Using the learner-generated drawing strategy: How much instructional support is useful?

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Learner-generated drawing is a learning strategy which is used to improve students’ text comprehension. Research has shown that benefits of the learner-generated drawing strategy strongly depend on drawing-accuracy and that students need instructional support to draw accurate drawings. However, less is known about how much support is needed. Thus, in the present study, one hundred and two 9th graders read a science text and were instructed to generate drawings during reading with varying degrees of instructional support. Results show that students who learnt with a toolbar showing all the relevant elements for drawing showed higher drawing-accuracy scores associated with less learning time than students who learnt with pre-drawn drawing backgrounds or those who learnt without any support during drawing.

Objective and Theoretical Framework

Students reading complex and difficult scientific texts do often have problems with the cognitively highly demanding processes of text comprehension. Based on models of self-regulated learning (e.g., Boekaerts, 1999; Weinstein & Mayer, 1986; Zimmerman, 2001) the so-called learner-generated drawing strategy is one possible way to foster students’ text comprehension (Alesandrini, 1984; Schwamborn, Mayer, Thillmann, Leopold, & Leutner, 2010; van Meter & Garner, 2005). In doing so, students’ are instructed to read a text and to generate drawings by themselves that reflect the important ideas of the text. According to van Meter and Garner (2005) this generation process causes students to engage in cognitive and metacognitive processes which foster deep-level understanding of the to-be-learned information. The integration of the internal verbal and pictorial representations into a coherent mental model, for example, is induced (Mayer, 2009). Additionally, metacognitive processes such as self-monitoring and self-regulation are induced. Thus, drawing a picture to a text is a productive learning activity that encourages generative processing and thus fosters deep level understanding (de Jong, 2005; Kirschner, Sweller, & Clark, 2006; Mayer, 2003, 2004; Schwamborn et al., 2010).

However, instructing students to generate drawings to a text does not automatically guarantee deep level understanding. Problems concerning the product of drawing can occur, like a low quality of the students’ self-generated drawings (Leopold, 2009; van Meter, 2001; van Meter, Aleksic, Schwartz, & Garner, 2006). A low quality of the self-generated drawing means that the drawing does not accurately reflect all important ideas and causal relations that are described in the text which are necessary for deep-level understanding. Thus, benefits of the learner-generated drawing strategy depend on the quality respectively the accuracy of students’ self-generated drawings during reading – which is the so-called prognostic drawing effect (Schwamborn et al., 2010).

Accordingly, research on the learner-generated drawing strategy showed that the accuracy of students’ self-generated drawings respectively the benefits of the strategy depend on scaffolding students to use the strategy appropriately. That is, positive effects of the strategy on text comprehension depend on the instructional support mediated by the accuracy of the learner-generated drawings (e.g. Schwamborn et al., 2010). In studies of Leutner, Leopold, and Sumfleth (2009) and Alesandrini (1981), for example, students’ did not benefit from using the pure, unsupported learner-generated drawing strategy. Lesgold, Levin, Shimron, and Guttman (1975), van Meter et al. (2001, 2006), and Schwamborn et al. (2010), however,instructionally supported the drawing process in their studies and found benefits of the drawing strategy. Van Meter et al. (2001, 2006), for example, supported students with illustrations and prompting questions after the drawing process. Lesgold et al. (1975) supported students during the generation process by giving them cut-out figures. Accordingly, Schwamborn et al. (2010) implemented a drawing prompt to instructionally support students during the drawing process and thus to increase the accuracy of the generated drawings. The drawing prompt included (a) a toolbar showing (and labeling) all the relevant elements for drawing and (b) partly pre-drawn backgrounds for students’ drawings (see Figure 1). The authors found a significant positive effect of the learner-generated drawing strategy on text comprehension. Thereby high-accuracy drawers outperformed low-accuracy drawers.

In sum, research on the learner-generated drawing strategy has shown that benefits of the strategy strongly depend on the accuracy of students’ drawing during reading the text. That is, the accuracy of learners’ drawings during learning can predict the quality of their text comprehension. Thus, the accuracy of drawing during learning is a reflection of the actual use of the learner-generated drawing strategy (e.g. Schwamborn et al., 2010).
Additionally, results of Schwamborn et al. (2010) give indication that students do need instructional support during the use of the learner-generated drawing strategy to generate high-accuracy drawings. However, we do not know how much instructional support is necessary to enable students to generate high-accuracy drawings. Indeed, Schwamborn et al. (2010) suggested a drawing prompt; however, they did not conduct a treatment-check of their drawing prompt. Thus, it would be useful to vary the amount of drawing support given to the learner ranging from high support, as in the study of Schwamborn et al. (e.g., giving the learner a partially drawn background and a toolbar that presents and labels each element to be drawn) to low support (e.g., giving the learner only a partially drawn background).

Thus, in the present study four experimental drawing conditions with varying degrees of instructional support during the use of the learner-generated drawing strategy were implemented: (a) a toolbar showing (and labeling) all the relevant elements for drawing; (b) partly pre-drawn backgrounds; (c) a complete drawing prompt, that is a toolbar and partly pre-drawn backgrounds; (d) a control condition without any support during drawing. The goal of our study was to investigate how much instructional support students actually need to generate ‘good’ respectively accurate drawings while using the learner-generated drawing strategy. The accuracy of students’ drawings during learning was used as predictor of the quality of students’ text comprehension.

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**Figure 1.** Screen shot of the complete drawing prompt for the second paragraph of the learning booklet (cf. Schwamborn et al., 2010; p. 875).

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**Data Source**

One hundred and two 9th graders in higher track secondary schools participated in this study. The mean age was 14.3 years \( (SD = 0.55) \) and 56.9% were female.

**Method**

There were four treatment groups: 25 students served in the toolbar group, 26 served in the pre-drawn-background group, 25 served in the complete drawing prompt group, and 26 served in the control group without any instructional support during drawing. The materials used were adapted from Schwamborn et al. (2010). In addition, we also measured students’ individual learning times. The dependent variables were students’ drawing accuracy as well as their individual learning times.

Participants were tested in classrooms at their schools. All materials were paper-pencil based. Within their classes, students were randomly assigned to one of the four groups. First, students completed a participant questionnaire (e.g., current chemistry-grade). Second, students were tested on spatial ability (paper-folding test; Ekstrom, French, & Harman, 1976). Third, students were given instructional booklets corresponding to their assigned group. They were instructed to read the instruction and were then tested on their current motivation (questionnaire on current motivation; Rheinberg, Vollmeyer, & Burns, 2001). Then they were instructed to learn with the text. The text was about the chemistry of doing laundry, consisted of about 1000 words, and was divided into six paragraphs (cf. Schwamborn et al., 2010). Students did not have prior-knowledge about the topic of the text, as according to the curriculum this topic is introduced at the end of grade nine. Students in all four conditions were instructed to carefully read the text in order to comprehend the material and additionally were instructed to draw pictures for each text paragraph that represent the main ideas of that paragraph. Students in the toolbar condition were instructed to read the text and additionally to draw pictures for each paragraph...
using the elements from the toolbar. Students in the pre-drawn-background condition were instructed to read the text and additionally to draw the pictures for each paragraph using the partly pre-drawn picture backgrounds. Students in the complete drawing prompt condition were instructed to read the text and then to draw pictures using the drawing prompt, which means to use the elements from the toolbar and draw the pictures into the pre-drawn background. Students in the control group were instructed to read the text and additionally to draw pictures for each paragraph without any instructional support. Each student was allowed to learn at his/her own pace whereby learning time was measured.

Results and Conclusions

Scoring

We determined the drawing-accuracy score using a coding scheme. This coding scheme was based on expert drawings and a checklist specifying important features of the drawings (cf. Schwamborn et al., 2010). Students could get a maximum of 27 points on the drawing-accuracy score. Two independent raters, student assistants from science education, scored each of the six drawings for each student with an acceptable interrater reliability of Goodman-Kruskal gamma = .78.

Are the groups equivalent on basic characteristics?

Before looking at group differences on the dependent variables, drawing accuracy and learning time, we analyzed whether the four experimental groups differed on basic characteristics. A chi-square analysis indicated that there were no significant differences on gender ($p > .05$). Separate one-way analyses of variance revealed that the four experimental groups did not differ significantly on age, $F(3,98) = 2.02, p = .12$; spatial ability, $F < 1$; chemistry-grade, $F(3,98) = 2.15, p = .09$; or motivation, $F < 1$. Overall, we concluded that the groups were equivalent on basic characteristics.

Are the groups equivalent on drawing accuracy and learning time?

First, mean proportion correct and $SD$s on drawing accuracy during learning for all four conditions are presented in Table 1. There was a significant main effect of group on the accuracy score, $F(3,98) = 6.49, p < .001$, partial $\eta^2 = .17$. Tukey’s test (with $p < .05$) showed that students in the control group and the pre-drawn-background group generated significantly less accurate drawings than students in the toolbar group and in the complete-drawing-prompt group. There were no additional significant differences between the groups (all $p > .05$).

Second, results revealed that students in the toolbar group ($M = 30.64, SD = 4.67$) and in the complete drawing prompt group ($M = 31.08, SD = 4.27$) needed significantly less learning time to work with the science text than students in the pre-drawn background group ($M = 34.31, SD = 3.53$) and in the control group ($M = 33.73, SD = 4.50$), $F(3,98) = 4.79, p < .01$, partial $\eta^2 = .13$. Again there were no additional significant differences between the groups (all $p > .05$).

Overall, our results show that the most effective instructional support seems to be the toolbar showing (and labeling) all the relevant elements for drawing. Both, students in the complete-drawing-prompt group and students in the toolbar group showed higher drawing-accuracy scores associated with less learning time than students in the pre-drawn-background group or those in the control group. Students in the pre-drawn-background group, however, did not differ significantly from those in the control group on drawing accuracy and learning time. Apparently, the pre-drawn background was not an adequate instructional support for using the learner-generated drawing strategy. The toolbar, however, was successful in supporting students during the use of the learner-generated drawing strategy. Students in the toolbar groups did not differ significantly from those in the complete-drawing-prompt group – that is, toolbar and pre-drawn backgrounds – on drawing accuracy and learning time. In short, giving students all the relevant elements they need for drawing increases the accuracy of their self-generated drawings and simultaneously decreases the time they need to work with the text.

Table 1: Mean proportion correct on drawing accuracy during learning for all four groups.

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<thead>
<tr>
<th>group</th>
<th>drawing accuracy score</th>
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<td>control</td>
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<tr>
<td>toolbar</td>
<td>25</td>
</tr>
<tr>
<td>pre-drawn background</td>
<td>26</td>
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<tr>
<td>complete drawing prompt</td>
<td>25</td>
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</tbody>
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Scientific and Educational Significance

Concerning scientific implications, the results of this study are consistent with previous research on the learner-generated drawing strategy (cf. Lesgold et al., 1975; Schwamborn et al., 2010; van Meter & Garner, 2005). That is, students do need instructional support during the use of the learner-generated drawing strategy to generate high-accuracy drawings. With regard to the amount of instructional support that is needed to enable students to generate high-accuracy drawings, our results give evidence that the proposed drawing prompt respectively the toolbar by Schwamborn et al. (2010) seems to be a better instructional support of the learner-generated drawing strategy (by means of drawing-accuracy and learning time) than the pure, unsupported drawing instruction respectively the pre-drawn backgrounds, only. One reason might be that the toolbar which shows (and labels) all the relevant elements for drawing, presents the students important concepts that they need for drawing a coherent mental model of the chemical processes discussed in the text. That is, constraining and structuring the drawing activity by giving students the main concepts presented in the text fosters additional generative processing while minimizing additional extraneous processing (Schwamborn et al., 2010).

Thus, concerning educational implications, this study shows that using the learner-generated drawing strategy as proposed by Schwamborn et al. (2010) can be an effective way to improve students’ drawing accuracy, which in turn should result in better text comprehension. As several studies have shown positive correlations between drawing accuracy and text comprehension (e.g. Schwamborn et al., 2010; van Meter et al., 2001, 2006), in this study we assessed drawing accuracy only. That is, we used an indirect measure of text comprehension. However, to ensure our conclusions are appropriate, future work is needed to investigate whether the reported effects can also be replicated with direct measures of text comprehension (i.e. learning outcome tests on retention and transfer).

References