Self-monitoring of self-regulation during math homework behaviour using standardized diaries

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Abstract This study aims at enhancing math learning and general self-regulation by supporting daily self-regulated learning during math homework. The authors use standardized diaries as a self-monitoring tool to support self-regulatory behaviour. Following the theory of self-monitoring, frequent selfmonitoring of self-regulation will lead to an enhancement of self-regulated learning. Complete data stem from a sample of 195 8th grade students. 95 students from the experimental group answer questions in diaries for a period of 49 days and participate in the pre-post measurement whereas the control group only works on the pre- and posttests. The diary consists of questions regarding main components of self-regulation. The time-series analyses of the diary variables show a positive linear trend for self-regulation. The results of the analyses of variance for the pre-post experimental-control group comparison yielded time by group interactions for self-regulation and the math test.

Keywords Self-monitoring · Self-regulation · Diaries · Time-series · Homework · Math

The idea is to stimulate students daily self-reflection about their actual self-regulation behaviour during math homework by presenting them questions within diaries. And that this ongoing self-reflection will enhance daily self-regulation of homework behaviour. E.g., the students are asked after they had a look at their kind of math homework task whether they will plan how to proceed. This question might stimulate a student to reflect about whether it might be helpful to plan. Moreover, if the student is asked this question for a series of more than 40 days the probability might be enhanced that he will reflect his planning.

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The importance of monitoring processes is described in Veenman et al. (2006). A definition of self-monitoring is given by Webber et al. (1993, p.38): "Self-monitoring refers to the act of recording or rating one's own behaviour". Self-monitoring was introduced as data recording technique, (cf. Shapiro 1984) but important for our purposes is that it turned out also to induce changes in behaviour. This phenomenon was referred to as *reactivity* of self-monitoring. Although this effect introduces some difficulty in using it as data collection technique, it was used for studies to directly induce reactivity and therefore, change in behaviour. The underlying assumption is that the act of recording might prompt self-reflection processes. For educational purposes this method of behaviour change seems to be rather promising: if one only needs to record behaviour, educational goals can easily be obtained. Indeed, self-monitoring[1] worked in school for children with various disturbances: if they recorded their problematic behaviour, it changed in the desired direction, cf. Webber et al. (1993).

Until now self-monitoring was mainly used for changing specific behaviour, measured by one or a few variables. More general approaches, e.g., changing self-regulation was advocated by Zimmerman and Paulsen (1995), very convincing by Zimmerman et al. (1996) and also by Zimmerman and Kitsantas (2007) and Schunk and Zimmerman (2008). The behaviour to be changed is not just one aspect but instead a group of variables defined by the whole cycle of self-regulation. Because self-monitoring applied to the whole cycle of self-regulation is different from the definition introduced above, we try to distinguish a *high-level-self-monitoring-process from general self-monitoring*. A *high-level-self-monitoring-process*[2] is defined as a series of recordings of the whole cycle of self-regulation. This definition contains three components level of observation, scope of variables and frequency of observation: first, it observes the whole cycle of self-regulation and, this has to be done from a *higher level* looking upon the self-regulation cycle. Second, the scope of observation is not a single variable but the *whole cycle* of self-regulation variables. Third, we assume that not a single observation of one's behaviour is recorded, but a series and therefore a higher frequency of recordings is needed. Even though this concept of higher-level-self-monitoring-process with respect to the cycle of self-regulation seems rather promising and generative for educational practice, literature does not present data, which proves the effectiveness of this kind of self-monitoring procedure neither for real life learning nor for a longer period of time.

The reason why we deal with ways of enhancing self-regulated learning is related to it's growing importance. The relevance of self-regulated learning is increasing because in the process of life long learning there cannot always a teacher be provided for each new learning period. Furthermore, self-regulated learning is more motivating by specifying one's own goals, gives more responsibility to the student for his own learning process, and can be adapted to individual requirements of the learner.

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[1] In the literature one is sometimes confronted with definitional problems of self-monitoring leading to possible confounding. The term self-monitoring is also used by Snyder (1974). He defines high self-monitoring people as particular sensitive to the ways they express and present themselves in social situations and skillfully adjust their performance in order to create or maintain appearances particular suited to their current situations. To be clear: we use the term self-monitoring in the sense of the definition of Webber et al. which was given above.

[2] To avoid unnecessary lengthy wording we still use the term self-monitoring if the meaning is clear.

What are the aims of the study? The most important goal is to show the effects of self-monitoring with respect to self-regulation. In order to reach this overall goal we deal with more specific aims: (1) describing our process model of self-regulation, (2) elaborate our concept of self-monitoring and finally (3) evaluate the self-monitoring procedure. First, to make our concept of self-regulation clear we elaborate on our process model of self-regulation based on Zimmerman (2000). We also want to clarify the complex interrelation of self-monitoring and self-regulation. Regarding the second aim, we want to summarize the literature with respect to the theory of self-monitoring describing functional mechanisms of self-monitoring. We want to propose a self-monitoring procedure which is important for applications in real life natural learning situations. As an effect of this kind of self-monitoring it is expected that self-regulation is enhanced. Notice that this kind of enhancing self-regulation is easy to apply for different kinds of target groups. Because self-regulated learning is especially important for contexts where students have at least some degrees of freedom, we study the field of homework learning, where students have much more options to self-regulate their learning compared to learning in class. At least they can decide when they learn, how they learn and how long they learn. Usually, in schools homework is given for different subjects. We concentrate our study of homework behaviour to math learning because math homework plays an important role in school learning and because students spend a large amount of their daily time with math homework. We suppose that our kind of research could be applied to other subjects. As a result of the enhancement of homework behaviour we expect to find effects for results of math learning, in this case measured by the results of a math test. Finally, the third aim of this article is to evaluate the application of our self-monitoring procedure. Following Webber et al. (1993) there exist only a few studies using a control group design. Hence we apply a control group design with pre- and post-measurements. Additionally, we combine the control-group design with a time-series analysis. Literature shows that former evaluations of self-monitoring are often purely based on self-report measures. Hence, we also apply a test of math competences.

The process model of self-regulation

Our self-regulation model, see Perels et al. (2005) (cf. Schmitz, and Wiese 2006), represents an adaptation of Zimmerman's (2000) three-phase cyclical model, which focuses on state aspects of self-regulation. Consequently, it contains situational influences and effects, such as the learning situation, actual goals, the actual use of learning and volitional strategies as well as actual goal attainment. Figure 1 displays our process model. According to Zimmerman (2000), "self-regulation refers to self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals." (p. 14). It is important to know that Zimmerman explicitly regards this definition as a *process* definition. One key aspect of the definition is the cyclical nature of self-regulation since it contains a feedback-loop relating prior learning to current learning. To label the phases of self-regulated learning we prefer the widely-used notation of Heckhausen and Kuhl (1985): preaction phase, action phase and postaction phase.
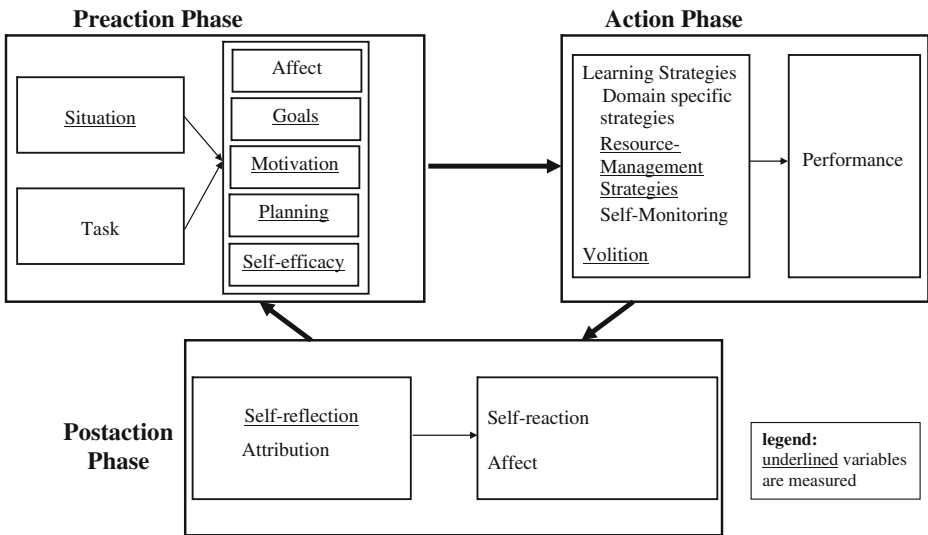
Fig. 1 Self-regulation model

Preaction phase

The self-regulation model (s. Fig. 1) can be used to describe the learning behaviour of an example student. He has to perform his math homework in a given situation containing some tasks given by the teacher. Before the student tries to self-regulate his behaviour, some preliminary decisions have to be made. First, he will check whether the task is easy and can be solved with automated routines. Then self-regulation is not necessary. If the task is more difficult the student will roughly check his resources, (e.g. motivation and affect). After that the student will start with goal setting in relation to the task and plan his homework. Self-efficacy beliefs play also an important role, (cf. Bandura 1997; Zimmerman 2000). Although in our model self-efficacy is included in the preaction phase and, therefore, is conceptualized as a predictor for applying learning strategies, the feedback structure of the model simultaneously implies that self-efficacy is also effected by the learning process and learning results (e.g., satisfaction with the mastery of difficult tasks should increase self-efficacy beliefs). Regarding the stability of self-efficacy, Bandura (1997) points to the fact that self-efficacy beliefs can change over time. Therefore, in line with Schmitz and Skinner (1993) who investigated the concept of state control-beliefs, we apply a state self-efficacy as well as a trait self-efficacy concept.

Action phase

During the action phase of homework students have to apply volitional (see Kuhl and Fuhrmann 1998) and learning strategies. Following the general lines of research regarding learning strategies (see Pintrich et al. 1991), one can differentiate between three kinds of

learning strategies: cognitive, metacognitive and resource-management strategies. Cognitive strategies are more math related. Metacognitive strategies include planning (which is part of the pre-action phase), regulation, and monitoring. In our approach monitoring is of special importance because we try to support self-monitoring by the use of the diaries. Resource-management strategies are important during the action phase, among them, e.g., effort-regulation and concentration-management.

Postaction phase

Following Bandura (1986) and Zimmerman (2000), the postaction phase is characterized by *self-reflections* that contain self-judgement and evaluation procedures, including comparisons of one's behavior with goals and attributions. The results of the self-reflection process may lead to positive or negative affect. In case of failure self-reactions may stimulate the student to draw consequences for the next learning episode: changing his learning goals or try some other strategies. Important is the cyclical nature of the model which implies that each variable can be regarded both as predictor and as outcome.

Functions of the process approach

Why do we emphasize a process approach? Because the process model is based on states. A learning state is the learning behavior measured in one situation at one point in time, i.e., within 1 day (Schmitz and Wiese 2006). Following Hertzog and Nesselroad (2003), states are attributes of individuals that are relatively changeable. A learning state itself contains subcomponents which are the components of self-regulation. By our procedure of higher-level self-monitoring we ask using diaries for states of self-regulation. Viewed from a statistic perspective, the series of states measured by the diaries will lead to a time-series of self-regulation variables. Hence, we have a convergence of three aspects: of our *model*, the *way of intervention* and the *kind of data*. First, we rely on a process *model* of self-regulation based on states. Second, our *way of higher-level self-monitoring* consists of observing daily state self-regulation behavior by diaries and, third, the series of daily self-regulation measurements leads to *time-series data*. What will we expect by the higher-level self-monitoring procedure? Because one observation per day will not change the core self-regulation but the series of observation for a time span of 49 days will lead to a slight trend in self-regulation. For the pre-post comparison we suppose that the level of self-regulation might be enhanced.

Theory of self-monitoring

Description of our self-monitoring procedure

How do we try to apply the self-monitoring procedure? Our concept is based on the idea to self-monitor the whole self-regulation cycle very often. This is accomplished by applying a standardized diary (s. Schmitz and Skinner 1993; Schmitz and Wiese 2006). Within this diary students were asked daily for a period of 7 weeks to answer questions related to the components of self-regulation we described above. An exemplar of a part of the self-monitoring instrument is contained in the appendix.

What are the topics which are asked in the diary? Following the self-regulation model we ask for all the important topics in the diary related to the three phases. Before learning we ask questions to the pre-action phase. The questions regarding the action phase were asked at the beginning of the post-action phase, because we do not want to disturb the core learning process. In the pre-action phase we ask whether the student plans how to reach his goals. The topic of self-efficacy is also included. During learning (action phase) we do not ask questions. Only in case the student takes a break we ask to report that and during breaks we also ask whether they can motivate themselves to go on learning. After learning the topics asked in the procedure deal with the action and the post-action phase.

The way how general self-monitoring could enhance learning

In order to understand the functioning of self-monitoring we present some results from the literature explaining reactivity effects. A group of mechanisms is described in the literature, from which we extract the following main functions: attention focusing/awareness, reminder/checklist, and self-reflection. Finally, the view on the interrelatedness of all the components of self-regulation may enhance self-regulation. A very detailed analysis is given by Zimmerman and Paulsen (1995).

First we turn to the attention focusing/awareness and *reminder*/checklist function. Webber et al. (1993) argue that by asking questions regarding a special behaviour attention is focused on this behaviour. This attention may already lead to a change in behaviour. A similar argument focuses on the *reminder effect* of questions in the self-monitoring instrument, which presents cues regarding the importance of topics in the moment. E.g., being asked about your plans at the beginning of homework leads you to think about your plans and specify them. If the self-monitoring instrument contains a series of questions like a checklist, it may help you as reminder to do what the items suppose or at least to think about the topics asked for in the questions.

Metacognitive researchers would focus on the effect of self-monitoring on *self-reflection*. The questions in the self-monitoring procedure stimulate thinking about the behaviour more intensively (e.g., "I thought about whether the solution is reasonable?"). Students learn to discriminate between effective and ineffective performance and to detect the adequacy or inadequacy of a learning strategy.

The final mechanism of self-monitoring is to look to the interrelations of the self-regulation components. Above we described our self-monitoring procedure. The idea behind the self-monitoring procedure is to enhance all these single components of self-regulation. In addition, we also suppose to enhance the whole cycle of self-regulation by combining them within one questionnaire and stimulating the self-reflection about their interrelatedness. E.g., we hope to stimulate the formulation of goals, to plan actions to reach that goal, to execute these actions and monitor their application, and in case of discrepancies between goals and actual performance to regulate the behaviour. And moreover, because it will not be enough to self-monitor students' behaviour for one self-regulation cycle, they were stimulated to self-monitor the self-regulation cycle for more than 40 cycles.

In sum, we suppose the following explanations for reactivity effects: attention focusing, reminder/checklist, self-reflection and the enhancement of the whole self-regulation cycle.

Different levels of self-monitoring and self-regulation

As we mentioned before, we define *self-monitoring* as the observation and possible recording of one's own behaviour. Self-monitoring can occur on different *levels*. One could monitor one's concentration during homework performance. This means monitoring of *one variable* which is a part of the action phase within the self-regulation cycle. One could also record the whole self-regulation cycle. This could be done looking from a higher level on the whole self-regulation cycle. One could also record ones behaviour for 1 day or for a longer period in time, e.g. for weeks, months or a year. We defined *high-level-self-monitoring-process* as recording the cycle of self-regulation from a higher level (having a broader scope) and a high frequency. Note that high-level-self-monitoring of the self-regulation cycle includes monitoring important variables from all the three phases. Note also, that high-level-self-monitoring includes observing state self-efficacy by asking a question in the diary like "I am sure that I will finish what I have planned to do". More complicated is that monitoring is also a part of the self-regulation cycle. That is the reason to use different terms for higher-level self-monitoring and self-monitoring (which is on a lower level).

The main questions of the study

We have two design components: the daily measurements (time-series) using the diary and the pre-post control group comparison. The main hypothesis is that our self-monitoring procedure using diary enhances single states of self-regulation. Because the observation period contains a series of states of self-regulation continuous enhancement of these states will lead to a positive trend of (state) self-regulation across time. For self-efficacy which is regarded as an important parameter of self-regulation we also expect a positive trend of (state) self-efficacy. Because of the continuous enhancement of state self-regulation we expect a change in (trait) self-regulation and (trait) self-efficacy after the intervention period. Because the students will be expected to learn more self-regulated and to apply more efficient math strategies during math homework for the intervention period, we also assume an enhancement in math performance.

Method

Participants

The sample consisted of 249 8th grade students (106 boys and 143 girls) aged 13 (67%), 14 (31%), and 15 (2%) from three German grammar schools (Gymnasium). Resulting from the exclusion of 33 participants with incomplete or incorrect filled out questionnaires for the pre-test and post-test evaluation, 18 participants who only filled out either the pre-test questionnaire or the post-test questionnaire and further three participants with incomplete filled out questionnaires of the process evaluation, the data of 195 participants were finally integrated in the analyses. The students were recruited by asking three schools for participation. The group aimed at were 8th graders from grammar schools because in the TIMS-study the problems found for German pupils with respect to self-regulated learning and math learning were related to 7th and 8th graders. The parents had to give a written consent that their children could take part in the study. Participation was voluntary.

Design

In the present study, a control-group-design combined with a time-series design part was implemented. The subjects were randomly assigned to the experimental group ($n=95$; 42.1% male and 57.9% female, mean age=13 (SD=.52)) and the control group ($n=100$; 34% male and 66% female, mean age=13 (SD=.51)). The experimental condition consisted of the work with a learning diary. The subjects in the experimental group were involved in the time-series procedure, which consisted of the completion of a learning diary for 7 weeks.

Procedure

A pre-test was conducted consisting of a self-regulatory questionnaire and a math test. The post-test was conducted via a math test consisting of tasks with the same difficulty and the identical self-regulation questionnaire directly after the intervention. After the pre-test the students of the experimental group received an instruction how to apply the diaries. After handing out a booklet of diaries for 1 week to every student, the instructors which were senior students from the Educational Psychology department exemplified how to work on the open-ended questions and how to answer the closed questions. The learning diary should invite the students to observe and reflect upon their learning behaviour outside school. Over a time span of 49 days, it should be filled out every single day, starting with the day of the instruction to the diary. The students were instructed to fill out the first part, which included the pre-action variables, before learning or doing homework. At this moment, the students could state whether they would learn or not that day. If they did not learn they were asked for a reason not to learn. For learning days the student filled out the second part consisting of the action and post-action variables. This second part was worked on after learning in order not to disturb the learning process. The booklets were recollected every week personally by our research assistants in the schools. The students returned their booklet from the last week and they got a new booklet for the next week. The students were instructed to choose a code that was contained in the diary and that was identical to that on the pre-post questionnaires. The students were informed that analyses of the diaries were performed anonymous that means neither teachers nor parents nor class-mates were shown the diaries and also that our researchers and research assistants could not know which child filled out which diary.

Weekly, the instructors came to the schools and there was time to discuss problems concerning the learning diaries. A booklet consisted of seven diaries (one for each day) and an additional worksheet on which the students were asked to write down their personal goals regarding mathematics.

The students received a gratification for filling out the diaries. A CD- or book-voucher worth 7.5 Euro was raffled at the beginning of each weekly distribution of the diaries among the students who had filled out the diary thoroughly according to clearly defined rules. At the end of the project, every student received a voucher for a CD, book or game worth 7.5–37.5 EURO, depending on the quality of his or her work on the diaries over the whole 49 days. That means students were ranked with respect to their regularity and completeness of their diaries. The students were also explained that they would get a feedback after the end of the study. This was done by given each child three figures with his individual time-trajectories and the corresponding trend lines.

The teachers in school were math teachers with the German examination for teaching in secondary schools, topic during that time in grade 8 following the state dependent curricula were linear equations within algebra and computation of volume of cuboids within geometry.

Instruments

Learning diary

As means to enhance self-regulation, a learning diary in a standardized format was adopted (cf. Appendix for a part of the diary). The students were instructed to fill out the diary every day before and after doing their homework. The diary contained a general part, which was to work on every day and a math related part which has to be worked on for days they had to perform math homework. The diary was to be filled out for 7 weeks until the post-test. The students received new learning diaries every week and returned them on a weekly basis. 80,8% of the diary data could be used for analysis. The scales and indicators had been chosen in reference to the process model of self-regulation cf. Figure 1 (Schmitz and Wiese 2006). Most items are self-provided, whereas, if possible, existing trait measures have been altered in their time dimension to obtain reasonable state measures. Some items were included in the diary to support self-reflection, which were not used for measurement (e.g., "How much time are you planning for this altogether").

The diary starts on page 1 with a description of how to construct an individual code. Page 2 was presented only weekly, the students were asked about their learning goal for the school half-year and subgoals for this week to come closer to that goal and for concrete steps to reach these subgoals. Page 3 (cf. appendix) starts with asking for date, time and code, and then for the mood in that situation, whether they plan to learn that day and the amount of time they are planning to investigate that day. In case they do not learn: reasons for not learning. The following questions in the diary (cf. appendix) build the basis for the daily state measurements and are all Likert-type questions.

Diary measurements of self-regulation and self-efficacy

These state measurement items are: motivation, self-efficacy (single item, which is not contained in the overall self-regulation scale), (whether there are problems and, kind of problems, (not used for measurement)), planning, and motivation. All these items pertain to the pre-action phase (an example item for planning: "Before I learn I will plan how I will proceed"). Then the student is asked to begin his learning. The next series of questions is presented after learning. The action-phase is rendered by resource-management strategies and volition. Questions regarding the action phase were asked after learning, in order to avoid to disturb the students during learning. Self-reflection and goal-attainment are mainly located in the action and post-action phase. Items had to be answered on a 4 point scale ("absolutely fits, rather fits, doesn't really fit, doesn't fit at all", cf. appendix). (The items deal with: learning environment, internal resources (concentration), internal resources (effort), volition (distraction, recoded), handling mistakes, self-reflection (solution reasonable, different ways of solution), and goal attainment (realisation of planned actions, realisation of intentions). The daily self-regulation scale is composed from these 13 items. Cronbach's Alpha for this overall self-regulation scale was .69 and the coefficient of stability (cf. Schmitz and Skinner 1993) was .75. Note that self-efficacy was measured by a single item ("I am sure that I will

finish what I have planned to do"). (The next part of the diary asks for the kind of learning strategies which were used and in case no strategies were used, a reason is asked.) (Not contained in the appendix: questions regarding math were presented, asking whether the students thought about what the task deals with, whether the student tried to make some figure to illustrate the task, and which strategy they used, these items were not analysed.) The last part contains questions with intentions for the next learning day and again mood measurements which were not analysed here, s. appendix.

Measurements of the pre-test-post-test evaluation

The pre-test-post-test evaluation has been carried out in consideration of a self-regulation and a self-efficacy questionnaire and of a math test which were conducted before and after the intervention.

Self-regulation questionnaire

The self-regulation questionnaire was composed of topics that as serve to cover the corresponding trait analog of the most important components of the process model of self-regulation, namely endurance in pursuing goals (Brandstädter and Renner 1988), motivation (Schiefele and Moschner 1997), dealing with the learning environment (Wild et al. 1992), planning (Wild et al. 1992), volition (Schiefele and Moschner 1997), attention (Wild et al. 1992), attribution to effort (Baumert et al. 1997) and handling mistakes (self-provided). These components were aggregated to an overall self-regulation scale consisting of 46 items (Cronbach's alpha=.83). The students responded to the respective statements given on a scale with scores ranging from 1 to 4 (1 = I don't agree at all; 2 = I don't agree; 3 = I agree; 4 = I agree completely). Self-efficacy was measured by a 12 item scale by Schwarzer and Jerusalem 1981 (Cronbachs alpha=.86).

Math test

Two parallel math tests were conducted before and after the intervention respectively. They were designed to assess the students' mathematical problem-solving competence and consisted of 17 tasks representing the subject areas of basic mathematics and heuristic strategies (working for- and backwards, principle of invariance, tables, figures, and equation). For instance, to test the application of the principle of invariance, the following problem was presented: "Anne is 4 years younger than Eva. In 6 years they are together 34 years old. How old are the two girls today?" For each test, an overall measure of reliability was computed (α=.75). The math test aimed at assessing the students' basic mathematical knowledge and problem-solving strategies. The tasks testing the students' basic knowledge were used to find out how much mathematical knowledge students at the beginning of 8th grade have and to decide whether mathematical more ambitious tasks aren't solved because basic knowledge isn't available. The tested basic knowledge included percentage calculation, translating a word problem into an algebraic term and area calculation.

Tasks requiring problem-solving strategies were mainly comprehension skills and capacity for abstraction, figure decomposition, flexibility components (reversing a train of thoughts), knowledge and application of heuristic tools as well as knowledge and application of different heuristic strategies and principles (working for- and backwards, principle of invariance).

Analyses

For the time series data we calculate linear trend analyses with day as predictor and self-regulation and self-efficacy as dependent variables. For the pre-post comparisons we perform analyses of variance with self-monitoring (yes/no) and time as factors (self-monitoring as between subject and time as within subject factor) and self-regulation, self-efficacy and math performance as dependent variables. The expected intervention effect can be detected if the change between pretest and posttest for a dependent variable is different for control and experimental group. Statistically, this effect can be seen as interaction between group (control vs. experimental) and time (pre vs. post).

Results

Following the succession of the hypotheses, the tests of time-series hypotheses are reported first and then the results of the pre-post control group- experimental group comparison.

Evaluation of the process information

Trend analyses: self-regulation

The results from the trend analyses of the process information are given for self-regulation and self-efficacy. The time-series-data of the scale overall scale self-regulation, which were delivered by the experimental group filling out the diaries, were analyzed concerning the existence of a linear trend. Figure 2 shows that self-regulation shows a highly significant positive linear trend ($p=.000$; $b_0=2,91$; $b_1=.004$, RSQ$=.49$) over the period of 49 days. The time trend explains a high amount of the variance (nearly 50%) of self-regulation. Note that because we also wanted to study self-efficacy separately, we computed self-regulation without self-efficacy to avoid redundancy.

Trend analyses: self-efficacy

Likewise, the linear trend coefficients for self-efficacy were estimated, which led to a similar result: For this essential part of self-regulation, an increase in terms of a highly

Fig. 2 Trajectory and Linear trend for self-regulation
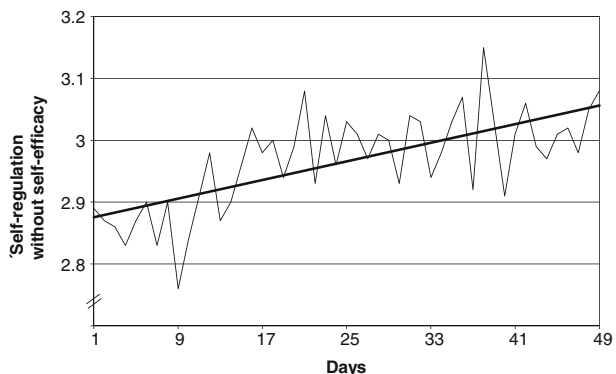
significant linear trend can be asserted ($p=.00$; $b_0=3,25$; $b_1=.005$, RSQ=.38). Also for self-efficacy the amount of variance explained by the trend is high (38%), cf. Fig. 3.

Treatment effects

For this purpose, pre-post measurements for the control and the experimental group were compared with regard to the dependent variables: self-regulation, self-efficacy and the math-test. Table 1 summarizes the results of the computed pre-post-comparisons by displaying the respective statistical parameters. The time * group interaction represents the effect under consideration. The test for the variable self-regulation resulted in a significant increase in the expected direction ($F(1,193)=11,70$ $p<.001$, partial $\eta^2=.06$). Only the experimental group shows increased self-regulation in the post test, which is shown in Fig. 4. We also tested the effect of the intervention on self-efficacy which is an important part of self-regulation, cf. Fig. 1. Again, also for self-efficacy, cf. Table 1, the experimental group is characterized by a significant augmentation in this measure from pre-test to post-test but not the control group ($F(1,192)=4,3$; $p<.05$, partial $\eta^2=.02$). With regard to the math test we perform the similar analyses which also yielded a significant time * group interaction ($F(1,191)=9.53$, $p<.01$, partial $\eta^2=.05$). The results are depicted in Fig. 5. The effect size measures (partial η^2) for all these tests are lower than .06 which can be viewed as small.

Discussion

Summary of effects

The trends show that the pre-post differences in the experimental group are in line with a continuous increasing of self-regulation and self-efficacy during the intervention period. That means change could not be observed e.g., after a single application of the diary, but instead after a series of applications of the self-monitoring procedure.

The pretest-posttest comparisons revealed that for self-regulation, self-efficacy, and the mathematical test we observed significant pre-post differences between the control and the self-monitoring group. Therefore, the self-monitoring procedure showed effects for all dependent variables we expected, although the effects were generally low. It can be concluded that there were effects of the self-monitoring intervention that led to pre-post differences for self-regulation, self-efficacy and the math test.

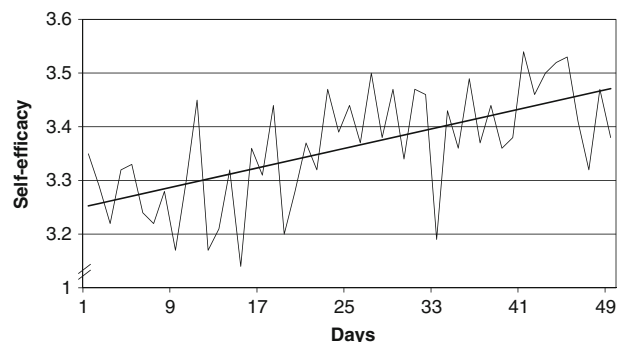Fig. 3 Trajectory and Linear trend for self-efficacy

Table 1 Comparison of the pre-post measurements for experimental and control group

	Experimental group				Control group				Time * group interaction			
	Pretest		Posttest		Pretest		Posttest					
Variables	M	SD	M	SD	M	SD	M	SD	F	df1	df2	Effect size
Self-regulation[a]	2.90	.37	3.02	.42	2.91	.41	2.89	.47	11.70**	1	193	.06
Self-efficacy	2.72	.49	2.82	.52	2.76	.51	2.74	.54	4.32*	1	192	.02
Math-Test	14.73	4.6	16.6	5.8	15.30	5.1	15.36	5.4	9.53**	1	191	.05

*$p<.05$, **$p<.01$

[a] The self-regulation-scale does not include the self-efficacy-scale to avoid redundances. If the self-regulation-scale is computed including the self-efficacy-scale, the time * group interaction remains significant ($F=11.81$**, Effect size=.06)

Theoretical implications

The overall aim of the study was to enhance self-regulated learning by applying a self-monitoring procedure based on diaries. Our results show that our self-monitoring procedure could be used to enhance self-regulated learning in a natural learning environment. We have empirically demonstrated that just by repeatedly answering questions in a standardized diary students applied more self-regulation strategies. We could demonstrate this by using a control group design comparing pre- and post measurements. Our results included an overall measure for self-regulation as well as self-efficacy as an important aspect of self-regulated learning.

Previous literature could show that self-monitoring for single variables had an effect on behaviour (Shapiro 1984; Webber et al. 1993; Morgan 1985). But a lot of these studies restrict to single cases analyses or to small samples. There are no empirical demonstrations of complex self-monitoring procedures capturing more than 13 questions. Zimmerman et al. (1996) advocated the use of diaries for supporting self-regulated learning. Although their theoretical and practical suggestions were convincing they did not present empirical evidence for their procedure. In this respect our results provide new evidence. Our findings are in line with recent attempts to enhance math learning via procedures supporting metacognition (Kramarski and Mevarech 2003; Mevarech and Fridkin 2006).

From a theoretical point of view we showed that a procedure which combined important parameters of self-regulation worked quite well. For further research it might be interesting to analyze which components of the self-monitoring procedure are most important and which of them could be omitted without reducing the effects of the whole instrument. Interesting from a theoretical perspective was also that we devised self-monitoring as well as self-regulation as process that means as sequence of states (cf., Schmitz 2006; Perels et al. 2007). This dynamic approach allowed us to consider a high amount of variability across time for self-monitoring as well as for self-regulation. That means a student could be highly self-regulated on 1 day but not self-regulating the next day. The same holds for self-monitoring. This process view tries to image the reality of students in natural learning environments. One advantage of the process approach is also that it helps to clarify the theoretically important question whether the one-time use of the diary would change behaviour. The results of the time-series part of the study showed an continuous increase of self-regulation over time.

Fig. 4 Result of the pre-post-comparison for self-regulation
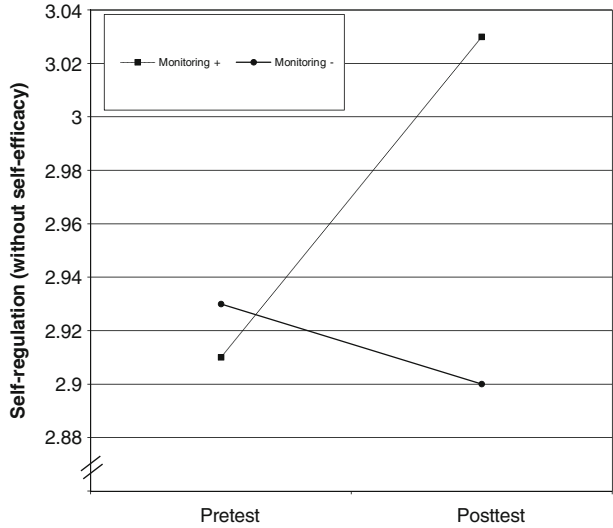
Note that the effects in the time-series analyses and the pre-post-comparisons were different: small effects in the pre-post comparisons but high amount of explained variance for the time-series trends. It seems that the time-series approach is more sensitive to detect changes than the pre-post comparison. The time-series results also clearly demonstrate that change does not occur after a single use of the diary but following a series of applications of the self-monitoring instrument. That is remarkable with respect to the concept of learning journals, cf. Hübner et al. (2010); Nückles et al. (2010) and lots of other metacognitive or self-regulation interventions which could be applied within a single point in time. The differences between the learning journal and our diary are threefold. The learning journal is applied with respect to school (or university) lessons, it is retrospective and can be used for a single point in time whereas the diaries are related to homework, are partly prospective as they also ask for goals for homework
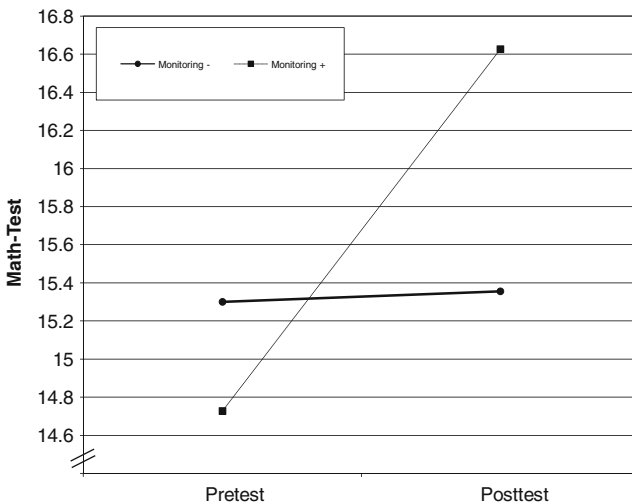

Fig. 5 Result of pre-post-comparison for math test

before learning and they are applied for longer periods. Therefore, learning journals and learning diaries have similar intentions to enhance self-reflection but follow different lines to reach that goal. Theoretically, as well as for practical reasons it might be interesting to combine these approaches.

It should be noted that the application of self-monitoring performed by diaries is based on preconditions. Basic strategies which belong to the mathematical topic dealt with in the homework tasks have to be known. A student who wants to solve a math task for which he does not know suitable strategies will not find them by self-reflection and therefore he will not benefit from self-monitoring.

Limitations of the study

The application of this kind of self-monitoring assumes a highly motivated group to answer the group of daily questions for a period of 7 weeks. The sample consisted of 8th grade students and therefore the results cannot be generalized to other samples.

As control group we used a no treatment control. One might argue that it could also be interesting to use other kinds of control group, e.g. other kinds of self-reflection.

One might criticize that the diary and also the pre-post measurements include a lot of self-report questionnaires, but acknowledge, that we also applied a math test as objective measure in the pre-post comparison. Further research should include behavioural measures of self-regulation.

With respect to the stability of effects it would be interesting to include in further research measures which were administered 6 or 8 weeks after the intervention.

Practical implications

In sum, we presented data which should demonstrate that our diary method of self-monitoring could enhance self-regulation for homework behaviour and also performance in math. For evaluation purposes we used time-series analyses and pre-post measurements. The diary included important variables of the self-regulation model. The self-monitoring procedure could be easily adapted to other kinds of behaviour and to other settings. Further research could examine whether the frequency of answering questions in the diary could be reduced and also whether the time-lag between measurements could be enhanced without reducing the effectiveness of the procedure.

The way we support self-regulated learning and homework behaviour seems to be easy to apply. One has to adapt a form of our self-monitoring procedure to the target group, to the content and the context of the learners. In sum, it is a quite easy and a low budget intervention technique. But one has to explain the students why they should self-monitor and how they should do that. E.g., a teacher from a school not participating in our project heard about our study and gave his class a bunch of diaries and he wondered why the self-regulated learning of his students did not change. Clearly, without a proper instruction students will not understand the possible benefits of the self-monitoring procedure. Note also, that the procedure is rather schematic; therefore the point in time will come when it becomes boring for the students to further work with the diaries. Hence, it cannot be applied for a too lengthy time period. But our assumption is that by the frequent application of the self-monitoring procedure the self-monitoring behaviour will be automated and needs not to be supported by the diary anymore.

Appendix: part of the diary

Date: _____   **Time:** _____   **Code:** _ _ _ _ _

Right now I'm: in a good mood ☺   ○   ○   ☹ in a bad mood

At the moment I'm: awake   ○   ○   ○   ○ tired

Do you plan to learn something today (this includes homework)?   Yes ○   No ○

      If **yes**, how much time are you planning for this altogether? _____ minutes

If you're **not learning** today, please answer the following five statements!
Please also note the corresponding questions on the last page!

Why are you not learning today?	Absolutely fits	Rather fits	Doesn't really fit	Doesn't fit at all
I don't have homework.	☐	☐	☐	☐
I have a lot of extracurricular commitments.	☐	☐	☐	☐
I don't feel like it.	☐	☐	☐	☐
I don't know how to proceed.	☐	☐	☐	☐
At the moment, I'm occupied with a problem I have.	☐	☐	☐	☐

→ If yes, what kind of problem? _____

If you're learning today, please answer the following questions!

How are you going to do this today **exactly**?	Absolutely fits	Rather fits	Doesn't really fit	Doesn't fit at all
Today I have a good mind to learn	☐	☐	☐	☐
I am sure that I will finish what I have planned to do.	☐	☐	☐	☐
At the moment I have a problem that occupies me.	☐	☐	☐	☐
→ If yes, what kind of problem? _____				
Before I learn I think about how I will proceed.	☐	☐	☐	☐
If I didn't study /do my homework today, it would have unpleasant consequences.	☐	☐	☐	☐

<u>After learning:</u>

Answer now the following statements!

	Absolutely fits	Rather fits	Doesn't really fit	Doesn't fit at all
I did look closely at my exercise and thought about how I would proceed.	☐	☐	☐	☐
Before learning I arranged my workplace in a way that I was able to learn undisturbed.	☐	☐	☐	☐
Today, while working, I was concentrated.	☐	☐	☐	☐
Today I put much effort in my work.	☐	☐	☐	☐
I didn't let myself get distracted from studying.	☐	☐	☐	☐
I tried to learn something from my mistakes.	☐	☐	☐	☐
I thought about whether the solution is reasonable.	☐	☐	☐	☐
I thought about whether there are also different ways of solution.	☐	☐	☐	☐
Today I did learn everything I had planned.	☐	☐	☐	☐
I managed to realize my intentions for today!	☐	☐	☐	☐

Today I did use learning strategies.

→ If yes, which ones? _____

→ If no, why not? (Please mark only one statement.)

☐   I didn't think of it.

☐   To apply them, seemed too much work to me.

☐   I don't know any suitable strategies for learning.

Compared to today, what will you be doing different or better the next time you learn?

For example, set yourself specific goals?

Or are there any strategies, which you want to apply the next time?

I will _____

Right now I'm: **in a good mood** ☺   ○   ○   ☹ **in a bad mood**

At the moment I'm: **awake**   ○   ○   ○   ○ **tired**

References

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy. The exercise of control*. New York: Freeman.

Baumert, J., Lehmann, R., Lehrke, M., Schmitz, B., Clausen, C., Hosenfeld, I., et al. (1997). *TIMSS-Mathematisch- naturwissenschaftlicher Unterricht im internationalen Vergleich.[Third International Mathematics and Science Study- International comparison of mathematic and science classes.]*. Opladen: Leske + Budrich.

Brandstädter, J., & Renner, G. (1988). Fragebogen zur Erfassung von Flexibilität der Zielanpassung und Tenazität der Zielverfolgung.[Questionnaire to measure the flexibility of goal adjustment and the durability of goal pursuance.] Arbeitsgruppe "Entwicklung und Handeln" (Hrsg.), Hartnäckige Zielverfolgung und flexible Zielanpassung. Zur Explikation und altersvergleichenden Analyse assimilativer und akkomodativer Kontroll- und Bewältigungsstrategien. Trier: Universitätsveröffentlichung.

Heckhausen, H., & Kuhl, J. (1985). From wishes to actions: The dead ends and short cuts on the long way to action. In M. Frese & J. Sabini (Eds.), *Goal-directed behaviour: The concept of action in psychology* (pp. 134–159). Hillsdale: Erlbaum.

Hertzog, C., & Nesselroad, J. R. (2003). Assessing psychological change in adulthood: An overview of methodological issues. *Psychology and Aging, 18*, 639–657.

Hübner, S., Nückles, M., & Renkl, A. (2010). Writing learning journals: Instructional support to overcome learning-strategy deficits. *Learning and Instruction, 20*, 18–29.

Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and meta-cognitive training. *American Educational Research Journal, 40*, 281–310.

Kuhl, J., & Fuhrmann, A. (1998). *VCQ- Volitional components questionnaire*. Osnabrueck: University of Osnabrueck.

Mevarech, Z., & Fridkin, S. (2006). The effects of IMPROVE on mathematical knowledge, mathematical reasoning and meta-cognition. *Metacognition Learning, 1*, 85–97.

Morgan, M. (1985). Self-monitoring of attained subgoals in private study. *Journal of Educational Psychology, 77*, 623–630.

Nückles, M., Hübner, S., & Renkl, A. (2010). Enhancing self-regulated learning by writing learning protocols. *Learning and Instruction, 19*, 259–271.

Perels, F., Gürtler, T., & Schmitz, B. (2005). Training of self-regulatory and problem- solving competence. *Learning and Instruction, 15*, 123–139.

Perels, F., Otto, B., Landmann, M., Hertel, S., & Schmitz, B. (2007). Self-regulation from the process perspective. *The Journal of Psychology, 215*, 149–204.

Pintrich, P. R., Smith, D., Garcia, T., & McKeachie, W. (1991). *The motivational strategies for learning questionaire (MSLQ)*. Ann Arbor: University of Michigan.

Schiefele, U., & Moschner, B. (1997). Motivationale Orientierungen und Lernstrategien im Studium. [Motivational orientation and learning strategies during college.] Selbstkonzepte, Lernmotivation, Lernstrategien, epistemologische Überzeugungen, Instruktionsqualität und Studienleistung. Längsschnittliche Verläufe und kausale Zusammenhänge. Antrag an die Deutsche Forschungsgemeinschaft.

Schmitz, B. (2006). Advantages of studying processes in educational research. *Learning and Instruction, 16*, 433–449.

Schmitz, B., & Skinner, E. (1993). Percieved control, effort, and academic performance: Interindividual, intraindividual, and multivariate time-series analyses. *Journal of Personality and Social Psycholgy, 64*, 1010–1028.

Schmitz, B., & Wiese, B. S. (2006). New perspectives for the evaluation of training sessions in self-regulated learning: Time-series analyses of diary data. *Contemporary Educational Psychology, 31*, 64–96.

Schunk, D. H., & Zimmerman, B. J. (2008). *Motivation and self-regulated learning: Theory, research, and applications*. New York: Taylor & Francis.

Schwarzer, R., & Jerusalem, M. (1981). Skalen zur Erfassung von Lehrer- und Schülermerkmalen. [Scales measuring teacher and student characteristics] Freie Universität Berlin: Veröffentliche Skalendokumentation.

Shapiro, E. S. (1984). Self-monitoring procedures. In T. H. Ollendich & M. Hersen (Eds.), *Child behaviour assessment: Principles and procedures* (pp. 148–165). New York: Pergamon.

Snyder, M. (1974). Self-monitoring of expressive behaviour. *Journal of Personality and Social Psychology, 30*, 526–537.

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

Webber, J., Scheuermann, B., McCall, C., & Coleman, M. (1993). Research on self-monitoring as a behaviour management technique in special education classrooms: A descriptive review. *Remedial and Special Education, 14*, 38–56.

Wild, K.-P., Schiefele, K., & Winteler, A. (1992). *LIST - Ein Verfahren zur Erfassung von Lernstrategien im Studium. [A tool to measure learning strategies during college]*. München: Universität der Bundeswehr.

Zimmerman, B. J. (2000). Attaining self-regulation. A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). London: Academic.

Zimmerman, B. J., & Kitsantas, A. (2007). Reliability and validity of Self-Efficacy for Learning Form (SELF) scores of college students. *The Journal of Psychology, 215*, 157–163.

Zimmerman, B. J., & Paulsen, A. S. (1995). Self-monitoring during collegiate studying: An invaluable tool for academic self-regulation. *New Directions for Teaching and Learning, 63*, 13–27.

Zimmerman, B. J., Bonner, D., & Kovach, R. (1996). *Developing self-regulated learners*. Washington: American Psychological Ass.