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Learner Achievement and Attitudes under Different Paces of Transitioning to Independent Problem Solving

Recent studies demonstrated the benefits of instructional designs that transition from worked examples (where all steps are worked out) to independent problem solving (requiring the learner to attempt all solution steps), but did not address the question as to how *fast* this transition should occur. Studies in the existing literature typically reduced the number of worked problem steps by one for each new example, thus fading away the worked steps one by one.

Our goal in this study and a related study (J. Reisslein, P. Seeling, and M. Reisslein, Comparing Static Fading with Adaptive Fading to Independent Problem Solving: The Impact on the Achievement and Attitudes of High School Students Learning Electrical Circuit Analysis", ASEE Journal of Engineering Education, July 2006) was to examine the impact of the pace of the transitioning on learning outcomes. More specifically, the primary research questions for the study were:

1. What is the effect of the pace of transitioning from worked examples to independent problem solving on learner posttest achievement?

2. Is there an interaction between the pace of transitioning from worked examples to independent problem solving and the level of prior knowledge of the learners?

3. How does the transition pace affect learner attitudes?

A 3 (prior knowledge of learner: high, medium, and low assessed with pretest) x 3 (pace of transitioning to independent problem solving: slow, fast, immediate) experimental design was employed to answer these research questions. A computerized learning program was used to implement the slow (one less worked example step for every second example), fast (one less worked example step for every problem), and immediate (practice problems without any worked steps immediately after presentation of concepts) transitioning. A paper-based post-test was used to determine the subject mastery for near-transfer (retention) problems and far-transfer (transfer) problems. The student attitudes were captured using a 5-choice Likert-type questionnaire.

The data for the individual learning and attitude measures were analyzed with a 3 (level of prior knowledge) x 3 (pace of transitioning) analysis of variance (ANOVA) and follow-up Fisher’s LSD post hoc tests. The main result was a significant prior knowledge by pace of transitioning interaction on retention: The high prior knowledge participants scored higher under the fast fading and immediate transitioning conditions than under the slow fading condition. The medium prior knowledge participants performed at a similar level under all three treatments. In contrast to the high prior knowledge participants, the low prior knowledge subjects had higher retention scores under the slow fading condition than under the fast fading and immediate transitioning conditions.

The result that the high prior knowledge participants perform worse under the slow transitioning condition provides further empirical evidence for the existence of the expertise reversal effect. According to the expertise reversal effect, the worked examples are redundant information for the learners with higher knowledge levels. This redundant information burdens the advanced learners as extraneous cognitive load and reduces their germane cognitive load, resulting in a reduced capability to further advance their understanding of the subject matter. The better performance of the low prior knowledge participants under the slow transitioning condition compared to the immediate and fast transitioning conditions is consistent with the worked-example effect. The worked examples provide the novice learners with an analogical base for solving other problems and free the learners from performance demands during the initial skill acquisition. For the medium prior knowledge participants there were no significant differences in the posttest retention performance across the three treatment groups. These participants apparently had a sufficiently high level of prior knowledge to cope with the problem solving demands placed on them by the fast and immediate transitioning conditions. At the same time their level of prior knowledge was likely sufficiently low to avoid a pronounced expertise reversal effect.

The results of this study indicate that tailoring the pace of transitioning to independent problem solving to the levels of prior knowledge of the students can significantly increase the effectiveness of the instruction for the retention learning performance of high prior knowledge and low prior knowledge participants. In particular, this study found that slow transitioning for learners with low levels of prior knowledge and fast or immediate transitioning for learners with high levels of prior knowledge achieve significant improvements in learning. In educational practice, this study suggests to first administer the students a pretest that assesses their prior knowledge of the concepts to be taught. Next, the learners are split into three groups of higher, medium, and lower prior knowledge according to two cut-off thresholds. The present study used the mean pretest score plus/minus one standard deviation of the pretest score as the two cut-off thresholds. Depending on the distribution of the prior knowledge levels of the learners and the difficulty level of the learning material, different cut-off points may be appropriate. Once the learners are divided into three groups, the high prior knowledge learners are taught with the immediate transitioning technique, the medium prior knowledge learners with the fast fading technique, and the low prior knowledge learners with the slow transitioning technique.

Author 1: Jana Reisslein jana.reisslein@intel.com

Author 2: Howard Sullivan sully@asu.edu

Author 3: Martin Reisslein reisslein@asu.edu

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