Effects of Detailed Diagrams on Science Learning

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Abstract

Many textbooks and documents have incorporated a more colorful and realistic diagram design. This type of diagram is usually more aesthetically appealing. The higher realism provided by realistic details may also help learners make link to the real-world situation, thus understand the abstract contents more easily. However, since colors and realistic details are seldom related to essential learning contents, they may interfere with processing the essential information and hamper learning. To provide insights to this debate, the present study examined the effects of colored and detailed diagrams on science learning, focusing on the motivational, cognitive, and metacognitive perspectives.

Chapter 1 provides a theoretical background for the effects of realistic details on learning. It begins by explaining the cognitive process of text and diagram comprehension, focusing on the *Cognitive theory of multimedia learning* (Mayer, 2005), followed by theories on the motivational and metacognitive perspectives of learning. Based on the theoretical background, the role of detailed diagrams in multimedia learning is examined by considering the following three themes: (1) the motivation and comprehension debate, (2) influences on metacomprehension accuracy, and (3) moderating factors on the effectiveness of realistic details.

Chapter 2 focused on the motivation and comprehension debate by incorporating eye-tracking methodology to assess the influence of detailed, colorful diagrams on learning. A pre-study was conducted to confirm an aesthetic preference for detailed diagrams. In the main experiment, participants studied eight human anatomy texts; four were accompanied by detailed diagrams, and the other four were accompanied by simplified diagrams. Participants completed a comprehension test and an evaluation questionnaire after studying each text. The results showed that detailed and simplified diagrams were equally effective in terms of learning outcomes. Eye-tracking data showed that the detailed diagrams attracted attention in the initial learning stage and received more visual attention during the overall learning process. Notably, correlation analysis revealed that spending a greater proportion of time re-inspecting the simplified diagrams was associated with higher test performances. By contrast, greater proportion of time spent re-inspecting the detailed diagrams was not significantly correlated with learning outcomes. Findings on learning support the motivational advantages and cognitive disadvantages

of detailed diagrams, and may explain the equal effectiveness of detailed and simplified diagrams on learning outcomes.

Metacognitive factors may also play an important role in the success of learning. For instance, students who can accurately monitor their level of comprehension may make better choices about the materials that need to be restudied, or whether some learning strategies should be applied, and thereby influence the eventual learning outcomes. Therefore, Chapter 3 focused on the effects of detailed diagrams on metacomprehension accuracy. The participants studied six human anatomy texts with either detailed or simplified diagrams, judged how well they understood each text, and completed tests for each text. The participants also rated their emotions before and after studying the texts. Metacomprehension accuracy was computed as the intra-individual correlation between judgments and test performance. The results showed that participants who had learned with detailed diagrams were less accurate in judging their comprehension than those who had learned with simplified diagrams. Positive emotions significantly decreased after learning with detailed diagrams, whereas they did not change significantly after learning with simplified diagrams. These findings indicate that detailed diagrams may not support comprehension monitoring. One interpretation is that adding unnecessary details in diagrams may lead students to rely on invalid cues for assessing their own level of comprehension, thus resulting in poor monitoring accuracy.

The effectiveness of colored and detailed diagrams on learning may depend on different learning stages, and may be moderated by color. Chapter 4 differentiated color and detail factors in diagram design, and included both immediate and delayed tests to provide a more detailed explanation regarding the effects of detailed diagrams on learning. Based on a 2 (detailed vs. simplified) × 2 (colored vs. grayscale) experimental design, participants studied 12 illustrated texts on human anatomy. The participants completed an evaluation questionnaire and an immediate test after studying each text. Delayed tests were administered after a week. The results showed that realistic details increased the difficulty, learning effort, total learning time, and visual search time. Although color did not increase enjoyment or learning interests, eye-tracking data showed that colored diagrams attracted attention more effectively in the initial learning stage. Realistic details in grayscale resulted in a smaller proportion of time spent on diagrams and less immediate learning. When combined with color, realistic details led to a larger proportion of time on diagrams and improved immediate learning. Neither realistic details nor color fostered learning in the delayed tests. These results provide evidence that realistic details alone have negative effect on immediate and delayed learning. Moreover, color might moderate the effectiveness of realistic details by increasing students' engagement with the diagrams and resulting in improved immediate learning.

Finally, Chapter 5 summarizes the findings of this study by considering three important learning influences: motivation and interest, immediate and delayed learning, and metacomprehension. Findings in the present study provide deeper understanding regarding how detailed diagrams can affect science learning. These findings offer new theoretical insights for research on multimedia learning, and have practical implications for applying realistic details and color in diagram designs in learning environments.