of 1 kg oranges?*) relies on the efficient use of mental computation of what is known as a 'unitary' concept. Unsurprisingly, based on this unitary concept, the unitary approach is one of the popular methods in mathematical problem solving (McSeveny, Conway, & Wilkes, 2004). In contrast, mathematics textbooks rarely advocate the equation (algebra) approach for mathematical problem solving (e.g., McSeveny et al., 2004). The equation approach requires students to integrate relevant information in an equation for subsequent generation of a solution.

Several researchers have designed mathematics instructions and test their effectiveness by conducting randomized, controlled experiments in a regular classroom with school age students (Jitendra, Star, Rodriguez, Lindell, & Someki, 2011; Rittle-Johnson & Star, 2007). In the current study, differing from previous inquiries, we compared the *unitary approach* and *equation approach* that could facilitate effective learning of percentage change problems from a cognitive load perspective.

2. Cognitive load theory

Recent development in cognitive load theory (Sweller, 2012) has stipulated five major components that have implications for instructional designs and pedagogical practices in mathematics education. These are:

1. *Information store principle* refers to a huge long-term memory capacity to store organized information in the form of schemas that can be handled as a single element in working memory. Thus, one main aim of instruction is to acquire schemas and store them in long-term memory. For example, once the learner has acquired a schema for percentage quantity (e.g., $15\% \times 72$), the learner can retrieve the schema from long-term memory and treat this as a single element in working memory.

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