Liu, C.-C. et al. (Eds.) (2014). Proceedings of the 22nd International Conference on Computers in Education. Japan: Asia-Pacific Society for Computers in Education

Supporting Regulatory Processes by Prompting and Visualising Monitoring Judgments

Lenka SCHNAUBERT[a*] & Daniel BODEMER[a]
[a]*Media-Based Knowledge Construction, University of Duisburg-Essen, Germany*
*lenka.schnaubert@uni-due.de

Abstract: Computer-based learning environments offer various opportunities to learn self-regulated as well as to support learners in doing so. For instance, they may provide various possibilities for students to purposefully interact with the system and control their learning processes in their own time. Metacognitive theories on self-regulated learning assume that learners need to utilise their own monitoring to control their learning processes. By carefully designing learning environments, we may guide these processes without interfering with self-regulation, but rather by building on individual regulatory skills. In the current study, we investigate the effects of two support components that potentially can facilitate learners' usage of their metacognitive skills: (a) explicitly asking learners to provide subjective validity ratings in order to stimulate metacognitive monitoring (prompting) and (b) feeding back these individual monitoring judgments at strategic points within the learning process in order to foster their usage for effectively controlling the learning process (visualisation). First results indicate that prompting and additionally visualising subjective validity ratings supports students in regulating their learning and resolving uncertainties, but it had no effect on the objective quality of their control decisions or domain specific learning outcome. One possible explanation might be the students' lack of ability to accurately monitor their learning. Continuing analyses are in progress to disentangle the relations between monitoring judgments, control behaviour, performance and monitoring accuracy. Further research should build on this study and use the learners' individual potentials to implicitly guide learning processes, but researchers and practitioners should be aware that a lack of self-regulatory skills might also produce the need for more explicit interventions.

Keywords: Metacognition, self-regulated learning, computer-based learning, validity ratings

1. Introduction & Research Questions

Successful learning highly depends on the individual skills to make beneficial study decisions. Such control decisions include when to initiate, continue and terminate a learning activity (Nelson & Narens, 1990) and, consequently, influence learning outcome. Metacognitive theories of self-regulated learning assume a cyclic model including a cognitive (object-) level and a metacognitive (meta-) level with the object-level informing the meta-level via monitoring processes (e.g., monitoring performance by judging the validity of one's own answers) and the meta-level influencing the object-level via control activities, e.g., initiating a search for more information (Nelson & Narens, 1990, see also Efklides, 2008). However, learners do not always spontaneously monitor their learning, even if they are capable of doing so (production deficit; Winne, 1996). And even if they do, they still may fail to use this information effectively for controlling the learning process (Dunlosky & Rawson, 2012). Since the individual ability to regulate one's own learning is regarded as central for lifelong learning, support mechanisms need to be developed which build on existing skills without disrupting individual learning procedures. Thus, even though explicit instructions can be effective, guiding learners less directive by assessing and visualising valuable, user-provided information might be a way to scaffold favourable self-regulation strategies. The usage of computers in education allows for such interventions. Not only do they provide the possibility to create learning environments in which learners can navigate self-directed and still have navigational support, they also may assess, store, prepare and visualise valuable information and allow users to dynamically alter inputs as well as access specific information pre-organised by teachers or the system itself in their own time.

In our study we want to test mechanisms to support monitoring and control processes by using the benefits computer-based learning scenarios offer. One way to encourage learners to use their full potential is to prompt metacognitive processes (Bannert, 2006), e.g., by explicitly asking for monitoring judgments. To additionally support the usage of these judgments for deciding upon reasonable control behaviour, they should be adaptable and made available to the students while they make relevant study decisions. Therefore, our main research question is: Does prompting monitoring judgments and visualising them in a computer-based learning scenario support learning processes and outcomes? As yet, we only focused on a subset of relevant questions: What effect does such support have on the quality and quantity of control decisions? What effect does it have on immediate learning outcomes?

2. Research Methods

To answer these questions, we conducted an experimental study with 92 participants (university students, 25% male, 75% female). They were randomly assigned to one of three conditions: The prompting condition (PC) aimed at supporting learners to overcome a production deficit of monitoring by asking for monitoring judgments (i.e., validity ratings), the visualisation condition (VC) additionally aimed at supporting the usage of this information to control the learning process by providing the learners' with these self-set ratings during learning. A control condition (CC) received no such support.

All instructions were given by the computer and – except for two upper time limits – the students worked entirely self-paced. After an introduction to the procedure and the assessment of some basic learner data (e.g., age, sex), the students had up to 20 min to study a text on blood sugar regulation and diabetes mellitus and then answered 20 binary learning tasks (t1). CC just answered the questions, while PC and VC additionally rated the validity of each answer (monitoring judgment) on a binary scale (prompting; cf. figure 1). The learners were then again provided with the learning tasks as well as their answers and had the opportunity to access additional information on each task (control behaviour). CC and PC were provided only with their answers, while VC was additionally provided with their previously assigned validity ratings (visualisation). They all were allowed to navigate freely for up to 15 min between the 20 tasks and additional information and were able to change their answers and – VC only – their validity ratings (t2). Afterwards, they had to answer the learning tasks again from scratch and all rated the validity of their answers (t3). At the end they conducted a multiple-choice post-test.

Up until now, our analyses focused on easily accessible process data, i.e., the number of information requests, and of correct or certain answers to the learning tasks. Additionally, we were interested in the quality of control decisions. While it is favourable to request mainly information on incorrectly solved items (objective quality), from a subject-centred perspective, low subjective validity should also trigger information requests (subjective quality).

Figure 1. Learning tasks with (left) and without (right) validity ratings.

3. Results and Discussion

To measure the objective quality of control decisions for each student, we computed within-subject phi-coefficients between the requests for specific information (requested vs. not requested) and the objective validity of the corresponding answer (correct vs. incorrect). To estimate subjective quality, we computed phi-coefficients between information requests and the respective subjective validity ratings (sure vs. unsure) for students providing such ratings (PC & VC). A one-way ANOVA revealed that the conditions did not affect objective quality ($F(2, 86) = 0.86$, $p = .427$), but a two-sample t-Test showed that visualisation ($M_{VC} = .69$, $SD_{VC} = .05$) in addition to mere prompting ($M_{PC} = .14$, $SD_{PC} = .05$) affected subjective quality ($t(56) = 7.87$, $p < .001$).

Quantity of control behaviour was operationalised by the number of items (0-20) to which additional information was requested. A Welch-test confirmed an overall effect for the conditions

($F(2, 56.70) = 3.49$, $p = .037$), with PC requesting most information ($M_{PC} = 11.23$, $SD_{PC} = 5.99$), closely followed by VC ($M_{VC} = 10.70$, $SD_{VC} = 3.34$) and with CC requesting fewest information ($M_{CC} = 8.23$, $SD_{CC} = 4.67$). Planned contrasts (Helmert) revealed that learners in the two experimental conditions (PC & VC) requested significantly more information than those in the control condition ($t(89) = 2.58$, $p = .011$), but the experimental conditions did not differ ($t(89) = -0.43$, $p = .670$).

Regarding cognitive and metacognitive learning outcomes, we compared the number of correct as well as certain answers to the learning tasks after learning (t3). There was no significant difference in performance between the conditions ($F(2, 89) = 1.99$, $p = .143$), but they differed with regard to their certainty ($F(2, 89) = 11.56$, $p < .001$). Helmert contrasts revealed significant effects between the experimental conditions and the control condition ($t(89) = 4.10$, $p < .001$) as well as between the experimental conditions ($t(89) = 2.55$, $p = .012$), with VC being most confident ($M_{VC} = 17.70$, $SD_{VC} = 2.42$) followed by PC ($M_{PC} = 15.87$, $SD_{PC} = 3.00$) and CC ($M_{CC} = 14.26$, $SD_{CC} = 2.92$).

In summary, learners were partially supported in regulating their learning behaviour, but this did not translate into cognitive learning gains. Prompting monitoring judgments seems to affect how much information learners request, although visualising does not add to this effect. And while it does not help the objective quality of study decisions, learners having their own judgments available during learning use these judgments more consequently to guide their control decisions (subjective quality) and successfully clear up perceived uncertainties. This – unfortunately – does not translate into knowledge gains. One explanation for these ostensible inconsistencies might be a possible lack of monitoring accuracy, which is frequently reported (Winne & Nesbit, 2009). While learners seem to use their judgments to guide learning, and computer-based learning scenarios can be used to offer support, this might be ultimately futile, if the basis of their decisions (monitoring) is flawed. Thus, analyses are in progress to study and integrate measures of monitoring accuracy to disentangle the relations between monitoring judgments, control behaviour and performance. Further, we currently evaluate more process data (e.g., time data) as well as learning outcomes for untrained material (post-test) and conduct pre-post-test analyses on the learning tasks. Various further analyses are planned, for instance analysing the sequential data in more detail to find out how students use (1) their self-set validity ratings to structure their learning process and (2) the additional information to adjust their answers as well as their validity ratings. Also using two measures of diagnostic efficiency (sensitivity and specificity; cf. Schraw, Kuch, & Gutierrez, 2013) instead of phi-coefficients to estimate quality will eliminate some of the bias due to guesswork. Further research should build on this study and use the individual potential of students to implicitly guide learning processes, but researchers and practitioners should be aware that a lack of self-regulatory skills (availability deficit; Veenman, Van Hout-Wolters, & Afflerbach, 2006) might also call for a more blatant or directive approach.

References

Bannert, M. (2006). Effects of reflection prompts when learning with hypermedia. *Journal of Educational Computing Research, 35*(4), 359–375.

Dunlosky, J., & Rawson, K. A. (2012). Overconfidence produces underachievement: Inaccurate self evaluations undermine students' learning and retention. *Learning and Instruction, 22*(4), 271–280.

Efklides, A. (2008). Metacognition - Defining its facets and levels of functioning in relation to self-regulation and co-regulation. *European Psychologist, 13*(4), 277–287.

Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. In G. H. Bower (Ed.), *Psychology of Learning & Motivation* (Vol. 26, pp. 125–173). New York: Academic Press.

Schraw, G., Kuch, F., & Gutierrez, A. P. (2013). Measure for measure: Calibrating ten commonly used calibration scores. *Learning and Instruction, 24*, 48–57.

Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning, 1*(1), 3–14.

Winne, P. H. (1996). A metacognitive view of individual differences in self-regulated learning. *Learning and Individual Differences, 8*(4), 327–353.

Winne, P. H., & Nesbit, J. C. (2009). Supporting self-regulated learning with cognitive tools. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of Metacognition in Education* (pp. 259–277). New York: Routledge.