Contents and Graphics in Line: When is it Beneficial to Schematize Pictures in Expository Prose?

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Abstract. Learners generally benefit from representational pictures that are added to expository text. But what determines whether it is better to design such pictures as schematized drawings or as detailed photographs? In some studies learning outcomes are positively affected by schematized pictures, but in other studies null effects are reported. We argue that learners' ability to identify key concepts in pictures is an important predictor of effectiveness of representational pictures, and that this ability can be facilitated by using schematized pictures. We present results of a pilot study (N=36), which indicate that the aforementioned ability correlates with learning outcomes. We are planning to test our hypotheses in a full-scale experiment, and to present results of this experiment at the conference.

Keywords: Connecting text and pictures; Schematization; Visual detail.

Introduction

Adding relevant representational pictures to expository text is generally found to positively affect learning outcomes (e.g., Mayer, 2005). One important function of such pictures is representing key concepts in a pictorial modality, to help learners to encode the educational materials into memory. A prerequisite for serving this function is that learners are able to identify these concepts in the pictures (i.e., link key concepts in the text to corresponding picture elements; e.g., Mayer & Gallini, 1990).

In this study we investigate whether using schematized rather than detailed pictures can aid learners find these key elements. Schematized pictures are for example line drawings with little detail, that discard irrelevant details and highlight important concepts. Detailed pictures, like photographs or other detailed graphics that often resemble reality to a high degree, show many visual features. Because in schematized pictures irrelevant details are omitted (and therefore attention is guided towards what is important) finding visual referents to key concepts in the pictures may be easier and more efficient compared to when detailed pictures are used. This idea is in line with proposed principles of good instructional design: schematization reduces irrelevant details that may distract attention away from what is important (e.g., Harp & Mayer, 1998); and by highlighting key concepts in graphics schematization can be said to act as visual cues that direct learners attention (e.g., De Koning, Tabbers, Rikers, & Paas, 2010).

Studies that directly compare learning with schematic pictures versus detailed pictures have yielded differing results, however. Some studies show that schematic graphics lead to better learning outcomes than detailed ones (e.g., Butcher, 2006; Joseph & Dwyer, 1984), both for animations and for static pictures, but other studies present null effects concerning this distinction (e.g., Imhof et al., 2011; Reinwein & Huberdeau, 1998). Although these varying results can easily be ascribed to methodological differences between experiments (e.g., different topics, different learners, different tasks, static vs. animated graphics), the extent to which learners are able to identify key concepts in the pictures may be an overarching factor that discerns pictures that are helpful for learners from less helpful ones. To our knowledge, no studies have yet focused on this proposed relationship between the extent to which learners can make connections between text and pictures and whether pictures are schematic or detailed. The ability to make connections is expected to be an important predictor of the effectiveness of schematization in pictures with expository prose, and to be related to pictures being schematic or detailed.

We have conducted a pilot study to investigate this hypothesis. In this study, participants (N=36) learned about mitosis (inspired by Scheiter et al., 2009) using schematic or detailed pictures. They answered comprehension questions and performed a task in which they were asked to make connections between the text and the pictures. In the coming months we plan to carry out a full-scale experiment.
Pilot study

Method

Participants. Sixteen men and twenty women (age M=19.3, SD=1.0 yrs) volunteered for the study. All did their final secondary school exam between 2009 and 2013. They estimated their biology grade on average as 6.7 out of 10, as a course measure of prior knowledge. They were randomly assigned to one of two equal-sized groups, which did not differ in the exam year nor in the biology grade (p's>.7).

Materials and procedure. Each individual participant received a paper booklet, that started with demographic questions and questions about the final exam and biology grade. Then, the participant was given five minutes to study a 315-word text about mitosis (i.e., the biological process of cell reproduction), broken up into six parts corresponding to the six phases of mitosis. Each part was accompanied by a static picture depicting a cell in the respective phase. Crucially, this picture was either a microscopic photograph or a schematized line drawing1. See Figure 1 for examples.

Following the study phase, questions were asked about the difficulty of the task and the perceived added value of the pictures (results are not reported due to space constraints). Then, a multiple choice test was administered (four-choice questions: six questions about functions of cell parts, six about definitions of parts, and five about stage-specific dynamics of mitosis). Subsequently, a sorting task required participants to put the six mitosis pictures in the correct order, and to name the phases.

The procedure ended with a linking task, to test the extent to which learners make connections between text and pictures. In this task, participants were instructed to draw arrows between 21 key concepts in the text and the accompanying pictures. In both the sorting and the linking task, pictures were in the same condition as in the study phase.

Results

In the linking task, the schematic group drew more correct arrows (M=13.6, SD=3.7) than the detailed group did (M=9.2, SD=2.5), $F(1,35)=17.95$, $p<.001$, $\eta_p^2=0.345$. Importantly, performance on this task correlated significantly with performance on the multiple choice test, Pearson $r=.51$, $n=36$, $p<.005$, as shown in Figure 2.

As a consequence, the number of correctly answered questions was higher in the schematic group (M=9.4, SD=3.3) than the detailed group (M=6.8, SD=3.5), $F(1,35)=5.04$, $p<.05$, $\eta_p^2=0.129$. Scores on the linking task also correlated significantly with scores on the sorting task, $r=.50$, $n=36$, $p<.005$. In the sorting task, the schematic group numbered and named more phases correctly (M=3.4 SD=1.8) than the detailed group (M=1.6, SD=1.7), $F(1,35)=10.01$, $p<.005$, $\eta_p^2=0.227$.

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1 The photographs were selected from the internet. The line drawings were taken from Scheiter et al., 2009.
Discussion and future work

The results of our pilot study support the hypothesis that students' ability to connect key concepts in expository text to relevant parts of pictures is an important predictor of the pictures' effectiveness for learning, and that this ability is supported best by schematic pictures, when compared to detailed ones. We also found a main effect of schematization on two learning outcomes (a multiple choice questionnaire and a sorting task), replicating results that Scheiter et al. (2009) report for similar materials. Crucially however, we found that scores on a linking task (i.e., drawing arrows from key concepts in the text to corresponding parts of pictures) are strongly correlated with learning outcomes.

A relatively small and diverse group of participants took part in this pilot study, and these results clearly need to be replicated in another sample of students. Preferably, this sample consists of high school students all following the same study curriculum, with more uniform prior knowledge. Also, the control measures gathered in this pilot (e.g., self-reports of biology grades) should be improved to increase their reliability. We plan to present the results of this experiment at the conference.

Although the correlation between the link test and the questionnaire suggests that the ability to link key concepts in a multimodal instruction mediates learning outcomes, further empirical work should be carried out to disentangle the potential effects of leaving out detail in pictures on the one hand, from effects of highlighting what it is important on the other hand. Therefore, we include a third condition, with abundant visual detail but where important parts are highlighted (see Figure 3).

Further studies should aim at investigating other topics relevant to secondary education. Because students are not familiar with looking at biological cells (i.e., they have no phenomenal experience with seeing chromosomes etc.), recognizing important parts in photographs may be especially difficult. Therefore, benefits of schematization compared to detailed photographs may be less conspicuous when the photographs show concepts with which students actually do have phenomenal experience, such that they are readily able to identify key concepts in the pictures. Not every task or domain requires the same connections to be made between text and picture, but when it is important, schematization may be a good aid for learners to make these connections.

References