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WRITING LEARNING PROTOCOLS: PROMPTS FOSTER COGNITIVE AND METACOGNITIVE ACTIVITIES AS WELL AS LEARNING OUTCOME

Abstract. Although learning protocols seem to be a promising possibility as a form of follow-up course work, cognitive and metacognitive learning activities proved to be suboptimal in “naive” protocols. Therefore, learning protocols were structured by prompts to elicit cognitive and metacognitive learning activities and thereby improve their effects. An experiment with four conditions was conducted. The learners received either (a) cognitive prompts, (b) metacognitive prompts, (c) mixed prompts, or (d) no prompts (control group) for writing a learning protocol. The prompts produced large effects on cognitive and metacognitive learning activities in the learning protocols. Nevertheless, only the groups who received cognitive or mixed prompts were superior with regard to (a) the learning outcomes on an immediate comprehension test and a 7-day-delayed test and (b) the accuracy of self-assessment in these tests. However, the learners did not perceive these prompts as helpful which should be addressed in an informed training.

1. INTRODUCTION

Typically the contents of lessons and lectures "evaporate" rather quickly. After the learners have left their classroom or the lecture hall, only a few continue to reflect upon the material they just heard. A personal organization of the learning contents is not performed, examples are not thought of, critical reflections are not carried out, and knowledge gaps are neither noticed nor closed. These factors result in a lack of understanding and therefore also lead to poor long-term retention. Yet understanding is surely one of the best memory "strategies". Furthermore, illusions of understanding occur. One method that can be a remedy in these respects is the writing of a learning protocol in which the learners are supposed to perform the above mentioned activities.

2. THEORETICAL BACKGROUND

2.1. Writing a Learning Protocol

A learning protocol typically represents a written explication of one’s own learning process and outcomes. When this occurs over an extended period of time, it is termed learning diary (Nückles, Schwonke, Berthold, & Renkl, 2004). The learning protocol is not merely a product of the writer’s cognitive and metacognitive activities. The writing can also have an epistemic function (Bereiter & Scardamalia, 1987), that is, via writing knowledge is actively worked through and transformed (knowledge transforming). For example, the learners organize the text in a new way and thereby, also reorganize their knowledge. Compared to a verbal protocol, in a written learning protocol, the thoughts about the learning material do not “fade
away” but are retained. Only by that, the possibility is provided to re-read single passages, think them through, modify them by the application of cognitive activities, and thereby, transform the knowledge (learning by writing). Furthermore, within metacognitive activities, gaps and inconsistencies in the text and, most importantly, also in the knowledge can be more easily discovered by the learner (reflecting by writing).

Learning by Writing: Cognitive Processing

A deeper cognitive processing of the subject matter can be achieved through the application of cognitive learning activities such as organizational activities (e.g., the identification of main ideas), elaboration activities (e.g., the generation of examples), and as a special elaboration activity critical reflection (e.g., discussing an issue from different perspectives) (Kuhn, 1991; Weinstein & Mayer, 1986). Increased cognitive learning activities should foster the comprehension and retention of the contents to be learned (cf. Pintrich, Smith, Garcia, & McKeachie, 1991).

Reflecting by Writing: Metacognitive Processing

In the framework of metacognitive activities in the learning protocol, learners may consciously acknowledge which aspects they have already understood well or discover gaps in knowledge (positive and negative monitoring). As a next step, the learners are to explain to themselves the cause of their knowledge gaps (self-diagnosis). This is a prerequisite of the strategy of self-regulation, which comprises the initiation of learning activities in order to solve the problem. By implementing these metacognitive activities, illusions of understanding may be prevented (cf. Chi, Bassok, Lewis, Reimann, & Glaser, 1989), which may lead to a more accurate self-assessment. If learners consciously realize what they have and have not understood, they should be able to assess their learning success in a more realistic way. However, this outcome of metacognitive activities is not always found (Gräsel, 1997).

2.2 Deficits in Naive Learning Protocols?

Do learners actually show productive cognitive and metacognitive processing in a learning protocol? Nückles et al. (2004) had students write learning protocols about each weekly lesson. The students in the seminar had only received brief and rather informal advice about how to write their protocols, thus the protocols can be considered naive. Hence, an analysis of these protocols could reveal important insights and allow for conclusions about how to provide instructional support for writing more effective learning protocols. It turned out that learners’ use of cognitive and metacognitive learning activities proved to be rather less than optimal. Thus, writing a learning protocol does not guarantee deep and reflective learning activities. Hence, it appeared worthwhile to structure the writing. The research on prompts offers a promising starting point how to structure it.
2.3 Structuring by Prompts

Prompts are a promising way to stimulate more sophisticated learning activities (Pressley et al., 1992). For example, King (1994) obtained positive results with prompts for deeper follow-up course work. Also, Bereiter and Scardamalia (e.g., 1987) - starting from an analysis of expert writing - created and evaluated a set of effective prompts to scaffold the writing of novices. However, for continued use of these strategies, it is not enough that the prompts are effective but they should also be perceived as being helpful by the learners (King, 1994).

3. RESEARCH QUESTIONS

Is it possible to prompt cognitive and metacognitive learning activities in learning protocols? What would be the effects of such prompts? Sets of prompts that promote the elicitation of cognitive and metacognitive activities should lead to favorable learning activities (Pressley et al., 1992). Learning outcomes should be enhanced by cognitive activities (Pintrich et al., 1991). It was an open question to what extent metacognitive activities would be useful (Gräsel, 1997) and if they would, in fact, lead to a more accurate self-assessment (Bereiter & Scardamalia, 1987). Specifically, the following research questions were addressed: (a) Can sets of prompts foster cognitive and metacognitive learning activities in learning protocols? (b) Which effects do sets of prompts have on the comprehension and retention of the learning contents? (c) Which effects do sets of prompts have on the accuracy of self-assessment? (d) Are the effective sets of prompts perceived as helpful?

4. METHOD

4.1 Participants and Design

The participants of the experiment were 84 undergraduate students of psychology. In the first condition, the instruction for writing the learning protocol included six cognitive prompts (condition cognitive prompts, \( n = 22 \)), the second condition six metacognitive prompts (condition metacognitive prompts, \( n = 19 \)), the third condition a mixture of three cognitive and three metacognitive prompts (condition mixed prompts, \( n = 21 \)), and the last condition no prompts at all (condition no prompts, control group; \( n = 22 \)).

4.2 Procedure

The experimental procedure included two sessions. In the first session, the participants filled out a pretest on prior knowledge about the topic of conceptual change. Next, they attended a video-taped lecture on developmental psychology (specific topic: conceptual change). After that, the participants wrote a learning protocol. During this phase, the experimental manipulation was realized, that is, the participants received one of the four instructions for writing their learning protocol. The time spent for writing the protocol was held constant. Then, the participants an-
answered a question about the perceived helpfulness of their instruction for writing the protocol, completed an immediate comprehension post-test, and self-assessed their learning success. Seven days later the participants again rated the perceived helpfulness, completed the comprehension test again in order to provide a measure of retention, and self-assessed their learning success.

4.3 Materials and Instruments

Pretest and Video-Based Lecture
The pretest, assessing prior knowledge, consisted of six open-ended questions (e.g., "Which problems can occur during conceptual change?").

A lecture on developmental psychology was videotaped. The videotape guaranteed that the lecture contents and the presentation would be standardized across experimental conditions.

Instructions for Writing the Learning Protocol and Rating on Perceived Helpfulness
In all four conditions, the participants were provided with short general instructions on writing a learning protocol, and - except for the control group - all the conditions received specific prompts. Three sets of prompts were developed for the corresponding conditions. The instruction for the condition cognitive prompts included six cognitive prompts that were intended to foster cognitive learning activities, such as organizational activities (e.g., “How can you best organize the structure of the learning content?”), elaboration activities (e.g., “What examples can you think of that illustrate, confirm, or conflict with the learning contents?”), and critical reflection (e.g., “Which aspects of the learning contents do you find interesting, useful, convincing, and which not?”). The participants of the group metacognitive prompts were provided six metacognitive prompts that were supposed to elicit metacognitive learning activities, such as monitoring (e.g., “Which main points haven’t I understood yet?”), self-diagnosis (e.g., “What’s the reason for this?”), and self-regulation (e.g., “What possibility do I have now to overcome my comprehension problems?”). The participants in the condition mixed prompts received three cognitive and three metacognitive prompts. The participants of all four conditions had 30 minutes at their disposal to write the protocol. Thereby, learning time was held constant across the conditions. After finishing the protocol, the participants rated on a 6-point scale (1 = very low; 6 = very high), how helpful they perceived the instructions (i.e., the prompts) for writing the learning protocol.

Comprehension Test and Retention Test
The comprehension test and the identical retention test consisted of eight open-ended questions (e.g., “A teacher comes to you and tells you that her students often have theories that contradict scientific knowledge. She asks you as a psychologist how to deal with this problem. What would you answer?”).
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Self-Assessment of Learning Success
In order to use a "fair" set of outcome variables for all conditions, we also included - besides the cognitive measure comprehension - an outcome measure for metacognitive activities by having the students self-assess their performance on the comprehension and retention test. To this purpose we asked the learners to grade each of their answers they gave in the tests (self-assessment of learning success). The accuracy of self-assessment was determined by computing the signed difference between the raters’ mean score (polarity reversed) and the student’s grade. Thus, scores close to zero indicate a high accuracy of self-assessment.

5. RESULTS
Two independent raters scored the amount of cognitive and metacognitive learning activities in the learning protocols, as well as the level of comprehension on the open-ended questions on the pretest and post-tests by using a 6-point rating scale ranging from one (= dimension not present) to six (= dimension clearly present). Inter-rater reliability was very good (intra-class-coefficient: .92).

Table 1 presents the mean scores and standard deviations for each group on the pretest, the learning activity of the protocols, and the outcome measures. Each dependent measure was subjected to a separate ANOVA. A priori contrasts were calculated, comparing the conditions including prompts with the control group.

Table 1. Mean Scores and Standard Deviations on each measure

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cognitive Prompts (n = 22)</th>
<th>Metacogn. Prompts (n = 19)</th>
<th>Mixed Prompts (n = 21)</th>
<th>No Prompts (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Pretest</td>
<td>1.65</td>
<td>1.32</td>
<td>1.55</td>
<td>1.04</td>
</tr>
<tr>
<td>Cogn. Activity</td>
<td>5.00</td>
<td>.94</td>
<td>2.53</td>
<td>.88</td>
</tr>
<tr>
<td>Metacogn. Activity</td>
<td>1.77</td>
<td>1.19</td>
<td>5.84</td>
<td>1.20</td>
</tr>
<tr>
<td>Comprehension (1&lt;sup&gt;st&lt;/sup&gt;)</td>
<td>3.97</td>
<td>.80</td>
<td>3.22</td>
<td>.68</td>
</tr>
<tr>
<td>Comprehension (2&lt;sup&gt;nd&lt;/sup&gt;)</td>
<td>3.93</td>
<td>.97</td>
<td>3.11</td>
<td>.69</td>
</tr>
<tr>
<td>Acc. of Self-Ass. (1&lt;sup&gt;st&lt;/sup&gt;)</td>
<td>.06</td>
<td>.58</td>
<td>.66</td>
<td>.65</td>
</tr>
<tr>
<td>Acc. of Self-Ass. (2&lt;sup&gt;nd&lt;/sup&gt;)</td>
<td>.00</td>
<td>.82</td>
<td>.73</td>
<td>.60</td>
</tr>
<tr>
<td>Helpfulness (1&lt;sup&gt;st&lt;/sup&gt;)</td>
<td>3.32</td>
<td>.95</td>
<td>2.53</td>
<td>1.22</td>
</tr>
<tr>
<td>Helpfulness (2&lt;sup&gt;nd&lt;/sup&gt;)</td>
<td>3.27</td>
<td>.87</td>
<td>2.74</td>
<td>1.20</td>
</tr>
</tbody>
</table>

Note. 1<sup>st</sup> means measure in the first session; 2<sup>nd</sup> means measure in the second session.

An ANOVA revealed no significant differences with respect to the student’s prior knowledge \((F(3, 80) = .35, p = .791)\). Thus, the experimental groups were comparable with respect to cognitive learning prerequisites.
5.1 Effects of Prompts on Learning Activities

There were significant and strong group differences with respect to cognitive learning activities, $F(3, 80) = 37.30, p < .001, \eta^2 = .58$, and also with regard to metacognitive learning activities, $F(3, 80) = 149.10, p < .001, \eta^2 = .85$. A priori contrasts revealed that the conditions cognitive prompts and mixed prompts showed significantly more cognitive learning activities than the group no prompts, $t(42) = 8.60, p < .001$, and $t(41) = 6.15, p < .001$, respectively. The a priori contrast comparing the condition metacognitive prompts with the control group revealed no significant difference, $t(39) = -.12, p = .910$. An analogous pattern of results emerged with respect to the metacognitive strategies. A priori contrasts revealed significant differences between the condition metacognitive prompts and the group no prompts, $t(39) = 18.21, p < .001$, and between the condition mixed prompts and the group no prompts, $t(41) = 13.56, p < .001$. The group cognitive prompts showed significantly higher metacognitive activity than the control group, $t(42) = 2.87, p = .005$. Thus, learners who received cognitive or mixed prompts significantly outperformed their counterparts in the group no prompts with regard to the amount of cognitive learning activities in the learning protocols. Similarly, participants who received metacognitive prompts showed a high degree of metacognitive learning activity in their learning protocols. Thus, cognitive and metacognitive prompts do in fact foster cognitive and metacognitive learning activities in learning protocols.

5.2 Analysis of Learning Outcomes

Separate ANOVAs showed a significant and strong effect both for the immediate comprehension test, $F(3, 80) = 6.84, p < .001, \eta^2 = .20$, and for the retention test, $F(3, 80) = 6.23, p = .001, \eta^2 = .19$. A priori contrasts revealed significant differences between the condition cognitive prompts and the group no prompts, $t(42) = 3.79, p < .001$, as well as between the condition mixed prompts and the no prompts condition (i.e., the control group), $t(41) = 3.52, p < .001$. No significant effect was found between the condition metacognitive prompts and the no prompts condition, $t(39) = 1.00, p = .320$. The same pattern of effects was obtained for the retention measure. Comparable to immediate comprehension, the groups who had received cognitive prompts or mixed prompts clearly outperformed the group who had received no prompts, $t(42) = 3.53, p < .001$, and $t(41) = 3.29, p < .001$, respectively. Again, there was also no significant effect for the comparison of the group with metacognitive prompts and the control group, $t(39) = .71, p = .479$. Hence, the participants who had received cognitive or mixed prompts performed significantly better on the immediate comprehension test questions, as well as on the delayed retention test questions when compared with those students who had received no such prompts but had the same learning time at their disposal.
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5.3 Analysis of Accuracy of Self-Assessment

To test for accuracy of self-assessment, separate ANOVAs were conducted for the comprehension and the retention test. For both measures, a significant and strong effect resulted, \( F(3, 80) = 5.63, p = .002, \eta^2 = .17, \) and \( F(3, 80) = 8.52, p < .001, \eta^2 = .24. \) Planned comparisons showed that the accuracy of self-assessment in the immediate comprehension test was more precise in the conditions with cognitive and mixed prompts compared with the no prompts condition, \( t(42) = -3.26, p = .002, \) and \( t(41) = -3.16, p = .002. \) There was no significant difference between the groups metacognitive prompts and no prompts, \( t(39) = -.59, p = .556. \) The same pattern of findings resulted for the accuracy of self-assessment in the retention test. Again, the participants of the conditions cognitive prompts and mixed prompts outperformed their counterparts in the group no prompts, \( t(42) = -3.35, p = .001, \) and \( t(41) = -4.09, p < .001. \) No significant difference was found between the condition metacognitive prompts and the group no prompts, \( t(39) = -.27, p = .786. \) Thus, cognitive as well as mixed prompts lead to a better self-assessment of one’s own learning success.

5.4 Analysis of Perceived Helpfulness

Are the effective prompts perceived as helpful? To answer this question, we computed planned contrasts that compared the successful prompts conditions (i.e., the cognitive and mixed prompts conditions) with the group no prompts. There was neither a significant difference between the effective prompts conditions and the group no prompts \( t(42) = -.11, p = .271 \) for the condition cognitive prompts, and \( t(41) = -1.62, p = .109 \) for the condition mixed prompts) at the first measurement point, nor at the second measurement point \( t(42) = -.58, p = .564, \) and \( t(41) = .36, p = .714, \) respectively). Thus, the effective prompts conditions were not perceived as more helpful than the instructions of the group no prompts.

6. DISCUSSION

In summary, our study revealed three essential contributions for educational research and practice: (1) It is – in fact - possible to prompt cognitive and metacognitive learning activities in learning protocols. (2) The elicitation of cognitive learning activities or cognitive and metacognitive activities (mixed prompts) in a learning protocol strongly fosters learning outcomes along with the accuracy of self-assessment, whereas in this respect metacognitive activities are not effective. (3) However, the effective prompts are not perceived as being more helpful by the learners.

These findings implicate important aspects for the instructional design of writing learning protocols. When implementing such a learning method, the effects can be – within the same learning time – substantially enhanced by using cognitive or a combination of cognitive and metacognitive prompts. Nevertheless, the fact that the learners of the successful groups did not perceive their prompts as more useful than the participants of the less successful groups suggests that learners should be informed in detail about the potential value of such learning activities in order to in-
crease the likelihood of their continued application (principle of informed training; Paris, Lipson, & Wixson, 1983).

Should an instructional design of writing learning protocols exclude metacognitive prompts? We believe that it would be premature to say "no". (a) In our study, we used a one-shot intervention. However, metacognitive activities may be especially effective in long-term interventions, particularly if the learners have supporting materials at their disposal. Then they can look up and solve comprehension problems which they discovered during their metacognitive processing. (b) The group which simultaneously received metacognitive and cognitive prompts was as successful as the participants who worked with cognitive prompts. It is possible that metacognitive learning activities have to be applied in combination with cognitive learning activities in order to foster learning.

The present results also have implications for computer-assisted learning because it is easily possible to implement our procedure of writing a learning protocol scaffolded by prompts into a computer-based learning environment. Based on these insights, we designed the computer-based program eHELP (electronic Help for writing and managing learning protocols) that provides an integrated working and learning environment intended to support learning by writing learning protocols (Nückles et al., 2004).

AFFILIATIONS
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REFERENCES