Short-Term versus Long-Term Effects of Cognitive and Metacognitive Prompts in Writing-to-Learn

Matthias Nückles, University of Göttingen, Göttingen, matthias.nueckles@psych.uni-goettingen.de
Sandra Hübner, Alexander Renkl, University of Freiburg, Freiburg,
Email: renkl@psychologie.uni-freiburg.de

Abstract: Journal writing is a promising follow-up to course-work. A learning journal is a written explication of one's own learning processes and outcomes after a lecture or seminar session. To fully exploit the potential of journal writing, instructional support is required. Experimental studies showed that prompts are effective in optimizing journal writing. To investigate the long-term effects of prompts, we conducted a longitudinal study. Students (N = 50) wrote journal entries about weekly seminar sessions over a whole term. The experimental group received cognitive and metacognitive prompts for their writing. The control group received a non-specific instruction without prompts. The prompts proved to be effective in the short term. However, in the long term, they had negative effects on (1) learning strategies elicited in the journals, (2) learning success and (3) students' writing motivation. In order to avoid such pitfalls of over-prompting, a gradual fading of the prompts might offer a solution.

Introduction

Typically, lesson and lecture content "evaporates" rather quickly. After the students have left the classroom or lecture auditorium, only a few continue to reflect on learning contents they have just been confronted with. The students rarely organize learning contents in a meaningful and coherent fashion. Seldom do they come up with examples to illustrate abstract concepts. Also, few students routinely monitor their understanding for knowledge gaps and employ remedial strategies that could help close the gaps. Students' failure to apply such beneficial cognitive and metacognitive learning strategies typically results in a lack of understanding and, thereby, also leads to poor long-term retention. The writing of learning journals (Berthold, Nückles, & Renkl, 2007; McCrindle & Christensen, 1995) is a learning method that may help to overcome these shortcomings. A learning journal typically represents a written explication of one's own learning processes and outcomes over an extended period of time (e.g. over a whole term or school year). Learning journals are especially appropriate for follow-up course work. They help students apply the above-mentioned cognitive and metacognitive strategies.

Journal writing has been shown to be effective in improving students' learning across various educational settings and subjects (e.g., Cantrell, Fusaro, & Dougherty, 2000; Connor-Greene, 2000; McCrindle & Christensen, 1995). However, there is also evidence that without appropriate instructional support, students do not apply the learning journal method in an optimal way (Nückles, Schwonke, Berthold, & Renkl, 2004). Therefore, we have developed specific prompts that support the writing of effective learning journals. In this contribution, we present an experimental longitudinal study that examined the long-term effects that prompts had on the application of cognitive and metacognitive strategies, as well as on students' learning success and motivation for journal writing.

Cognitive and Metacognitive Strategies in Writing Learning Journals

Typically, a learning journal is not merely a summary of a writer's learning outcomes gained in preceding learning episodes (e.g., a lecture or seminar session). Rather, it is an opportunity to apply beneficial cognitive and metacognitive learning strategies in order to deepen and expand the newly acquired knowledge. Cognitive learning strategies include organization and elaboration strategies. Organizational strategies refer to the identification of main ideas and their interrelations, the highlighting of central concepts, and the structuring of contents (Weinstein & Mayer, 1986). That way, "internal" links that relate relevant aspects of the new material to each other are constructed (Mayer, 1984). In other words, the learning contents are organized in a meaningful way. Elaboration strategies help to construct so-called "external" links that relate the new material to the learner's prior knowledge (Mayer, 1984). The generation of examples, the use of analogies, and the critical discussion of issues are commonly regarded as prototypical elaboration strategies (Weinstein & Mayer, 1986). Such strategies assist the learner in going beyond the given knowledge by creating links between her or his prior knowledge and the new information (Mayer, 1984), thus enabling deeper understanding and retention (Barnett, DiVesta, & Rogozinski, 1981; McCrindle & Christensen, 1995).

Besides cognitive strategies, the writing of learning journals is further supposed to stimulate the application of metacognitive strategies. Metacognition refers to the knowledge and awareness of one's own cognitive processes and the ability to actively control and manage those processes (Efklides & Vauras, 1999;

Flavell, 1976). Learners may use journal writing to consciously acknowledge which aspects of the learning material they have already understood well (*positive monitoring*), or they may identify comprehension difficulties (*negative monitoring*; see Chi, Bassok, Lewis, Reimann, & Glaser, 1989). The elicitation of metacognitive strategies during the production of a learning journal can help to prevent illusions of understanding (Chi et al., 1989; Renkl, 1999) and trigger remedial cognitive strategies in order to clarify a previously identified comprehension problem.

To stimulate the use of cognitive and metacognitive strategies in writing learning journals, we developed different sets of prompts. Prompts are questions or hints that induce productive learning processes in order to overcome superficial processing (King, 1992; Pressley et al., 1992). They can be conceived of as *strategy activators* (Reigeluth & Stein, 1983) because they induce learning strategies that the learners are, in principle, capable of, but do not spontaneously demonstrate, or demonstrate to an unsatisfactory degree. Several experimental studies investigated the effects of prompts on strategy use and learning outcomes. In the study by Berthold et al. (2007), students received one of four instructions for writing a journal entry – a so-called "learning protocol" – about a videotaped lecture they had previously viewed. The instruction either included six cognitive (i.e., organizational and elaborative) prompts (e.g., "How can you best structure the learning contents in a meaningful way?"), six metacognitive prompts (e.g., "Which main points haven't I understood yet?"), a mixture of three cognitive and three metacognitive prompts, or no prompts at all (control condition). Results showed that learners who received cognitive, or cognitive *and* metacognitive prompts significantly outperformed the control group with regard to (a) the amount of cognitive and metacognitive strategies in the learning protocols, and (b) the learning outcomes on both an immediate comprehension test and a seven-days delayed retention test. Hübner, Nückles, and Renkl (2006) successfully replicated the results of Berthold et al. using an improved and expanded experimental design. They further showed that prompting the application of regulation strategies, that is, "remedial" cognitive strategies in order to solve comprehension problems previously identified by self-monitoring, had a surplus value regarding learning success. Accordingly, in Hübner's et al. study, the highest learning success resulted in that experimental condition where students received prompts for (1) the organization and elaboration of learning contents, (2) the monitoring of their understanding, and (3) the application of regulation strategies in case of perceived comprehension problems.

Together, these studies suggest that prompts can be a very effective means to support the application of beneficial cognitive and metacognitive learning strategies in writing a learning journal. Nevertheless, in both experimental studies, students were required to produce only one single journal entry (i.e., a learning protocol). In real world instructional settings, such as, university seminars or lectures, students typically do not produce just one single learning protocol or journal entry like they did in the experimental studies. Rather, they are required to write journal entries regularly over a longer period of time, for example as follow-up course work over a whole term. Thus, the question arises, whether prompts will be effective in stimulating productive learning strategies not only for a short time but also in the long term.

Research Questions

To investigate the long-term effects that cognitive and metacognitive prompts had on strategy use, and learning success, we conducted an experimental longitudinal study. In this study, we were further interested in the students' motivation for writing a learning journal. Inasmuch as prompts as "strategy activators" are an external requirement to apply cognitive and metacognitive strategies, their effects on intrinsic motivation for writing learning journals were of particular interest. In our study, undergraduate students of psychology kept a learning journal as follow-up course work for an introductory course in developmental psychology. They wrote a journal entry about each weekly seminar session over the whole term. The experimental group received a combination of cognitive and metacognitive prompts that had proved to be most effective in previous research (cf. Berthold et al., 2007; Hübner et al., 2006). These students were compared with a control group who received a rather vague and non-specific instruction that contained no prompts at all. We addressed the following research questions:

1. Will cognitive and metacognitive prompts foster the application of cognitive and metacognitive strategies in the learning journals not only in the short term but also in the long term?
2. Will cognitive and metacognitive prompts foster learning outcomes not only in the short term but also in the long term?
3. How will the prompts affect the students' motivation for journal writing in the long-term?

Method

Sample and Design

Fifty first semester students of Psychology (34 females, 16 males, mean age: 21.74 years) participated in the study. They were randomly assigned to two parallel introductory courses in Developmental Psychology. The courses lasted four months. Within this time, 14 seminar sessions were held. Except the first and the last session, the students were required to write a learning journal entry after each session as follow-up course work.

Hence, the students had to write twelve journal entries in total. In both courses the same contents were taught by the same lecturer (i.e., the first author). The students completed these courses as regular part of their undergraduate studies in Psychology at the University of Freiburg. They received 20 Euro for their participation in the testing sessions. To investigate the long-term effects of prompts, we used a control-group design: The participants of one course (i.e., the experimental group, n = 25) received prompts for writing their journal entries, whereas the participants of the other course (i.e., the control group, n = 25) received no prompts. Dependent variables encompassed measures of the learning strategies elicited in the learning journals, the students' knowledge acquisition as well as measures of the students' motivation for writing the learning journal.

Materials, Codings and Instruments

Instructions for Writing the Learning Journal (Experimental Variation).

In both conditions, a brief general instruction on writing a learning journal was given. The participants in the experimental condition additionally received six prompts, that is, three cognitive and three metacognitive prompts. The cognitive prompts were intended to stimulate organization strategies ("Which were the main points of today's seminar session in your opinion?") and elaboration strategies ("What examples can you think of that illustrate, confirm, or conflict with the learning contents?" – "Which cross-links can you construct between today's seminar session and the previous sessions?"). We further applied two types of metacognitive prompts: Monitoring prompts were meant to elicit monitoring strategies ("Which main points haven't I understood yet?" – "Which main points have I already understood well?"). A planning-of-regulation prompt encouraged the students to consider ways of regulating their learning process ("What possibilities do I now have to overcome my comprehension problem?").

Analysis of the Learning Journals

Two independent raters, who were blind to the experimental conditions, scored the amount of cognitive and metacognitive learning strategies in the journal entries by using 6-point rating scales ranging from 1 (= *dimension not present*) to 6 (= *dimension clearly present*). A score of 6 on the rating scale of cognitive strategies could be achieved if the journal entries were highly organized (e.g., by identifying main points and arranging them in an ordered sequence, such as "first …, second …, third …") and highly elaborated (e.g., by providing own examples to illustrate abstracts concepts: "A good example of Piaget's notion of infantile egocentrism is when my little son shows me something in his picture book and disregards that I cannot see what he sees from my perspective."). A score of 6 on the rating scale of metacognitive strategies could be achieved if the journal entries included a high amount of monitoring (e.g., by specifying which contents were not yet understood: "I have not yet understood the exact difference between Piaget and Carey."), and planning of self-regulation (e.g., attempts to solve the perceived gap in one's knowledge: "I will try to call to mind the presentation where different approaches to conceptual change were explained…"). Inter-rater reliability as determined by the intra-class coefficient was very good (*ICC* = .81 for the rating of cognitive strategies, *ICC* = .84 for the rating of metacognitive strategies).

Learning Success

Learning success was assessed by two comprehension tests, one of which was administered after the first half of the term and the other at the end of the term. Each test consisted of six open-end questions regarding the topics that had so far been discussed in the preceding seminar sessions. In order to answer these questions, the learners had to apply their knowledge, for example, by using theoretical concepts to explain self-generated examples (e.g., "Please provide a moral justification of a solution for the 'Heinz dilemma' which is on the conventional level according to Kohlberg's theory of moral development!"), or by dealing with the material in a critical manner (e.g., "Please discuss the challenges and rewards of Piaget's theory of cognitive stages critically!"). To score the level of comprehension in the answers we used the SOLO-Taxonomy ("Structure of Observed Learning Outcome") by Biggs and Collis (1982). Following the SOLO-Taxonomy, each answer was differentiated into six levels of knowledge ranging from 1 (= *no central points, low level of understanding, incoherent*) to 6 (= *all central points, high level of understanding, very coherent*). Inter-rater reliability as determined by the intra-class coefficient was very high (*ICC* = .96).

Motivation for Writing Learning Journals

The students' motivation for writing learning journals was assessed after the first half of the term and again at the end of the term. We were interested to what extent the students enjoyed writing a learning journal, evaluated this type of follow-up coursework as valuable and useful, and how competent they perceived themselves to be in doing this. To measure these motivational factors, the students received subscales of the intrinsic motivation inventory which we adapted to the domain of journal writing (IMI; cf. Deci, Eghari, Patrick, & Leone, 1994). In detail, we administered modified versions of the subscale *interest/enjoyment* (e.g., "I enjoyed doing this activity very much"), of the subscale *effort/importance* (e.g., "I put a lot of effort into this"),

and of the subscale *perceived competence* (e.g., "I think I am pretty good at this activity"). The students responded to these items on a 7-point rating scale ranging from 1 (= *not at all true*) to 7 (= *very true*). The reliability of the scales was good (Cronbach's α = .74 – 86).

Procedure

The students were asked to write a journal entry after each weekly seminar session. The required minimum text length was one page. For writing their weekly journal entry, the students logged on a web server. They downloaded a prepared file in Rich Text Format which included the instructions for writing the journal entry. Thus, it was guaranteed that the students had the instructions available while writing. After completing the journal entry, the students uploaded it on the web server. Students who failed to upload their journal entry in time got a friendly reminder via email by the experimenter. That way it was ensured that the journals entries were written regularly and the number of missing protocols was kept low. The students' learning success and their motivation for journal writing were assessed twice: Once after the first half of the term and once again at the end of the term. These assessments took place in extra sessions at the Institute of Psychology. As part of these sessions, the students completed a comprehension test and the motivation questionnaire. Each session lasted about 1.5 hours.

Results

Table 1 shows the mean scores and standard deviations for both experimental groups on the learning strategy measures, the comprehension tests, and the motivation scales. The mean scores are plotted separately for the two measurement times, that is, after the first half of the term and at the end of the term. In case of the learning strategy ratings, mean scores were obtained by averaging the ratings for the six journal entries which a student had produced in the first half of the term, and, similarly, by averaging the following six entries the student had written until the end of the term. An alpha level of .05 was used for all statistical tests. As an effect size measure, we used η^2 – qualifying values < .06 as a weak effect, values in the range between .06 and .13 as a medium effect, and values > .13 as a large effect (see Cohen, 1988).

Table1: Means and Standard Deviations (in Parentheses) of the Analysis of the Learning Journals, Learning Success and Motivation for Journal Writing in the Experimental Groups.

		Cognitive Strategies[a]	Meta-cogitive Strategies[a]	Learning Success[b]	Interest/ Enjoy-ment[c]	Effort/ Impor-tance[c]	Perceived Compe-tence[c]
1st Half of Term	Prompts	4.00 (0.76)	2.68 (1.18)	3.95 (0.97)	3.96 (0.89)	4.43 (1.20)	3.84 (0.72)
	No Prompts	3.70 (0.74)	2.19 (0.91)	3.55 (0.88)	4.01 (1.15)	4.44 (1.06)	3.75 (1.17)
2nd Half/ End of Term	Prompts	3.78 (0.63)	1.63 (0.71)	3.51 (0.79)	3.10 (1.00)	3.38 (1.09)	3.41 (0.89)
	No Prompts	3.90 (0.82)	1.68 (0.84)	3.56 (0.85)	3.89 (1.31)	4.01 (1.17)	3.90 (1.42)

[a] 6-point rating scale ranging from 1 (= *dimension not present*) to 6 (= *dimension clearly present*).
[b] 6-point rating scale ranging from 1 (= *no central points, low level of understanding, incoherent*) to 6 (= *all central points, high level of understanding, very coherent*).
[c] 7-point rating scale ranging from 1 (= *not at all true*) to 7 (= *very true*).

Analysis of the Learning Journals

We analyzed the extent to which cognitive and metacognitive strategies were present in the learning journals. For this purpose, we compared the mean ratings of the six journal entries written in the first half of the term with the mean ratings of the six journals entries written in the second half of the term. Averaging across single journal entries had two major advantages: 1) The single journal entries produced by a student may vary considerably. Thus, using average scores provided us with a more reliable measure of the learning strategies which a student elicited in her or his learning journal. 2) We avoided an unnecessary loss of data. As we analyzed the learning strategy measures with repeated measures analyses of variance (our sample size was too small for HLM), students who had one or more missing journal entries would have been completely excluded as cases from the data analysis. Accordingly, the mean ratings for cognitive and metacognitive strategies were subjected to separate mixed repeated measures analyses of variance with measurement time (first half of the

term vs. end of the term) as a within-subjects factor and experimental condition (prompts vs. no prompts) as a between-subjects factor. In the first MANOVA, the mean ratings of cognitive strategies were treated as the dependent variable. The MANOVA revealed a significant interaction effect between experimental condition and measurement time, $F(1, 48) = 9.68$, $p < .01$, $\eta^2 = .17$ (large effect). Neither the main effect of experimental condition, $F(1, 48) = 0.20$, *ns*, nor the main effect of measurement time, $F(1, 48) = 0.34$, *ns*, were significant. Figure 1 (left graph) shows the interaction between experimental condition and measurement time with regard to the presence of cognitive learning strategies in the students' learning journals.

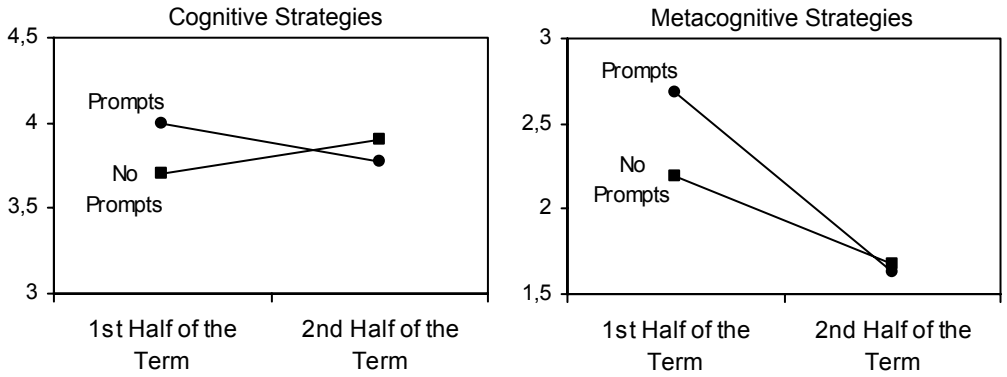

Figure 1. Interaction effects between experimental condition and measurement time with regard to the presence of cognitive strategies (left diagram) and metacognitive strategies (right diagram) in the learning journals.

As the left diagram in Figure 1 shows, students who regularly received prompts for writing their learning journal, elicited more cognitive strategies in their learning journal in the first half of the term as compared with the journals entries produced in the second half. In contrast, students who received only a general instruction that contained no specific prompts applied less cognitive strategies in the first half of the term than in their journal entries written in the second half of the term.

Similar results were obtained with regard to the presence of metacognitive strategies in the learning journals. Again, there was a significant interaction effect between experimental condition and measurement time, $F(1, 48) = 5.78$, $p < .05$, $\eta^2 = .11$ (medium effect). The main effect of the experimental condition was not significant, $F(1, 48) = 0.88$, *ns*. However, a significant main effect of measurement time was found, $F(1, 48) = 48.07$, $p < .001$, $\eta^2 = .50$ (large effect). As Figure 1 (right diagram) shows, the extent to which the students in both conditions elicited metacognitive strategies in their learning journals clearly decreased in the second half of the term. However, the significant interaction effect indicates that the students in the prompting condition were more strongly affected by this decrease because they started on a higher level and applied more metacognitive strategies in their journals entries written in the first half of the term than the students in the control condition.

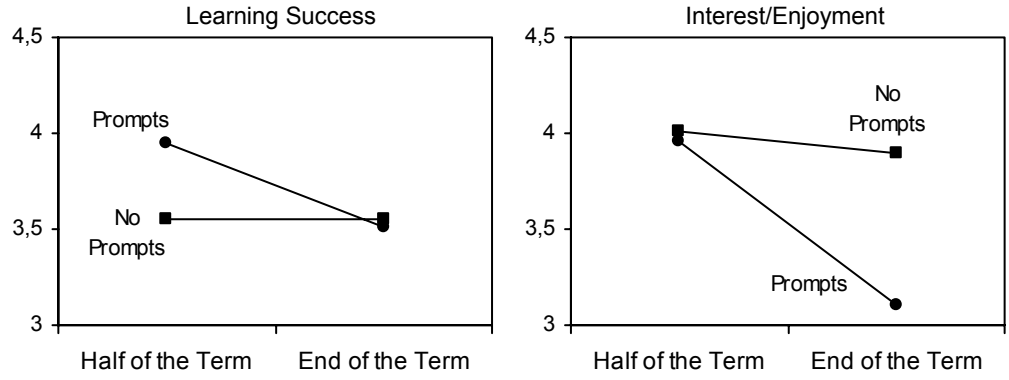

Figure 2. Interaction effects between experimental condition and measurement time with regard to learning success (left diagram) and the students' interest/enjoyment for writing learning journals (left diagram)

Learning Success

The analysis of the two comprehension tests, administered in additional sessions, one taking place after the first half of the term and the other at the end of the term, adds to the overall picture provided by the analysis of the learning journals. As before, a significant interaction effect between experimental condition and measurement time occurred, $F(1, 48) = 4.29$, $p < .05$, $\eta^2 = .08$ (medium effect). The main effect of experimental

condition was not significant, $F(1, 48) = 0.59$, *ns*. However, the main effect of measurement time approached statistical significance, $F(1, 48) = 4.10$, $p < .05$, $\eta^2 = .08$ (medium effect). As Figure 2 (left diagram) shows, this main effect of measurement time cannot be interpreted independently of the significant interaction effect: In the first comprehension test after half of the term, the students in the prompting condition achieved clearly higher test scores than the students in the control condition. However, when learning success was measured again at the end of the term, the experimental group did not perform any better than the control group without prompts.

Motivation in Writing Learning Journals

To investigate the effects of prompts on the students' motivation for writing a learning journal, we analyzed the students' mean ratings for interest/enjoyment, effort/importance and perceived competence. The results fit in the overall pattern reported so far. For interest/enjoyment, a significant main effect of measurement time resulted, $F(1, 48) = 14.47$, $p < .001$, $\eta^2 = .24$ (large effect). However, this main effect should be qualified by the significant interaction between experimental condition and measurement time, $F(1, 48) = 8.36$, $p < .01$, $\eta^2 = .15$ (large effect). As Figure 2 (right diagram) shows, the students' enjoyment of writing a learning journal decreased over the course of the term. However, this decrease was evidently much more marked for the prompting condition as compared with the control condition. The main effect of experimental condition was not significant, $F(1, 48) = 2.13$, *ns*.

Similar results occurred for the students' invested effort and their perceived competence in journal writing. When invested effort was treated as the dependent variable, again a significant main effect of measurement time, $F(1, 48) = 30.61$, $p < .001$, $\eta^2 = .39$ (large effect), and a significant interaction between experimental condition and measurement time, $F(1, 48) = 5.37$, $p < .05$, $\eta^2 = .11$ (medium effect), were obtained. Thus, the students generally put less effort in writing their learning journal towards the end of the term. However, this decrease was substantially stronger for the students in the prompting condition than for the students in the control condition. The main effect of experimental condition was not significant, $F(1, 48) = 1.21$, *ns*.

In the final analysis, we tested whether the students' perceptions regarding their competence in writing a learning journal changed over the course of the term. In this MANOVA, the main effects of measurement time and experimental condition were not significant, $F(1, 48) = 1.28$ and $F < 1$, respectively. However, consistent with the previous analyses, the interaction between experimental condition and measurement time again reached statistical significance, $F(1, 48) = 5.62$, $p < .05$, $\eta^2 = .11$ (medium effect). Surprisingly, the students in the experimental condition felt more competent in journal writing in the beginning of the term than in the end of the term. In contrast, the perceived competence of the students in the control condition increased towards the end of the term.

Discussion

The aim of the present longitudinal study was to investigate the long-term effects of prompts as a method to support the writing of productive learning journals. Previous experimental research suggests that prompts may be very effective in stimulating cognitive and metacognitive strategies in writing a learning protocol or journal entry (cf. Berthold et al., 2007; Hübner et al., 2006). However, usually students are not required to merely produce one single journal entry. In school and academic educational settings, journal writing is typically introduced as a regular follow-up course work activity, for example, writing a journal entry after each weekly seminar session (cf. McCrindle & Christensen, 1995; Nückles et al., 2004). Thus, the question arises how the provision of prompts as strategy activators (cf. Reigeluth & Stein, 1982) will influence the application of beneficial learning strategies, the students' learning success and also their motivation and interest in keeping a learning journal.

The results of the present study confirm the results of the previous experimental studies inasmuch as short-term effects are concerned. In the short term, the prompts effectively stimulated beneficial learning strategies in the students' journal entries: Students who received cognitive and metacognitive prompts elicited a higher degree of cognitive and metacognitive strategies in their first six journal entries in the beginning of the term than the students in the control condition. In the long term, however, this picture changed. Students who received prompts applied significantly fewer strategies than in their initial journal entries. Their learning success, their invested effort and interest in journal writing clearly decreased. The control students' writing, in contrast, developed more positively over the course of the term: They elicited more cognitive strategies in their journal entries written in the second half of the term than in their entries produced in the first half. Also, their writing motivation evidently suffered less than the motivation of the students in the experimental group.

How can these results be explained? One can say that the results of the present study impressively demonstrate the pitfalls of prompting procedures in writing-to-learn. In the beginning of the term, the prompts successfully activated strategies which the students were, in principle, capable of, but which they would have spontaneously demonstrated to a rather unsatisfactory degree. However, the more the students became familiar with the learning journal method and "internalized" the tendency to elicit the desired strategies spontaneously by

themselves, the more the external guidance by prompts became dispensable and might have interfered with the students' internal tendency to apply the strategies by themselves. Thus, at some point in the term, the prompts probably did not function any longer as strategy *activators* – in the sense of Reigeluth and Stein (1982) –, but they rather functioned as strategy "inhibitors". As a consequence, the students in the experimental condition felt more and more restricted and controlled by the prompting instruction. Consequently, their effort to elicit cognitive and metacognitive strategies decreased resulting in a substantially lower learning success.

Negative side-effects of instructional support methods, such as this "over-prompting-effect" in journal writing, have also been reported in other domains and learning settings. Kalyuga, Ayres, and Chandler (2003) reported experimental evidence for a so-called expertise-reversal effect. That is, instructional aids which effectively facilitate learning for beginners and off-load working-memory may produce reverse effects when offered to advanced learners with a higher level of prior knowledge and/or skills. Following Kalyuga et al., for advanced learners, the instructional aids turn into "redundant" information which is difficult to ignore and therefore produces additional extraneous cognitive load (see also Kalyuga, 2007). Accordingly, it is possible that the more the students in our study became skilled in applying the desired strategies, the more the external guidance by prompts turned into a redundant stimulus and increased the amount of extraneous cognitive load.

Similarly, in the domain of computer-supported collaborative learning, several authors have recently discussed the problem of "over-scripting" in relation to computer-supported cooperation scripts (cf. Dillenbourg & Jermann, 2007; Weinberger, Reiserer, Ertl, Fischer, & Mandl, 2005). In the case of cooperation-scripts, the danger of over-scripting is particularly likely if the script makes very concrete and detailed prescriptions of how to behave. These prescriptions may limit the learners' autonomy and latitude too much. As a result, the learner's motivation to enact the activities prescribed by the script may be corrupted. Similar detrimental effects of external regulation on intrinsic motivation have previously been discussed in relation to Deci and Ryan's self-determination theory (cf. Deci, Koestner, & Ryan, 1999).

Regardless of whether the over-prompting effect found in the present longitudinal study was mainly cognitive, or rather motivational, or both, a gradual fading of the prompts might offer a possible solution to such problems. Fading of instructional support has originally been proposed within the theory of cognitive apprenticeship (Collins, Brown & Newman, 1989). Since then, this principle has been successfully applied in different settings (McNeill, Lizotte, Krajcik, & Marx, 2006; Puntambekar & Hübscher, 2005). Hence, future research should explore how the negative side-effects of over-prompting in writing learning journals can be successfully mitigated by a gradual fading of the prompts.

References

Barnett, J. E., DiVesta, F. J., & Rogozinski, J. T. (1981). What is learned in note taking? *Journal of Educational Psychology, 73*, 181-192.

Berthold, K., Nückles, M., & Renkl, A. (2007). Do learning protocols support learning strategies and outcomes? The role of cognitive and metacognitive prompts. *Learning and Instruction, 17*, 564-577.

Biggs, J. B., & Collis, K. F. (1982). *Evaluating the quality of learning: The SOLO taxonomy*. New York. Academic Press.

Cantrell, R. J., Fusaro, J. A., & Dougherty, E. A. (2000). Exploring the effectiveness of journal writing on learning social studies: A comparative study. *Reading Psychology, 21*, 1-11.

Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. *Cognitive Science, 13*, 145-182.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Hillsdale, NJ: Erlbaum.

Collins, A., Brown, J. S. & Newman, S. E. (1989): Cognitive apprenticeship: Teaching the crafts of reading writing, and mathematics. In: L. B. Resnick (Eds.): Knowing, learning, and instruction. Hillsdale, NJ: Erlbaum, 453-494.

Connor-Greene, P. A. (2000). Making connections: Evaluating the effectiveness of journal writing in enhancing student learning. *Teaching of Psychology, 27*, 44-46.

Deci, E. L., Eghari, H., Patrick, B. C., & Leone, D. R. (1994). Facilitating internalization: The self-determination theory perspective. *Journal of Personality, 62*, 119-142.

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin, 125*, 627-668.

Dillenbourg, P., & Jerman, P. (2007). Designing integrative scripts. In F. Fischer, I. Kollar, H. Mandl & J. M. Haake (Eds.). *Scripting computer-supported collaborative learning. Cognitive, computational and educational perspectives* (pp. 259-289). Berlin: Springer.

Efklides, A., & Vauras, M. (Eds.). (1999). Metacognitive experiences in their role in cognition (Special Issue). *European Journal of Psychology of Education, 14*, 455-584.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), *The nature of intelligence* (pp. 231-235). Hillsdale, NJ: Lawrence Erlbaum.

Hübner, S., Nückles, M., & Renkl, A. (2006). Prompting cognitive and metacognitive processing in writing-to-learn enhances learning outcomes. In R. Sun, N. Miyake & C. Schunn (Eds.), *Proceedings of the 28th Annual Conference of the Cognitive Science Society* (pp. 357-362). Mahwah: Erlbaum.

Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review, 19*, 509-539.

Kalyuga, S., Ayres, P., Chandler, P. & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist, 38*, 23-31.

King, A. (1992). Comparison of self-questioning, summarizing, and note-taking-review as strategies for learning from lectures. *American Educational Research Journal, 29*, 303-323.

Mayer, R. E. (1984). Aids to text comprehension. *Educational Psychologist, 19*, 30-42.

McCrindle, A., & Christensen, C. (1995). The impact of learning journals on metacognitive and cognitive processes and learning performances. *Learning and Instruction,* 5, 167-185.

McNeill, K. L., Lizotte, D. J., Krajcik, J., & Marx, R. W. (2006). Supporting students' construction of scientific explanations by fading scaffolds in instructional materials. *Journal of the Learning Sciences, 15*, 153-191.

Nückles, M., Schwonke, R., Berthold, K., & Renkl, A. (2004). The use of public learning diaries in blended learning. *Journal of Educational Media, 29*, 49-66.

Pressley, M., Wood, E., Woloshyn, V. E., Martin, V., King, A., & Menke, D. (1992). Encouraging mindful use of prior knowledge: Attempting to construct explanatory answers facilitates learning. *Educational Psychologist, 27*, 91-109.

Puntambekar, S., & Hübscher, R. (2005). Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed? *Educational Psychologist, 40*, 1-12.

Reigeluth, C. M., & Stein, F. S. (1983). The elaboration theory of instruction. In C. M. Reigeluth (Ed.), *Instructional-Design theories and models: An overview of their current status* (pp. 335-382). Hillsdale, NJ: Lawrence Erlbaum Associates.

Renkl, A. (1999). Learning mathematics from worked-out examples: Analyzing and fostering self-explanations. *European Journal of Psychology of Education, 14*, 477-488.

Weinberger, A., Reiserer, M., Ertl. B., Fischer, F., & Mandl, H. (2005). Facilitating collaborative knowledge construction in computer-mediated learning environments with cooperation scripts. In R. Bromme, F. W. Hesse, & H. Spada (Eds.). *Barriers, biases and opportunities of communication and cooperation with computers* (pp. 15-37). New York: Springer.

Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In C. M. Wittrock (Ed.), *Handbook of research in teaching* (pp. 315-327). New York: Macmillan Publishing Company.