The Influence of Procedural and Conceptual Examples on Mathematical Problem Solving

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Introduction

There is a considerable body of research studies on worked-out examples. Learning from worked-out examples is of major importance for the initial acquisition of cognitive skills in well-structured domains such as mathematics, physics, and programming (e.g., VanLehn, 1996; Renkl, 2002). Worked-out examples consist of a problem formulation, solution steps, and the final solution itself (Renkl, 2002), but they do not include the conception and principles (conceptual knowledge). In learning from examples, it has been found that those which include conceptual knowledge (the conceptual example) produced better transfer performances than examples without conceptual knowledge (the procedural example) (Lovett, 1992). However, previous studies have not investigated the effect of combinations between the conceptual and procedural example.

Therefore this study investigated whether four patterns of combinations between the conceptual and procedural example influenced transfer performance. The participants chosen had low prior knowledge because prior knowledge influences the acquisition of conceptual knowledge strongly (e.g., Shneider & Stern, 2005).

Method

One hundreds and forty two high school students (age 15-16 yrs) were randomly assigned to one of four experimental conditions which were presented with different combinations between the first and the second example.: (a) The procedural example and the procedural example (P-P, n = 30), (b) The conceptual example and the conceptual example (C-C, n = 30), (c) The conceptual example and the procedural example (C-P, n = 30), and (d) The procedural example and the conceptual example (P-C, n = 28). For example, in the C-P condition, the first example was the conceptual example and the second was the procedural example. The experiment consisted of five parts; (1) All participants initially solved pretest problems. (2) Then they studied the first example involving quadratic inequality and worked on a work sheet. (3) Following that, they solved a problem that could be solved with the same procedure as the first example. (4) Next they studied the second example and worked on a work sheet. (5) Finally they solved transfer problems. Four conditions were presented with different combinations between the first and the second examples.

Results

The participants who scored 2.5 (Max = 7) or less on the pretest were considered as learners that have low prior knowledge and data collected from them were analyzed. The participant numbers in the four conditions were as follows: P-P = 21, C-C = 23, C-P = 19 and P-C = 21. The mean scores of the transfer problems are presented in Table 1.

Table 1: Mean scores of transfer problems (SDs)

P-P	C-C	C-P	P-C
0.43(0.60)	0.43(0.59)	1.00(0.65)	0.48(0.64)

(Max = 4)

The transfer problems scores were analyzed using a one-factor between-subjects ANOVA. There was a significant different between groups ($F(3,80)= 3.964$, $p < .05$). According to Tukey's HSD test, the C-P condition performed better than all other conditions ($p < .05$).

Discussion

This result revealed that low-knowledge learners learned more effectively by the instruction that the procedural example was presented after the conceptual one. These participants were likely to have facilitated processing conceptual knowledge with procedural knowledge because procedural knowledge became definite in the second example given.

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