The Effect of Prior Conceptual Knowledge on Procedural Performance and Learning in Algebra

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Introduction

Errors are inevitable when individuals are first learning any skill; solving algebraic equations is no exception. Students often use incorrect procedures when learning Algebra (e.g., Lerch, 2004), and use of incorrect procedures has been hypothesized to be attributable to misunderstandings or gaps in students' conceptual knowledge of Algebra (Anderson, 1989; Van Lehn & Jones, 1993). Experiment 1 in the current study tests this hypothesis; Experiment 2 examines whether these pretest misconceptions also affect learning of algebraic problem-solving

Methods

In Experiment 1, 112 middle and high school students using the Algebra I Cognitive Tutor, a self-paced intelligent tutor system (Koedinger, Anderson, Hadley, & Mark, 1997), completed a test assessing their conceptual and procedural knowledge of algebra before beginning the unit on solving two-step linear equations; there were two forms of the test and half of the students were randomly assigned to receive each.

In Experiment 2, the 97 students who completed the tutor unit took the opposite form of the test.

Results and Discussion

Students in Experiment 1who had a good concept of the equals sign made equals sign-related errors (e.g., performing operations to only one side of an equation, dropping the equals sign from the equation) on fewer problems (10%) than those with a poor concept of the equal sign (21%; $t(110) = 2.07$, $p < .05$). Similarly, those with a good concept of like terms combined unlike terms in fewer problems (1%) than those with poorer knowledge of like terms (9%; $t(110) = 2.59$, $p < .01$).

Lack of conceptual knowledge of certain features was also correlated with fewer procedural problems solved correctly (negatives ($R(112) = .38$, $p < .01$), like terms ($R(112) = .32$, $p < .01$) and equals sign ($R(112) = .59$, $p < .01$); lack of equals sign knowledge is predictive of performance beyond the other two misconceptions (21% variance added; $t(109) = 5.95$, $p < .01$)

In Experiment 2, improved equals sign knowledge correlated with improvement in problem-solving (controlling for the amount of procedural improvement possible), (partial $R(97) = .23$, $p < .05$). In addition, two marginally significant trends were found suggesting that pretest knowledge of negatives and of like terms predicted students' learning on transfer problems (partial $Rs(97) = .17$, $ps < .10$).

Results from this study indicate that a lack of knowledge about certain conceptual features is associated with use of related incorrect procedures when solving equations. These misconceptions lead students to solve less problems correctly and, in some cases, to learn less from instruction unless they are corrected. This suggests that improving students' knowledge of the conceptual features that underlie Algebra may be necessary for robust learning to occur.

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