Fostering Self-Regulated Learning Online

Development and Evaluation of Interventions for E-Learning Scenarios

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Dedicated to the memory of my father

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Abstract

Self-regulated learning (SRL), defined as systematic orientation of thoughts, feelings, and actions towards the attainment of learning goals, is crucial for academic success in school, at university, and at work. Particularly in the context of e-learning, regulation of one's learning process is essential because of the personal responsibility learners typically have in such scenarios. Deficits in SRL competency can lead to procrastination, dissatisfaction, and deteriorated performance.

A variety of SRL interventions has been developed by researchers in order to support self-regulatory processes during learning or to increase SRL competency. Empirical studies showed that trainings are capable of improving learning behavior and academic performance. However, with increasing numbers of participants, personnel expenses for this approach rise linearly, making it unattractive when facing large groups of learners (e.g. all beginning students of one university).

Therefore, in the present work a web-based training (WBT) was developed in order to increase SRL competency of university students. Target groups in the three empirical studies were students in STEM fields, participating in a mathematics preparation course. The WBT consisted of three lessons of approximately 90 minutes, comprising videos, presentations, exercises, games, and group discussions. In the empirical studies, effects of the WBT were compared to other SRL interventions such as a learning diary, peer feedback groups, and a digital learning assistant.

In study 1, 211 prospective students took part in a mathematics preparation course that was administered completely online, covering mathematical school knowledge and lasting for four weeks. Participants were randomly assigned to one of four experimental conditions: Having access to the WBT (group T), filling in a learning diary (group D), having access to both interventions (group TD), or the none of them (control group C). A pre-post evaluation design found significant increases in declarative knowledge about SRL, in self-reported SRL behavior, and in self-efficacy for participants of the WBT. A small detrimental effect of the WBT on mathematics performance could be observed. The learning diary was found to have no significant effect on the employed measures. Time series analyses of the diary data confirmed a positive trend in SRL behavior and found large intervention effects of the first two lessons particularly.

In study 2, the WBT was augmented by a peer feedback intervention. Participants were assigned to groups of five persons each and were given peer feedback exercises after each lesson of the WBT. In these exercises, participants gave mutual feedback on time schedules, learning

strategies, and goal setting. Additionally, participants in this experimental condition (group TDP) filled in a learning diary. Results were compared to a group with access to the regular WBT (without peer feedback intervention) and the learning diary (group TD), a group with access only the learning diary (group D), and a control group without any intervention (group C). Significantly positive effects of the WBT were found on declarative SRL knowledge, SRL behavior, and self-efficacy. In the condition with additional peer feedback, the above mentioned positive effects were even larger. Furthermore, a significant positive effect on mathematics performance was observed. However, no significant effects were found for the learning diary.

Study 3 aimed at enhancing the learning diary to a digital learning assistant by adding dynamic, interactive elements. In a interdisciplinary project, methods from Learning Analytics (LA) were used to provide visual and textual feedback to their learning behavior as documented in the learning diary. The completed software *PeerLA* allows to define learning goals, to schedule a time plan, and to judge the success of learning goals afterwards. On the basis of these judgments, machine learning algorithms calculate suggestions how much time to invest for future goals. Additionally, user data (e.g. time investment or learning progress) is visualized and compared to data from other users as a social frame of reference. Results of a first pilot study showed a satisfying acceptance of the software by the users.

Summing up, the WBT presented in this work can be regarded as an effective and efficient intervention for fostering self-regulated learning of university students. Positive effects can even be increased through additional peer feedback interventions; in this case positive effects are also observed for objective academic performance measures. While a mere learning diary did not show positive effects in two empirical studies, a promising concept was developed in an interdisciplinary approach: A digital learning assistant.

Zusammenfassung

Abstract in German

Selbstreguliertes Lernen (SRL), also das systematische Ausrichten von Gedanken, Gefühlen und Verhalten auf selbstgewählte Lernziele, ist von entscheidender Bedeutung für akademischen Erfolg in der Schule, an der Universität und im Berufsleben. Insbesondere im E-Learning ist die Regulation des eigenen Lernprozesses wichtig, da hier dem Lerner typischerweise eine hohe Eigenverantwortung zukommt. Defizite in der SRL-Kompetenz können zu Prokrastination, Unzufriedenheit und schlechteren Leistungen führen.

In der SRL-Forschung wurde eine Vielzahl unterschiedlicher Interventionen entwickelt, um Selbstregulationsprozesse beim Lernen zu unterstützen oder die SRL-Kompetenz zu fördern. Empirische Untersuchungen konnten zeigen, dass Trainings in der Lage sind, das Lernverhalten zu verbessern und akademische Leistungen zu erhöhen. Allerdings steigt bei solchen Trainingsmaßnahmen mit zunehmenden Teilnehmerzahlen der zeitliche und personelle Aufwand linear an, weshalb dieser Ansatz ungeeignet erscheint, um sehr große Gruppen von Lernern (z.B. alle Studienanfänger einer Universität) zu erreichen.

In der vorliegenden Arbeit wurde daher ein web-basiertes Training (WBT) zur Steigerung der SRL-Kompetenz von Studierenden entwickelt und in drei empirischen Studien evaluiert. Die Zielgruppe des Trainings waren angehende Studierende von MINT-Studiengängen, die einen Mathematikvorkurs besuchten. Das WBT besteht aus drei Lektionen zu jeweils etwa 90 Minuten und enthält Videos, Präsentationen, Übungen, Spiele und Gruppendiskussionen. Im Rahmen der empirischen Studien wurden die Effekte des WBT mit anderen SRL-Interventionen wie einem Lerntagebuch, Peer-Feedback-Gruppen sowie einem digitalen Lernassistenzprogramm verglichen.

In Studie 1 nahmen 211 angehende Studierende teil, die einen Mathematikvorkurs besuchten. Dieser Vorkurs fand ausschließlich online statt und verfolgte das Ziel, innerhalb von vier Wochen das mathematische Schulwissen zu wiederholen. Die TeilnehmerInnen wurden randomisiert einer von vier Bedingungen zugewiesen, in denen sie entweder das WBT bearbeiteten (Gruppe T), ein Lerntagebuch führten (Gruppe D), beide Interventionen erhielten (Gruppe TD) oder keine davon (Kontrollgruppe C). In einem Prä-Post-Evaluationsdesign konnte dabei festgestellt werden, dass die TeilnehmerInnen des WBT signifikante Zuwächse im deklarativen Wissen über SRL, im selbstberichteten SRL-Verhalten sowie in ihrer Selbstwirksamkeitserwartung aufwiesen. Für die Mathematikleistung zeigte sich ein leicht

negativer Effekt des WBTs. Das Lerntagebuch hatte keinen signifikanten Einfluss auf die eingesetzten Maße. Zeitreihenanalysen der Tagebuchdaten bestätigten den positiven Trend im SRL-Verhalten und fanden große Interventionseffekte insbesondere für die ersten beiden Lektionen.

In Studie 2 wurde das WBT erweitert mit einer Peer-Feedback-Intervention. Dabei wurden die TeilnehmerInnen des WBT in Gruppen zu jeweils fünf Personen eingeteilt und erhielten im Anschluss an jede Lektion eine Peer-Feedback-Aufgabe. Im Rahmen dieser Aufgaben gaben sich die TeilnehmerInnen gegenseitig Feedback zu ihrem Zeitplan, ihren Lernstrategien und ihren Zielen. Zudem führten die TeilnehmerInnen ein Lerntagebuch. Diese Versuchsbedingung (Gruppe TDP) wurde verglichen mit einer Gruppe, die neben dem Lerntagebuch nur das normale WBT (ohne Peer-Feedback) bearbeiteten (Gruppe TD), einer Gruppe mit Lerntagebuch (Gruppe D) und einer Kontrollgruppe ohne Interventionen (Gruppe C). Es zeigten sich signifikant positive Effekte des WBTs auf deklaratives SRL-Wissen, SRL-Verhalten und Selbstwirksamkeitserwartung. In der Bedingung mit zusätzlichem Peer-Feedback waren die genannten Effekte noch größer. Zudem zeigte sich hier ein signifikant positiver Effekt auf die Mathematikleistung. Die reine Tagebuchbedingung zeigte hingegen keine signifikanten Effekte.

Studie 3 verfolgte das Ziel, das Lerntagebuch zu einem digitalen Lernassistenten weiterzuentwickeln, indem es um dynamische, interaktive Elemente erweitert wurde. In einem interdisziplinären Projekt wurden Methoden aus dem Bereich Learning Analytics (LA) verwendet, um den Nutzern visuelles und textuelles Feedback auf ihr im Lerntagebuch berichtetes Lernverhalten anzubieten. Die fertiggestellte Software *PeerLA* erlaubt es, Lernziele zu definieren, einen Zeitplan festzulegen und den Erfolg im Nachhinein zu bewerten. Auf Basis dieser Bewertungen werden dann bei zukünftigen Zielen mit Machine Learning-Algorithmen Vorschläge berechnet, wie viel Zeit für welche Aufgabe eingeplant werden sollte. Zudem werden die eigenen Daten (z.B. Zeitinvestment oder Lernfortschritt) visualisiert und mit den Daten anderer Nutzer zum Zweck einer sozialen Bezugsnorm verglichen. Die Ergebnisse einer ersten Pilotstudie zeigten eine überwiegend gute Akzeptanz der Software durch die Nutzer.

Zusammenfassend kann das im Rahmen der vorliegenden Arbeit entwickelte WBT als effektive und effiziente Intervention zur Verbesserung des selbstregulierten Lernens von Studierenden betrachtet werden. Die positiven Effekte können dabei durch die Hinzunahme von Peer-Feedback-Interventionen noch gesteigert und auf objektive akademische Leistungsmaße ausgeweitet werden. Während ein reines Lerntagebuch in zwei Studien keine Belege für eine Verbesserung des Lernverhaltens zeigte, wurde in einem interdisziplinären Ansatz ein aussichtsreiches Konzept für eine digitale Lernassistenz-Software entwickelt.

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List of Original Manuscripts

MANUSCRIPT 1:

Bellhäuser, H., Lösch, T., Winter, C. & Schmitz, B. (*in press*). Applying a Web-Based Training to Foster Self-Regulated Learning – Effects of an Intervention for Large Numbers of Participants. *The Internet and Higher Education.* doi:10.1016/j.iheduc.2016.07.002

MANUSCRIPT 2:

Bellhäuser, H., Liborius, P. & Schmitz, B. (*under review*). Fostering Self-Regulated Learning Online: Effects of Web-Based Training and Peer Feedback on Mathematics Performance. *Journal of Experimental Education.*

MANUSCRIPT 3:

Konert, J., Bohr, C. & **Bellhäuser, H.** (2016). PeerLA - Assistant for Individual Learning Goals and Self-Regulation Competency Improvement in Online Learning Scenarios. Proc. of the 16th IEEE International Conference on Advancing Learning Technologies (ICALT). IEEE (2016).

Part I – Synopsis

1. Derivation of Research Questions

1.1 Introduction

The technological development of recent years has changed our lives in many ways, one of them being the way we acquire knowledge. Learning environments increasingly involve technology and scientific research in the fields of e-learning and technology-enhanced learning is well-established in a multidisciplinary community.

There is a multitude of different e-learning scenarios, from blended learning (combining face-to-face instruction with e-learning elements) over M-learning (learning on mobile devices such as smartphones) to MOOCs (massive open online courses). A common feature of these scenarios is that learners are highly responsible for their own learning success as there are either little instructions by teachers on how to use the learning material or no instructions at all. Instead, learners typically face the situation that they have to decide on their own, when and where they intend to study, what to study, how to study, and even whether they want to study at all. The competency that learners need in such situations in order to succeed is called self-regulated learning and a growing body of research informs us about the conditions in which this competency is developed and used.

We know that self-regulation is a key to become a successful learner. This holds true regardless of whether learning involves modern technology or traditional paper-based methods. Further, it is crucial both in school and at university, and also for life-long learning. However, as will be explicated later, we do not develop into self-regulated learners only by growing older. Instead, it takes instruction and practice in order to gain this competency and in many cases learners do not reach this goal, possibly leading to lowered motivation, procrastination, decreased performance, and lower self-efficacy.

Different approaches have been demonstrated to foster self-regulated learning, one of the most successful being a human trainer giving instructions on self-regulation to a group of participants. However, this approach is very limited in the number of participants that can be reached.

In the present work, different interventions were developed and evaluated to foster self-regulated learning in online learning scenarios, focusing on a web-based training that consists of three lessons and delivers theoretical background as well as practical exercises on self-regulated learning. Further interventions include learning diaries, peer feedback groups, and an online assistant that helps applying self-regulation strategies by showing visualizations of learning progress. The aim is to establish empirical evidence for positive effects of these interventions on learning so that the best support for learners can be provided in future learning scenarios.

1.2 Theoretical Background

According to Zimmerman and Schunk (2011) „Self-regulated learning and performance refers to the processes whereby learners personally activate and sustain cognitions, affects, and behaviors that are systematically oriented toward the attainment of personal goals“ (p. 1). A key feature is the cyclical nature of self-regulated learning (SRL), with past experiences serving as feedback to adjust present or future actions.

The underlying model for this work is the process model of self-regulated learning by Schmitz and Wiese (2006) which differentiates three different phases of learning, namely preaction phase (before learning), action phase (during learning), and postaction phase (after learning) (see Figure 1).

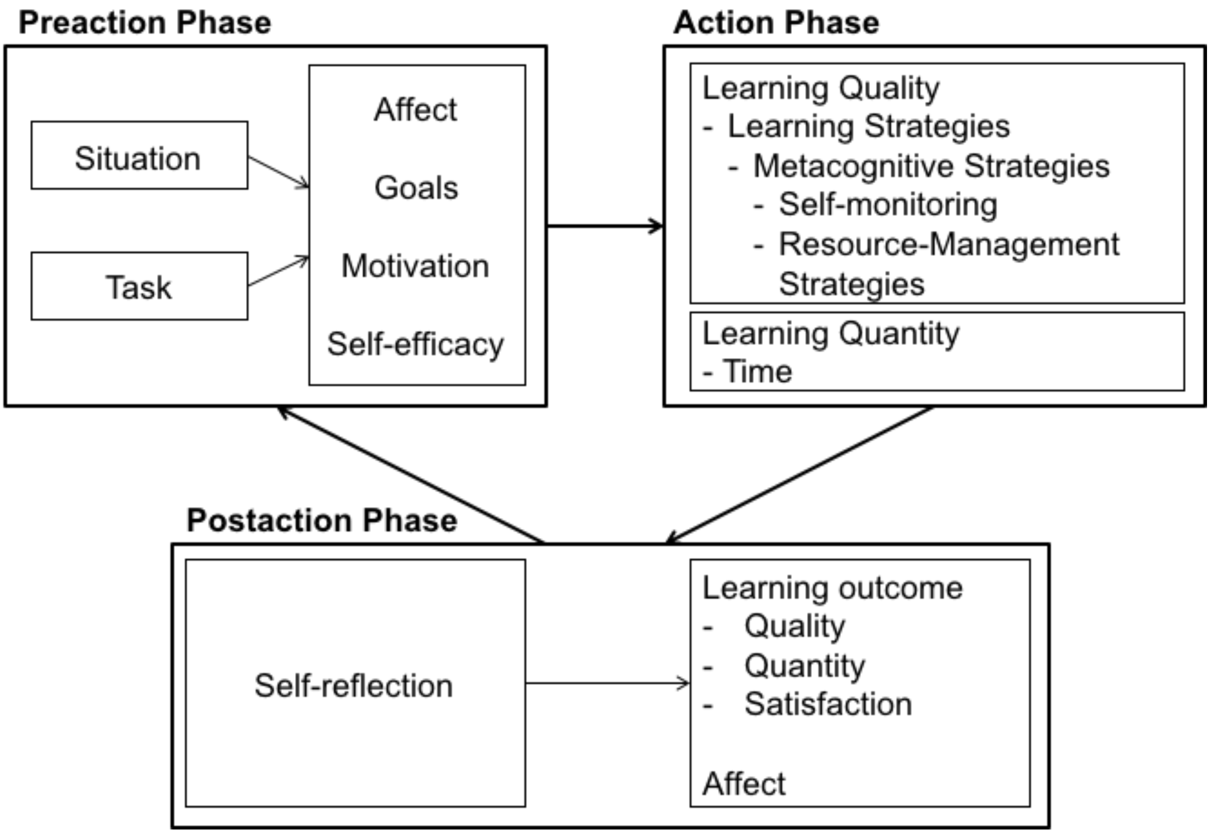

Figure 1. Process Model of Self-Regulated Learning (Schmitz & Wiese, 2006)

In the preaction phase, a learner faces a given task in a given situation. Depending on prior experiences, this leads to a certain affective state that might influence the success of the following learning episode. If the task is simple, no further self-regulatory actions are needed, because automatized behavior can be applied. However, when confronted with difficult tasks the learner engages in goal setting and planning. Personal resources like motivation (Ryan &

Deci, 2000) and self-efficacy (Bandura, 1994) serve as predictors for the successful application of learning strategies.

Learning takes place during the action phase, implying that strategies chosen in the preaction phase will be implemented during this phase. One important aspect is the mere quantity of learning which refers to the amount of time that is being invested in learning. However, the quality of learning is regarded to be even more important. The learner has to choose the appropriate learning strategies, with the distinction of cognitive, metacognitive, and resource-management strategies (Pintrich, Smith, Garcia, & McKeachie, 1993). Strategies that serve the purpose of resource-management are subdivided into internal and external strategies, where internal strategies focus on effort, time-management, as well as attention allocation, while external strategies are concerned with obtaining support from others, for example. Self-monitoring is considered to be crucial for successful self-regulation as it provides information about the current status quo of learning. Furthermore, volitional components like attention and motivation control are important to avoid procrastination and distractions.

Outcomes of learning actions are evaluated during the postaction phase after learning. The learner compares both quantity and quality of learning to his or her goals and reflects on his or her individual satisfaction. This results in an affective state and in an adjustment of future goal setting, thereby influencing the next preaction phase.

The cyclical nature of the process model implies that all variables are both predictors of subsequent phases (e.g., higher motivation in the preaction phase predicts better learning strategies in the action phase) and outcomes of prior learning episodes (e.g., better learning strategies in the action phase predict higher motivation in the next preaction phase). Note that the model assumes that all learners are involved in all processes described above, but that some processes might happen unconsciously or with a low intensity so that learner might not notice them.

The process model of SRL may be criticized for being very complex. It includes so many variables that literally every empirical finding can be explained within the framework. For example, a learner who experiences a successful learning episode is expected to maintain his or her level of learning strategies in order to be equally successful in the next learning episode. However, if the same learner reacts by lowering his or her standards the next time in order to economize the time investment, this process can as well be explained by the framework. In other words, it is hard to falsify the process model. From a cybernetic perspective, overly complex models can only be falsified by finding a more parsimonious model that can account for the same observations by using fewer variables (Bischof, 1985, p. 466).

Nevertheless, the process model provides a practically valuable framework that systematically considers a large number of variables that are each in itself indisputably important for successful learning—irrespective of whether their interrelations follow the assumptions of the process model or not. It has therefore been adopted as theoretical basis for many training interventions that showed positive effects on learning behavior and performance (e.g., Kistner et al., 2010; Mattern & Bauer, 2014; Perels, Gürtler, & Schmitz, 2005; Werth et al., 2012). Consequently, in the present work the process model of SRL was also chosen to be the foundation for the development of the interventions discussed in the following sections.

1.3 Outcomes of Self-Regulated Learning

From the beginnings of SRL research, Zimmerman (1990) stressed the "important role that students' use of self-regulated learning strategies plays in their academic achievement" (p. 7). One of the most convincing evidences for this notion was provided in a meta-analysis by Richardson, Abraham, and Bond (2012). Systematically reviewing 13 years of research on antecedents of university students' academic performance, they included 241 data sets that reported correlations between grade point average (GPA) and its possible predictors. The authors did not only investigate facets of SRL but also demographic factors, measures of cognitive capacity, personality traits, motivational factors as well as psychosocial contextual influences. Although the authors' categorization of constructs in the meta-analysis does not always match the process model of SRL (Schmitz & Wiese, 2006)—for example, test anxiety categorized as being a "self-regulatory learning strategy" or goal commitment as "psychosocial contextual influence"—this meta-analysis allows to compare the relative importance of SRL components to other constructs with respect to academic achievement. Results showed that academic self-efficacy (r = .31) and performance self-efficacy (r = .59), grade goals (r = .35), and effort regulation (r = .32) were more highly correlated to academic achievement than for example intelligence (r = .20), conscientiousness (r = .19), or stress (r = -.13). Other components of SRL, such as metacognition (r = .18), time management (r = .22), academic intrinsic motivation (r = .17), elaboration (r = .18), help seeking (r = .15), and goal commitment (r = .15) were also found to be important correlates of academic achievement.

In a similar approach, Sitzmann and Ely (2011) performed a meta-analysis on correlations between different self-regulation constructs and learning outcomes for adults in educational settings or workplace trainings. Analyzing 369 studies with 90,380 participants, they found goal level (r = .44), persistence (r = .27), effort (r = .28), and self-efficacy (r = .35) to have the strongest effects on learning. Components that were found to be comparably lower in their effect on learning outcomes included planning (r = .15), pretraining motivation (r = .10), help seeking (r = .08), and emotion control (r = .08).

Contrary to common beliefs (Bjork, Dunlosky, & Kornell, 2013), learners do not acquire adequate learning skills just by trial and error. Instead, it needs instruction and training to become a successful self-regulated learner. Therefore, researcher often observe deficits in SRL competency in many students (Azevedo & Cromley, 2004; Peverly, Brobst, Graham, & Shaw, 2003; van den Boom, Paas, & van Merriënboer, 2007). The following section will provide a brief overview over existing interventions for fostering SRL.

1.4 Interventions for Fostering Self-Regulated Learning

Considering the positive outcomes of SRL discussed above, it is highly desirable to foster SRL. Therefore, researchers have developed a variety of different interventions aiming at either a mediation deficiency or a production deficiency (cf. Schütte, Wirth, & Leutner, 2012). On the one hand, learners that suffer from a mediation deficiency do not possess enough knowledge on learning strategies and therefore need explicit instruction on possible strategies before the actual learning process. Learners with a production deficiency on the other hand do have the necessary knowledge but fail to apply the adequate learning strategies. In this case, process support is needed where learners are prompted to apply strategies during the actual learning process.

As an example for strategy instruction, a training intervention by Schmitz and Wiese (2006) will be sketched briefly. A group of 21 university students (civil engineering) were instructed by two assistant researchers, meeting for four weekly lessons of 2 hours each. In lesson 1, the general idea of SRL was discussed with a focus on goal setting. Participants were instructed to write down individually important study-related goals that were then examined with respect to certain criteria. In lesson 2, students derived learning plans on the basis of their individual goals and received advice concerning time management and the avoidance of procrastination. Lesson 3 focused on self-motivation strategies like self-rewarding or arranging a positive learning environment. In the last lesson, students reflected on their progress towards their individual goals and on how to proceed. Furthermore, self-instruction strategies like positive self-talk were explained and concentration exercises were conducted.

Process support can take on different shapes, one of them being learning diaries. Schmitz and Perels (2011) conducted a study with 95 students (8^{th} grade) over a period of seven weeks. During this time, each student fills in a daily learning diary consisting of two parts: One to be filled in before starting homework and one after finishing homework for that day. The first part focused on the preaction phase of SRL including items on goal setting, planning, and self-motivation. The second part covered the action and the postaction phase. Students reported their learning behavior (strategy usage, concentration, self-monitoring) and evaluated the success of their learning. The assumption behind this approach is that encouraging students repeatedly to monitor their learning behavior and their success will lead to a so-called *reactivity effect* (Korotitsch & Nelson-Gray, 1999), that is an increase in SRL behavior prompted by the items of the learning diary.

A different approach that also falls into the category of process support is prompting in computer-based learning environments (CBLE). As an example, in a study by Bannert and Reimann (2011) students had the task to use a hypertext information software in order to selfregulatedly learn basic concepts of learning theories. When they opened the first page, the computer automatically asked them to specify learning goals, to make a plan, and to orient themselves. After a predefined time, the instruction to write down and evaluate the first results of their learning task was prompted by the computer. A last prompt was shown towards the end of the learning session, instructing students to reflect on their learning outcomes.

Comparing the different approaches to fostering SRL reveals that each of them has its own benefits but also its own drawbacks. While strategy instruction might be the best way to equip learners with strategies that are independent of context, thereby making students truly self-regulated learners, this approach is very costly in terms of specialized trainers that are needed for instruction. Process support like learning diaries might be relatively inexpensive and feasible for all kinds of learning scenarios, however it remains an open question whether students keep using SRL strategies once they stop filling in the diaries. Lastly, prompting in CBLEs seems to be a promising new approach, but prompts are restricted only to the one context they were developed for—even slightly changed learning environments might cause the need to revise the prompts constructed for earlier versions.

The question how SRL can be improved most effectively has been the aim of so many different original studies that already several meta-analyses have tried to systematically analyze the body of research with respect to effects on relevant learning outcomes, additionally identifying important moderators for these effects.

Focusing on primary and secondary schools, Dignath and Büttner (2008) evaluated the effects of 74 SRL interventions on strategy use, motivation, and academic performance. They found a mean overall effect size of g_{Hedges} =.69, with varying results depending on school type and dependent variables. Effects on academic performance were found to be between .54 (in secondary schools) and .61 (in primary schools), while effects on strategy use (.72 in primary schools and .88 in secondary schools) and on motivation (.75 in primary schools and .92 in secondary schools) tended to be even higher.

Benz (2010) extended the view on SRL interventions by also including studies that were conducted outside of school context (e.g., at university or in experimental laboratory settings). While the overall weighted mean effect size was found to be Δ_{Glass} = .45, moderator analyses revealed that studies focusing on strategy instruction (.73) were more effective than studies focusing on process support (.33). Further moderator analyses showed that human teachers (.85) were more successful than computers (.11) in fostering SRL and that interventions that lasted for 3 to 6 weeks (.78) were superior to both shorter (.24) and longer (.45) interventions.

Taken together, the findings from these meta-analyses support the claim that SRL can be trained and that such training has indeed the potential for positive effects on desirable outcomes such as learning behavior and academic performance.

1.5 Purpose of the Present Thesis

Although SRL interventions have proven great *effectiveness* (i.e., they produce the the desired effect), *efficiency* of interventions (i.e., whether they produce the desired effect in an economic way) has received less attention. Typical trainings are performed as face-to-face instruction with one human trainer teaching a group of up to 30 participants. This approach can only reach a small number of learners. Werth and colleagues (2012) therefore used teachers as multipliers by teaching them how to teach SRL strategies to their students. But even this approach is limited with respect to the number of learners that eventually are instructed.

One way to overcome this limitation is the application of web-based training (WBT) where training content is delivered via internet to participants that are flexible with regard to time and location of participation. WBT seems to be equally effective in increasing both declarative and procedural knowledge (Sitzmann, Kraiger, Stewart, & Wisher, 2006) when compared to classroom instruction. While WBT has successfully been applied in clinical psychology (Wantland, Portillo, Holzemer, Slaughter, & McGhee, 2004), so far no attempts have been made to foster SRL using this approach.

In the light of the meta-analytic findings by Benz (2010), one might caution that computers were less effective than human trainers in improving academic performance. However, previous interventions conducted by computers have always been restricted to process support, whereas strategy instruction performed by computers (i.e., WBT) has not been included in the meta-analysis due to inexistence.

The central aim of the present work is therefore to develop and evaluate a WBT that instructs learners about SRL strategies and supports them during the implementation of these strategies. In order to judge the effectiveness of such a WBT, it is compared to further SRL interventions, including learning diaries, peer feedback groups, and an interactive learning assistant. Three separate evaluation studies were conducted, as briefly sketched in the following section.

In study 1, a first version of the WBT was developed and evaluated. In a randomized control design, it was compared to learning diary intervention with participants either receiving only the learning diary, only the WBT, both interventions or no intervention at all. The research aim was to investigate the effect that the WBT has on strategy knowledge, SRL behavior, and performance, while segregating its effect from a possible reactivity effect of the learning diary.

In study 2, the WBT was augmented by adding a peer feedback group intervention where participants gave mutual feedback on SRL strategies. This combined intervention was tested against the WBT without peer feedback as well as against a learning diary and a control group without interventions. The research aim was to confirm positive effects of the WBT found in study 1 and to contrast its effects to the effects of an additional peer feedback intervention.

In study 3, an interdisciplinary approach was chosen to develop an interactive learning assistant. Combining theoretical background from educational psychology with methods from computer science, a learning assistant software was programmed to overcome flaws of traditional learning diaries. The assistant prompts the application of SRL strategies and provides textual and graphical feedback on the individual learning progress. Additionally, it offers a social frame of reference by comparing individual data to peers. The research aim was the development of a theoretically based software concept and the implementation of a functioning software. Being a pilot study, the evaluation of the learning assistant software focused on user experience.

2 Study 1: Applying a Web-Based Training to Foster Self-Regulated Learning – Effects of an Intervention for Large Numbers of Participants

2.1 Purpose

SRL interventions have traditionally been classroom instruction of different types (Boekaerts & Corno, 2005) and have been shown to have positive effects on both SRL competencies and learning outcomes (Dignath & Büttner, 2008). However, most SRL trainings are effective yet not efficient as trainings in presence can only reach a certain number of participants at a time. A further limitation of face-to-face trainings is that they cannot be applied in distance learning scenarios.

An alternative to human trainers could be to involve computers as instance of delivery (e.g., Azevedo, Cromley, & Seibert, 2004; Kramarski & Mizrachi, 2006). But as Benz (2010) could show in a meta-analysis, so far computers have been less successful than human trainers in positively affecting learning outcomes. In this comparison though, the instance of delivery (human vs. computer) is confounded with the type of support (process support via scaffolding during learning vs. strategy support via trainings before learning), as most approaches involving computers provide process support.

No attempts have been made so far to equip learners with SRL strategies by applying a web-based training (WBT). Sitzmann, Kraiger, Stewart, and Wisher (2006) report WBT to be at least as effective as classroom instruction. This holds true not only for declarative knowledge (Hallgren, Parkhurst, Monson, & Crewe, 2002) but also for procedural knowledge as shown in different fields like health psychology, clinical psychology (Neve, Morgan, Jones, & Collins, 2010) or educational psychology (O'Reilly, Sinclair, & McNamara, 2004). Thus, the aim of this study was to develop a WBT on SRL and to evaluate its effect on SRL competencies and objective learning outcomes.

2.2 Method

We recruited 211 prospective students (166 male, 45 female) with a mean age of 20.2 (SD = 2.23) as participants for the evaluation study. They were enrolled in an online mathematics preparation course at a Technical University in Germany. The preparation course was developed for students of mathematically oriented fields of study (computer science, civil engineering, mechanical engineering or mathematics) in order to establish a common knowledge basis. The e-learning course (built with the learning management system Moodle) covered mathematical knowledge from all school grades and provided learners with definitions, arguments, examples, assignments and visualizations. Prior evaluations found the e-learning mathematics course to be more effective than a classroom alternative (Fischer, 2009). Duration of both the course and the study was four weeks in which all participants had the freedom to decide for themselves what to learn, when to learn and how to learn.

The study design was a pre-post test evaluation with participants randomly assigned to one of four study groups in a 2x2-factorial design: Group TD attended a web-based training on self-regulated learning and kept a learning diary. Group T attended only the training without keeping a diary while group D only kept the learning diary without access to the web-based training. Control group C was not supported in their learning process (i.e., they attended the regular preparation course the way prior cohorts did before the development of the WBT).

The WBT consisted of three lessons that were constructed with Moodle and were to be attended each within a two-day time frame with intervals of one week between two lessons. The content of the lessons was based on the process model of self-regulated learning (Schmitz & Wiese, 2006). The first lesson ("Before Learning") focused on the preaction phase and included the topics goal setting and time management. Lesson 2 ("During Learning") dealt with the action phase and included the topics volition, cognitive learning strategies and metacognitive learning strategies. The third lesson ("After Learning") highlighted the postaction phase and included the topics attribution and reflection. Each lesson applied videos, presentations, tests, exercises and group discussions in an online forum. The average duration of a lesson was 90 minutes. Participants from groups TD and T filled in short evaluation forms concerning the subjective satisfaction with the training after each lesson.

The learning diary was intended to prompt SRL strategies on a daily basis and thereby to enhance learning. It consisted of one part that was to be filled in before learning and one part to be filled in after learning. Both parts included open questions that were supposed to foster goal setting and planning or reflection respectively (e.g., "What learning goals have you set for yourself for today?" or "In case you did not achieve your goals today: What do you plan to do differently tomorrow?") and closed questions that were mainly intended for quantitative analyses (e.g., "How many hours have you spent on learning today?"). Based on the SRL items a daily SRL score for each participant was calculated.

In both pre- and post-test, the same instruments were employed. In the test of mathematical knowledge, participants had to solve 30 mathematical problems that referred to different chapters of the mathematics course within a time limit of 30 minutes. Pre- and post-test versions were paralleled. A test of declarative knowledge about learning strategies taught in the WBT was applied consisting of 20 multiple choice questions with a time limit of 10 minutes. Furthermore, self-regulation questionnaires were applied, including scales from the Motivated Strategies for Learning Questionnaire (MLSQ; Pintrich et al., 1993) and the Volitional Components Questionnaire II (VCQII; Kuhl & Fuhrmann, 1998).

2.3 Results

As a manipulation check, we analyzed the short evaluation forms after each lesson. As the rate of return of these evaluations was 97.9 %, the vast majority of participants seemed to comply with the training. The mean duration of lessons as reported by the participants fitted well with the intended duration of 90 minutes per lesson (Lesson 1: M = 89.78, SD = 35.84; Lesson 2: M = 92.96, SD = 34.89; Lesson 3: M = 79.58, SD = 28.42). Furthermore, participants rated the content of the training to be highly useful for the preparation course (on a Likert scale of 1 to 6: Lesson 1: M = 5.20, SD = 0.99; Lesson 2: M = 5.31, SD = 1.00; Lesson 3: M = 5.41, SD = 0.89).

Following an approach by Tabachnick and Fidell (2012), we conducted a mixed effects MANOVA with math achievement, SRL overall, SRL knowledge, and self-efficacy as dependent variables and the independent variables being SRL-training (yes/no), learning diary (yes/no), and time (repeated measure: pre- or post-training). A linear discriminant analyses (LDA) as suggested by Field, Miles, and Field (2013) served to clarify the multivariate results, with gain scores (post-score – pre-score difference scores) as the basis for factor extraction.

In the MANOVA, we observed a significant between-groups effect of training (F(4, 159) = 18.42, p < .001, partial η^2 = .32) as well as a significant time x training interaction (F(4, 159) = 36.50, p < .001, partial η^2 = .48), with the training groups showing higher improvements over time. The LDA revealed that this effect was largely due to improvements in SRL knowledge (.75), but also in SRL overall score (.45) and self-efficacy (.30). In the math test, however, training groups seemed to perform lower than the non-training groups (-.32).

Using the same procedure (MANOVA and LDA), we also analyzed the subscales of the SRL questionnaire and found positive effects of the training particularly for the subscales planning (.72), cognitive learning strategies (.26), self-instruction (.60), and goal setting (.36), whereas we found a negative effect on reflection (-.48).

Time-series analyses of the diary data revealed a positive linear trend for SRL in group TD (R^2 = .29; b_0 = 4.10; b_1 = .012; p <.01), but not in group D (R^2 = .001; b_0 = 4.07; b_1 = -.001; p =.86). To support the assumption that this increase was caused by the lessons of the WBT, we calculated individual intervention analyses for each participant and each lesson as described by

Schmitz (2006). The effect sizes were then aggregated over the whole sample by means of a meta-analysis. We found large mean effect sizes of d = 1.11 for the first lesson as well as for the second (d = 1.01), and a medium effect size (d = .51) for the third lesson, all of which were statistically significant.

2.4 Discussion

The results of this study show that SRL competencies can be trained by means of a web-based training. Participants from the training groups acquired more declarative knowledge about SRL and reported improved learning behavior in the SRL scales. They also showed improved self-efficacy over the non-training groups. Unfortunately, this was accompanied by lower performance in the mathematics test for the training groups. This could be due to the fact that a change in learning strategies can lead to deteriorated performance in the short term, even when long term effects are positive (Siegler, 2007).

By means of time-series analyses of the diary data revealed that training group TD linearly improved their SRL during the preparation course while diary group D did not improve. This was associated with significant impacts of the three WBT lessons, with lesson 1 and lesson 2 having the greatest effects.

We concluded that the WBT was a valuable approach to foster SRL, particularly for large numbers of participants that could hardly be trained with conventional training approaches. However, the decreased mathematics performance remained as a concern in study 1.

3 Study 2: Fostering Self-Regulated Learning Online: Effects of Web-Based Training, Learning Diaries and Peer Feedback on Self-Regulated Learning, Self-Efficacy, and Mathematics Performance

3.1 Purpose

Study 1 demonstrated the WBT to have positive effects on SRL knowledge, SRL behavior, and self-efficacy, but also a detrimental effect on mathematics performance in the online mathematics preparation course. The purpose of study 2 was therefore to replicate the findings of study 1 and to augment the WBT with a new peer-feedback intervention that helps participants in using the strategies from the WBT so that they improve SRL as well as performance. The rationale behind the peer-feedback approach was that collaborative learning has been shown to be more effective than individual learning (Johnson & Johnson, 2009). Peer feedback interventions can be successful in fostering affect and performance in language learning (Gielen, Peeters, Dochy, Onghena, & Struyven, 2010; Nelson & Schunn, 2009). In the field of SRL research, positive effects of teacher feedback on students' self-regulated learning have been demonstrated (Azevedo, Greene, & Moos, 2007; van den Boom, Paas, van Merriënboer, & van Gog, 2004), but peer feedback has not been explored as an intervention to foster SRL so far.

3.2 Methods

In study 2, we examined the effects of three different interventions that aimed at fostering self-regulated learning. Prospective university students in an online mathematics preparation course were assigned randomly to one of four experimental conditions: Group D (diary), group TD (training + diary), group TDP (training + diary + peer feedback group), and group C (control). Complete data was obtained for 136 participants (78.8% male; M = 19.8 years).

The learning diary consisted of two parts: The first part (to be filled in before studying) triggered goal setting, planning, and self-motivation with open questions. The second part (to be filled in after studying) triggered reflection and goal setting for the next day.

The WBT consisted of three lessons (90 minutes each) and applied videos, presentations, self-tests, exercises, and online bulletin boards. Compared to the WBT version from study 1, only little adaptations were made. Instead of animated videos, we applied videos with human actors in order to increase credibility and identification for the audience.

Participants in group TDP were randomly assigned to peer feedback groups of five persons each. Peer feedback groups had the possibility to communicate in a separate bulletin board in which discussion topics were suggested. After each lesson of the WBT, a group task referring to the current lesson was posted that was supposed to be solved collaboratively (Lesson 1: time schedule for the preparation course; Lesson 2: cognitive learning strategies; Lesson 3: reflection and adjustment of learning goals). In each group task, students were encouraged to discuss their usage of the respective SRL strategies. Discussions on mathematical problems were not encouraged.

Outcome measures included a test of declarative SRL knowledge (as manipulation check), an SRL questionnaire (overall score: 26 items, $\alpha = .85$; 7 subscales: goal setting, planning, self-motivation, volition, elaboration, metacognition, and reflection, $\alpha = .63 - .78$), and the General Self-Efficacy Scale (Schwarzer & Jerusalem, 1999; 10 items, $\alpha = .82$). In contrast to study 1, we applied a new mathematics test with 52 problems covering all chapters of the preparation course ($\alpha = .84$). Additionally, participants were asked to chose ten chapters to focus on in particular, depending on their individual needs. The corresponding ten problems in the mathematics test were taken to calculate the mathematics focus score (ranging from 0 to 10).

3.3 Results

We calculated a 2x2 repeated-measures MANOVA, with group and time as the independent variables and SRL knowledge, self-efficacy, mathematics overall score, and SRL overall score as the dependent variables. Results showed a significant main effect of group ($F(1, 132) = 6{,}70$; $p < .001$), a significant main effect of time ($F(1, 132) = 61{,}78$; $p < .001$), as well as a significant interaction of the two factors ($F(3, 132) = 10{,}19$; $p < .001$). To clarify these multivariate findings, univariate ANOVAs were conducted. For SRL knowledge, self-efficacy and the SRL overall score, we found significant interaction effects in the hypothesized direction, with group TDP showing the most prominent gains among treatment groups and group C showing either constant levels or even negative developments. The interaction effect for the mathematics overall score, however, missed the level of significance marginally, although descriptive statistics pointed into the hypothesized direction. Replacing the mathematics overall score by the mathematics focus score revealed a significant interaction effect. On an even deeper level of analyses, we conducted contrast analyses for the gain scores (post-test score minus pre-test score) of each experimental group in each dependent variable. These contrast analyses found diary group D not to differ from control group C in any of the dependent variables. Group TD in contrast showed significant gains in SRL knowledge, the SRL overall score, and self-efficacy, but not in the mathematics test. Group TDP had significant gains in all dependent variables, extending the effect to the domain of mathematics performance. Also, the size of effects for SRL knowledge, the SRL overall score, and self-efficacy in group TDP was greater than in group TD. Analyzing the subscales of the SRL questionnaire revealed that group TD primarily improved in the subscales planning and metacognition, while group TDP additionally improved in the subscales self-motivation, volition, and reflection.

3.4 Conclusion

In study 2, we found the combined intervention consisting of learning diary and web-based training on self-regulated learning with additional peer-feedback intervention to be the most successful. Beneficial effects were shown on self-regulated learning, self-efficacy, and mathematics performance. The combination of learning diary and web-based training without peer-feedback intervention was found to have significant, yet slightly less pronounced effects on self-regulated learning and self-efficacy, but not on mathematics performance, matching the results of study 1. As in study 1, the learning-diary-only condition could not demonstrate significant effects.

We conclude that the additional peer-feedback intervention seems to be a useful supplement to the WBT with organizational costs being comparably low. However, using a learning diary without supplementary interventions did not seem to improve self-regulated learning.

4 Study 3: PeerLA - Assistant for Individual Learning Goals and Self-Regulation Competency Improvement in Online Learning Scenarios

4.1 Purpose

While the WBT showed encouraging results in both study 1 and study 2, another common finding was that the learning diary intervention did not exhibit positive effects on learner in either study. This was a surprise as the reactivity effect (see section 1.4) is well documented (Fabriz, Dignath-van Ewijk, Poarch, & Büttner, 2014; Korotitsch & Nelson-Gray, 1999; Schmitz & Perels, 2011; Tobias & Inauen, 2010; Webber, Scheuermann, McCall, & Coleman, 1993). It is not possible to determine the reasons of our unexpected findings as we did not systematically manipulate the conditions under which participants made use of the diary. We did not implement different versions of the diary; neither did we vary the instructions on how to use the diary. However, a number of conditions seem reasonable to account for this pattern of results. First, the period of usage of the diary was only four weeks and participants were not obliged to fill in the diary daily; as a result the intensity of usage might not have been high enough. Further, there was no explicit instruction on the possible positive outcomes of diary usage; participant might not have understood the reasons why they had to fill in the diary. Another possibility is that the content of the diary (e.g., formulation of items) was suboptimal; however, as the diary was developed in collaboration with leading experts in the field, this seems to be rather unlikely.

A different view is that the learning diary as used in study 1 and 2 was presented in a computerized manner, yet without making use of the possibilities that computers provide. One could argue that although it was presented as a digital tool, it actually resembled more a paper-based, static diary without any interactive or dynamic features. While this was also the case for the previously mentioned studies that found reactivity effects, one difference is that they indeed used paper-based diaries. Therefore, participants of those studies never expected any form of feedback on their diary entries; in the case of our digital learning diary we cannot rule out that higher expectations on the part of our participants were disappointed.

A successful example of interactive digital learning diaries was reported by Wäschle and colleagues (2014). They developed a software that provided dynamic visualization of the learning behavior implemented in the Learning Management System (LMS) *Moodle* (Moodle, 2014). In this software, entries to the diary were used to calculate a procrastination score that were then depicted in a line graph, continuously adding data points with new entries made.

While the approach by Wäschle and colleagues (2014) was demonstrated to be successful in decreasing procrastination and increasing SRL, at least three aspects could be improved. First, the software did not actively support the goal setting and planning process. Users might need help in order to set their goals properly according to empirical findings. Second, feedback was restricted to the graphical visualization, leaving interpretation of the data to the students. Providing automatic textual interpretation predefined by experts might help students to draw the right conclusions out of their data. Third, it neglected the social perspective on learning: Visualizing the learning behavior of peer groups can offer a valuable frame of reference and might motivate students to engage more into learning.

Learning Analytics (LA) offers a methodology to overcome these restrictions. Based in computer science, LA aims at aggregating and visualizing user data in order to support reflection and insight of the stakeholders, that is either teachers or learner themselves (Drachsler & Greller, 2012). Data input stems from automatically retrieved log files (e.g., time spent on a certain website) or self-reported (psychological) variables—the latter being comparably seldom used for analysis.

The aim of this study was therefore to enhance the possibilities of online learning diaries by applying LA methods. After implementing such ideas, one can hardly still call the resulting product a learning diary; it rather resembles a learning assistant. As the development of such a complex learning assistant is beyond the scope and methodology of educational psychology, the software PeerLA—described in the following sections—was the result of an interdisciplinary collaboration with computer scientists.

4.2 Method

For an interdisciplinary project to be successful, researchers first have to find a common language for communication. We discovered that the idea of self-regulated learning translates well into the concept of SCRUM (Schwaber & Sutherland, 2013), a framework that guides organizations through complex product development processes. Comparable to demanding learning scenarios where learners can never fully predict their progress, the development of new products (e.g., software development for a client that occasionally comes up with new ideas and requirements) is characterized by uncertainty and constantly changing goals. In both cases, it is not possible to predetermine the whole process; instead, regulation in short intervals is needed.

The central components of SRL are translated to SCRUM taxonomy for better understanding. Long-term goals (following the SRL taxonomy) are called *user stories* as in the logic of SCRUM they resemble what users eventually are able to do with the product, once the development is completed. Short-term goals are translated into *tasks*, that is smalls units of the product features. The planning is called *planning poker*, the action phase could be translated as a *sprint*. Monitoring takes place as *daily scrum meetings* and is used for reflection and regulation (*sprint review and retrospective*). Once the common language was established, we were able to design the PeerLA software. Key features are described in the following section.

In the course planning stage, students formulate their learning goals including targeted grade. Then they judge their prior knowledge or skills with respect to dimensions that the teacher previously defined. For each learning interval (typically one week), students chose the topics they intend to study (short-term goals). Depending on the chosen goals, one's self-reported skill level, and data from former students in the same course, an algorithm calculates an estimated time investment that is regarded as realistic. Students are free to accept this suggestion or to modify how much time they want to invest on the learning goal. They are further prompted to decide on which days of the current learning interval they want to study.

When finishing a learning interval, students evaluate their success on each of their goals and whether their learning strategies need improvement. They further report their actual time investment (in case log file data is not available) and give and updated judgment of their current skills. These quantitative variables are used by a machine learning algorithm in order to provide improved estimates of necessary time investment for future learning intervals.

At any stage, students have access to interactive bar charts of their own learning behavior (time investment, improvements in skills). A social frame of reference is provided by adding bar charts of the respective variables for the mean of all other learners.

4.3 Results

In a first qualitative evaluation study, we installed the software in the mathematics preparation course described in study 1 and 2. As the software was in an early stage of development, research questions only concerned the stability of the software and the general acceptance by students, but not actual effects on learning behavior or performance.

As participation in the study was voluntary, only 83 out of 749 students in the preparation course filled in the evaluation form. The form included two open questions related to the PeerLA software: "What do you consider as positive about PeerLA?" and "What do you want to tell us additionally (improvements, Negative aspects, etc.)?". Answers were rated as being either positive, neutral, or negative and categorized with respect to frequent statements about the software.

The majority of evaluation statements was judged to be positive. Participants expressed general appreciation of the idea behind the software and emphasized different aspects to be particularly helpful: Features that were frequently rated positive included goal setting support, assistance with planning, monitoring both one's time management and one's skill development, and comparison with peers.

Neutral recommendations for improving the software included the plea to add reminders for the short-term goals chosen by the user and an exemplary schedule (e.g., a recommendation by the teacher of the preparation course).

Among the negative statements, two aspects were mentioned particularly often. Some students stated that they did not receive the information letter about the software at the beginning of the preparation course and therefore discovered it too late. Others complained about inaccessibility of the preparation course in general (an issue that we found out later to be not related to the installation of PeerLA), which prevented them from using the software as well. Only two participants found the planning process to be too detailed and time-consuming. A last negative aspect concerned the wording of the skills to be acquired as defined by the teacher.

4.4 Conclusion

The present evaluation study is only considered to be a pilot study and does clearly not satisfy the high standards of educational psychology. However, being an interdisciplinary project, the value of this study is not to be found in the empirical results but rather in the theoretically sound concept and the well-designed programming of the software. Transgressing the boundaries of mono-disciplinary research, we developed a new category of SRL intervention (named learning assistant) that combines well-established benefits of learning diaries with technological possibilities of Learning Analytics, including even social aspects of learning processes. As evaluation statements of users were predominantly positive, this approach seems to be promising.

Although several negative aspects were mentioned by participants, most of them concerned the general conditions in the preparation course (technical issues with the Moodle server, missing information about PeerLA, unclear wording by the teacher). Only two participants found the software to be too complex—a charge to be taken seriously. However, as we do not have further information about these two participants we cannot rule out the possibility that individual characteristics might at least partly have accounted for their opinion.

Obviously, strong quantitative-empirical data is required to determine the real effects the PeerLA learning assistant has on learning behavior and performance. An randomized experimental design, comparing PeerLA to a passive learning diary or possibly to a learning diary with visualizations as proposed by Wäschle and colleagues (2014) would be imperative to judge its usefulness.

5 General Discussion

5.1 Summary of Results

The central aim of the present work was the development of a web-based training to foster self-regulated learning. This WBT was evaluated in two studies (study 1 and study 2) and tested against the effects of a learning diary (study 1 and study 2). Furthermore, the WBT was extended through a peer feedback intervention (study 2). A completely new approach, namely a digital learning assistant, was developed and evaluated qualitatively in study 3.

In the following section, the results for the WBT in study 1 will compared to those in study 2. For this purpose, the WBT-only condition in study 2 (i.e., group TD) is referred to and not the extended version with additional peer feedback group intervention (i.e., group TDP). In this respect, study 2 can be viewed as a replication study although the WBT was refined slightly (particularly using real videos instead of animated videos).

One has to keep in mind, though, that measurement instruments were not identical in some cases. The SRL knowledge test and the self-efficacy questionnaire were adopted without changes. The SRL questionnaires in study 1 and 2 had a large overlap in items—however, as the questionnaire was shortened for study 2, the items chosen for each subscale were not identical. The mathematics test was developed completely new for the second study; all differences will be discussed in detail when comparing the results.

In general, the findings from study 1 were confirmed in study 2, with both studies emphasizing positive effects of the WBT. For many dependent variables, direction and size of effects in the two studies are in accordance. In these cases, the empirical evidence is judged to be strong. In cases of large effects that were only observed in one but not in the other study, the empirical evidence is considered moderate. If medium size effects were only found in one of the two studies, the empirical evidence is judged to be weak. Cases of small effect sizes in one study with no effect in the other are considered to provide no reliable empirical evidence. Deviations from these judgments can occur when measurement instruments were not congruous enough or when pretest scores differed largely between studies.

5.1.1 Effects of the Web-Based Training on Declarative Knowledge

The WBT was found to be effective in increasing SRL knowledge in both study 1 and study 2 with very large effect sizes. Relying on the identical test, even the mean pretest and posttest scores of the respective participants are almost the same. Thus, there is strong empirical evidence that the WBT is able to convey declarative knowledge about learning strategies.

5.1.2 Effects of the Web-Based Training on Self-Regulated Learning

Comparing the results of the overall score in the SRL questionnaire revealed that large positive effects on self-reported learning behavior were found in both studies. However, the patterns differed slightly: Participating in the WBT in study 1 on the one hand led to maintained levels of self-reported SRL, while control group participants deteriorated. In study 2 on the other hand, control group participants maintained their level of SRL while participation in the WBT led to increased SRL scores. Although the selection of items in the questionnaire was not identical, the overall scores had a great overlap. As both questionnaires furthermore showed high reliability scores, one can assume that they measured essentially the same construct. One objection might be that actual behavior might deviate from self-report (Wirth & Leutner, 2008). However, in study 1, the findings were supported also by trends in the learning diary (a measurement instrument that—despite being self-report as well—is much closer to actual behavior and therefore less susceptible to distortions (Schmitz, 2006). As a conclusion, the empirical evidence concerning positive effects of the WBT on SRL in general is judged to be strong.

Taking a closer look at the subscales of the SRL questionnaire allows for more sophisticated conclusions. For goal setting, study 1 found a medium positive effect by attenuating the general decrease of all participants in this subscale. Study 2, however, found no effect of the WBT on goal setting. As the selection of items was essentially the same in both cases, comparison of the mean scores between studies is warranted. This reveals a large discrepancy in pretest scores, with participants in study 2 starting on a much higher level. As a ceiling effect in study 2 therefore cannot be ruled out, the empirical evidence for the WBT to foster goal setting is considered to be moderate.

For the subscale planning, results are absolutely in accordance: Both studies found large positive effects of the WBT. In fact, in both cases this subscale revealed the largest increase within the SRL questionnaire. As the selection of items in study 2 was a shortened version of the subscale in study 1, the empirical evidence for the WBT to improve planning is judged to be strong.

The subscale self-motivation (named "motivation" in study 1 while using a similar selection of items) showed a small negative effect in study 1 and no effect in study 2. Therefore, there seems to be no empirical evidence for the present WBT to increase the usage of self-motivation strategies.

For volitional strategies, there was a large discrepancy in the selection of items between the studies. While study 1 differentiated between “distraction avoidance” (4 items) and “self-instruction” (9 items), in the overhauled questionnaire of study 2 only one subscale (“volition”, 4 items) was used (constructed out of the two subscales above). Study 1 found no effect on distraction avoidance, but a large effect on self-instruction (attenuating a general decline in all participants). Study 2, however, showed no effect on volition. Given this heterogeneous findings, only weak empirical evidence was found for the WBT to improve volition.

For cognitive learning strategies, the subscale in study 1 included items on organizing, summarizing, elaboration, and repetition (8 items), revealing a medium positive effect of the WBT. In study 2, only the three items on elaboration were included in the questionnaire, with no significant effect to be found for the WBT. Possibly, the previously found effect relied more on the aspects omitted in study 2. With no data base supporting this assumption, the empirical evidence for the WBT to foster cognitive learning skills is considered to be weak.

The subscale metacognition was only applied in study 2, where it indicated a large positive effect of the WBT. Without replication, the empirical evidence for the WBT to increase metacognition is considered to be moderate for the time being.

The subscales reflection in study 2 (4 items) was constructed be shortening the previous one (6 items)—therefore comparability is acceptable in this case. Surprisingly, study 1 demonstrated a large negative effect on this subscale that was contrasted with no significant effect at all in study 2. As it seems improbable that the WBT really had a deteriorating effect on participants’ reflection, no empirical evidence for positive effects of the WBT on reflection was found.

5.1.3 Effects of the Web-Based Training on Self-Efficacy

Self-efficacy was measured with the exact same scale (Schwarzer & Jerusalem, 1999) in both studies. The results were comparable, yielding a medium size positive effect of the WBT in both cases, yet the patterns differed slightly. While pretest scores were substantially lower in study 1 for all participants, posttest scores were essentially on the same level for the two studies—with larger increments for participants of the WBT in both cases. In my view, this discrepancy even substantiates the finding: Irrespective of the pretest level, there is strong empirical evidence that the WBT improves self-efficacy. Although self-efficacy was not the main focus of the present work, this finding emphasizes the value of the WBT as self-efficacy is strongly associated with academic achievement (Richardson et al., 2012).

5.1.4 Effects of the Web-Based Training on Performance

Concerning mathematics performance, there was a large discrepancy between the tests applied in the two studies: In study 1, there were 30 items with a time limit of 30 minutes, while the test (having a one-hour time limit) consisted of 52 items newly constructed for study 2 in order to have a better fit with the content of the preparation course (with one item for every chapter of the courses). Furthermore, one has to differentiate between two scores that were calculated in study 2: The overall score consisting of all items and the focus score based on an individual selection of 10 items (depending on personal goal setting). Results ranged from a medium size negative effect in study 1 to no significant effects for either overall nor focus score in study 2 (note that in this section only the WBT without additional peer feedback intervention is discussed). As descriptive results in study 2 were in favor of the WBT (yet missing the level of statistical significance marginally), no empirical evidence for a negative effect of the WBT on mathematics performance was found. One has also to keep in mind that the training interval of only four weeks is very short for behavioral changes to translate into performance. Therefore, temporarily no empirical evidence for a short-term positive effect of the WBT on performance was observed.

5.1.5 Conclusion: Effects of the Web-Based Training

In conclusion, there is strong empirical evidence for positive effects of the WBT on declarative SRL knowledge, on self-reported SRL (particularly the subscale planning), and on self-efficacy. Moderate empirical evidence was found for the SRL subscales goal setting and metacognition. Only weak empirical evidence was observed for positive effects on the subscales volition and cognitive learning skills, whereas there was no empirical evidence for positive effects on self-motivation, reflection, and short-term performance.

5.1.6 Effects of the Peer Feedback Intervention

The peer feedback intervention that extended the WBT was only evaluated in one study. Therefore, confirmation of the results in future replication studies is needed before drawing final conclusions on empirical evidence. Nevertheless, results of this study were promising: When compared to the WBT-only condition, participants in additional peer feedback groups showed better outcomes in almost every dependent variable. With peer feedback, participants increased their declarative SRL knowledge even more than participants without the extension, reported a greater improvement in self-efficacy, as well as a greater increase in SRL behavior in general (including the subscales planning, self-motivation, volition, metacognition, and reflection).

The most notable finding of the present work is the positive effect of the additional peer feedback intervention on short-term mathematics performance, at least when considering the focus score of the mathematics test. Study 2 gives reason to believe that the combined intervention is able to improve SRL so that it helps participants to focus on individually defined goals. Meanwhile, no negative outcomes were observable for the items not being part of the focus score—on the contrary, descriptive statistics pointed to increased performance in areas not chosen as focus as well (yet not reaching the level of statistical significance).

5.1.7 Effects of the Learning Diary and the Learning Assistant

In the case of the learning diary, however, study 1 and 2 were in agreement that no positive effects for this intervention type was detectable when compared to a control group. This holds true although the so-called reactivity effect was reported by many different researchers (Fabriz et al., 2014; Korotitsch & Nelson-Gray, 1999; Schmitz & Perels, 2011; Tobias & Inauen, 2010; Webber et al., 1993). This surprising result lead to the development of the learning assistant software PeerLA in study 3. Being an interdisciplinary approach, the strength of this study was more on the conceptual than on the empirical level. The interactive learning assistant is based on the idea of learning diaries, but extends the concept by providing visual and textual feedback, incorporating the comparison to peers. It provides support for the learning process in an unprecedented way by prompting SRL behavior and providing textual and visual feedback including a social frame of reference. The evaluation of the software has to viewed as tentative, relying only on a pilot study with a rather small sample of participants. However, participants' judgments of the software were promising, with only few critical remarks being reported.

5.2 Limitations

One of the major limitation of the present work is that all studies were conducted in the same scenario, namely the mathematics preparation course. Features peculiar in this scenario are for example that it is taught completely online without face-to-face interaction, that is covers a relatively short time span of only four weeks, and that it is a voluntary course without grades. As participants are enrolled in science, technology, engineering, and mathematics (STEM disciplines), one can not assume representativeness for other populations of students. Particularly, male students were massively overrepresented in the samples. Further, all studies suffered from a substantial dropout of participants that was possibly related to personality traits and therefore representing a threat to external validity.

As studies were conducted within relatively short time frames, only short-term effects can be interpreted. Follow-up tests would have been desirable. However, ethical standards imposed that control groups were given access to the WBT after the study was conducted, thereby eliminating differences between experimental conditions. Nevertheless, trying to change learning behavior can be associated with negative short-term outcomes even when long-term outcomes are improved (Siegler, 2007).

Although studies 1 and 2 afforded comparisons of the WBT to at least one different SRL intervention (the learning diary), it would have been worthwhile to have more experimental conditions. In order to demonstrate the usefulness of the WBT, a traditional face-to-face training would have been an interesting condition to be added to the study design. However, as mentioned above, the scenario prohibited the conduction of face-to-face instruction. In a recent study not included in the present thesis (Butz et al., 2016), it was demonstrated that face-to-face instruction was not superior to the WBT but instead both interventions exhibited the same positive effects. Another interesting approach would have been to compare the WBT to a placebo training using the same methods of instruction but conveying different contents. This way, it would have been possible to exclude a so-called Hawthrone effect (Adair, 1984), that is participant exaggerating their self-reported behavioral change after the training, just because of the knowledge of being part of an experiment.

An additional flaw is that measurement of SRL in the present work relied heavily on self-reported behavior. Although self-report data has been criticized (Wirth & Leutner, 2008), questionnaires remain the most prominent instruments that researchers apply (Roth, Ogrin, & Schmitz, 2015). In order to create a good fit between the measurement instrument and the contents the WBT, it was even necessary to develop a new questionnaire capable of detecting the intended behavioral changes.

Finally, the WBT, being based on the process model of SRL (Schmitz & Wiese, 2006), contained instructions on a variety of different strategies. Although time series analyses in study 1 partly revealed differential effects of the three lessons of the WBT, it remains largely uncertain which exact parts of the WBT caused participants to change their learning behavior. Therefore, the question whether a shortened version of the WBT could possibly lead to the same positive effects remains unanswered for the time being.

5.3 Future Research Perspectives

Having established an empirical evidence for the positive effects of the WBT in one particular sample, several open questions remain: Which elements could be improved or supplemented in order to further improve the intervention? What are the long-term outcomes of the WBT? Can the WBT successfully be applied to other target groups? Which parts of the WBT contribute to the positive effects? Do all participants profit from the WBT to a similar extent and if not, what are the predictors of training success?

There are a number of aspects where existing elements of the WBT could be improved or even new elements could be added. First of all, there was no detectable effects of the WBT on the subscales self-motivation, volition, cognitive learning strategies, and reflection. Improvements should therefore tackle the corresponding chapters of the WBT. Applying additional peer feedback seemed to help but at least the chapter on cognitive learning strategies remained unsatisfactory.

A promising combination would be supplementing the learning assistant PeerLA to the existing WBT. In order to make full use of the potential, a chapter on how to use the learning assistant—with an emphasis on the benefits expected—should be added to the first lesson of the WBT, along with occasional references in later chapters (e.g., on reflection).

In scenarios where face-to-face interaction is possible, a blended learning approach seems to be reasonable. This way, the benefits of web-based instruction (e.g., participants can adjust the speed of instruction to their personal needs) and classroom instruction (e.g., greater feeling of belonging to the group of participants through the sharing of personal experiences in group discussions) might add up to even more substantial effects.

As peer feedback groups proved effective, a new research question arises: How should group formation be implemented? The choice of group members can influence motivation, engagement, and performance (Price, Harrison, Gavin, & Florey, 2002). Research has identified several criteria of group composition that are important for group formation: For example, the values for group members' conscientiousness should be distributed homogeneously whereas heterogeneous distributions of extraversion seem to be beneficial (Bell, 2007). In an interdisciplinary project, a software was developed that allows teachers to optimize group formation on the basis of a diagnostic test (Konert, Bellhäuser, Röpke, Gallwas, & Zucik, 2016). It seems worthwhile to investigate the potential of optimizing group formation in the context of the peer feedback intervention described in the present work.

As all studies presented in this thesis only had durations of four weeks (due to the scenario in which the research was conducted), information on long-term outcomes is largely missing. It would be important to investigate whether the findings in the studies presented are still observable in follow-up measurements. In addition, effects on academic achievements (e.g., better course grades) should be evaluated. Here, the idea of the focus score from study 2 could be applied again: As SRL strategies help prioritizing personal goals, positive effects of the WBT might potentially be seen in particular for those courses that participants chose as personal goals, whereas mean achievement over all academic courses might be less increased. With improved self-efficacy and performance, it further seems possible that retention rates could be improved through large-scale application of the WBT (i.e., lower dropout from university).

Participants in the present work were recruited from STEM fields (Science, Technology, Engineering, and Mathematics), therefore empirical evidence is needed that the WBT exhibits positive effects also on different target groups. However, as other SRL interventions (e.g., face-to-face trainings) have successfully been applied in a variety of academic fields and also age groups (for a review, see Benz, 2010) there is little reason to believe that this would not hold true for the WBT presented here. First positive indications have been found for students in teacher training (Butz et al., 2016).

As described above, the WBT—being based on the process model of SRL (Schmitz & Wiese, 2006)—included a great variety of strategies proposed to participants. Therefore, it is virtually impossible to decide which elements of the WBT contributed to the overall effects. Note that the same is true for previously conducted studies with face-to-face trainings (e.g., Perels, Merget-Kullmann, Wende, Schmitz, & Buchbinder, 2009; Schmitz & Wiese, 2006). Separating the different components of SRL from each other would hence be fruitful also for advancing theoretical understanding of the components of SRL and their intertwining. Future study designs should therefore incorporate either leaving out parts of the WBT (for testing the respective effects of each part) or changing the order of presentation (for testing sequential effects).

With sample sizes of less than 50 participants in the WBT condition, it was not possible to investigate interindividual differences in intervention effects of the WBT. Nevertheless, it was observable that participants differed in the extent to which they experienced beneficial effects of the WBT. Future studies should hence incorporate larger samples in order to investigate the predictors of intervention success. Possible predictors include: Prior declarative SRL knowledge (participants with more prior knowledge might not learn learn many strategies new to them in the WBT), SRL competency (attending a WBT without external regulation through a teacher might premise a certain level of SRL competency), conscientiousness (working through all materials of the WBT might need at least a moderate level of conscientiousness), openness to new experience (as the instruction mode of a WBT is new to many participants it might be necessary to have a positive attitude towards new experiences), computer literacy (although the present WBT should not pose great technological difficulties, participants with more experience in the use of computers might still have an advantage), change willingness (participants that do not see the need to change their learning behavior might not be susceptible), and age (with growing age, learning strategies might become more rigid, leaving less potential for modification).

Once strong empirical evidence on the predictors of training effects is established, it would be possible to provide individual training variants, following an aptitude-treatment-interaction approach (Hooper, Wakely, de Kruif, & Swartz, 2006). Based on a diagnostic test, participants could be presented a version of the WBT optimized for individual needs, accompanied by individual feedback. This way, duration of the training could be shortened, while simultaneously providing deeper instruction matching personal requirements.

5.4 Implications for Educational Practice

Given the relevance of SRL for academic performance (Richardson et al., 2012) established above, fostering SRL competency is highly desirable. Expected benefits do not only concern the individual student (profiting from increased satisfaction, self-efficacy, and better performance), but also teachers (being interested in guiding their students to academic success), and even education administration (by reducing costs of other interventions such as counseling or costs associated with academic dropout).

With numbers of students being historically high (Statistisches Bundesamt Deutschland, 2015), traditional intervention methods such as face-to-face trainings are unlikely to satisfy the need. In this sense, face-to-face interventions can be regarded as effective, yet not efficient because the costs of providing such a training increase linearly with the number of participants. It would be desirable to provide a total coverage of all students irrespective of academic subject, so that every student entering university receives a minimum of instruction on the learning strategies that universities demand (but hardly ever teach). The WBT presented in this work provides an economic, scalable intervention: Once created, the costs for providing access to a large number of participants nearly remain the same as for small numbers of participants.

As educational background of students is increasingly different, the WBT could serve another purpose: To establish a common knowledge basis for students. In our globalized world, students do not only have different cultural roots, but also experienced very diverse school systems with varying emphasis on self-determination and SRL. Additionally, more different routes can lead to university, with acceptance conditions not only including A-levels (“Abitur”), but also permitting access to university to persons with a certain level of vocational training (oftentimes associated with less knowledge about learning strategies). The WBT could therefore provide a theoretical background shared by all students, possibly reducing differences in academic performance between students.

A number of German universities (Darmstadt, Hamburg, Kassel, Paderborn, Lüneburg, Heidelberg, and Mainz) have shown interest in the WBT and implemented pilot studies for their respective students, mostly for students entering the university. These collaborations proved that practitioners have recognized the value of the concept of SRL and that innovative methods such as the WBT presented in this thesis are indeed of interest for educational practice.

With the emergence of MOOCs as a new form of education, a common observation is extremely high dropout rates of around 90% (Onah, Sinclair, & Boyatt, 2014). One possible reason discussed in the literature is a lack of instructional quality in many MOOCs (Margaryan, Bianco, & Littlejohn, 2014). But even in cases where instructional quality is high, dropout remains an issue because many users of MOOCs do not have the appropriate learning strategies for such demanding self-regulatory tasks. Therefore, it seems reasonable to improve one's SRL competency by taking part in the WBT presented here before using a MOOC.

As SRL strategies are already essential in school, it would be desirable to develop different versions of the WBT for younger students, each focusing on different age groups with age appropriate wording (e.g., avoiding technical terms for young students) and using examples corresponding to the respective target group (e.g., preparation for the German Abitur examinations, that is the school-leaving certificate). In an unpublished bachelor's thesis, two of my students developed a version of the WBT for the ninth grade of German Gymnasium. In order to create smaller chunks of information for the younger target group, the content of the WBT was divided into eight lessons of 30 minutes each. In line with the present work, they found promising results with increased self-reported SRL behavior in the training condition (particularly in the subscales goal setting, self-motivation, and volition) compared to a control group. However, high dropout rates demonstrated the necessity of supervision by the teacher for students in this age.

Fostering SRL is also relevant for vocational training, as employees are increasingly expected to take responsibility for their qualifications. In business contexts, however, the term self-regulated learning does not seem to be wildly used. Instead, a large body of research has been conducted under the term *self-leadership* (Manz & Sims, 1980; Stewart, Courtright, & Manz, 2011), with definitions and findings being comparable to SRL research. Two of my students conducted a pilot study for their unpublished bachelor's thesis, recruiting employees from an international company that were expected to learn basics of pressure measurement from an e-learning course. We developed a version of the WBT focusing on the requirements of the target group that was presented to the experimental group, while the control group took part in the e-learning course without access to the additional WBT. Results showed that the experimental group reported to use more SRL strategies in the e-learning course and, more importantly, also performed better in the knowledge test on pressure measurement—both directly after the e-learning course and in a follow-up test three months later.

Finally, an international internet platform would be recommendable to grant access to learners from every part of the world. Translations of the WBT would be comparably inexpensive, yet helpful for the dissemination of the idea of SRL. This way, even learners from developing countries could be reached in order to increase their chances for educational success.

Part II – Original Manuscripts

6 Study 1: Applying a Web-Based Training to Foster Self-Regulated Learning – Effects of an Intervention for Large Numbers of Participants

6.1 Abstract

Trainings on self-regulated learning (SRL) have been shown to be effective in improving both competence of self-regulated learning and objective measures of performance. However, human trainers can reach only a limited number of people at a time. Web-based trainings (WBT) could improve efficiency, as they can be distributed to potentially unlimited numbers of participants. We developed a WBT based on the process model of SRL by Schmitz and Wiese (2006) and tested it with 211 university students in a randomized control evaluation study including additional process analyses of learning diaries. Results showed that the training had significant effects on SRL knowledge, SRL behavior measured by questionnaires and diaries, as well as on self-efficacy. Time-series analyses revealed a positive linear trend in SRL for the training group but not for the control group as well as intervention effects for each of the three WBT lessons.

6.2 Introduction

The study of self-regulated learning (SRL) has received increasing attention over the last years (Alexander, 2008; Alonso Tapia, Panadero, & Ruiz, 2014; Artino & Stephens, 2009; Hadwin, Järvelä, & Miller, 2011; Schmitz & Perels, 2011; Winne, 2014; Zimmerman & Kitsantas, 2014). As shown in several meta-analyses (Hattie, Biggs, & Purdie, 1996; Richardson et al., 2012; Sitzmann & Ely, 2011), SRL has an important positive impact on learning success and is, therefore, highly relevant for students. Particularly online courses require high SRL competency from students (Broadbent & Poon, 2015). Fostering this competency through training interventions has been shown to be successful regarding both self-report measures and objective performance (Benz, 2010; Dignath, Buettner, & Langfeldt, 2008).

However, one disadvantage of current SRL trainings is that a face-to-face training can only reach a limited number of participants at the same time. This is a major problem in new technology-based learning scenarios, such as Massive Open Online Courses (MOOC). Web-based trainings (WBT), in contrast, are conveyed via the Internet and can thus reach virtually unlimited numbers of participants. The aim of this paper is to explore the possibility of fostering SRL with the help of a WBT that we created based on traditional SRL trainings. We evaluated the training effects by means of pre-post comparisons and time-series analyses. Key findings were that participants of the WBT improved their declarative knowledge on SRL, reported using more SRL strategies (documented not only by a retrospective questionnaire but also by a daily learning diary), and increased their self-efficacy.

6.2.1 Self-Regulated Learning

The theoretical model underlying this article is the process model of self-regulated learning developed by Zimmerman (2000) and adapted by Schmitz and Wiese (2006). The model divides the learning process into three phases (see Figure 1, p. 3).

One major aspect of this model is its cyclical orientation – i.e., the learning process contains a feedback-loop. The way in which future learning tasks are addressed depends on past learning activity. The model assumes three learning phases according to (H. Heckhausen & Kuhl, 1985) called the *preaction, action,* and *postaction phase*. In each of these phases, a learner faces different challenges, must complete different tasks, and should use different learning-strategies to achieve a good learning outcome.

In the preaction phase, learners must analyze the individual situation and respective task and then apply the appropriate filters, e.g. if the task is easy and can be solved through the use of automated strategies, no self-regulation is necessary. More complex tasks, however, require self-regulation. In this case, learners must assess the resources available to them. The specific task and situation result in a certain motivation and affect, which in turn influence the learning process. Therefore, learners must regulate their resources to utilize them effectively. In line with this, self-efficacy-beliefs represent an additional important resource. The central activities during the preaction phase include goal setting. Clearly defined goals serve as a guide throughout the learning process, helping learners to effectively allocate resources and use appropriate learning-strategies. A learning plan can be derived from specific goal setting. Note that all the variables in this phase are both affected by previous learning phases and predicative of the subsequent learning process. Because of the model's cyclical orientation, motivation, for example, may be influenced by how successful the previous learning action was.

In the action phase, the main learning occurs. The learning outcome is determined by the quality and quantity of learning (Schmitz, 2001). Learning quality is a function of volitional strategies and learning strategies. Volition (Kuhl & Fuhrmann, 1998) refers to strategies such as self-instruction and the handling of distractions. Learning strategies can be categorized into cognitive, meta-cognitive, and resource-management strategies (Pintrich, Smith, Garcia, & McKeachie 1991). Cognitive learning strategies refer to either topic related strategies such as solving equations or strategies such as memorizing and summarizing content. Meta-cognitive strategies refer primarily to the monitoring of the learning process (Schmitz & Perels, 2011), whereas resource management includes strategies such as effort regulation and concentration management as well as environment control and help-seeking behaviors.

In the postaction phase, learners reflect on the learning process. Depending on the learning outcome, learners will experience either positive or negative affect. If the outcome does not match previously set goals, leaners may modify either their strategies or the goals of future learning activities. These modifications of future learning activities may be influenced by attribution and frame of reference. Individuals' attribution of their success and failure may be internal or external, variable or stable (Peterson et al., 1982). The frame of reference (Nagengast & Marsh, 2012) refers to comparisons that individuals make between either their own and others' achievements or between past and present achievements.

Based on this theoretical model, trainings have been developed that were shown to foster both self-regulated learning and achievement (Perels et al., 2009; Schmitz & Perels, 2011; Schmitz & Wiese, 2006). In general, the effectiveness of fostering self-regulated learning has been demonstrated in meta-analytic studies. Hattie and collegues (1996) were the first to show that trainings aiming at different cognitive or metacognitive study skills could improve learning outcomes across all age groups. Especially effective were trainings embedded in a situational context, trainings fostering a high level of student activity, and interventions focusing on metacognitive awareness. Dignath and Büttner (2008) analyzed interventions focusing on primary and secondary school students and found that these approaches were effective. This was especially true when the interventions were in the subject of mathematics or conducted by a researcher rather than a teacher. Benz (2010) examined both training interventions and scaffolding approaches fostering self-regulated learning across all age groups and found both to be effective. Traditionally, most SRL interventions are designed as a classroom training held face-to-face by a real trainer (Perels et al., 2005; Schmitz & Perels, 2011; Schmitz & Wiese, 2006). These trainings equip learners with learning strategies that can be employed in different learning situations.

6.2.2 Fostering SRL in Computer-Based Learning Environments

Computer-based learning environments (CBLEs), including online learning environments, offer great possibilities to improve learning but at the same time pose problems for many students lacking the necessary self-regulatory competency. As Broadbent and Poon (2015, p.12) point out, "we should not assume that online learning in itself fosters SRL strategies use or development". Therefore, researchers have developed many approaches in order to foster SRL in CBLEs. Winters, Greene, and Costich (2008) have proposed a classification of approaches by distinguishing support tools, conceptual supports, and metacognitive supports.

Support tools are defined as "affordances within a CBLE that allow learners to engage and manipulate resources and ideas in the CBLE" (Winters et al., 2008, p.436). As an example of this approach, the *gStudy* software (Zhou & Winne, 2012) allows users to take notes, create glossaries, highlight text, or construct concept maps (among other features). Such tools can undoubtedly support learners, but only if they know when and how to apply them, which unfortunately is not always the case (Trevors, Duffy, & Azevedo, 2014).

Conceptual support is defined as "aids inside or outside of the CBLE that guide students' understanding of content" (Winters et al., 2008, p.436). This approach can be exemplified by Schwonke and colleagues (2013) who provided a static conceptual scaffold in form of a cue card that encouraged participants to employ instructional resources more strategically. Although such scaffolds have been repeatedly demonstrated to be effective (Devolder, van Braak, & Tondeur, 2012), they need to be newly created for every learning context as students are not instructed *how* to learn.

Metacognitive support is defined as tools that "guide students' ways of thinking and reflecting on their task" (Winters et al., 2008, p.436). A typical example for this approach is prompting SRL behavior such as goal setting at the beginning of a task or reflecting at the end of it (e.g. Duffy & Azevedo, 2015). A new line of research in this field is to combine measurement and intervention within the same prompting tool (Panadero, Klug, & Järvelä, 2015). While prompting has been shown to be successful, such scaffolds can only be employed in the specific learning situation for which they were created.

6.2.3 Web-Based Training

Web-based training (WBT) could combine the advantages of classroom training (teaching general learning strategies that are applicable to most learning situations) with those of computer-based interventions (reaching virtually unlimited numbers of learners).

Web-based trainings are conveyed to participants via the Internet and represent an alternative method that can be used with different target groups, e.g., students and professionals. The development of this type of learning environment is comparatively costly; however, updates and modifications for different subjects are easier to implement. In a meta-analysis, Sitzmann, Kraiger, Stewart, and Wisher (2006) confirmed that web-based trainings and classroom instruction are equally effective in improving both declarative and procedural knowledge.

WBTs have also been successfully applied in the field of clinical psychology. Training effects were found in studies aiming to encourage health behavior in chronically ill individuals (Wantland et al., 2004), smoking cessation (Myung, McDonnell, Kazinets, Seo, & Moskowitz, 2009), and weight loss in obese individuals (Neve et al., 2010). To the best of our knowledge, however, WBT has not been applied for fostering self-regulated learning. According to the classification by Winters and colleagues (2008), this approach falls into the category of metacognitive support.

6.2.4 Learning Diaries

Learning diaries follow two concurrent objectives: 1) they encourage self-monitoring of the learning process and, thus, can serve as an intervention (Schmitz & Perels, 2011) and 2) they represent a measurement instrument that allows researchers to examine learning processes in large samples over long periods of time, resulting in rich time series data (Schmitz, 2006). Subsequent time series analyses, in turn, allow for both nomothetic and ideographic approaches (M. Schmidt, Perels, & Schmitz, 2010).

Many SRL training interventions (e.g. Leidinger & Perels, 2012; Perels et al., 2005, 2009; Schmitz & Wiese, 2006) include a learning diary as component in order to help participants transfer the strategies taught in the training to their daily learning routines. In the case of our new web-based training approach we expect an additional learning diary to be helpful as well.

6.2.5 Research Question

In this study, we developed a WBT designed to equip prospective university students with SRL strategies. In a naturalistic scenario of an online preparation course, we randomly assigned participants to one of four experimental conditions: group TD (training + diary), group T (training only), group D (diary only), and group C (control). The aim of this study is to demonstrate the effectiveness of WBT on SRL knowledge, learning behavior, and performance while segregating it from the possible intervention effect of the learning diary. Process analyses based on the diary data from groups TD and D are further used to investigate the impact of each of the three lessons.

We tested three main hypotheses. Hypothesis 1 was that the web-based training has a positive effect on the following pre-post measures: We expected participants' declarative knowledge about self-regulated learning to increase in the training groups T and TD but not in the control groups C and D (H1a). We further expected participants in the training groups T and TD to improve their self-regulated learning behavior more than participants in the control groups C and D (H1b). This effect was expected to manifest in both an overall SRL score, but also in the subdomains of goal setting, planning, motivation, distraction avoidance, self-instruction, learning strategies, and reflection. Participants' self-efficacy was expected to increase in the training groups T and TD more than in the control groups C and D (H1c) and participants in the training groups T and TD were expected to increase their performance in a mathematics test more than participants in the control groups C and D (H1d).

Hypothesis 2 was that the learning diary has a positive effect on pre-post measures of self-regulated learning behavior (overall SRL score and the subdomains of goal setting, planning, motivation, distraction avoidance, self-instruction, learning strategies, and reflection; H2a), self-efficacy (H2b), and on the mathematics test (H2c). In contrast to hypothesis 1, we did not expect the learning diary to increase declarative knowledge about self-regulated learning.

Hypothesis 3 was that the web-based training has positive effects on process measures: We expected that the web-based training leads to a steady increase in self-regulated learning in group TD but not in group D (H3a). We further expected the three lessons of the web-based training each to have a positive impact on self-regulated learning in general (H3b) and that every lesson of the web-based training has a positive impact on its targeted behavior (Lesson 1: Goal setting, planning, and process model concept; Lesson 2: Distraction avoidance, procrastination avoidance, and learning strategies; Lesson 3: Reflection, attribution, and motivation; H3c).

6.3 Method

6.3.1 Participants

The initial sample of the evaluation study consisted of 211 prospective students (166 male) with a mean age of 20.2 years (*SD* = 2.23). Participants were enrolled in an e-learning course at a technical university in Germany, in which they prepared themselves for mathematically oriented fields of study (computer science, civil engineering, mechanical engineering, or mathematics). Participants were randomly assigned to four groups in a 2 (training vs. no training) x 2 (diary vs. no diary) between-subjects design. Group TD (training plus diary) attended the web-based training and kept an online diary, whereas group T (training) attended the same training but did not keep a diary. Group D (diary) kept a diary but had no access to the WBT. Finally, group C (control) did not receive training nor did they keep a diary. When assigning participants to the experimental groups, we first divided the sample into eight subpopulations due to gender and field of study (e.g. female computer scientists). We then conducted the randomized assignment for each subpopulation separately, thereby making sure to keep the proportion of gender and field of study constant in every experimental group. As we expected differential dropout rates between experimental groups due to the different workloads required of participants, we assigned disproportionally more participants to the diary groups D and TD.

Due to dropout (n=42) and exclusion because of extreme outliers (n=3), the final sample for analyses included 166 participants (128 male): 49 in group TD (38 male), 34 in group T (26 male), 47 in group D (38 male), and 36 in group C (26 male).

6.3.2 Procedure and Training

The mathematics preparation course took place in the fall during the last four weeks leading up to participants' first semester at university. Within this timeframe, participants had online access to a large learning management system containing instructions and tests covering 53 mathematics topics in six chapters ("Arithmetic", "Powers", "Functions", "Higher Functions", "Analysis" and "Vectors"). All topics followed the same structure: diagnostic pre-test, overview, introduction to the domain, information, interpretation, application, typical mistakes, exercises, and diagnostic post-test. Figure 2 shows a screenshot from the preparation course. Purpose of the preparation course was to repeat mathematical school knowledge in order to establish a common ground for all students in mathematically oriented fields of study. Participation was voluntary, there was no graded final exam. The preparation course was conducted completely online without classroom instruction by teachers.

At the beginning of the preparation course, participants were given three days to complete the pre-test consisting of questionnaires, an SRL knowledge test, and a mathematics test. In the following four weeks, participant had access to the WBT on SRL strategies and kept the learning diary, depending on the experimental group to which they were assigned. At the end of the course, they again had a timeframe of three days to complete the post-test.

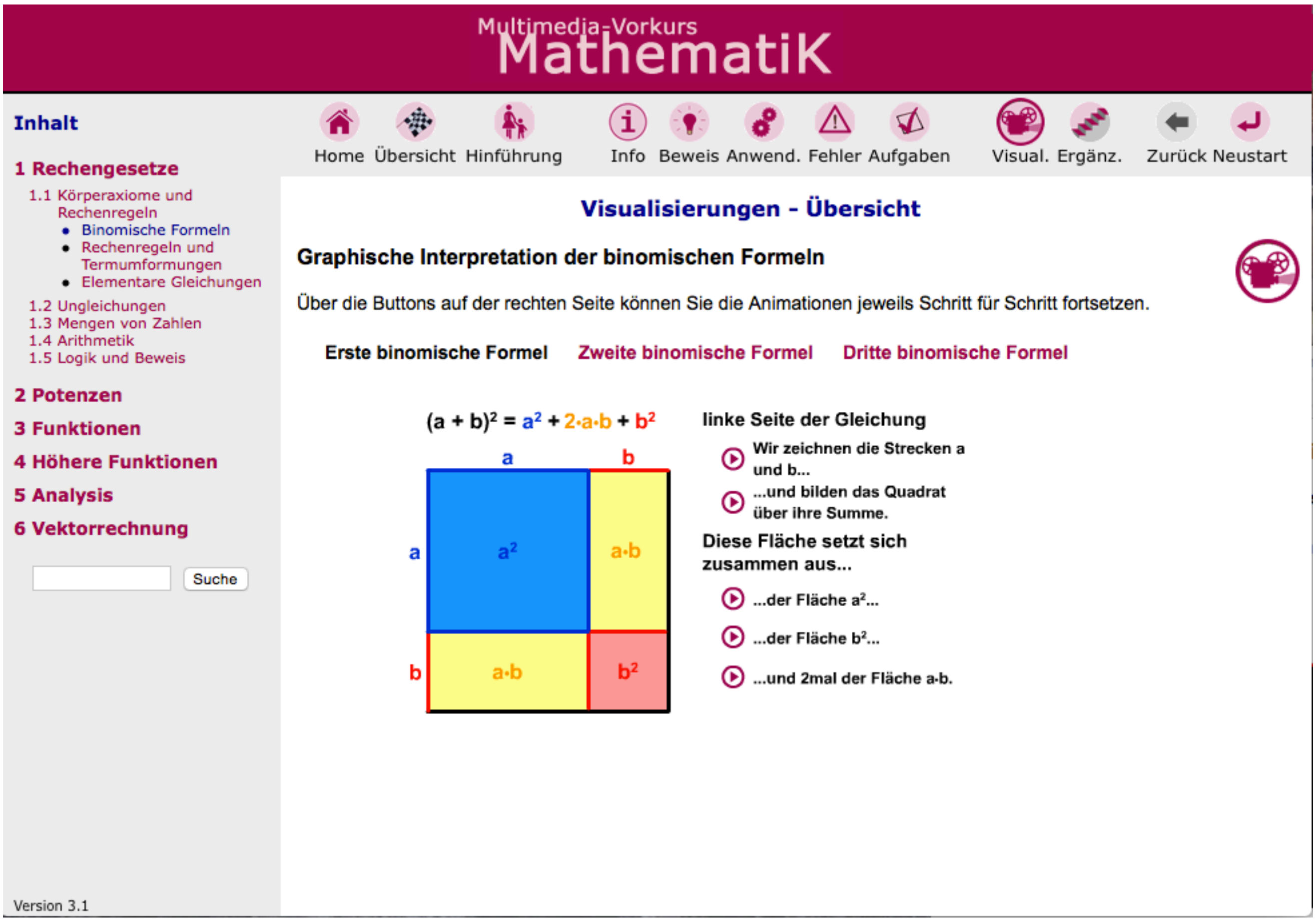

Figure 2. Screenshot of Online Mathematics Preparation Course

6.3.3 Pre- and Post-Test

The pre- and post-tests were conducted online in the learning management system. Both included the same measurement instruments: questionnaires on self-regulated learning and other constructs, a test on declarative knowledge of SRL, and a mathematics test on the content of the preparation course in two parallel versions. Additionally, demographic information was collected in the pre-test.

Self-Regulated Learning Questionnaire. Self-regulated learning was measured with 42 items. The overall score had a Cronbach´s α = .89. The scale contained the sub-scales goal setting (4 items, Cronbach´s α = .71, e.g. "*I write out my goals in complete detail.*"), planning (6 items, Cronbach´s α = .70, e.g. "*Before starting a new topic I try to get a comprehensive overview.*"), self-motivation (5 items, Cronbach´s α = .74, e.g. "*A boring topic gets more interesting the* *more I engage in it."*), dealing with distractions (4 items, Cronbach´s α = .65, e.g. "*I notice when I get distracted during learning."*), self-instruction (9 items, Cronbach´s α = .74, e.g. the inverted item "*I frequently don't have the strength to start working although I know what to do."*), cognitive learning strategies (8 items, Cronbach´s α = .70, e.g. *"I try to find the structure of a topic so that I can memorize it better."*), and reflection (6 items, Cronbach´s α = .76, e.g. *"At the end of the day I ask myself whether I am satisfied with my performance."*). Items were chosen to match the content of the WBT and were either taken from the MSLQ (Pintrich et al., 1993) and the VCQ (Kuhl & Fuhrmann, 1998) or created specifically for the purpose of this study.

SRL Knowledge Test. The SRL knowledge test consisted of twenty multiple-choice items (Cronbach´s α = .81). Each item had four possible answers – one correct answer and three distractors – resulting in a total score between 0 and 20 points. The questions covered the constructs explained in the WBT, e.g.: "According to the process model of self-regulated learning, what should you do in the preaction phase? a) set goals (right answer), b) concentrate (distractor), c) reflect (distractor), d) relax (distractor)".

Mathematics Test. The mathematics test evaluated the mathematical knowledge before and after the mathematics course using two parallel versions. Participants were given 30 minutes to solve 30 problems that were created by mathematicians responsible for the mathematics preparation course (Cronbach's α = .82) and represented a selection of the topics addressed in it. One point was awarded for each correct solution, resulting in a total score between 0 and 30.

6.3.4 Web-Based Training on Self-Regulated Learning

The WBT consisted of three weekly lessons (with three to four chapters each) constructed with the learning management system Moodle (see http://docs.moodle.org). Participants were given a timeframe of two days to attend each respective session – within that timeframe participants were free to choose the exact time of their attendance.

To support training transfer, the individual lessons were created according to the three phases of learning. At the beginning of each lesson, learning goals were formulated. At the end, the most important thoughts were summarized and participants were instructed to summarize the lesson in a personal "strategy manual". A major goal while creating the lessons was to use a variety of online-tools and methods provided by the Internet and online technology. As a result, each lesson contained various videos, presentations, self-tests, exercises, and group discussions in an online bulletin board. An animated comic-figure was used as a trainer who appeared in several videos and most presentations. The average duration of each training lesson was intended to be 90 minutes. After each lesson, participants filled in a short evaluation form.

Questions included the actual duration of the lesson, the novelty of the content on a six-point rating scale from “already known” to “novel”, the perceived usefulness of the strategies taught on a six-point rating scale from “not useful” to “useful”, and an overall grade for the quality of the lesson using the German grading system (1= very good; 2= good, 3= satisfactory, 4= sufficient, 5= deficient, 6= insufficient).

The lessons’ respective content was based on the process-model of self-regulated learning (Schmitz & Wiese, 2006). The content of the lessons are briefly described here, for more details and screenshots see Appendix A.

In the first lesson, “Before Learning”, the process-model was explained with a focus on the preaction phase and included the chapters *goal setting*, *planning*, and *time-management*. The lesson started with an animated welcome video. The process-model of self-regulated learning was then presented, comparing learning to one of three available examples (e.g. a soccer coach preparing his team for a tournament). In the course of the lesson, users were then guided to write down personal goals for the preparation course and to modify them according to the SMART technique (Doran, 1981). Creating a learning plan for the four weeks of the preparation course was the major outcome of the chapter on time management. In order to attain this, participants reflected their own activities and chores using a mind map, discussed personal issues with time management in an online forum, and derived concrete actions plans from their individual learning goals.

The second lesson, “During Learning”, focused on the action phase and included the chapters of *volitional learning strategies* such as dealing with distractions and avoiding procrastination as well as *cognitive and meta-cognitive learning strategies*. The lesson started by introducing the concept of procrastination and helped users to identify circumstances in which they might also tend to delay important tasks. Participants could then test the effect of background music on their own performance in the Stroop color word interference test (Cassidy & MacDonald, 2007) and received hints on how to deal with distractions. For the purpose of self-motivation, users developed a personal motto. In the last chapter of the lesson, cognitive (e.g. elaboration), metacognitive (e.g. monitoring), and resource-oriented learning strategies (e.g. help seeking) were explained. Exercises guided participants how to use such strategies for the preparation course.

The final lesson, “After Learning”, addressed the chapters of *attribution, frame of reference* and *reflection* in the postaction phase. The lesson started with a video demonstrating different attribution styles after situations of failure, promoting internal and unstable attribution as being most favorable. In the subsequent chapter on frame of reference, participants analyzed their time investment in the preparation course to date and tried to increase it in the remaining week of the preparation course. The concept of reflection was applied to the three time levels short-term (e.g. reflection after one particular mathematical problem), medium-term (e.g. reflection at the end of one learning day), and long-term (e.g. reflection after examination period). Afterwards, the individual learning goals formulated in lesson 1 were presented again, with participants being instructed to reflect their goal achievement and to adjust their goal setting if necessary. The last chapter included self-motivation strategies like implementation intentions (Gollwitzer, 1999) and self-rewarding. After summarizing the whole training, the lesson ended with participants writing a letter to their future self on what they intended to change in their learning behavior.

6.3.5 Learning Diary

The standardized learning diary was accessible for experimental groups TD and D during the whole preparation course (resulting in a maximum of 28 diary entries). Participants in these groups were asked to fill in the diary on a daily basis, but at least four times a week. It consisted of both a pre-learning and post-learning part. Each part contained open questions to foster metacognition (e.g., pre-learning: "What are your learning goals for today?"; post-learning: "What strategies do you plan to use tomorrow?") and closed questions for measurement. For examples of answers given to the open questions see Appendix B. Twelve items, eleven for different components of SRL and one for self-efficacy, were assessed in the pre-learning diary (intended SRL strategies, e.g. "I have made a time schedule for today.") as well as in a reformulated version in the post-learning diary (accomplished SRL strategies, e.g. "I adhered to my time schedule today."). Additionally, positive and negative affect were assessed with three PANAS items (Watson, Clark, & Tellegen, 1988) in both the pre- and post-learning diaries. Finally, we assessed willingness to change in the pre-learning diary and satisfaction with learning in the post-learning diary. All items were assessed on a six-point rating scale from "strongly disagree" to "strongly agree". Planned and accomplished learning time was assessed in hours.

A reliability analysis for the SRL items on goal setting, planning, motivation, procrastination avoidance, distraction avoidance, self-instruction, learning strategy, reflection, attribution, frame of reference, and process model concept indicated high intercorrelations for all but one item (frame of reference). Cronbach's α without this item was .85. It was therefore omitted for the calculation of the mean SRL score.

In order to analyze whether each lesson fostered specifically those SRL components that were taught in the corresponding lesson, we created three SRL subscales: "Lesson 1 components" (goal setting, planning, process model concept), "Lesson 2 components" (distraction avoidance, procrastination avoidance, learning strategies), and "Lesson 3 components" (reflection, attribution, motivation). This was done in order to evaluate the impact of each lesson not only on SRL strategies in general but also on the specific behaviors targeted in the respective lesson. For example, participants should set more goals after the first lesson, use more cognitive learning strategies after the second, and make use of an internal variable attribution style after the third.

6.3.6 Statistical Analyses

Screening. Prior to data analysis, we conducted a screening procedure as suggested by Tabachnick and Fidell (2012), including checks of missing values, distribution assumptions, univariate and multivariate outliers, and multicolinearity.

Pre-Post Analyses. To test our hypotheses concerning the training effect, we conducted two mixed effects MANOVAs (i.e., doubly multivariate profile analysis; Tabachnick & Fidell, 2012). Each mixed effects MANOVA included the same independent variables but different dependent variables. The dependent variables in the first MANOVA were *math achievement*, *SRL overall*, *SRL knowledge,* and *self-efficacy.* This MANOVA was intended as a broad test of training effects in all targeted constructs. The dependent measures in the second MANOVA were the seven SRL-subscales *goal-setting*, *planning*, *motivation*, *distraction avoidance*, *self-instruction*, *learning-strategies,* and *reflection.* The goal of this analysis was to differentially analyze improvements in the individual SRL components. Our three dichotomous independent variables were *SRL-training* (yes/no), *learning diary* (yes/no), and *time* (pre- or post-training). This resulted in a 2 x 2 x 2 design, with *time* being the repeated measure. A significant *time* x *training* interaction would indicate a positive training effect. The effect sizes *partial* η^2 were calculated as suggested by Tabachnik and Fidell (2012). However, as they outline, *partial* η^2 for MANOVAs may not be interpreted as the proportion of variance explained in all DVs. Nevertheless, it still represents a measure of relative importance of the effect.

To clarify the multivariate results and determine which variables were dominantly affected by the training, we followed up on these analyses by conducting linear discriminant analyses (LDA) as suggested by Field, Miles, and Field (2013) as well as Tabachnick and Fidell (2012). In LDA, a number of factors (or discriminant functions) are extracted from the DVs that best discriminate between groups (i.e., the IVs). As we were primarily interested in 1) change in variables 2) caused by our training (the time x training interaction), we used the post-score – pre-score difference scores of our DVs as the basis for factor extraction. As groups, we only compared training vs. no-training groups to describe their differences as accurately as possible. Therefore, we estimated only one discriminant function. To produce LDA coefficients that are not influenced by the respective scale, we standardized all pre and post scores based on pre measurement statistics – e.g., we standardized the post math score using the mean and standard deviation of the pre math score. This procedure led to equally scaled post – pre differences that reflected individual changes in pre-measurement standard deviations.

Time-Series Analyses. For time-series analyses, we included only the diary groups TD and D. We examined process aspects of SRL by calculating trend analyses and intervention analyses. To carry out trend analyses, the daily data of each participant was aggregated to a daily mean. For the resulting 27 days, a linear regression was modeled with time as the predictor and the value of the scale as the criterion. This can be done either at the individual level, which results in a trend for each person, or as a group aggregate. We chose the latter approach in order to investigate the mean training effect on group TD compared to control group D.

Intervention analyses (interrupted time series analysis) were calculated in order to examine whether an intervention has an effect on a system, how the intervention influences the system, and which other variables influence the dependent variable. The intervention effect is indicated, similar to a *t*-test, by the comparison of the baseline level of the dependent variable to the level after the intervention. A transfer function is used to estimate how the intervention influences the system. ARIMA models (Schmitz, 1990) serve to describe other sources of impact.

Traditionally, intervention analyses are calculated for the whole group by aggregating over persons (for a detailed description see Schmitz, 1990). This approach was not suitable for our study design because participants could choose the day on which they took part in a lesson. Aggregating over participants would therefore result in a loss of data or accuracy as some might have already completed a lesson at a given day while others might not have started yet. In cases of varying intervention onset for each individual, we propose another approach: by calculating an intervention analysis for each participant, each individual is treated as its own sample. All samples are then aggregated by means of meta-analytic methods.

This approach results in a t-value for each individual and each intervention, which can be converted to an effect size d following the formula

(1) $$d = t * \sqrt{\frac{n_1+n_2}{n_1*n_2}}$$

with n_1 and n_2 referring to the number of diary entries before respectively after the intervention. This effect size represents the impact a given intervention had on a given participant. Aggregating over participants is then done with meta-analytic techniques using a random-effects model. For this purpose each effect size is weighted by the inverse of the variance to give more weight to effects based on large samples. The variance is calculated as

(2) $$v_i = \frac{(n_1+n_2)}{(n_1*n_2)} + \frac{{d_i}^2}{2(n_1+n_2)}$$

Computation of random effects models for meta-analysis is described in detail by Raudenbush (1994). We applied this procedure for each of the three lessons separately with both the mean SRL score and the three subscales for lesson 1 strategies, lesson 2 strategies, and lesson 3 strategies.

6.4 Results

6.4.1 Screening Results

To improve the quality of our data, we conducted a screening procedure. Participants with missing pre or post measurement values were excluded from all pre-post comparisons. Concerning distribution, we observed no severe problems. Deviations from normality were found either in only one group at one time or could be explained by intervention effects (e.g., SRL knowledge in post measurement indicated a small ceiling effect). Nevertheless, 2 participants in group T and 1 participant in group D were excluded due to extreme standardized scores in excess of -3.29 or 3.29 (equaling 0.1% of the distribution) on one or more measures. After the exclusion of these univariate outliers, no multivariate outliers remained. Based on the variance inflation factor, multicolinearity was not an issue in our analyses.

6.4.2 Manipulation check

The short evaluation forms after each lesson were filled in by the vast majority of participants from groups T and TD, with the exception of one participant from group TD missing after lesson 2 and four participants from group TD missing after lesson 3 (rate of return = 97.9%). As each evaluation form was only visible after completing all parts of the corresponding lesson, noncompliance did not appear to be an issue.

Analyses revealed that the mean self-reported duration fitted well with the intended duration of 90 minutes each, with lesson 3 being slightly shorter than the other two lessons (Lesson 1: $M = 89.78$, $SD = 35.84$; Lesson 2: $M = 92.96$, $SD = 34.89$; Lesson 3: $M = 79.58$, $SD = 28.42$). Participants reported the content of the lessons to be moderately novel to them (Lesson 1: $M = 4.15$, $SD = 1.34$; Lesson 2: $M = 4.20$, $SD = 1.33$; Lesson 3: $M = 4.33$, $SD = 1.22$). Usefulness of the content was perceived to be high (Lesson 1: $M = 5.20$, $SD = 0.99$; Lesson 2: $M = 5.31$, $SD = 1.00$; Lesson 3: $M = 5.41$, $SD = 0.89$). The majority of participants rated the overall quality of lessons with the grade “very good” (Lesson 1: 18.1%; Lesson 2: 25.9%; Lesson 3: 67.0%) or “good” (Lesson 1: 18.1%; Lesson 2: 62.4%; Lesson 3: 65.4%).

6.4.3 Evaluation of Training and Diary Effects

The effects of training and diary (Hypothesis H1 and H2) were both analyzed in one 2 (time) x 2 (training) x 2 (diary) mixed-effects MANOVA and are therefore reported together. Because of linear dependency of the SRL overall score on its subscales, the analysis of subscales had to be separated from the SRL overall score.

First, we determined the overall effectiveness of the training and the diary concerning SRL-knowledge test, overall SRL score, self-efficacy, and performance on the mathematics test (Hypotheses H1a, H1b, H1c, H1d; Hypotheses H2a, H2b, and H2c). In the second analysis, we focused on the seven SRL-subscales of *goal-setting*, *planning*, *motivation*, *distraction avoidance*, *self-instruction*, *learning-strategies,* and *reflection* (Hypotheses H1b and H2a).

Overall Effects. As described above, we first conducted a mixed-effects MANOVA, with participation in training and completing a learning diary as independent variables. Table 1 summarizes the descriptive statistics, Table 2 displays the results of the MANOVA. Overall, we observed a significant main effect of *time*, indicating changes in the dependent variables across the entire sample. Additionally, we found a significant between-groups effect of *training*. These effects were qualified by a significant *time x training interaction*, where the training group generally showed a higher improvement over time. The *between-groups effect of the diary*, as well as the *training x diary interaction* were not significant. The same was the case for the mixed-effects interactions *time x diary*, and *time x training x diary*, indicating that the learning diaries had no additional impact on learning behavior.

To illustrate the significant improvement through the training, we conducted a linear discriminant analysis predicting whether an individual participated in the training condition based on difference scores from post – pre measures. One discriminant function was estimated using the corresponding weights displayed in the last column of Table 1. Positive weights indicate that training was associated with higher post – pre scores. As can be seen, the group differences are largely explained by improvements in SRL knowledge. The SRL overall score and self-efficacy also explained some group differences. In contrast, improvements in math performance were generally associated with the groups receiving no training. We did not calculate a discriminant function for the diary condition because the diary did not show a significant overall effect that would warrant this procedure.

Effects for SRL-Variables. In the same manner as our overall-test, we also analyzed the seven specific SRL scales with a mixed-effects MANOVA. Table 1 shows the respective group and overall means, Table 2 includes the results of the MANOVA. Again, we found a significant main effect of *time*. However, we observed a general decrease in SRL behavior. The main effect of *training* was found significant as well. The decrease over time varied depending on training condition, as indicated by a significant *training* x *time interaction*. Apparently, the general decrease in SRL behavior was reduced due to training. As before, neither the *between-groups effect of the diary* nor the *diary x training interaction* were significant. The same was the case for the mixed-effects interactions where neither the *time* x *diary* nor the *time* x *training* x *diary* interactions were significant. This indicated that the learning diaries had no additional impact on SRL behavior.

Table 1

Means and Standard Deviations and Coefficients of the Linear Discriminant Function for the Overall and SRL-Focused Mixed Effects MANOVA

	Overall *M* (*SD*)	Group C *M* (*SD*)	Group D *M* (*SD*)	Group T *M* (*SD*)	Group TD *M* (*SD*)	LDA
Overall measures						
Math test PRE	11.16 (4.16)	11.62 (3.94)	10.35 (3.90)	11.12 (4.25)	11.62 (4.51)	-.32
Math test POST	14.83 (4.84)	15.44 (4.68)	14.24 (4.39)	14.53 (4.78)	15.16 (5.43)	
Self efficacy PRE	3.24 (0.89)	3.28 (0.97)	3.34 (0.89)	3.24 (0.91)	3.13 (0.83)	.30
Self efficacy POST	4.34 (0.67)	4.26 (0.66)	4.29 (0.66)	4.30 (0.65)	4.46 (0.72)	
SRL knowledge PRE	3.86 (1.57)	3.99 (1.77)	3.81 (1.45)	3.81 (1.44)	3.87 (1.63)	.75
SRL knowledge POST	6.21 (2.15)	4.69 (1.59)	4.55 (1.75)	7.69 (1.09)	7.89 (1.22)	
SRL questionnaire PRE	3.84 (0.65)	3.85 (0.68)	3.83 (0.61)	3.76 (0.62)	3.90 (0.68)	.45
SRL questionnaire POST	3.52 (0.46)	3.37 (0.50)	3.35 (0.42)	3.67 (0.41)	3.71 (0.41)	

Note. Overall = All groups; Group C = control group, Group D = intervention group that kept a diary; Group T = intervention group that attended the training; Group TD = intervention group that kept a diary and attended the training; LDA = Standardized coefficient to calculate the linear discriminant function maximizing differences between the training and no-training conditions

Table 1 continued

Means and Standard Deviations and Coefficients of the Linear Discriminant Function for the Overall and SRL-Focused Mixed Effects MANOVA

	Overall *M* (*SD*)	Group C *M* (*SD*)	Group D *M* (*SD*)	Group T *M* (*SD*)	Group TD *M* (*SD*)	LDA
SRL measures						
Goal Setting PRE	3.79 (1.17)	3.78 (1.35)	3.65 (1.11)	3.74 (0.99)	3.96 (1.23)	.36
Goal Setting POST	3.00 (0.72)	2.75 (0.75)	2.70 (0.69)	3.32 (0.60)	3.24 (0.62)	
Planning PRE	3.38 (0.95)	3.41 (0.99)	3.51 (0.96)	3.25 (0.93)	3.34 (0.94)	.72
Planning POST	4.03 (0.92)	3.76 (0.98)	3.82 (0.96)	4.10 (0.75)	4.36 (0.86)	
Motivation PRE	4.18 (1.01)	4.19 (1.11)	4.15 (0.91)	4.19 (0.98)	4.21 (1.08)	-.12
Motivation POST	3.55 (0.63)	3.41 (0.78)	3.51 (0.63)	3.66 (0.46)	3.62 (0.60)	
Distraction Avoidance PRE	3.75 (0.88)	3.73 (0.84)	3.84 (0.92)	3.51 (0.84)	3.86 (0.91)	.07
Distraction Avoidance POST	3.48 (1.18)	3.69 (1.20)	3.45 (1.27)	3.53 (1.09)	3.33 (1.13)	
Self-Instruction PRE	3.97 (0.82)	3.96 (0.76)	3.90 (0.84)	3.95 (0.86)	4.05 (0.84)	.60
Self-Instruction POST	3.50 (0.64)	3.17 (0.52)	3.24 (0.58)	3.74 (0.64)	3.82 (0.57)	
Learning Strategies PRE	3.92 (0.81)	3.96 (0.88)	3.94 (0.76)	3.80 (0.68)	3.95 (0.90)	.26
Learning Strategies POST	3.85 (0.86)	3.66 (0.96)	3.59 (0.86)	4.01 (0.67)	4.14 (0.81)	
Reflection PRE	3.83 (1.03)	3.83 (1.13)	3.78 (1.04)	3.76 (1.04)	3.93 (0.98)	-.48
Reflection POST	2.98 (0.64)	3.06 (0.76)	2.95 (0.62)	3.00 (0.66)	2.93 (0.57)	

Note. Overall = All groups; Group C = control group, Group D = intervention group that kept a diary; Group T = intervention group that attended the training; Group TD = intervention group that kept a diary and attended the training; LDA = Standardized coefficient to calculate the linear discriminant function maximizing differences between the training and no-training conditions

Table 2

Results of the Overall and SRL-Focused Mixed Effects MANOVA

	Overall MANOVA			SRL MANOVA		
Factor	$F(4, 159)$	p	partial η^2	$F(7, 156)$	p	partial η^2
Time	148.60	< .001	.79	37.15	< .001	.63
Training	18.42	< .001	.32	5.67	< .001	.20
Diary	0.13	.97	< .01	0.65	.71	.03
Time x Training	36.50	< .001	.48	4.79	< .001	.18
Time x Diary	0.18	. 95	.01	1.00	.43	< .01
Training x Diary	0.78	.54	.02	1.88	.99	.01
Time x Training x Diary	0.28	.89	.01	0.56	.79	.02

Note. Training, Diary, and the Training x Diary interaction are between subject effects, Time is a within subjects effect, and the Time x Training, Time x Diary, and Time x Training x Diary interaction are mixed effect

To analyze which SRL behaviors were especially affected by training, we conducted a linear discriminant analysis predicting whether an individual participated in the training condition based on post – pre difference scores. One discriminant function was estimated using the corresponding weights shown in the last column of Table 1. Positive weights indicate that training was associated with higher post – pre scores. We found the greatest differences concerning training for the planning scale. Moreover, only the SRL behaviors planning and the use of learning strategies were associated with a positive post – pre mean. In addition, higher post – pre differences in self-instructions were strongly associated with training. In comparison, goal setting and reflection were moderately related to training, whereas this relationship was reversed in the case of reflection, as training participants showed a greater decrease in reflecting behavior. Compared to the other SRL behaviors, motivation, distraction avoidance, and learning strategies explain only little inter-group variance. As before, we did not calculate a discriminant function for the diary condition because the diary did not show a significant overall effect that would warrant this procedure.

6.4.4 Process Data

Trend Analysis. In order to further explain differences between the groups as well as between pre- and post-tests, various time-series analyses were conducted.

Based on the learning diaries, we calculated an overall SRL score and tested for a linear trend (Hypothesis H2a). To do so, we aggregated the daily data of each participant to a daily mean. For the resulting 27 days, we modeled a linear regression with time as the predictor and scale value as the criterion. For the diary groups, separate trends were calculated in order to compare both groups. According to our hypotheses, group TD should improve their SRL behavior, whereas group D should not show such improvements.

For group D, we observed no significant linear trend for the overall SRL score (R^2 = .001; b_0 = 4,07; b_1 = -.001; p =.86). For group TD, we observed a significant positive linear trend for the overall score (R^2 = .29; b_0 = 4,10; b_1 = .012; p <.01). Figure 3 shows the aggregated SRL scores and linear trends over the course of the WBT for both diary groups. Both groups are very similar in terms of parallel peaks and minima. However, the score of group TD varies at a higher level; and the differences between the groups increase over the course of time.

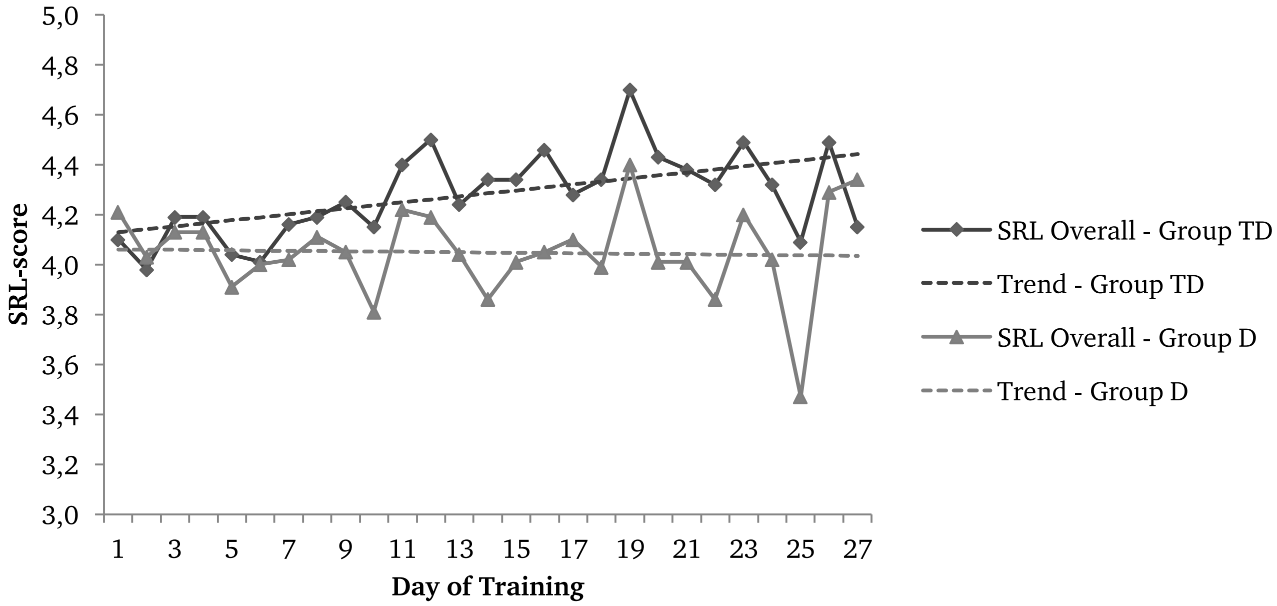

Figure 3. Aggregated SRL score and resulting trend for the groups TD and D

Intervention Analysis. The trend analysis revealed that the group TD gradually developed more self-regulated behavior, whereas participants in group D did not. Thus, it is likely that the three lessons caused this increase. In order to provide additional support for this hypothesis, we conducted intervention analyses for the overall SRL score in group TD (Hypothesis H2b). The analyzed interventions were the three lessons “Before Learning”, “During Learning”, and “After Learning”.

Due to the study design with differing intervention onsets for the participants, it was not possible to conduct a traditional intervention analysis. As described above, we conducted a separate intervention analysis for each participant and for each of the three lessons. For each analysis, we calculated a single measure of effect size. Then, each of the analyses was included as a single “study” in a meta-analytic random effects model. Mean effect sizes of the intervention analyses are displayed in Table 3.

The first analyses refer to the general SRL score as measured with all items of the learning diary. For the first two lessons, we observed large significant effects. The effect of the third intervention on the general SRL score was smaller but still moderate in size and also significantly excluded zero. Therefore, it is likely that the three WBT lessons caused the positive developments in participants’ self-regulated learning-behavior that we observed in this study.

Table 3

Results of Intervention Analyses (Group TD)

	Effects on General SRL			Effects on Targeted SRL Components		
	d	ci_l	ci_u	*d*	ci_l	ci_u
Lesson 1	1.11	0.66	1.55	1.43	1.01	1.85
Lesson 2	1.01	0.68	1.33	0.56	0.29	0.82
Lesson 3	0.51	0.32	0.71	0.12	-0.06	0.31

Note. General SRL = Mean score calculated on the basis of all self-regulated learning items in the learning diary; Targeted SRL Components = Subscales calculated on the basis of the self-regulated learning items corresponding to the content of the respective lesson (Lesson 1: goal setting, planning, process model concept; Lesson 2: distraction avoidance, procrastination avoidance, learning strategies; Lesson 3: reflection, attribution, motivation); d = mean effect size (after meta-analytically aggregating individual effect sizes for each participant and each lesson); ci_l = lower bound of a 95% confidence interval; ci_u = upper bound of a 95% confidence interval

In order to test the effect of each lesson on its targeted behavior, we conducted intervention analyses for each of the three SRL subscales with the corresponding lesson as intervention (Hypothesis H2c). Mean effect sizes for lesson 1 and 2 were statistically significant, with the effect for lesson 1 being large and the one for lesson 2 being moderate (see Table 3). In contrast, the effect size for “Lesson 3 components” was not significantly different from zero. These findings suggest that lesson 1 and 2 promoted the intended behavioral changes, whereas lesson 3 did not.

6.5 Discussion

The current study examined the effect of two interventions in an online mathematics preparation course: a web-based training on self-regulated learning (SRL) and a learning diary – resulting in four experimental groups C (control), D (diary only), T (training only) and TD (training plus diary). The effects were assessed on an SRL knowledge test, an SRL questionnaire, a self-efficacy questionnaire, and a mathematics test. Furthermore, process data from the learning diary was analyzed for trends and intervention effects on SRL.

Comparing the four groups, results showed significant effects of the web-based training (WBT) but not the diary. The positive effect of the WBT was observed primarily for the knowledge test but also for the questionnaires on SRL and self-efficacy. A slightly negative effect was found for the mathematics test.

Based on evaluation forms after each of the three training lessons, we found the experimental manipulation check to be positive: Participants in groups T and TD reported duration of the training to be very close to the intended duration and judged the content of the training to be both novel to them and very useful. This finding was further supported by the fact that declarative knowledge concerning SRL was greatly increased in the two training groups T and TD but not in the control groups C and D. Without this finding, a training effect for the WBT could hardly be plausible, because knowledge about strategies is a prerequisite for their application. Concerning the SRL questionnaire, all groups demonstrated decreases in self-regulated learning over the course of the study, although this was significantly more pronounced in the control groups C and D. The web-based training, on the other hand, appeared to attenuate this decrease in the training groups T and TD. Self-efficacy increased in all groups during the study but was significantly greater in the two training groups. Performance in the mathematics course also improved in all groups; however, the improvement was unexpectedly less pronounced in the training groups.

Trend analyses provide additional support for the positive effect on self-regulated learning, as we found a significant positive linear trend for the training and diary group TD but not for the diary only group D. This result makes a strong case against social desirability, as it is not plausible that participants slowly and linearly increased socially desirable answers over time.

The positive trend in the diary seems to contradict the decrease in the pre-post analysis of the SRL questionnaire. However, one must keep in mind that the questionnaire is more of a trait measurement, whereas the diary is a state measurement. We suppose that participants tended to overestimate their competence of SRL in the pre-questionnaire – perhaps due to their recent accomplishment of successfully completing their compulsory education. In the unusual setting of the online preparation course, however, where no teacher is there to advise them what to do next, many participants might have experienced a subjective lack of competence of SRL. While daily reported SRL behavior increased due to the WBT (as observed in the diary), participants might still have been disappointed in their overall performance during the course, which manifested itself in lower SRL scores in the post-questionnaire.

Taking a closer look at the subscales of the SRL questionnaire revealed that training effects were predominantly observable for planning and self-instruction. While effects on goal setting and cognitive learning strategies were less prominent, effects on self-motivation and distraction avoidance were close to zero. Surprisingly, we found a slightly negative training effect on reflection.

As the intervention analyses indicate, increasing SRL in the diary was directly linked to the onset of the three WBT lessons. The intervention effect of each training lesson was significant and moderate to large in magnitude for the overall SRL score in the diary. Taking a closer look at the specific SRL strategies that each lesson was intended to foster revealed an even greater effect for lesson 1 “Before Learning”, a moderate effect for lesson 2 “During Learning”, and a nonsignificant effect for lesson 3 “After Learning”. Thus, lesson 1 and, to a lesser degree, lesson 2 served their intended purpose. Results regarding lesson 3, on the other hand, indicate that modifications of this particular lesson could help improve the training effect of the WBT in general.

These findings strongly support the methodology of time series analysis – by estimating the intervention effects in this manner, we now know which lesson to focus on when revising the WBT. Because lesson 1 already had a very strong effect on SRL, there was likely little possibility of further improving SRL through lessons 2 and 3. Lesson 3 still had an impact on general SRL strategies, probably due to repetition of the earlier lessons, but failed to convey the specific strategies it was intended to address.

Mathematics knowledge increased in all experimental groups – this increase was especially large in the control groups. There are several possible explanations for this finding. First, participation in the WBT and the resulting SRL behavior was certainly time consuming and may have reduced the time available to participants to work on the mathematical problems. Second, as stated in the overlapping waves model by Siegler (2007), the application of new strategies often results in a short-term decrease in performance. Third, due to time constraints, it was not possible to cover all topics in the mathematics test. It is possible that the selection of items included in the test (and thereby the selection of topics) favored participants who simply worked their way through the topics in the exact order in which they were presented in the course. Participants who selected topics to work on based on their subjective importance (as was recommended in the WBT) may have chosen a different order of topics.

Nevertheless, this outcome should not be interpreted as a failure of the WBT. The intervention was specifically designed for long-term improvement that might not be observable within a four-week preparation course. A future follow-up study could investigate in depth possible long-term training effects. In the present study a follow-up measurement was not feasible due to the fact that groups C and D were permitted access to the WBT at the end of the online preparation course, virtually eliminating the differences between conditions.

6.5.1 Limitations

The study's main limitation is the selection of participants. The sample was recruited from prospective students in mostly technology-oriented fields: computer science, civil engineering, mechanical engineering, and mathematics. As a result, the sample is dominated by male students and is therefore not representative of prospective students in other fields. There could also be an additional selection bias within the selected fields of study. On the one hand, it is likely that those who demonstrate low self-regulated behavior might not participate in the training due to lacking motivation. On the other hand, it is just as possible that individuals with good self-regulated behavior might not feel the need to participate in the training, if they believe that the WBT does not offer them additional benefits. Another problem concerning the participants is that the training situation is somewhat paradox. The training aims to increase self-regulated learning behavior. However, at the same time, self-regulated behavior is necessary to successfully complete the WBT. Thus, individuals lacking self-regulated behavior may not comply thoroughly with the training and may therefore have less training effect. Thus, it is possible that lacking self-regulated behavior reduced the size of the training effect.

Another limitation concerns students' behavior during the lessons. In contrast to trainings in a classroom setting, we were unable to observe participants' behavior in specific situations as well as their compliance to training instructions. To further clarify the processes leading to promoted self-regulated learning, future research could observe participants during training sessions – for instance, using think-aloud protocols.

Due to the study design, it could be seen as problematic that the untrained groups did not receive placebo training. It is possible that the observed effects would have emerged when participants were trained on any content related to learning. However, we chose this approach because it would be ethically problematic to waste prospective students' time with a training that is not expected to be beneficial.

A final limitation arises as a result of the study's design. The study provides no answer to the question whether the WBT is equally effective as a face-to-face training held by a real trainer. The study provides information regarding advantages and disadvantages of WBT but no comparison to different approaches. However, although such a comparison would be interesting, it is difficult to realize. To do so, both approaches would have to be parallelized – i.e., include the exact same content, use similar training methods, and identical measurement instruments. However, such parallel trainings are difficult to create and would neglect the unique advantages associated with each method. Face-to-face trainings, for instance, focus heavily on the interaction between participants, whereas WBTs can offer highly individualized training. Methods such as a group discussion are very different depending on whether discussion partners are physically or only virtually present. This holds true for other features, as well, such as games and materials that are available online whenever needed. Thus, it may be appropriate to view WBTs and traditional trainings not as two methods with a common purpose but rather as two methods suitable for different situations and offering different advantages that should be capitalized on to their fullest extent.

6.5.2 Perspectives and Future Research

The present study makes a strong case for time series analysis in intervention studies using learning diaries. Using this methodology, naturalistic studies can be conducted in an economical manner. Advantages are the possibility to analyze both nomothetically and ideographically as well as to differentiate partial effects when there is more than one instance of intervention.

Concerning the lack of positive effect on mathematics performance there are a number of improvements in research design that we propose: First, it seems necessary to cover all mathematical topics of the preparation course with one problem in the mathematics pre and post test. Although two or even more problems per topic might be eligible, but this would result in too much of a burden for participants. Adaptive testing could offer a solution for this dilemma. Second, asking participants which topics they intended to focus on would afford the possibility to investigate whether they improved their knowledge consistent with their personal learning goals. We believe that a score calculated only for the problems individually relevant to a person should reflect the result of self-regulated learning much better than an overall score including topics that a person intentionally left out. Third, a follow-up test after several weeks seems to be more realistic time frame for a change of learning behavior to translate into increased performance.

In order to increase efficiency of the WBT, shortening of content might appear to be desirable, although the current duration of three lesson with 90 minutes each is already more concise than comparable face-to-face trainings (e.g. Perels et al., 2005: 6 * 1.5 h; Schmitz & Wiese, 2006: 4 * 2 h; Werth et al., 2012: 6 * 1 h). A feasible approach would be to experimentally test the effect of each lesson (or even each chapter) of the WBT separately, pruning out all parts without significant effects on performance. However, one has to bear in mind that differential effects might occur depending on the initial SRL competency: One person might lack goal setting strategies but be proficient in self-motivation, while another person might show a contrary profile. We therefore advocate a diagnostic test with individual feedback preceding the WBT. This way, contents of the training could be recommended depending on the needs of each participant.

An improvement in the training method might be a combination of WBT and traditional trainings. That is, participants could acquire the declarative knowledge of the training via WBT in their individual learning tempo and with automatized feedback on a knowledge test. At a later time, they could discuss their personal experience in a real training group and observe the trainer as a role model for self-regulated behavior.

Future developments should emphasize the intervention character of the learning diary – by exploiting the possibilities of online diaries, learning diaries can be used to implement feedback interventions (K. Schmidt et al., 2011). Automatized feedback provided by the computer could refer to SRL components reported by participants on rating scales. For example, participants with low SRL performance on a particular day could be prompted to reflect more on that day's learning experience in the post-learning diary and set ambitious goals in the pre-learning diary on the following day. Furthermore, peer feedback could be used to analyze the open questions in the diary – for example, by evaluating the formulation of learning goals.

We believe that a central advantage of fostering SRL by means of a WBT over other approaches such as scaffolding or prompting often used in CBLEs is the possible transfer of newly acquired SRL strategies to different learning tasks. Although our WBT was created in the context of the online mathematics preparation course, the SRL strategies taught are universal and students should be able to apply them in other courses as well. However, this hypothesis was not tested in this study and requires further research.

As a conclusion, we find that WBT has great potential in the training of SRL, particularly in situations where face-to-face training is not possible, e.g. due to geographical distances or when the number of participants exceeds the resources of human trainers.

7 Study 2: Fostering Self-Regulated Learning Online: Effects of Web-Based Training and Peer Feedback on Mathematics Performance

7.1 Abstract

Although training in self-regulated learning (SRL) is effective in improving performance, human trainers can reach only a few people at a time. We developed a web-based training (WBT) for potentially unlimited numbers of participants based on the process model of SRL by Schmitz and Wiese (2006). A prior study (Bellhäuser, Lösch, Winter & Schmitz, 2016) observed statistically significant positive effects on SRL and self-efficacy and detrimental effects on performance. In the present study, we investigated an improved version of the WBT, augmented by the application of peer feedback groups. For 136 prospective university students attending an online mathematics preparation course, a combined intervention with WBT, a learning diary, and peer feedback groups was determined to be successful in fostering time investment, SRL, self-efficacy, and mathematics performance. While the WBT without peer feedback also fostered time investment, SRL, and self-efficacy, but not mathematics performance, the diary-only condition did not have beneficial effects.

7.2 Introduction

Self-regulated learning (SRL) has been shown to be highly relevant to academic achievement both in secondary schools (Dignath & Büttner, 2008) and at the university level (Richardson et al., 2012). In particular, SRL strategies are a requirement for the success of students in computer-based learning environments (CBLE) (Broadbent & Poon, 2015). However, many students appear to have difficulties regulating their own learning process. Fortunately, researchers have demonstrated that training in SRL strategies is possible and that participants in SRL training substantially increase their academic performance (Benz, 2010). Most approaches to fostering SRL apply face-to-face training that inherently limits the number of students who can participate. Therefore, Bellhäuser, Lösch, Winter, and Schmitz (2016) developed a web-based training (WBT) to foster SRL strategies online. In their evaluation study, this WBT was demonstrated to have a positive effect on SRL knowledge, SRL behavior, and self-efficacy. However, the training also had a detrimental effect on mathematics performance in an online mathematics preparation course. The aim of the present study is therefore to augment the WBT applied by Bellhäuser and colleagues (2016) with a new peer feedback intervention that helps participants use the strategies from the WBT to improve their self-regulated learning as well as their performance.

7.2.1 Process Model of Self-Regulated Learning

Our study is based on the process model of self-regulated learning by Schmitz and Wiese (2006), which is an adaptation of Zimmerman's (2000) conception of self-regulation. According to this model, learning is a process that can be divided into three phases: pre-action, action, and post-action. These phases follow one another cyclically in every learning episode (i.e., one cycle of pre-action, action, and post-action phases such as homework on one day) and influencing the next learning episode (i.e., the next cycle of the phases such as homework on the next day) via a feedback loop. Every phase is characterized by a different set of tasks and challenges for the learner; therefore, different strategies and different competencies are required to achieve good learning results.

In the pre-action phase, learners establish goals according to the situation in which these students find themselves and the task with which the students are confronted. The next step is to deduce a plan to achieve these goals. If intrinsic and extrinsic motivation is not sufficient to initiate learning, self-motivation strategies serve as a further resource. In the action phase, learners operate with the actual learning content. Here, cognitive learning strategies (such as elaboration) and meta-cognitive learning strategies (such as monitoring) are crucial to learning success. Further, learners must utilize volitional strategies when observing a decrease in motivation to avoid procrastination. In the post-action phase, learners reflect on their learning episode and determine their level of satisfaction with their performance. For this purpose, learning goals are compared to actual achievement. The result of this comparison triggers the next pre-action phase in which learners establish new learning goals or modify unfinished goals.

7.2.2 Fostering SRL with Web-Based Training

The process model of SRL (Schmitz & Wiese, 2006) has been the foundation for many training interventions intended to foster SRL (Leidinger & Perels, 2012; Perels et al., 2005, 2009; Schmitz & Wiese, 2006; Werth et al., 2012). Although those trainings differ in terms of the target groups, focus, and success, in all trainings, a human trainer conducts three or more face-to-face training sessions of approximately two hours with a group of up to 30 participants. The effects of such trainings have been shown to be substantial not only in terms of improved self-reported learning behavior but also in increased performance (Benz, 2010; Dignath & Büttner, 2008). The disadvantages of face-to-face training, however, are that participants cannot flexibly choose when and where to attend training sessions and that trainers must restrict the number of participants in each training. For research purposes, another disadvantage is that sessions of face-to-face training are never absolutely identical on different occasions. Often because of time constraints, different persons conduct the trainings, leading to different effects. Even in studies in which only one person was the trainer, that person may have varied the exact wording of explanations from one training group to the next. Finally, with different participants in every training group, the quantity and quality of contributions by participants may also vary greatly.

Bellhäuser and colleagues (2016) therefore developed a web-based training that can be attended by virtually unlimited numbers of participants who are free to choose the time and location for their training. The WBT comprises three lessons of approximately 90 minutes each. The first lesson (“Before Learning”) focuses on the pre-action phase and covers goal-setting and time management. Lesson 2 (“During Learning”) addresses the action phase and covers volition, cognitive learning strategies and metacognitive learning strategies. The third lesson (“After Learning”) highlights the post-action phase and covers attribution and reflection. Each lesson utilizes videos, presentations, tests, exercises and group discussions in an online forum.

The WBT was evaluated in the context of an online mathematics preparation course in which prospective students prepared themselves for their first university term in mathematically oriented fields of study (computer science, civil engineering, mechanical engineering or mathematics). The preparation course occurred during the last four weeks before the university term began; covered mathematical knowledge from all school grades; and provided learners with definitions, arguments, examples, assignments and visualizations. Because the preparation course was conducted completely online (created with the learning management system *Moodle*), no face-to-face instruction occurred. The preparation course took four weeks, during which all participants had the freedom to decide for themselves what to learn, when to learn and how to learn.

In a randomized experimental design, Bellhäuser and colleagues (2016) investigated the effects of the WBT on SRL knowledge, self-regulated learning, self-efficacy, and mathematics performance. The intervention was deemed successful in conveying declarative knowledge regarding SRL, increasing self-efficacy, and improving self-reported SRL behavior. However, the results indicated a detrimental effect on participants' mathematics performance. The authors discussed several possible explanations for this undesirable finding. The WBT required a certain amount of time that participants did not invest in the actual learning task (i.e., the preparation course). Furthermore, according to Siegler's (2007) overlapping waves model, the acquisition of new strategies can impair performance in the short term, with beneficial effects appearing only in the long term. Finally, flaws in the mathematics test may have contributed to the decrease in mathematics performance. No matter how convincing these arguments may appear, an intervention with negative effects on performance is not satisfactory for practical use, and improvements in the training are therefore highly desirable.

7.2.3 Peer Feedback Interventions

In the evaluation forms, participants in the study by Bellhäuser and colleagues (2016) described bulletin boards in the WBT to be less helpful than elements of instruction such as videos and presentations. This response was surprising because as Davies and Graff (2005) stated, online discussions are expected to promote learning and performance. One possible explanation may be that participants did not know their peers on the bulletin boards and therefore did not have sufficient trust in their peers to share the details of their learning difficulties. Trust among members of virtual communities has been shown to be essential in the exchange of information (Ridings, Gefen, & Arinze, 2002). Grouping participants into smaller peer groups (Wheelan, 2009) with a common interest such as a certain field of study (Ziegler & Golbeck, 2007) and the personal introduction of each participant (Rusman, Bruggen, Cörvers, Sloep, & Koper, 2009) can reduce anonymity and increase trust.

Peer feedback refers to "a communication process through which learners enter into dialogues related to performance and standards" (Liu & Carless, 2006). By contrast to peer assessment, peer feedback does not involve grading. In language teaching, peer feedback has been shown to be successful in fostering affect and performance (Gielen et al., 2010; Nelson & Schunn, 2009). Although the positive effects of teacher feedback on students' self-regulated learning are well documented (Azevedo, 2002; Azevedo et al., 2006, 2007), to the best of our knowledge, there have been no attempts to foster SRL by means of peer feedback.

7.2.4 Research Questions

In the present study, we examined the effects of three different interventions designed to foster self-regulated learning. Prospective university students in an online mathematics preparation course were assigned to one of four experimental conditions: Group D (diary), Group TD (training + diary), Group TDP (training + diary + peer feedback group), and Group C (control). We expected each of the interventions to have positive effects on SRL knowledge, self-reported SRL behavior, self-efficacy, and mathematics performance.

Hypothesis 1 covered the positive effects of the learning diary. Because of the reactivity effect (Korotitsch & Nelson-Gray, 1999), we expected the diary to have a positive effect on SRL behavior (H1a), self-efficacy (H1b), mathematics performance (H1c), and time investment (H1d). These effects should result in greater gains for Group D than for Group C. However, we expected no effect on SRL knowledge because SRL strategies were not taught explicitly in the diary.

Hypothesis 2 covered the positive effects of the web-based training. By explicitly explaining SRL strategies and helping participants test the strategies personally (Bellhäuser et al., 2016), we expected the training to increase knowledge regarding SRL (H2a) and thereby improve SRL behavior (H2b) and self-efficacy (H2c), which should result in increased mathematics performance (H2d). We also expected an increased time investment in the preparation course (H2e) The effects should be visible in the comparison between Group D and Group TD, with the latter achieving higher gains.

Hypothesis 3 covered the positive effects of the peer group interventions. Because students were deepening the content of the training and affiliating with peers, we expected statistically significant gains in SRL behavior (H3a), self-efficacy (H3b), mathematics performance (H3c), and time investment (H3d). These effects should exceed the gains of Group TD. No effect on SRL knowledge was expected.

7.3 Method

7.3.1 Participants

We recruited 289 prospective students from an online mathematics preparation course at a technical university in Germany. The mean age was 19.8 years (SD = 1.48). Because participants were enrolled in mathematically oriented fields of study (computer science, civil engineering, mechanical engineering, or mathematics), the sample was predominantly male, comprising 233 male and 56 female students. We assigned participants randomly to one of four experimental conditions: Group D (Diary) kept a learning diary throughout the preparation course. Group TD (Training + Diary) had access to web-based SRL training and kept a learning diary. Participants in Group TDP (Training + Diary + Peer feedback group) also kept a diary and attended the web-based SRL training. In addition, members of Group TDP were placed in groups of 5 students each; these groups worked on additional SRL tasks that included peer feedback. Participants in control Group C did not have access to the training or the diary, nor were they placed into peer feedback groups. The randomized assignment controlled for gender and field of study by dividing the sample into eight subpopulations (2 gender x 4 fields of study, e.g., female mechanical engineers) and randomizing within each subpopulation separately. We expected more dropouts in Groups TD and TDC because of the higher workload and therefore assigned disproportionally more participants to these groups.

Complete data were obtained for 170 participants (134 male): 45 in group TDP (34 male), 45 in Group TD (37 male), 36 in Group D (29 male), and 44 in Group C (34 male). Because of the high dropout rate (41.2%), we investigated differences between participants and dropouts. Analyses revealed significantly lower scores in conscientiousness and the mathematics test for dropouts but no significant differences in demographic data (gender, age, school grades), SRL (including subscales), self-efficacy, extraversion, openness, agreeableness or neuroticism.

7.3.2 Procedure

The online mathematics preparation course is an e-learning course that covers the last four weeks before participants begin university lectures. The course is a voluntary option for students enrolled in mathematically oriented fields to prepare for course work, deepen school knowledge and establish a common knowledge base among students (Bausch et al., 2014). The preparation course included six chapters (“Arithmetic”, “Powers”, “Functions”, “Higher Functions”, “Analysis”, and “Vectors”) with 52 mathematical topics, each of which comprised the following elements: diagnostic pre-test, overview, introduction to the domain, information, interpretation, application, typical mistakes, exercises, and diagnostic post-test. The preparation course was delivered in an online learning management system that involved no classroom instruction by tutors or teachers.

Within the first three days, participants completed the online pre-test in the learning management system, which comprised a demographic survey, an SRL knowledge test, a mathematics test, and several questionnaires that are discussed later. Depending on their experimental condition, participants had access to up to three separate interventions during the preparation course that were intended to foster SRL by different processes: a learning diary (prompting SRL strategies daily), a WBT on SRL (conveying SRL knowledge), and peer feedback groups (providing social support). The post-test was accessible online for three days after the end of the preparation course and comprised the SRL knowledge test, an SRL questionnaire, the mathematics test, and an evaluation sheet. As an incentive, all participants who completed both the pre- and post-tests were included in a lottery drawing (an electronic device and several monetary prizes).

7.3.3 Interventions

Learning Diary. Groups D, TD and TDP were requested to keep a learning diary throughout the preparation course. When filling in the diary, participants first decided whether they planned to learn on that day. If the students chose not to learn, the diary requested reasons and whether they planned to learn on the following day. Participants were further asked for their learning goals for the next learning day.

When participants chose to learn on a particular day, the students filled in two sections of the learning diary: one section to be completed before learning and one section to be completed after learning. Before learning, open-ended questions triggered goal-setting, planning, and self-motivation. Participants were requested to choose chapters from the preparation course to study on that day and set individual goals for those chapters (e.g., to solve all of the problems and to get at least 70% of the problems correct). Learners were further asked which learning strategies the learner intended to apply and how much time the learner planned to invest. Closed questions were applied primarily for measuring purposes (e.g., motivation and well-being). Because this paper investigates the learning diary only as an intervention and not as a measurement instrument, the closed questions are not described in detail here.

The second section of the learning diary triggered reflection and goal-setting for the following day. Participants were asked which chapters they truly worked on and how much time the learners had invested in learning. By explicitly separating general time investment from effective learning time, participants critically reflected on their use of time. Learners were then requested to review the learning goals established in the first portion of the learning diary and judge the degree to which learners had reached each goal. Further, students described which obstacles the learners had encountered during the day and how the learners planned to overcome such obstacles on the next learning day. For measuring purposes, participants rated their learning behavior on that day in closed questions (e.g., concentration, effort, and satisfaction).

Web-Based Training on SRL. Groups TD and TDP had access to three lessons on self-regulated learning that were unlocked consecutively in one-week intervals. Participants were asked to work through each lesson within a time frame of three days. Lessons were designed to take approximately 90 minutes. As described by Bellhäuser and colleagues (2016), the WBT imparts knowledge of the process model of self-regulated learning (Schmitz & Wiese, 2006) and utilizes videos, presentations, self-tests, exercises, and online bulletin boards to help participants transfer the knowledge to their daily learning routines.

Unlike the previous study, we did not include animated videos. Instead, real-life videos were created by two amateur actors in a real classroom scenario, one actor acting as the trainer, the other actor acting as a participant in the training. Choosing human actors was intended to increase credibility and personalize the experience for the audience, thereby improving satisfaction with and the effects of the WBT.

The first lesson, “Before Learning”, covered the pre-action phase, including chapters on goal-setting, planning, and time-management. Participants were advised to establish learning goals for the preparation course according to the SMART technique (Doran, 1981). After a presentation regarding time-management, participants reflected on their own time-management and discussed individual problems on a bulletin board. The last step was developing a learning plan for the entire four weeks of the preparation course, considering personal learning goals and time restrictions such as chores or hobbies.

The second lesson, “During Learning”, focused on the action phase, the chapters including volitional learning strategies (such as addressing distractions and avoiding procrastination) and cognitive and metacognitive learning strategies. A video introduced the concept of procrastination, and participants analyzed whether they were prone to delaying tasks. To avoid distractions in the future, participants were advised to switch off mobile phones and communication software on their computers before entering the preparation course. Self-motivation strategies (e.g., self-reward) were presented, and participants developed a personal motto for situations in which they may lack motivation to learn. Referring to examples from the preparation course, presentations explained how to use cognitive learning strategies (e.g., structuring, elaborating, and summarizing) and metacognitive learning strategies (particularly monitoring).

The third lesson, “After Learning”, addressed the post-action phase, including chapters on attribution, frame of reference, reflection, and motivation. A video exemplified different attribution styles in the face of failure. Participants were encouraged to identify personal but changeable causes to alter motivation. Similarly, an individual frame of reference was promoted: instead of comparing oneself to other students, participants were instructed to focus on improving their own performance. In the chapter on reflection, a presentation explained how reflection can be applied on a short-term basis (e.g., whether one successfully solved a particular mathematical problem), on a medium-term basis (e.g., whether one was satisfied with today's learning progress), and on a long-term basis (e.g., whether one would approach future examinations in a different manner). Participants were instructed to review their learning goals from Lesson 1 and to reflect on necessary adjustments for the remaining days of the preparation course. In the last chapter on motivation, implementation intentions (Gollwitzer, 1999) were presented as a strategy to increase motivation. After a summary of the process model of self-regulated learning, the training ended with participants writing a letter to their future selves regarding what they planned to change in their learning behavior.

Peer Feedback Intervention. Participants in Group TDP were assigned to peer feedback groups of five persons each. Although group assignments were random, when possible, group members were chosen from the same field of study (e.g., five civil engineers). Peer feedback groups were able to communicate on a separate bulletin board on which discussion topics were suggested. Beginning with a welcome message, participants were encouraged to get to know their peers by creating quiz questions about themselves, posting them on the bulletin board, and guessing the right answers to their peers' quiz questions. After each lesson of the WBT, a group task referring to the current lesson was posted; this task was meant to be solved collaboratively. Lesson 1 was followed by the group task of sharing students' individual time schedules and commenting on their peers' plans (peer feedback Task 1). After Lesson 2, participants were asked to discuss the cognitive learning strategies taught in the lesson and how to apply those strategies to the mathematical chapters (peer feedback Task 2). The group task for Lesson 3 was to reflect on their time management in the preparation course to date and to adjust their learning goals if necessary (peer feedback Task 3). Although discussion regarding the content of the mathematical preparation course was not forbidden, the instructional topics were only related to strategies of self-regulated learning behavior. Inspection of the bulletin boards revealed that participants focused on the instructed group tasks.

All instructions for the discussions were also presented in videos. When members of a group did not participate in the group discussion, the experimenters reminded and encouraged participants to engage; however, no pressure was applied.

7.3.4 Instruments

Self-Regulated Learning Questionnaire. The self-regulated learning questionnaire comprised 26 items with 7 subscales. The overall score had a Cronbach's α of .85. The sub-scales were goal-setting (4 items, Cronbach's α = .66, e.g., "*I choose my goals so that they are a challenge for me.*"), planning (4 items, Cronbach's α = .63, e.g., "*I write down all important tasks and appointments.*"), self-motivation (3 items, Cronbach's α = .71, e.g., "*I recall my past achievements to motivate myself for difficult tasks.*"), volition (4 items, Cronbach's α = .71, e.g., "*I can modify my mood so that I find everything easier.*"), elaboration (3 items, Cronbach's α = .71, e.g., "*When reading, I try to connect the things I am reading about with what I already know.*"), metacognition (4 items, Cronbach's α = .64, e.g., "*I regularly think about my learning behavior.*"), and reflection (4 items, Cronbach's α = .78, e.g., "*At the end of a day, I ask myself whether I am satisfied with my performance.*"); all subscales were determined to be sufficiently reliable. The questionnaire was developed in the context of former studies to match the content of the WBT. Most items were created specifically, except for three items from the LIST (Wild & Schiefele, 1994) and six items from the VCQ (Kuhl & Fuhrmann, 1998).

SRL Knowledge Test. The SRL knowledge test included twenty multiple-choice items (Cronbach's α = .81). Participants were required to choose one of four possible answers: one choice was the correct answer and three were distractors. Calculating the number of correct answers resulted in a total score of 0 to 20 points. The questions concerned constructs that were explained in the WBT, e.g., "According to the process model of self-regulated learning, what should you do in the pre-action phase? a) set goals (right answer), b) concentrate (distractor), c) reflect (distractor), d) relax (distractor)".

Self-Efficacy. We applied the Generalized Self-Efficacy Scale (Schwarzer & Jerusalem, 1999), which comprises 10 items (Cronbach's α = .78, e.g., "*I can always manage to solve difficult problems if I try hard enough.*").

Mathematics Test. The mathematics test, comprising 52 problems (Cronbach's α = .84), was created by mathematicians who were responsible for the preparation course. Each problem addressed one of the chapters in the course. In two parallel versions (before and after the mathematics course), participants were allotted 60 minutes; the time investment was measured to identify lack of engagement in the test. With one point for each correct solution, the mathematics overall score ranged from 0 to 52.

Additionally, participants were requested to choose ten chapters to particularly focus on, according to their individual needs. The corresponding ten problems on the mathematics test were calculated to determine the mathematics focus score (ranging from 0 to 10).

7.4 Results

7.4.1 Screening Procedure

We compared the time investment on the mathematics pre- and post-tests to identify participants who did not apply sufficient effort on the post-test. The rationale behind this comparison was that participants may have simply opened the mathematics test to fulfill the criteria for the lottery drawing. We therefore excluded participants who spent 20% less time on the mathematics post-test than the same participants spent on the mathematics pre-test, resulting in a sample of 136 participants.

7.4.2 Evaluation of Training Effects

Descriptive statistics for all dependent variables are shown in Table 4. We calculated three separate repeated-measures MANOVAs with group and time as the independent variables and different sets of dependent variables. In the first MANOVA, we entered SRL knowledge, self-efficacy, mathematics overall score, and SRL overall score as the dependent variables. The results showed a statistically significant effect of the group (Pillai's trace = .51, $F(3, 132) = 6{,}70$; $p < .001$), a statistically significant main effect of time (Pillai's trace = .66, $F(1, 132) = 61{,}78$; $p < .001$), and a statistically significant interaction between the factors (Pillai's trace = .71, $F(3, 132) = 10{,}19$; $p < .001$), justifying running univariate ANOVAs for the four dependent variables. As seen in Table 5, SRL knowledge, self-efficacy and the SRL overall score showed statistically significant interaction effects in the hypothesized direction, with Group TDP showing the most prominent gains among treatment groups and Group C showing either constant levels or even negative developments. Figure 4 depicts the increases in the SRL overall score for all four experimental groups. The interaction effect for the mathematics overall score, however, marginally missed the level of statistical significance although descriptive statistics indicated the hypothesized direction.

Table 4

Mean and standard deviation for each experimental group for SRL knowledge, self-efficacy, overall SRL score, SRL subscales, mathematics overall score, and mathematics focus score on pre- and post-tests

	Group C (n = 34)	Group D (n = 28)	Group TD (n = 40)	Group TDP (n = 34)
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
SRL Knowledge Test				
Pre-test	3.34 (1.76)	3.50 (1.59)	3.74 (1.55)	3.81 (1.79)
Post-test	3.28 (2.07)	3.54 (2.10)	7.69 (1.35)	8.43 (0.83)
Self-Efficacy				
Pre-test	4.23 (0.76)	4.16 (0.74)	4.04 (0.69)	4.03 (0.78)
Post-test	4.10 (0.69)	4.25 (0.77)	4.23 (0.69)	4.31 (0.69)
SRL Overall Score				
Pre-test	3.52 (0.56)	3.72 (0.59)	3.50 (0.61)	3.65 (0.66)
Post-test	3.52 (0.65)	3.65 (0.68)	3.81 (0.67)	4.17 (0.67)
SRL Goal-Setting				
Pre-test	4.78 (0.76)	4.90 (0.75)	4.54 (0.83)	4.79 (0.79)
Post-test	4.50 (0.88)	4.79 (0.73)	4.56 (0.74)	4.92 (0.61)
SRL Planning				
Pre-test	3.48 (0.97)	3.38 (1.09)	3.42 (1.17)	3.60 (0.84)
Post-test	3.54 (0.93)	3.66 (1.09)	3.98 (1.02)	4.40 (0.79)
SRL Self-Motivation				
Pre-test	4.31 (1.28)	4.44 (1.04)	4.18 (1.02)	4.05 (1.24)
Post-test	4.28 (1.25)	4.07 (1.09)	4.50 (0.93)	4.55 (0.92)
SRL Volition				
Pre-test	3.21 (0.79)	3.62 (0.98)	3.24 (0.85)	3.40 (0.93)
Post-Test	3.32 (0.84)	3.35 (1.06)	3.57 (0.95)	3.88 (1.08)
SRL Elaboration				
Pre-Test	4.38 (1.00)	4.45 (1.00)	4.03 (1.06)	4.40 (0.98)
Post-test	4.06 (0.97)	4.26 (0.97)	4.23 (0.83)	4.64 (0.91)
SRL Metacognition				
Pre-test	2.10 (0.64)	2.24 (0.82)	2.23 (0.71)	2.31 (0.93)
Post-test	2.29 (0.74)	2.42 (0.84)	2.67 (0.75)	3.19 (1.20)
SRL Reflection				
Pre-test	2.79 (1.09)	3.35 (0.98)	3.16 (1.00)	3.29 (1.21)
Post-test	2.96 (1.02)	3.23 (0.99)	3.44 (1.04)	3.82 (1.06)

Table 4 continued

Mean and standard deviation for each experimental group for SRL knowledge, self-efficacy, overall SRL score, SRL subscales, mathematics overall score, and mathematics focus score on pre- and post-tests

	Group C (n = 34)	Group D (n = 28)	Group TD (n = 40)	Group TDP (n = 34)
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Mathematics Overall Score				
Pre-test	19.48 (6.62)	19.93 (7.40)	19.89 (5.87)	18.63 (5.45)
Post-test	19.08 (7.41)	21.16 (8.10)	21.66 (5.91)	20.69 (7.00)
Mathematics Focus Score				
Pre-test	2.95 (1.51)	2.44 (1.57)	2.64 (1.61)	2.27 (1.53)
Post-test	2.98 (1.92)	3.18 (1.94)	3.20 (1.71)	3.50 (1.62)

For the second MANOVA, we replaced the mathematics overall score with the mathematics focus score, which was calculated individually for the ten chapters that each participant personally chose as the most important. The rationale was that improved SRL competency after the intervention may lead to a stronger focus on personal goals rather than improved performance in all chapters (including those chapters outside of individual focus). Because the mathematics focus score was calculated only on chapters that participants chose to be personal goals, it appears reasonable that gains were manifested in this score rather than the overall score. Again, the MANOVA showed a statistically significant main effect of the group (Pillai's trace = .51, $F(3, 132) = 6{,}66$; $p < .001$), a statistically significant main effect of time (Pillai's trace = .66, $F(1, 132) = 62{,}22$; $p < .001$), and a statistically significant interaction of the two factors (Pillai's trace = .73, $F(3, 132) = 10{,}49$; $p < .001$). The univariate ANOVA for the mathematics focus score in fact revealed a statistically significant interaction effect between group and time (see Table 5). Gains for the four experimental groups in the mathematics focus score are presented in Figure 5.

Table 5

Univariate repeated-measures ANOVAs for SRL knowledge, self-efficacy, overall SRL score, SRL subscales, mathematics overall score, and mathematics focus score on pre- and post-tests

	Main Effect Group				Main Effect Time				Interaction Effect			
	df	F	*p*	$\eta^2 p$	*df*	F	*p*	$\eta^2 p$	*df*	F	*p*	$\eta^2 p$
SRL Knowledge Test	3, 132	38.20	<.001	0.46	1, 132	206.34	<.001	0.40	3, 132	59.23	<.001	0.34
Self-Efficacy	3, 132	0.06	.978	0.00	1, 132	9.44	.003	0.06	3, 132	5.912	<.001	0.11
SRL Overall Score	3, 132	2.49	.063	0.05	1, 132	29.40	<.001	0.15	3, 132	12.55	<.001	0.19
SRL Goal-Setting	3, 132	1.67	.177	0.04	1, 132	.99	.322	0.01	3, 132	2.34	.076	0.05
SRL Planning	3, 132	2.03	.112	0.04	1, 132	43.70	<.001	0.23	3, 132	5.94	<.001	0.09
SRL Self-Motivation	3, 132	.04	.989	0.00	1, 132	3.479	.064	0.01	3, 132	6.79	<.001	0.13
SRL Volition	3, 132	1.75	.322	0.03	1, 132	6.69	.011	0.04	3, 132	4.58	.004	0.09
SRL Elaboration	3, 132	1.34	.263	0.03	1, 132	.01	.973	0.00	3, 132	3.88	.011	0.08
SRL Metacognition	3, 132	3.37	.020	0.07	1, 132	41.07	<.001	0.22	3, 132	5.66	.001	0.09
SRL Reflection	3, 132	3.06	.030	0.07	1, 132	7.73	.006	0.05	3, 132	2.37	.074	0.05
Mathematics Overall Score	3, 132	.44	.727	0.01	1, 132	11.50	<.001	0.08	3, 132	2.50	.062	0.05
Mathematics Focus Score	3, 132	.06	.978	0.00	1, 132	17.31	<.001	0.11	3, 132	2.69	.049	0.05

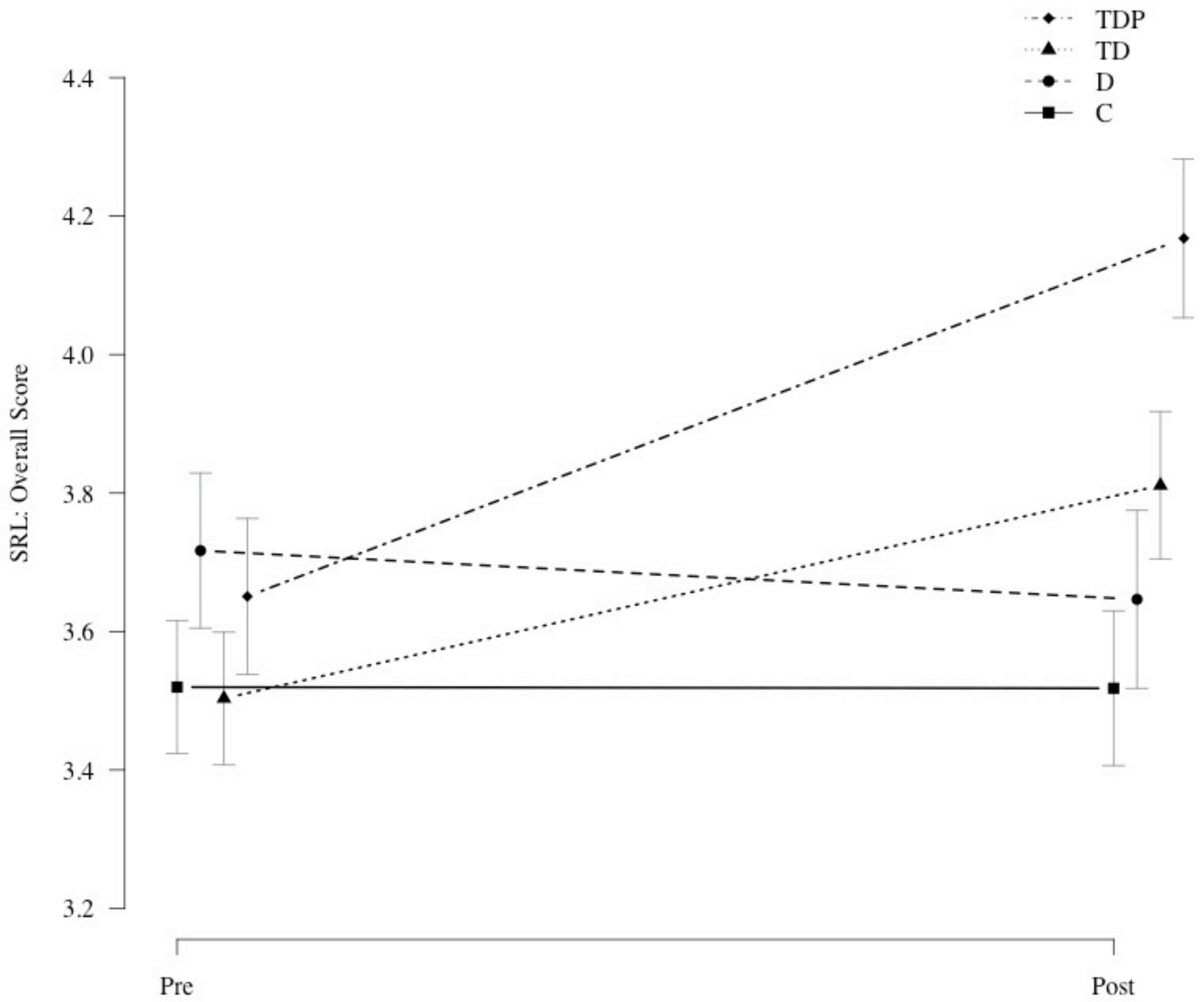

Figure 4. SRL overall scores on pre- and post-tests for Groups C (control group), D (diary), TD (training + diary), and TDP (training + diary + peer feedback intervention)

To investigate the group differences in depth, we calculated contrasts for the selection of dependent variables used in the second MANOVA. We tested whether the gains of the four experimental groups (e.g., mathematics focus score for Group TD in the post-test minus mathematics focus score for Group TD in the pre-test) differed from zero in a statistically significant manner.

As seen in Table 6, Group TD showed statistically significant increases in SRL knowledge (β = 3.95; $p < .001$), in the SRL overall score (β = .31; $p < .001$) and in self-efficacy (β = .20; p = .04) but not in mathematics scores. Similarly, for Group TDP, the increases in SRL knowledge

($\beta = 4.61$; $p < .001$), in the SRL overall score ($\beta = .52$; $p < .001$) and in self-efficacy ($\beta = .28$; $p < .01$) were determined to be statistically significant. By contrast to Group TD, Group TDP showed statistically significant increases in the mathematics focus score ($\beta = 1.23$; $p < .001$). Groups C and D showed no statistically significant increases in any dependent variable.

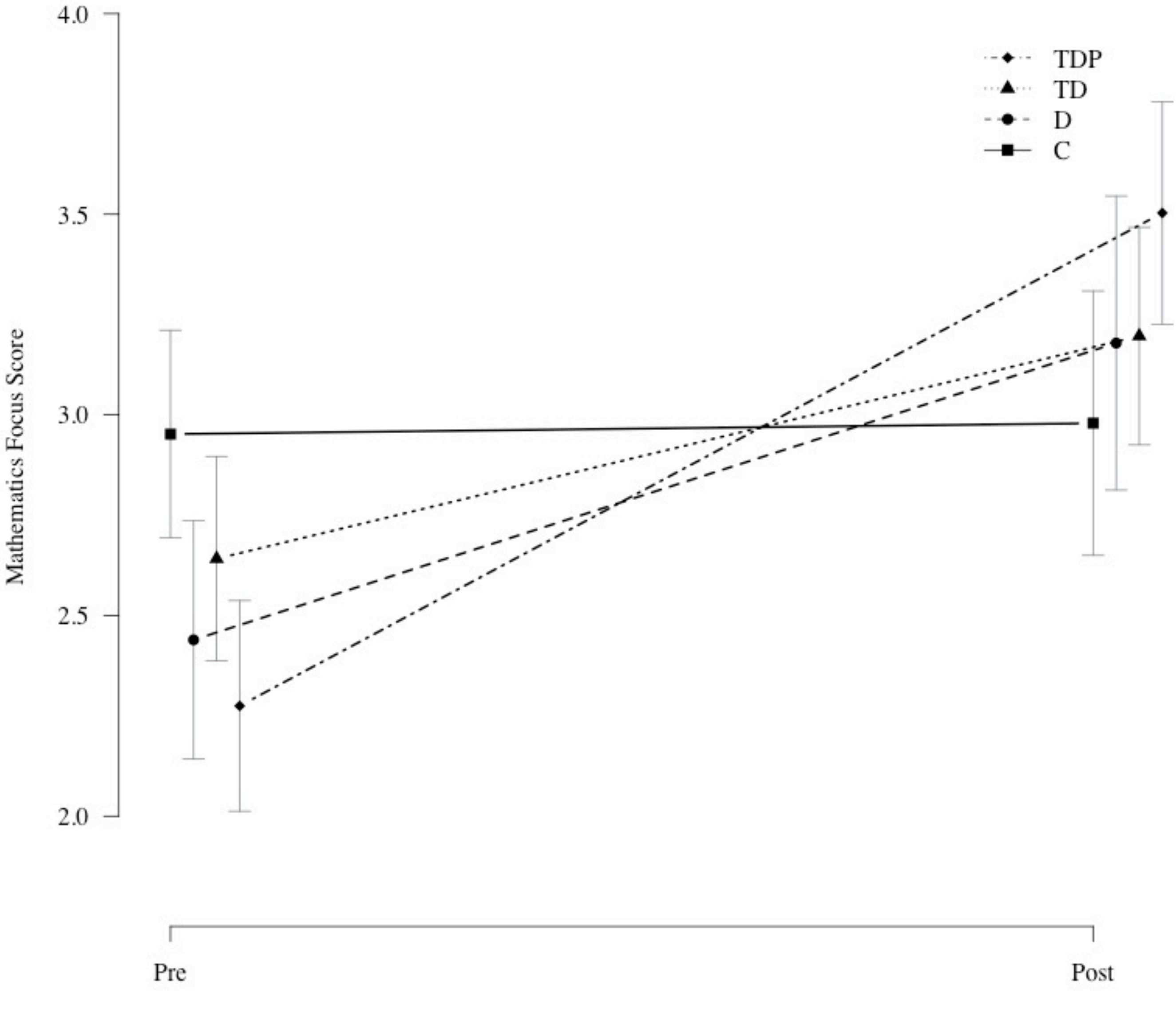

Figure 5. Mathematics focus scores on pre- and post-tests for Groups C (control group), D (diary), TD (training + diary), and TDP (training + diary + peer feedback intervention)

In the third MANOVA, we examined the influence of the interventions on the SRL subscales goal-setting, planning, self-motivation, volition, elaboration, metacognition, and reflection. Here as well, we observed a statistically significant main effect of group (Pillai's trace = .62, $F(3, 132) = 3{,}23$; $p < .001$), a statistically significant main effect of time (Pillai's trace = .70,

$F(1, 132) = 28{,}15$; $p < .001$), and a statistically significant interaction between the two factors (Pillai's trace = .85, $F(3, 132) = 4{,}98$; $p < .001$). The results of the following univariate ANOVAs are presented in Table 5. The subscales planning, self-motivation, volition, elaboration, and metacognition all revealed statistically significant interaction effects consistent with our hypotheses, with Group TDP outperforming the other two intervention groups and control Group C showing no positive or negative trends. For the subscales goal-setting and reflection, the interaction effects marginally missed statistical significance although descriptive data indicated the hypothesized direction.

Table 6

Planned contrasts: Gains of the four experimental groups from pre-test to post-test

	Group C (N = 34)	Group D (N = 28)	Group TD (N = 40)	Group TDP (N = 34)
	β (SE)	β (SE)	β (SE)	β (SE)
SRL Knowledge Test	-.06 (.32)	.04 (.35)	3.95 (.30) ***	4.62 (.32) ***
Self-Efficacy	-.13 (.07)	.09 (.08)	.20 (.07) *	.28 (.07) **
SRL Overall Score	.00 (.08)	-.07 (.08)	.31 (.07) ***	.52 (.08) ***
SRL Goal-Setting	-.28 (.11)	-.12 (.13)	.02 (.11)	.13 (.11)
SRL Planning	.06 (.13)	.29 (.15)	.55 (.12) ***	.80 (.13) ***
SRL Self-Motivation	-.04 (.14)	-.37 (.16)	.32 (.13)	.50 (.14) **
SRL Volition	.12 (.15)	-.28 (.16)	.33 (.13)	.48 (.15) *
SRL Elaboration	-.32 (.14)	-.19 (.16)	.20 (.13)	.23 (.14)
SRL Metacognition	.19 (.14)	.18 (.15)	.44 (.13) **	.88 (.14) ***
SRL Reflection	.16 (.16)	-.12 (.18)	.28 (.15)	.52 (.16) *
Mathematics Focus Score	.03 (.30)	.74 (.33)	.56 (.28)	1.23 (.30) ***

Note. * $p < .05$. ** $p < .01$. *** $p < .001$

Again, we calculated contrasts for the selection of the dependent variables used in the third MANOVA to investigate gains of the four experimental groups (see Table 6). Although Group C and Group D showed no statistically significant increases in any of the SRL subscales, Group TD showed statistically significant increases in planning ($\beta = .55$; $p < .001$) and in metacognition ($\beta = .44$; $p < .01$). Group TDP also showed statistically significant increases in planning ($\beta = .80$; $p < .001$) and in metacognition ($\beta = .88$; $p < .001$); in addition, Group TDP showed statistically significant increases in self-motivation ($\beta = .50$; $p < .01$), volition ($\beta = .48$; $p =$

.01), and reflection ($\beta = .52$; $p = .02$). However, gains in goal-setting and elaboration remained statistically non-significant for Group TDP.

Using a one-way ANOVA, we analyzed time investment in the preparation course measured by log files. Because there was no pre-test score for this measure, we could not include this variable in the MANOVA models described above. The differences between group means (Group C: $M = 21.03$ hours, $SD = 17.56$; Group D: $M = 28.23$ hours, $SD = 14.13$; Group TD: $M = 29.32$ hours, $SD = 17.79$; Group TDP: $M = 33.56$ hours, $SD = 18.87$) were determined to be significant ($F(3, 132) = 3{,}08$; $p = .030$; $\eta^2{}_p = .06$). Contrast analyses revealed that differences between adjacent Groups C and D ($p < .01$), D and TD ($p = .02$), and TDP and TD ($p = .03$) all were significant. Notably, the log files only reflected time spent on the mathematics platform; the files did not include time spent with the three interventions learning diary, WBT, and peer feedback groups.

7.5 Discussion

The present study investigated the effects of three separate interventions that all proposed to foster self-regulated learning in an e-learning environment. A sample of 136 prospective students (after dropout and data cleansing) participated in an online mathematics preparation course for four weeks before beginning their first university semester in mathematically oriented fields. Participants were randomized into one of four experimental groups that had access to either a learning diary (Group D), a combination of a diary and web-based self-regulation training (Group TD), a combination of a diary, web-based training and a peer-feedback intervention (Group TDP), or none of the interventions (control Group C). We measured the effects on an SRL knowledge test, an SRL questionnaire, and a self-efficacy questionnaire. To assess mathematical performance, we administered a mathematics test that covered all of the chapters from the preparation course. In addition to the overall score for this test, a focus score was calculated for a selection of mathematical problems that each participant chose to be particularly important to that participant personally. Furthermore, log files from the mathematics learning platform were analyzed with regard to time investment.

We conducted a series of analyses that began on a rather broad top level (MANOVA for all dependent variables), followed by a more detailed middle level (separate ANOVAs for each dependent variable), and ending on a quite specific low level (separate contrasts for gains of each experimental group in each dependent variable). Lower levels of analyses only occurred if significant results on the respective higher level warranted deeper inspection of the effects. All top-level MANOVAs showed significant interaction effects, indicating that different developments in the four groups occurred in at least some of the dependent variables. The following ANOVAs revealed statistically significant interaction effects for all dependent variables, except for the mathematics overall score and the SRL subscales goal-setting and reflection (all of which marginally missed the level of statistical significance). Because these findings did not provide information regarding the exact groups between which statistically significant differences occurred, we relied primarily on the contrast analyses to decide whether to accept or reject our hypotheses.

In Hypothesis 1, we postulated positive effects of the learning diary on self-reported SRL behavior, self-efficacy, mathematics performance, and time investment. Although on a descriptive level, at least some of the dependent variables (e.g., SRL subscale planning, self-efficacy, and the mathematics overall score) showed promising gains, none of the increases reached statistical significance. We only observed a greater time investment for the diary group compared with the control group. In the context of the present preparation course, this result may be regarded as desirable. Although in other learning scenarios, an increased time investment is not necessarily beneficial, a mean time investment of only 21 hours in the control group cannot possibly be sufficient to review all chapters of the preparation course when the responsible lecturers estimated a duration of four weeks of full-time work. A mean increase of seven hours in Group D, although desirable, is not satisfactory.

We therefore reject the first hypothesis. The learning diary used in the present study clearly did not provide substantial help to participants. This result matches findings from Bellhäuser and colleagues (2016), who observed no positive effects of a learning diary in a setting comparable to the present study. Perhaps the diary should have been accompanied by a tutorial explaining the potential benefits of learning diaries as demonstrated in other studies (Korotitsch & Nelson-Gray, 1999; Schmitz & Perels, 2011).

In Hypothesis 2, we postulated positive effects of the web-based self-regulation training on declarative SRL knowledge, self-reported SRL behavior, self-efficacy, and mathematics performance, exceeding the effects of the diary-only intervention. As expected, both groups with access to the web-based training increased declarative knowledge regarding SRL. This result may be regarded as a manipulation check that was positive. For the SRL questionnaire, we observed statistically significant increases in Group TD that were not present in Group D, indicating that the additional WBT was responsible for this improvement. Investigating the seven subscales of the SRL questionnaire provided even more detailed insights: descriptively, Group TD outperformed Group D on every subscale. Statistical significance, however, could only be determined for the subscales planning and metacognition. Clearly, the WBT was particularly successful in conveying these contents. Furthermore, we observed a statistically significant increase in self-efficacy for Group TD although less prominent than the gains on the SRL questionnaire. For mathematics performance, we did not observe gains in Group TD beyond the general positive main effect for time that was observed for all experimental groups. Concerning time investment, we observed a statistically significant difference between Groups TD and D (and therefore necessarily also between TD and C).

Combining the results of the web-based training on SRL, we concluded that our hypothesis can be accepted with one exception: the WBT helped participants improve their SRL knowledge, their SRL behavior (predominantly in the domains of planning and metacognition), their self-efficacy, and their time investment but not their mathematics performance. Comparing these results to Bellhäuser and colleagues (2016) leads us to believe that the WBT has been substantially improved in the present study because the previous study observed some negative effects of the WBT on mathematics performance.

Hypothesis 3 postulated positive effects of the peer feedback intervention groups on self-reported SRL behavior, self-efficacy, mathematics performance, and time investment, above and beyond the effects of the pure web-based training. Descriptively, we determined that effects for Group TDP in the majority of the dependent variables were more pronounced than the effects for Group TD (e.g., SRL overall score or self-efficacy). Furthermore, we determined all statistically significant gains present in Group TD to be statistically significant in Group TDP although several statistically significant gains could not be observed in Group TD.

As expected, the participants in Group TDP experienced increases in declarative SRL knowledge identical to the gains in Group TD. For self-reported SRL behavior, both the overall score and the subscales planning and metacognition showed gains, mirroring the results from Group TD and Group TDP. However, whereas Group TD experienced no statistically significant increases in any of the other subscales, Group TDP showed statistically significant improvements in self-motivation, volition, and reflection. The additional peer feedback intervention appears to have facilitated better use of the strategies concerning self-motivation, volition, and reflection taught in the WBT.

Because the peer feedback tasks involved discussions regarding the individual time schedule (Task 1 after Lesson 1 of the WBT), cognitive learning strategies (Task 2 after Lesson 2 of the WBT), and reflection on their progress to date (Task 3 after Lesson 3 of the WBT), we believe that all SRL subscales were targeted by the peer feedback intervention: goal-setting and planning were addressed in peer feedback Task 1 and Task 3; self-motivation, volition, and reflection were primarily addressed in peer feedback Task 3; elaboration and metacognition were primarily addressed in peer feedback Task 2. We therefore deem it plausible that Group TDP showed greater gains than Group TD on most SRL subscales. Nevertheless, no statistically significant increases could be detected for the subscales goal-setting and elaboration. For goal-setting, this may be the result of a ceiling effect – this subscale showed the highest pre-intervention scores, leaving less room for improvements than the other subscales. In the case of elaboration, the rather general learning strategies taught in the WBT may not have been sufficiently adjusted to the exact context of the mathematics preparation course. The peer feedback following Task 2 (discussing the use of the learning strategies taught in the WBT) can clearly only improve elaboration (as measured by our questionnaire) if the strategies taught in the WBT in fact fit the needs of participants in the preparation course. For self-efficacy, we observed slightly higher gains in Group TDC compared with Group TD. However, this positive effect appears to be rather small.

In our first analysis, the effect on the mathematics performance remained marginally below the level of statistical significance because we evaluated the mathematics overall score (including all problems from the mathematics test). However, when examining mathematics focus scores (including only those problems from chapters that participants chose as important to those participants personally) we observed statistically significant increases for Group TDP. This result may be regarded as the core finding of our study: the combination of learning diary, web-based training on SRL, and an additional peer feedback intervention group was effective in improving objective performance.

The mean time investment in Group TDP was 33 hours, which is longer than time spent in the other groups but nevertheless failed to meet the expectations of the responsible lecturers of the preparation course. However, voluntary mathematics preparation courses without face-to-face interaction with tutors and peers, particularly in the age group of approximately twenty-year-olds, may have had little chance to convince participants to sacrifice more of their leisure time.

The results from the peer feedback intervention groups support Hypothesis 3: the combined intervention in Group TDP helped participants increase their declarative SRL knowledge, improve their SRL behavior (in all but two subscales), increase self-efficacy, increase their time investment, and improve their mathematics performance. Compared with the results of Bellhäuser and colleagues (2016), the supplementary peer feedback tasks appeared to substantially improve the quality of the intervention. Because the time span of the present study was only four weeks and the combined intervention only took a few hours (including all three lessons of the WBT, the corresponding peer feedback tasks, and the learning diary), we consider the combined intervention quite successful and efficient.

7.5.1 Limitations

The major limitation of the present study concerns the sample of participants: because the mathematics course serves to prepare students for mathematically oriented fields (computer science, civil engineering, mechanical engineering, and mathematics), our sample was predominantly male and may not be representative of students from other fields. The rather large dropout rate in our study exacerbates this issue. However, we could only identify statistically significant differences between dropouts and remaining participants in conscientiousness and the mathematics test with the majority of the other variables showing no differences.

Another limitation arises from our study design: We did not separate the three different interventions (diary, WBT, and peer feedback intervention) but rather chose a nested design that tested a selection of three different combinations against one another. This approach was selected partially because the peer feedback intervention tasks were inherently cumulative to the web-based training and would not have made sense in isolation. A completely balanced design with all eight combinations of interventions was therefore not feasible; the sample size within each cell could have been problematic as well. We opted to leave out a possible Group T (web-based training without diary or peer feedback intervention) because Bellhäuser and colleagues (2016) included such a condition in their design. However, we implemented instead the diary-only Group D, mostly to collect time-series data for participants without access to the WBT although the present paper does not include these analyses.

One concern regarding our study may be that improvements in the mathematics test across all experimental groups appear to be relatively small. Of 53 possible points, the global mean was 19.5 on the pre-test and 20.7 on the post-test. Although this main effect of time did reach statistical significance, the effect did not meet expectations (similar to the manner in which the time investment of participants was not satisfying either). Perhaps the mathematics test was too difficult or that the time allotted was too restrictive. Another reason may be that participants were more motivated and concentrated more during the pre-test than the post-test, particularly because the test had no consequences for the students' future field of study. Without the external pressure, the primary motivation for good performance may have been to evaluate one's own knowledge and possibly compare oneself to future peers. Because the pre-test had previously provided crucial feedback evaluating current knowledge, when the time came for the post-test, some participants may have felt only the need to complete the test for the lottery – the self-evaluating aspect of the mathematics test may have been less important. Furthermore, allocating one uninterrupted hour for the mathematics test and trying to focus as much as possible on that test may have been easier for participants at the beginning of the preparation course (one month before beginning of the semester) than at the end of the course (a few days before the first lectures). Organizational problems such as moving to a different city or managing a household for the first time on one's own possibly conflicted more with academic aspirations on the post-test than on the pre-test.

7.5.2 Summary and Future Research

Our results indicated that the combined intervention comprising the learning diary, web-based training, and self-regulated learning with subsequent peer feedback intervention was the most successful, with beneficial effects on self-regulated learning, time investment, self-efficacy, and mathematics performance. The combination of the learning diary and web-based training without peer feedback intervention was determined to have statistically significant yet slightly less pronounced effects on self-regulated learning, time investment, and self-efficacy but not on mathematics performance. Using a learning diary without supplementary interventions did not appear to improve self-regulated learning. Because WBT, once that training is created, can serve virtually unlimited numbers of participants, we advocate its application in educational settings in which large groups of students require support in their self-regulated learning, particularly in distance learning environments that prevent face-to-face training. The additional peer feedback intervention appears to be a useful supplement to WBT, and its organizational costs are comparably low: Participants were assembled into groups of five and were given a group discussion task after each of the three lessons of the WBT. These group discussions regarding their individual learning schedules, their learning strategies, and their progress in the preparation course appeared to substantially increase the beneficial effects of the WBT.

Future studies should investigate the mechanisms of the peer feedback intervention. The mere act of forming small groups could have increased motivation, particularly because the online preparation course may be experienced as a rather solitary task. Our choice of group discussion tasks was theoretically grounded in the process model of SRL (Schmitz & Wiese, 2006); however, it would be possible to create different group tasks to investigate the effects of the exact formulation of the task. In our study, participants did not receive instruction on how to give feedback. As shown by Gielen and colleagues (2010), explaining to students the criteria of good peer feedback can increase the effectiveness of peer feedback. Therefore, future peer feedback interventions should include instruction.

A completely different yet certainly also promising approach would be to have learning groups discuss the actual learning content rather than their learning behavior on a meta-level. In the case of the online preparation course, members of a learning group could be asked to discuss their understanding of mathematical problems or even solve complex problems collectively. Possibly the best support for learners would be to combine group tasks that cover the actual learning content with a task that focuses on self-regulated learning.

Although the overall effect of the peer feedback intervention was convincing, not all groups benefitted to the same extent. It appears worthwhile to investigate the causes of inter-group differences. One approach may be to improve group formation by considering personality traits when determining the composition of groups. As Martins, Gilson, and Maynard (2004) noted, most personality traits are less important for successful group formation on virtual teams than in face-to-face interactions. However, technical expertise appears to be a key variable for virtual teams, and group composition should perhaps consider a minimum level of technical expertise for every team. Another approach may be to provide more support for the teamwork process. In particular, asynchronous communication appears to be an issue (Durnell Crampton, 2002). Inactivity or delayed activity on virtual teams can lead to problems in communication; participants may require instruction on how to address the resulting ambiguity. Although we are not aware of conflicts in any of the peer feedback intervention groups in our study, generally, virtual teams appear to be more prone to conflicts than face-to-face groups (Mortensen & Hinds, 2001). Again, this issue may require prior instruction.

8 Study 3: PeerLA - Assistant for individual learning goals and self-regulation competency improvement in online learning scenarios

8.1 Abstract

While online learning is already a part of university education and didactics, not all students have the necessary self-regulation competency to really learn on their own efficiently and effectively. In classroom a teacher can take over a moderating part, set intermediate goals and give feedback to one's progress, but participants of online learning courses (e.g. in blended scenarios or Massive Open Online Courses (MOOCs)) face a higher demand of self-regulation competency. This paper presents a course and content independent assistant, PeerLA, which assists in improving self-regulation competency. PeerLA allows setting of long-term goals, breakdown into intermediate goals and keeps track of knowledge increase or time needed. A graphical feedback allows comparison of existing and aimed level of knowledge or time investments. PeerLA adds peer comparison to the visualization charts for social frame of reference. This comparison is course-wide or only with similar learners (close in goals and knowledge levels). PeerLA is implemented as a Learning Management System (LMS) plugin to support learning progress in mixed formal and informal learning scenarios. PeerLA was evaluated with 83 students in an online mathematics preparation course over four weeks. Results indicate the benefits of such a self-regulation assistance, especially for university freshmen.

8.2 Introduction and Motivation

In contrast to educational data mining, learning analytics (LA) aims to aggregate data in the field of technology enhanced learning (TEL), visualize it to support reflection and insight, but leave the decision and action to the stakeholders (concept of human-in-the-loop) (Drachsler & Greller, 2012). The primary focus of research and LA software is on support for teachers to give them intermediate and immediate information about various parameters of learners' activity. Less than half of the research aims at supporting the learners themselves with such continuous analytics overview (Durall & Gros, 2014). Such LA solutions for learners provide primarily data about one's own learning activities and progress, but do not allow the comparison to other peers that are similar in knowledge level and learning goals (as these aspects are hard to track). As LMS, like Moodle (2014) or Edmodo (2008), as well do not support a social awareness of other learners' activities, online learning consequently lacks social interaction support. The potential of peer learning is widely known, especially in constructivist learning theory it is an important part of motivation and social norming (Damon, 1984). A peer learning group provides orientation about how to structure one's learning, how to set intermediate goals, what to prioritize and which scheduling of times for learning peers do. While academia is increasing use of blended learning and online learning scenarios, especially for first-term students, the learning analytics components of the used LMS need to increase their support for visualizations to learners and support for peer comparison as well. We call this the *lack of Peer Learning Analytics (L1)*.

Educational systems like universities originate from times when learners were not always-on and had an overwhelming amount of information sources at their fingertips. This availability demands a strongly developed self-regulation competency. Not all students have the needed competency level to set own goals and structure their learning activities, especially when migrating from school to university (Peverly et al., 2003). Consequently, the value of learning in classes is not anymore the offered access to information and knowledge, but the offered pre-structuring and guidance through the overwhelming amount of information (to be transformed in knowledge by learning activities). MOOCs offer primarily this value of pre-structuring and guidance (scaffolding). Still, this approach neglects the increasing diversity of learners' prior knowledge due to informal (online) learning or different prior study courses. Consequently, in an LMS a combination of predefined (formal) and individual (informal) learning paths needs to be supported that learners can set their own priorities and goals within the pre-structured courses. We call this the *lack of scaffolding for formal and informal learning together within a course (L2)*.

Finally, due to the individualization of the learning paths, as well as the different prior knowledge, uncertainty increases about the time investment needed for a learner to succeed in a course. In a heterogeneous learner group an average value from prior terms is insufficient as a reference. Still, learners need orientation for their scheduling. One correct calculable value does not exist as circumstances change in each term, e.g. participants and parts of course content. Prior research ambitions to track all invested times and activities to predict needed effort to reach set goals were of limited success due to the challenge to properly track learning activities outside of the online system, e.g. learning group meetings or book reading. In this context we see for existing online learning solutions the *lack of an individualized time investment estimation (L3).*

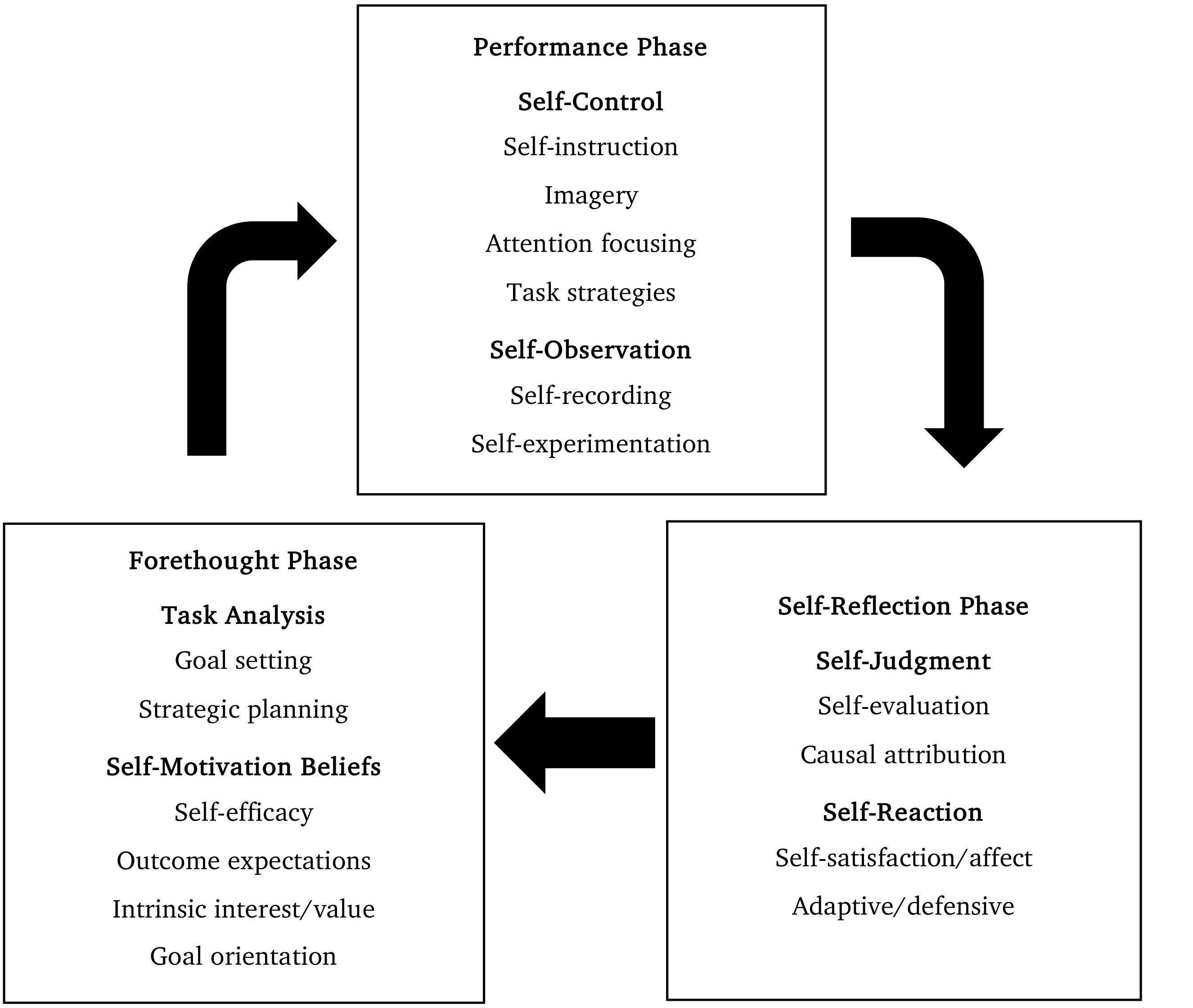

Figure 6. Model of Self-Regulation (Zimmerman & Campillo, 2003)

The goal of the proposed process model and implementation PeerLA is to support individual learners in setting learning goals, tracking their progress, planning learning intervals and assist them with visualizations and comparisons to not only course peers, but peers with similar goals and levels of knowledge. To the best of our knowledge no model and implementation exists that focuses on combined support for formal and informal learning in university courses with online learning parts. Furthermore, PeerLA proposes a new approach towards self-regulated learning support by combining accepted models from psychology, computer science and pedagogy. Section 8.3 will outline the related work and approach, followed by the detailed description of the implemented process model PeerLA in Section 8.4. After a brief summary of the implementation and evaluation in Section 8.5 the most relevant results are shown and discussed in Section 8.6 before the Conclusion and Outlook is given in Section 8.7.

8.3 Related Work and Approach

Even though a lot of computer science research activities are reported that focus on support for learners to set, track and reach their goals in informal learning scenarios, the majority of courses contain both, formal and informal parts (Malcolm, Hodkinson, & Colley, 2003). For such mixed scenarios with different levels of prior knowledge, different learning goals and time investment, but the same formal frame conditions, learners need a proper scheduling support to keep track of their individual goals, course goals and time restrictions. When mixed scenarios integrate online learning to allow students more individualized learning activities, the problem of learning (time) management and structuring learning into goals increases further (Lee, 2004; Nawrot & Doucet, 2014).

8.3.1 Using the Self-Regulation Model

From educational psychology, concepts for improving self-regulation competency are well investigated. While several different definitions and models exist (Burman, Green, & Shanker, 2015), we understand self-regulated learning as a learner's process of iteratively planning, acting and reflecting on learning activities towards the learner's individual goals. In this sense, the socio-cognitive model by Zimmerman and Campillo (2003) has been widely accepted. It is independent from learner's personality traits. This allows its usage in online scenarios where learner profiles are not covering personality aspects or learning style preferences. Additionally, the process character of the model allows the integration with process models from agile project management (see next section). In the model a learner passes the three phases of forethought, performance and self-reflection in a cycle (see Figure 6 for each phase's major psychological concepts and effects).

For the scenario of university courses with online learning we pay specific attention to support *goal setting* and defining *outcome expectations* (Forethought), *attention focusing*, *self-observation* tracking (Performance), *self-evaluation* and *adaption* (Self-Reflection) due to sophisticated research results about the positive effect of properly set goals for learning and performance. Properly means goals that are specific, measurable, accepted, realistic and terminated (SMART) (Locke & Latham, 2002). Specific goals are proven to increase self-motivation (Bandura, 1988) and if a goal is challenging (but realistic) it is even accepted in case in may not be fully reached (Locke & Latham, 2002). Mandatory termination and setting of measures allows a quantified decision about the level of success. PeerLA aims therefore for a two-level approach on goal-setting as suggested by Bandura (1988): Long-term (course) goals and goals within individual short-term learning intervals (e.g. lasting one week). The former primarily support goal-orientation and self-evaluation. It is important to allow open text answers in goal setting as well as assessment and reflection on one's progress and not limit learners to scales and dropdowns. Unfortunately, this leads to challenges in using the data for computational analysis of how well in time and value the goals were reached. Thus, short-term goals are supported to be set with an assisting form wizard that allows learners to connect goals with course topics, enter the desired skill levels and estimated time investments.

This two-level approach supports setting individual learning goals and priorities, but aligned to the preset, static course topics and content given (cf. L2).

8.3.2 Using SCRUM

Managing and structuring progress under uncertainty and changing goals is a problem that has been addressed in the field of software development earlier. Pre-structuring the whole process with intermediate goals and time estimations (waterfall model) proved to be too static and agile development models became popular. SCRUM is one of such elaborated models (Schwaber & Sutherland, 2013). Primarily it consists of user stories, that represent overall goals collected in a backlog. The most important ones are focuses on within a repeating time interval, called sprint, e.g. four weeks long. The time needed to finish the tasks related to a user-story is estimated by all team members individually to come to a concise effort estimation (planning poker). Each day the progress is quickly assessed in a daily scrum meeting. When a sprint is over a review and retrospective allows to reflect over the achievements and process. Our proposed solution uses parts of SCRUM in the online learning context to support individual learners in planning their next learning interval (the sprint). The needed parts of SCRUM map nicely to the self-regulation model as shown in Table 7.

Table 7

Mapping of SCRUM and self-regulation model elements

Self-regulation model part	**SCRUM model part**
Goal orientation, expectation	Backlog
(Long-term) goal	User story
(Short-term) goal	Task
Learning interval	Sprint
Time estimation	Planning poker
Self-recording	Daily scrum
Self-evaluation, adaption	Sprint review, retrospective

Time estimation during planning can be supported by calculating the accuracy of estimations of this learner in prior learning intervals and report this back as a *skill-improvement per time rate* which supports a more realistic time investment estimation (cf. L3). Self-recording during a learning interval can be supported by a wizard that provides assessment of skill level changes and time invested so far.

8.3.3 Using Peer Education

The third approach that is combined in PeerLA with the other two mentioned above, is the concept of peer education from pedagogics. We confer this to be the most innovative aspect of PeerLA as it extends the idea behind the time investment estimations from SCRUM to the possibility of social norming and orientation on other learners' set goals and levels of knowledge in the course topics (cf. L1). This is expected to support improvements on self-regulation competency, because the major problem in setting realistic (SMART) goals is a missing reference frame that gives orientation for the estimations. Specifically, for learning uncertainty about the complexity of the topics and about the amount of missing knowledge is common. The *Wise* framework for learning analytics with a focus on learners (Wise, 2014) proposes principles to be followed in order to prevent false interpretation and to provide data analysis assistance to learners: 1.) *Integration*: Data displaying needs to be grounded to learning activities and integrated into the learning environments, 2.) *Agency*: Learners need support in judging the data themselves and taking own conclusions, 3.) *Reference frame*: Learners need representative reference values for interpreting data. Wise highlights that average values as reference are often misleading as they are distorted by a.) inactive learners and b.) differing goals among learners. Our solution respects the principles as follows. Each learner is ranking the own level of knowledge for each area covered in the course before and after working on own learning goals (within one learning interval). Additionally, they estimate their time investments at the beginning and log the effective needed time. Such data not only allows a prediction of remaining time needed to reach an aimed level of knowledge for the individual, but also is used to calculate a similarity of learners and provide comparison to most similar other learners which are comparable in levels of knowledge, aimed levels and time investments (cf. L1 and L3).

The use of all three concepts (from computer science, psychology and pedagogy) will be explained in more detail in the following section.

8.4 Proposed Solution PeerLA

PeerLA has been developed with the primary focus on online learning scenarios where course material is pre-structured into n sections (e.g. chapters) and consists of several s sources (e.g. files) and k skills to be covered within a strict time period $[x, y]$ (e.g. one semester). The simplified PeerLA learning process model is shown in Figure 7. Each process element has its own more detailed sub-process as described in the following.

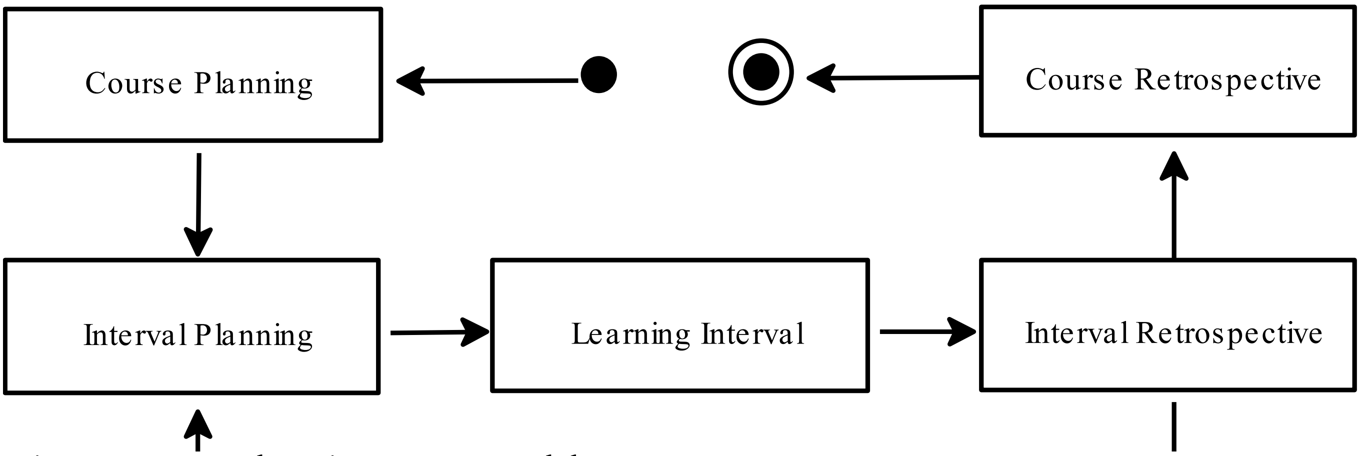

Figure 7. PeerLA learning process model

8.4.1 A two-level process to structure learning of skills

Teachers enter in the LMS the skills to be covered (usually as learning goals or similar). On first process step *course planning* learners (a.) formulate free text goals and enter their targeted course grade, (b.) they estimate their prior knowledge for each of the k skills and (c.) then map their text goals to targeted levels of skills (for a. and b. see Figure 8 and Figure 9)

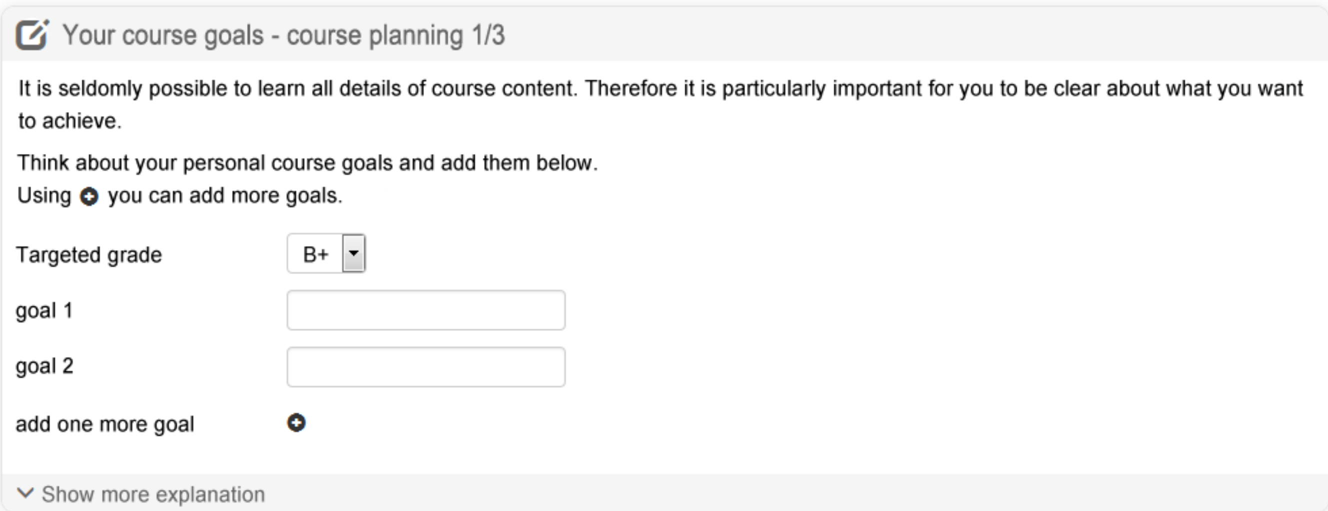

Figure 8. Targeted grade and free text long-term goals (course planning phase, step a)

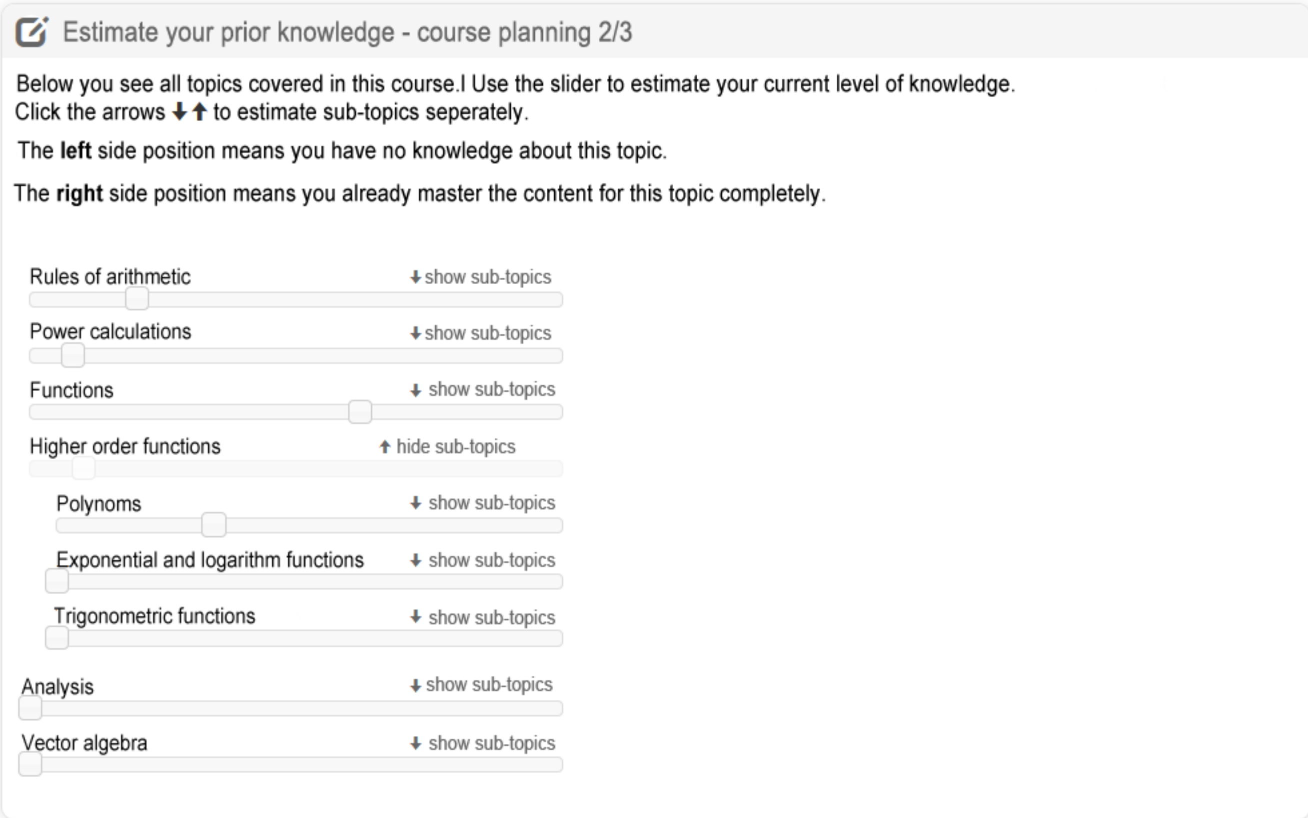

Figure 9. Estimation of skill level (course planning phase, step b)

8.4.2 Time Investment Tracking in Learning Intervals

Learning interval duration is aligned with the *n* course phases, e.g. repeating lecture times mark the end of an interval (usually each week). Learners select one specific skill for a short-term goal, select one of the *s* learning resource that is available in the course (or add a new one themselves) and the activity for it (looking at, summarizing, exercising, etc.). The activities are aligned to Bloom's taxonomy of learning goal levels (Bloom, 1956). Based on the selected skill, their own skill level and the selected activity a suggested value for time is displayed. It is calculated as the average of all learners similar in skill (current and targeted), skill selected and activity (see Figure 10). Finally, learners select their learning days of the interval and estimated time needed. During the interval they can always adjust the goal status, invested time and progress in the skills (see Figure 11).

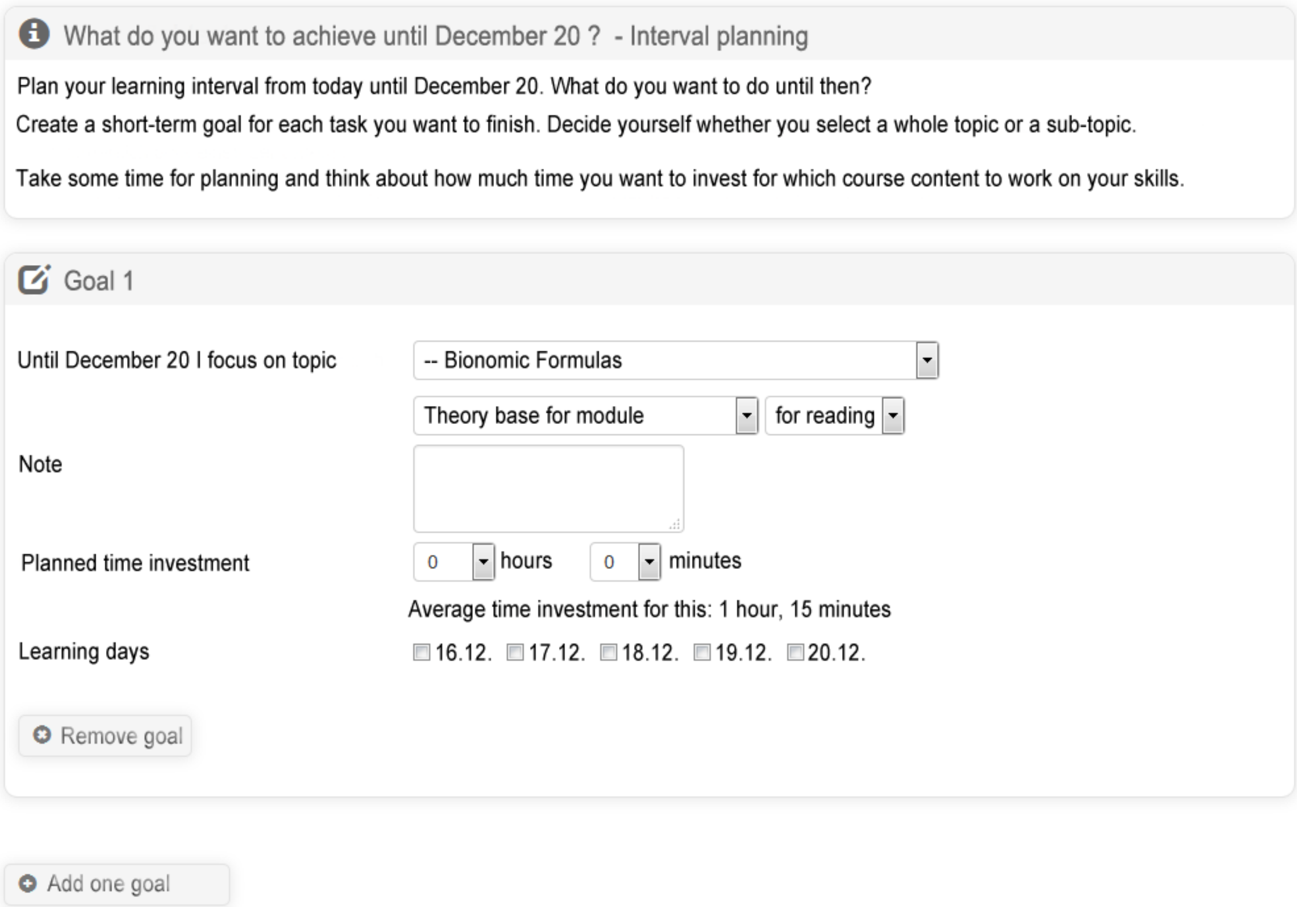

Figure 10. Setting up short-term goal(s), aligned with course skills (interval planning phase)

8.4.3 Reflection on and improving of learning activities

At the end of a learning interval learners update their interval progress finally. They are shown an overview of their long-term goals and the short-term goals worked on during the interval with a status icon (undone, in progress, done) for each. They can finally update these goals (all unfinished ones are automatically transferred to the next interval). Then can reflect over the good and bad aspects of their learning interval (using textual inputs). These are displayed on next interval planning (no figures for this in the paper).

When the last interval is over a similar screen is shown for the overall course retrospective and the final achieved grade is entered. This is used to calculate correlation of skill improvements, time investments and activities with the reaching of grade goals. The better the correlation the more such figures influence time suggestions for next term students (not discussed in detail here).

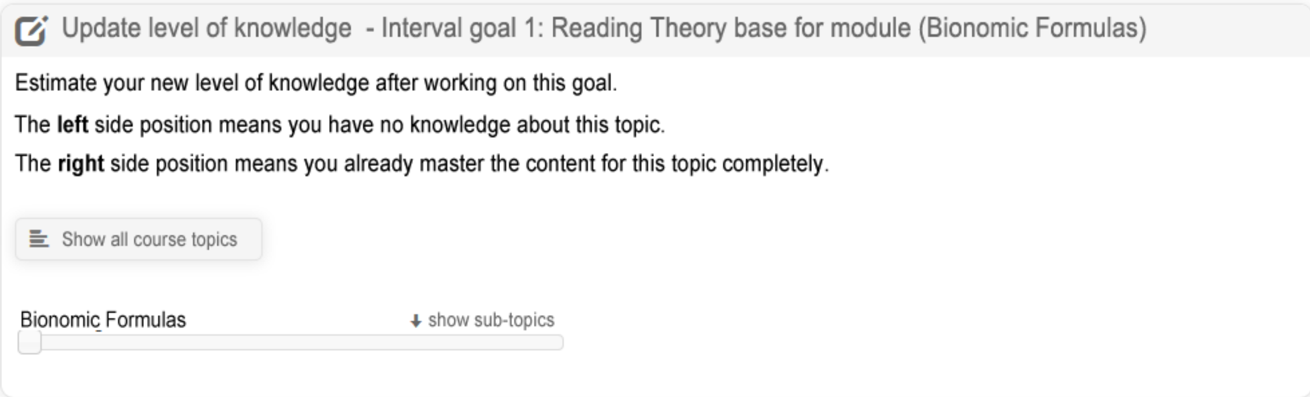

Figure 11. Adjusting level(s) of knowledge (during interval)

8.4.4 Learning Analytics with Social Alignment

In parallel to the process support described above, PeerLA offers an always accessible visualization of time investments and skill levels (current or targeted). The bar charts show learners own values, the average of similar users (see above description of similar) and all active learners of the course as displayed in Figure 12.

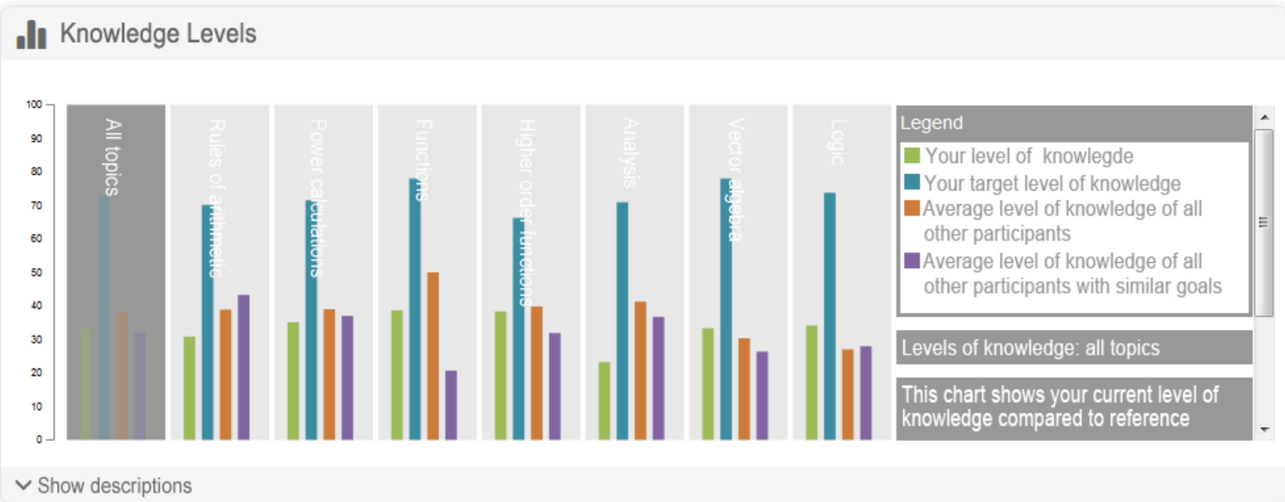

Figure 12. Peer learning analytics diagram (with legend)

This interactive chart is displayed directly below the dialogues mentioned above (respecting Wise's integration principle and reference frame). Thereby, PeerLA assists in time estimations and in social reference of levels of knowledge (current and targeted).

8.5 Implementation and Evaluation

PeerLA has been implemented as a set of plugins for the LMS Moodle v2.8, because Moodle is widely used in European universities. For interactive charts and responsiveness of the user interface JavaScript libraries jQuery and D3.js are used. PeerLA integrates into common course view as a side-box and parses the course structure automatically to assist in short-term goal setting (using the available learning material) and adjusts the time interval to course dates.

For evaluation we added PeerLA to the Moodle instance of our university for the math preparation courses in summer 2015. All freshmen of natural sciences can voluntarily take this course in the four-week period before their first semester starts. The course contains weekly examination tests to be conducted in order to identify one's own gaps in math knowledge. Consequently, PeerLA suggested four learning intervals. The course does not give any grades. Thus, the PeerLA question on the desired grade could be skipped.

After the four weeks, we asked them in a questionnaire about the whole math course as well two open text questions about PeerLA: *What do you consider as positive about PeerLA? What do you want to tell us additionally (improvements, negative aspects, etc.)?* Our aim for the first evaluation was to get insight about the level of acceptance for such functionality and how useful students find PeerLA for setting (and working on) their goals. This results are expected to identify how well the concept of integrating SCRUM and peer reference data with the self-regulation model works. With these results we will conduct a deeper study in summer 2016 about intensity of usage, number of set goals and effect to self-regulation competency and knowledge gain by using an AB-test setup.

8.6 Results

749 students participated in the math preparation course. 83 of them responded in the PeerLA evaluation. 83 of them responded in the PeerLA evaluation. Analysis of the evaluation answers revealed that the Moodle server was responding too slow or was completely offline for several days. Therefore, most students dropped the voluntary course. The answers to our questions were categorized in positive, neutral and negative aspects as shown in Figure 13.

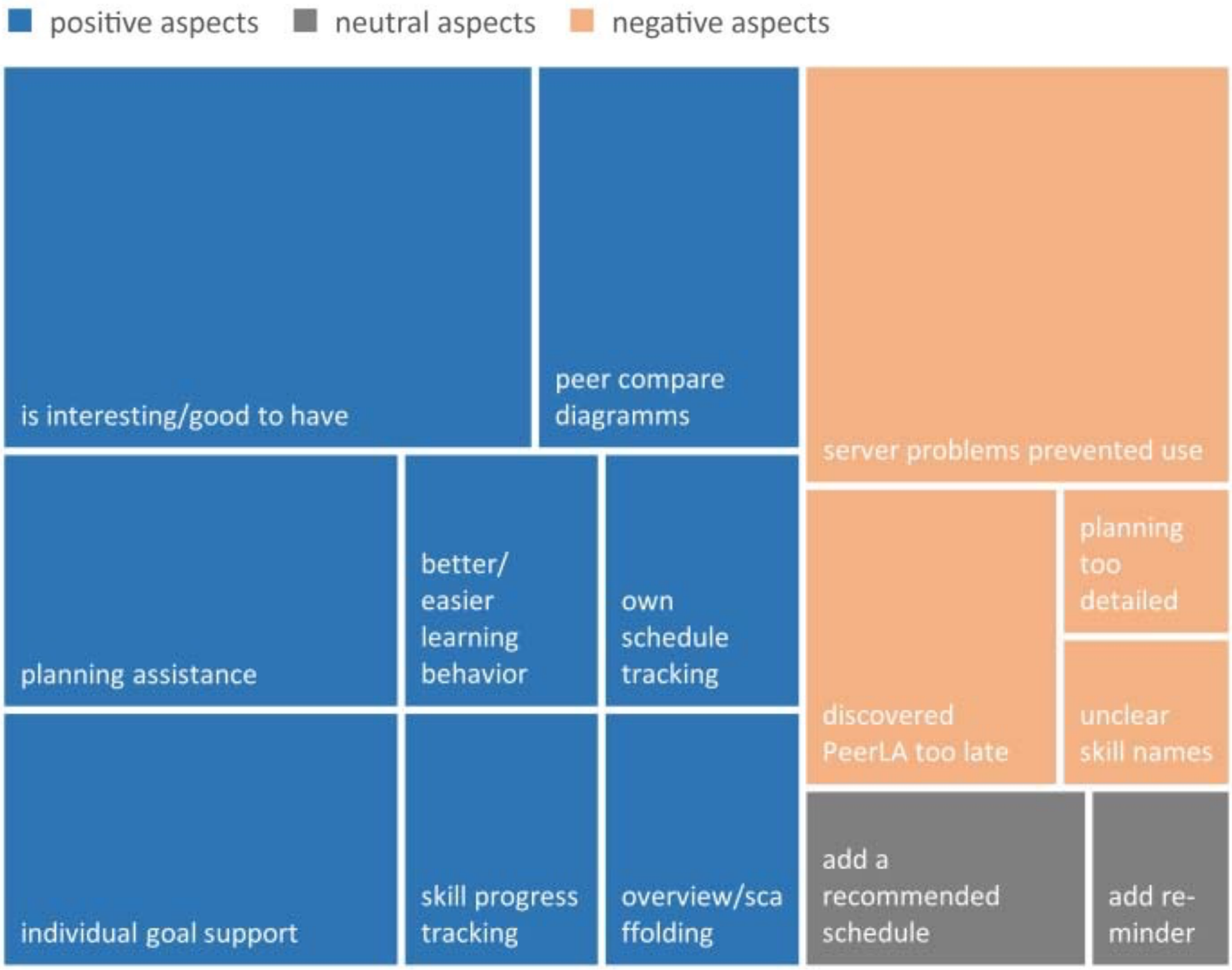

Figure 13. Treemap of categorized qualitative evaluation answers

The size of answer squares is relative to frequency. 67% of the answers were positive aspects. Beside a general appreciation (*good to have*), the planning assistance and possibility to set individual goals (aligned to course content) the mostly liked functionality is the comparison to other peers' knowledge level and time investment.

Only 2.3% found the planning process too detailed. For 7.1%, who discovered PeerLA too late, we will add an explicit notification of course functionality at start. For next evaluation the server outages must be addressed as they negatively influenced the results.

8.7 Conclusion and Outlook

The results indicate that PeerLA is a successful approach towards learning goal planning and assistance in self-regulation for online learning scenarios. It's most innovative value comes from the combination of SCRUM model and self-regulation model with the peer learning analytics. Participants valued the visualization of skill levels and time investments to track their own progress but as well align it with their similar peers. PeerLA will be published as an open-source plugin for Moodle on http://github.com/peerla/peerla. Open questions for the planned evaluation in summer 2016 are the effect to self-regulation competency and skill improvement. Additionally, a dynamic scaffolding is planned to address different levels of existing self-regulation competency. Also, PeerLA would benefit from more research on extensive reference value calculation.

References

Adair, J. G. (1984). The Hawthorne effect: A reconsideration of the methodological artifact. *Journal of Applied Psychology*, *69*(2), 334–345. doi:10.1037/0021-9010.69.2.334

Alexander, P. (2008). Why this and why now? Introduction to the special issue on metacognition, self-regulation, and self-regulated learning. *Educational Psychology Review*, *20*(4), 369–372. doi:10.1007/s10648-008-9089-0

Alonso Tapia, J., Panadero, E., & Ruiz, M. A. (2014). Development and validity of the Emotion and Motivation Self-Regulation Questionnaire (EMSR-Q). *The Spanish Journal of Psychology*, *17*(June 2015), 1–35. doi:10.1017/sjp.2014.41

Artino, A. R., & Stephens, J. M. (2009). Academic motivation and self-regulation: A comparative analysis of undergraduate and graduate students learning online. *The Internet and Higher Education*. doi:10.1016/j.iheduc.2009.02.001

Azevedo, R. (2002). Beyond intelligent tutoring systems: Using computers as METAcognitive tools to enhance learning? *Instructional Science*, *30*(1), 31–45.

Azevedo, R., & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? *Journal of Educational Psychology*, *96*(3), 523–535. doi:10.1037/0022-0663.96.3.523

Azevedo, R., Cromley, J. G., & Seibert, D. (2004). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia? *Contemporary Educational Psychology*, *29*(3), 344–370. doi:10.1016/j.cedpsych.2003.09.002

Azevedo, R., Greene, J. A., & Moos, D. C. (2007). The effect of a human agent's external regulation upon college students' hypermedia learning. *Metacognition and Learning*, *2*(2-3), 67–87. doi:10.1007/s11409-007-9014-9

Azevedo, R., Greene, J. A., Moos, D. C., Winters, F. I., Godbole-Chaudhuri, P., & Cromley, J. G. (2006). Is externally-regulated learning by a human tutor effective in facilitating learning with hypermedia? In *Proceedings of the 7th international conference on Learning sciences* (pp. 16–22).

Bandura, A. (1988). Self-regulation of motivation and action through goal systems. In *Cognitive Perspectives on Emotion and Motivation* (pp. 37–61). Dordrecht: Springer Netherlands. doi:10.1007/978-94-009-2792-6_2

Bandura, A. (1994). Self-Efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (4th ed., pp. 71–81). New York: Academic Press.

Bannert, M., & Reimann, P. (2011). Supporting self-regulated hypermedia learning through prompts. *Instructional Science*, *40*(1), 193–211. doi:10.1007/s11251-011-9167-4

Bausch, I., Biehler, R., Bruder, R., Fischer, P. R., Hochmuth, R., Koepf, W., & Wassong, T. (2014). VEMINT – Interaktives Lernmaterial für mathematische Vor- und Brückenkurse. In I. Bausch, R. Biehler, R. Bruder, P. R. Fischer, R. Hochmuth, W. Koepf, … T. Wassong (Eds.), *Mathematische Vor- und Brückenkurse: Konzepte, Probleme und Perspektiven* (pp. 261–276). Springer Fachmedien Wiesbaden. doi:10.1007/978-3-658-03065-0

Bell, S. T. (2007). Deep-level composition variables as predictors of team performance: A meta-analysis. *Journal of Applied Psychology*, *92*(3), 595–615. doi:10.1037/0021-9010.92.3.595

Bellhäuser, H., Lösch, T., Winter, C., & Schmitz, B. (2016). Applying a web-based training to foster self-regulated learning – Effects of an intervention for large numbers of participants. *The Internet and Higher Education*, 1–43. doi:10.1016/j.iheduc.2016.07.002

Benz, B. F. (2010). *Improving the quality of e-learning by enhancing self-regulated learning. A synthesis of research on self-regulated learning and an implementation of a scaffolding concept*. *E-learning*. TU Darmstadt, Germany. Retrieved from http://tuprints.ulb.tu-darmstadt.de/2194/

Bischof, N. (1985). *Das Rätsel Ödipus - Die biologischen Wurzeln des Urkonfliktes von Intimität und Autonomie*. München: Piper.

Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-regulated learning: Beliefs, techniques, and illusions. *Annual Review of Psychology*, *64*(1), 417–44. doi:10.1146/annurev-psych-113011-143823

Bloom, B. S. (1956). *Taxonomy of educational objectives, book 1, cognitive domain*. New York: Longman.

Boekaerts, M., & Corno, L. (2005). Self-regulation in the classroom: A perspective on assessment and intervention. *Applied Psychology*, *54*(2), 199–231. Retrieved from http://www3.interscience.wiley.com/journal/118652637/abstract

Broadbent, J., & Poon, W. L. (2015). Self-regulated learning strategies and academic achievement in online higher education learning environments: A systematic review. *The Internet and Higher Education*, *27*, 1–13. doi:10.1016/j.iheduc.2015.04.007

Burman, J. T., Green, C. D., & Shanker, S. (2015). On the meanings of self-regulation: Digital humanities in service of conceptual clarity. *Child Development*, *86*(5), 1507–1521. doi:10.1111/cdev.12395

Butz, S., Hertel, S., Bellhäuser, H., Karlen, Y., Spinath, B., Maag Merki, K., & Schmitz, B. (2016). Vermittlung von Selbstreguliertem Lernen in der Studieneingangsphase: Die Wirksamkeit von Präsenz- und E-Learning-Kursen im Vergleich. *Lehren Und Lernen*, *6*, 11–17.

Cassidy, G., & MacDonald, R. A. R. (2007). The effect of background music and background noise on the task performance of introverts and extraverts. *Psychology of Music*. doi:10.1177/0305735607076444

Damon, W. (1984). Peer education: The untapped potential. *Journal of Applied Developmental Psychology*, *5*(4), 331–343. doi:10.1016/0193-3973(84)90006-6

Davies, J., & Graff, M. (2005). Performance in e-learning: online participation and student grades. *British Journal of Educational Technology*, *36*(4), 657–663. doi:10.1111/j.1467-8535.2005.00542.x

Devolder, A., van Braak, J., & Tondeur, J. (2012). Supporting self-regulated learning in computer-based learning environments: Systematic review of effects of scaffolding in the domain of science education. *Journal of Computer Assisted Learning*, *28*(6), 557–573. doi:10.1111/j.1365-2729.2011.00476.x

Dignath, C., Buettner, G., & Langfeldt, H.-P. (2008). How can primary school students learn self-regulated learning strategies most effectively? *Educational Research Review*, *3*(2), 101–129. doi:10.1016/j.edurev.2008.02.003

Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. *Metacognition and Learning*, *3*(3), 231–264. doi:10.1007/s11409-008-9029-x

Doran, G. T. (1981). There's a SMART way to write management's goals and objectives. *Management Review*, *70*(11), 35–36.

Drachsler, H., & Greller, W. (2012). The pulse of learning analytics understandings and expectations from the stakeholders. In *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge - LAK '12* (p. 120). New York, New York, USA: ACM Press. doi:10.1145/2330601.2330634

Duffy, M. C., & Azevedo, R. (2015). Motivation matters: Interactions between achievement goals and agent scaffolding for self-regulated learning within an intelligent tutoring system. *Computers in Human Behavior*, *52*, 338–348. doi:10.1016/j.chb.2015.05.041

Durall, E., & Gros, B. (2014). Learning analytics as a metacognitive tool. In *Proceedings of the 6th International Conference on Computer Supported Education* (pp. 380–384). SCITEPRESS - Science and and Technology Publications. doi:10.5220/0004933203800384

Durnell Crampton, C. (2002). Finding Common Ground in Dispersed Collaboration. *Organizational Dynamics*, *30*(4), 356–367. doi:10.1016/S0090-2616(02)00063-3

Edmodo. (2008). Edmodo. Retrieved from http://www.edmodo.com

Fabriz, S., Dignath-van Ewijk, C., Poarch, G., & Büttner, G. (2014). Fostering self-monitoring of university students by means of a standardized learning journal—a longitudinal study with process analyses. *European Journal of Psychology of Education*, *29*(2), 239–255. doi:10.1007/s10212-013-0196-z

Festinger, L. (1954). A theory of social comparison processes. *Human Relations*. doi:10.1177/001872675400700202

Field, A., Miles, J., & Field, Z. (2013). *Discovering statistics using R*. London: Sage.

Fischer, P. R. (2009). E-Learning zwischen Schule und Universität? Ergebnisse einer empirischen Studie zum Einsatz einer E- Variante mathematischer Brückenkurse. In *Beiträge zum Mathematikunterricht*. Oldenburg: Gesellschaft für Mathematik.

Gielen, S., Peeters, E., Dochy, F., Onghena, P., & Struyven, K. (2010). Improving the effectiveness of peer feedback for learning. *Learning and Instruction*, *20*(4), 304–315. doi:10.1016/j.learninstruc.2009.08.007

Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist*, *54*(7), 493–503. doi:10.1037/0003-066X.54.7.493

Hadwin, A. F., Järvelä, S., & Miller, M. (2011). Self-regulated, co-regulated, and socially shared regulation of learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of Self-Regulation of Learning and Performance* (pp. 65–84). New York: Routledge.

Hallgren, R. C., Parkhurst, P. E., Monson, C. L., & Crewe, N. M. (2002). An interactive, web-based tool for learning anatomic landmarks. *Academic Medicine*, *77*(3), 263. Retrieved from http://journals.lww.com/academicmedicine/Abstract/2002/03000/An_Interactive,_Web_based_Tool_for_Learning.18.aspx

Hattie, J., Biggs, J., & Purdie, N. (1996). Effects of learning skills interventions on student learning: A meta-analysis. *Review of Educational Research*, *66*(2), 99–136. doi:10.3102/00346543066002099

Heckhausen, H., & Kuhl, J. (1985). From wishes to action. In M. Frese & J. Sabini (Eds.), *Goal Directed Behavior: The Concept of Action in Psychology* (pp. 134–159). Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Hooper, S.-R., Wakely, M.-B., de Kruif, R. E. L., & Swartz, C.-W. (2006). Aptitude–treatment interactions revisited: Effect of metacognitive intervention on subtypes of written expression in elementary school students. *Developmental Neuropsychology*, *29*(1), 217–241. doi:10.1207/s15326942dn2901_11

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, *38*(5), 365–379. doi:10.3102/0013189X09339057

Kistner, S., Rakoczy, K., Otto, B., Dignath-van Ewijk, C., Büttner, G., & Klieme, E. (2010). Promotion of self-regulated learning in classrooms: investigating frequency, quality, and consequences for student performance. *Metacognition and Learning*, *5*(2), 157–171. doi:10.1007/s11409-010-9055-3

Konert, J., Bellhäuser, H., Röpke, R., Gallwas, E., & Zucik, A. (2016). MoodlePeers: Factors relevant in learning group formation for improved learning outcomes, satisfaction and commitment in E-learning scenarios using GroupAL. In *Proc. of 11th Euopean Conference on Technology Enhanced Learning (EC-TEL 2016)*. Lyon, France.

Korotitsch, W. J., & Nelson-Gray, R. O. (1999). An overview of self-monitoring research in assessment and treatment. *Psychological Assessment*, *11*(4), 415–425. doi:10.1037/1040-3590.11.4.415

Kramarski, B., & Mizrachi, N. (2006). Online discussion and self-regulated learning: Effects of instructional methods on mathematical literacy. *The Journal of Educational Research*, *99*(4), 218–231. doi:10.3200/JOER.99.4.218-231

Kuhl, J., & Fuhrmann, A. (1998). Decomposing self-regulation and self-control: The volitional components inventory. In J. Heckhausen & C. S. Dweck (Eds.), *Motivation and self-regulation across the life span.* (pp. 15–49). New York, NY, US: Cambridge University Press. doi:10.1017/CBO9780511527869.003

Lee, I. (2004). Searching for new meanings of self-regulated learning in e-learning environments. In L. Cantoni & C. McLoughlin (Eds.), *Proceedings of EdMedia: World Conference on Educational Media and Technology 2004* (pp. 3929–3934). Lugano, Switzerland: Association for the Advancement of Computing in Education (AACE). Retrieved from http://www.editlib.org/p/12089

Leidinger, M., & Perels, F. (2012). Training self-regulated learning in the classroom: Development and evaluation of learning materials to train self-regulated learning during regular mathematics lessons at primary school. *Education Research International*, *2012*, 1–14. doi:10.1155/2012/735790

Liu, N.-F., & Carless, D. (2006). Peer feedback: the learning element of peer assessment.

Teaching in Higher Education, *11*(3), 279–290. doi:10.1080/13562510600680582

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, *57*(9), 705–717. doi:10.1037/0003-066X.57.9.705

Malcolm, J., Hodkinson, P., & Colley, H. (2003). The interrelationships between informal and formal learning. *Journal of Workplace Learning*, *15*(7/8), 313–318. doi:10.1108/13665620310504783

Manz, C., & Sims, H. (1980). Self-Management as a Substitute For Leadership: A Social Learning Theory Perspective. *Academy of Management Review*, *5*(3), 361–367. Retrieved from http://amr.aom.org/content/5/3/361.short

Margaryan, A., Bianco, M., & Littlejohn, A. (2014). Instructional Quality of Massive Open Online Courses (MOOCs). *Computers & Education*, *80*, 77–83. doi:10.1016/j.compedu.2014.08.005

Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual Teams: What Do We Know and Where Do We Go From Here? *Journal of Management*, *30*(6), 805–835. doi:10.1016/j.jm.2004.05.002

Mattern, J., & Bauer, J. (2014). Does teachers' cognitive self-regulation increase their occupational well-being? The structure and role of self-regulation in the teaching context. *Teaching and Teacher Education*, *43*(May), 58–68. doi:10.1016/j.tate.2014.05.004

Mischel, W., Shoda, Y., & Rodriguez, M. (1989). Delay of gratification in children. *Science*, *244*(4907), 933–938. doi:10.1126/science.2658056

Moodle. (2014). Moodle. Retrieved from http://moodle.org/

Mortensen, M., & Hinds, P. J. (2001). Conflict And Shared Identity In Geographically Distributed Teams. *International Journal of Conflict Management*, *12*(3), 212–238. doi:10.1108/eb022856

Myung, S.-K., McDonnell, D. D., Kazinets, G., Seo, H. G., & Moskowitz, J. M. (2009). Effects of web- and computer-based smoking cessation programs: Meta-analysis of randomized controlled trials. *Archives of Internal Medicine*, *169*(10), 929–37. doi:10.1001/archinternmed.2009.109

Nagengast, B., & Marsh, H. W. (2012). Big fish in little ponds aspire more: Mediation and cross-cultural generalizability of school-average ability effects on self-concept and career aspirations in science. *Journal of Educational Psychology*, *104*(4), 1033–1053. doi:10.1037/a0027697

Nawrot, I., & Doucet, A. (2014). Building engagement for MOOC students. In *Proceedings of the 23rd International Conference on World Wide Web - WWW '14 Companion* (pp. 1077–1082). New York, New York, USA: ACM Press. doi:10.1145/2567948.2580054

Nelson, M. M., & Schunn, C. D. (2009). The nature of feedback: how different types of peer feedback affect writing performance. *Instructional Science*, *37*(4), 375–401. doi:10.1007/s11251-008-9053-x

Neve, M., Morgan, P. J., Jones, P. R., & Collins, C. E. (2010). Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: A systematic review with meta-analysis. *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity*, *11*(4), 306–21. doi:10.1111/j.1467-789X.2009.00646.x

O'Reilly, T., Sinclair, G. P., & McNamara, D. (2004). iSTART: A web-based reading strategy intervention that improves students' science comprehension. In *Proceedings of the IADIS International Conference Cognition and Exploratory Learning in Digital Age: CELDA* (pp. 173–180). Lisbon: Citeseer. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.87.5605&rep=rep1&type=pdf

Oettingen, G., Pak, H., & Schnetter, K. (2001). Self-regulation of goal setting: Turning free fantasies about the future into binding goals. *Journal of Personality and Social Psychology*, *80*(5), 736–753. doi:10.1037/0022-3514.80.5.736

Onah, D. F. O., Sinclair, J., & Boyatt, R. (2014). Dropout rates of massive open online courses behavioural patterns. In *6th International Conference on Education and New Learning Technologies* (pp. 5825–5834). doi:10.13140/RG.2.1.2402.0009

Panadero, E., Klug, J., & Järvelä, S. (2015). Third wave of measurement in the self-regulated learning field: When measurement and intervention come hand in hand. *Scandinavian Journal of Educational Research*, 1–13. doi:10.1080/00313831.2015.1066436

Perels, F., Gürtler, T., & Schmitz, B. (2005). Training of self-regulatory and problem-solving competence. *Learning and Instruction*, *15*(2), 123–139. doi:10.1016/j.learninstruc.2005.04.010

Perels, F., Merget-Kullmann, M., Wende, M., Schmitz, B., & Buchbinder, C. (2009). Improving self-regulated learning of preschool children: Evaluation of training for kindergarten teachers. *The British Journal of Educational Psychology*, *79*(2), 311–27. doi:10.1348/000709908X322875

Peterson, C., Semmel, A., von Baeyer, C., Abramson, L. Y., Metalsky, G. I., & Seligman, M. E. P.

(1982). The attributional style questionnaire. *Cognitive Therapy and Research*, *6*(3), 287–299. doi:10.1007/BF01173577

Peverly, S. T., Brobst, K. E., Graham, M., & Shaw, R. (2003). College adults are not good at self-regulation: A study on the relationship of self-regulation, note taking, and test taking. *Journal of Educational Psychology*, *95*(2), 335–346. doi:10.1037/0022-0663.95.2.335

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement*, *53*(3), 801–813. doi:10.1177/0013164493053003024

Price, K. H., Harrison, D. A., Gavin, J. H., & Florey, A. T. (2002). Time, teams, and task performance: Changing effects of surface- and deep-level diversity on group functioning. *Academy of Management Journal*, *45*(5), 1029–1045. doi:10.2307/3069328

Raudenbush, S. W. (1994). Random effects models. In H. M. Cooper & L. V. Hedges (Eds.), *The Handbook of Research Synthesis* (pp. 301–321). New York, NY, US: Russell Sage Foundation.

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: A systematic review and meta-analysis. *Psychological Bulletin*, *138*(2), 353–87. doi:10.1037/a0026838

Ridings, C. M., Gefen, D., & Arinze, B. (2002). Some antecedents and effects of trust in virtual communities. *The Journal of Strategic Information Systems*, *11*(3-4), 271–295. doi:10.1016/S0963-8687(02)00021-5

Roth, A., Ogrin, S., & Schmitz, B. (2015). Assessing self-regulated learning in higher education: a systematic literature review of self-report instruments. *Educational Assessment, Evaluation and Accountability*, 1–44. doi:10.1007/s11092-015-9229-2

Rusman, E., Bruggen, J. Van, Cörvers, R., Sloep, P., & Koper, R. (2009). From pattern to practice: Evaluation of a design pattern fostering trust in virtual teams. *Computers in Human Behavior*, *25*(5), 1010–1019. doi:10.1016/j.chb.2009.01.002

Ryan, R., & Deci, E. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*(1), 54–67. doi:10.1006/ceps.1999.1020

Schmidt, K., Allgaier, A., Lachner, A., Stucke, B., Rey, S., Frömmel, C., … Nückles, M. (2011). Diagnostik und Förderung selbstregulierten Lernens durch Self-Monitoring-Tagebücher. *Zeitschrift Für Hochschulentwicklung*, *6*(3), 246–269.

Schmidt, M., Perels, F., & Schmitz, B. (2010). How to perform idiographic and a combination of idiographic and nomothetic approaches. *Zeitschrift Für Psychologie / Journal of Psychology*, *218*(3), 166–174. doi:10.1027/0044-3409/a000026

Schmitz, B. (1990). Univariate and multivariate time-series models: The analysis of intraindividual variability and intraindividual relationships. In A. von Eye (Ed.), *Statistical methods in longitudinal research, Vol. II: Time series and categorical longitudinal data* (pp. 351–386). New York: Academic Press.

Schmitz, B. (2001). Self-Monitoring zur Unterstützung des Transfers einer Schulung in Selbstregulation für Studierende: eine prozessanalytische Untersuchung. *Zeitschrift Für Pädagogische Psychologie*, *15*(3), 181–197. doi:10.1024//1010-0652.15.34.181

Schmitz, B. (2006). Advantages of studying processes in educational research. *Learning and Instruction*, *16*(5), 433–449. doi:10.1016/j.learninstruc.2006.09.004

Schmitz, B., & Perels, F. (2011). Self-monitoring of self-regulation during math homework behaviour using standardized diaries. *Metacognition and Learning*, *6*(3), 255–273. doi:10.1007/s11409-011-9076-6

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*(1), 64–96. doi:10.1016/j.cedpsych.2005.02.002

Schütte, M., Wirth, J., & Leutner, D. (2012). Lernstrategische Teilkompetenzen für das selbstregulierte Lernen aus Sachtexten. *Psychologische Rundschau*, *63*(1), 26–33. doi:10.1026/0033-3042/a000107

Schwaber, K., & Sutherland, J. (2013). The Scrum Guide. *Scrum Alliance*, 17. Retrieved from http://www.scrumguides.org/docs/scrumguide/v1/Scrum-Guide-US.pdf

Schwarzer, R., & Jerusalem, M. (1999). *Skalen zur Erfassung von Lehrer- und Schülermerkmalen - Dokumentation der psychometrischen Verfahren im Rahmen der Wissenschaftlichen Begleitung des Modellversuchs Selbstwirksame Schulen*. Berlin: Freie Universität Berlin.

Schwonke, R., Ertelt, A., Otieno, C., Renkl, A., Aleven, V., & Salden, R. J. C. M. (2013). Metacognitive support promotes an effective use of instructional resources in intelligent tutoring. *Learning and Instruction*, *23*(1), 136–150. doi:10.1016/j.learninstruc.2012.08.003

Siegler, R. S. (2007). Microgenetic analyses of learning. In D. Kuhn, R. S. Siegler, W. Damon, & R. M. Lerner (Eds.), *Handbook of child psychology* (6th ed., Vol. 2, pp. 464–510). Hoboken, NJ: John Wiley & Sons, Inc. doi:10.1002/9780470147658.chpsy0211

Sitzmann, T., & Ely, K. (2011). A meta-analysis of self-regulated learning in work-related training and educational attainment: What we know and where we need to go. *Psychological Bulletin*, *137*(3), 421–42. doi:10.1037/a0022777

Sitzmann, T., Kraiger, K., Stewart, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: A meta-analysis. *Personnel Psychology*, *59*(3), 623–664. doi:10.1111/j.1744-6570.2006.00049.x

Statistisches Bundesamt Deutschland. (2015). *Pressemitteilung vom 26. November 2014 – 2,7 Millionen Studierende im Wintersemester 2014/2015*. Wiesbaden. Retrieved from https://www.destatis.de/DE/PresseService/Presse/Pressemitteilungen/2014/11/PD14_419_213pdf.pdf?__blob=publicationFile

Stewart, G. L., Courtright, S. H., & Manz, C. C. (2011). Self-Leadership: A Multilevel Review. *Journal of Management*, *37*(1), 185–222. doi:10.1177/0149206310383911

Tabachnick, B. G., & Fidell, L. S. (2012). *Using multivariate statistics (6th ed.)*. London, UK: Pearson.

Tobias, R., & Inauen, J. (2010). Gathering time-series data for evaluating behavior-change campaigns in developing countries: Reactivity of diaries and interviews. *Evaluation Review*, *34*(5), 367–390. doi:10.1177/0193841X10383940

Trevors, G. J., Duffy, M. C., & Azevedo, R. (2014). Note-taking within MetaTutor: interactions between an intelligent tutoring system and prior knowledge on note-taking and learning. *Educational Technology Research and Development*, *62*(5), 507–528. doi:10.1007/s11423-014-9343-8

van den Boom, G., Paas, F., & van Merriënboer, J. J. G. (2007). Effects of elicited reflections combined with tutor or peer feedback on self-regulated learning and learning outcomes. *Learning and Instruction*, *17*(5), 532–548. doi:10.1016/j.learninstruc.2007.09.003

van den Boom, G., Paas, F., van Merriënboer, J. J. G., & van Gog, T. (2004). Reflection prompts and tutor feedback in a web-based learning environment: effects on students' self-regulated learning competence. *Computers in Human Behavior*, *20*(4), 551–567. doi:10.1016/j.chb.2003.10.001

Wantland, D. J., Portillo, C. J., Holzemer, W. L., Slaughter, R., & McGhee, E. M. (2004). The Effectiveness of Web-Based vs. Non-Web-Based Interventions: A Meta-Analysis of Behavioral Change Outcomes. *Journal of Medical Internet Research*, *6*(4), e40. doi:10.2196/jmir.6.4.e40

Wäschle, K., Lachner, A., Stucke, B., Rey, S., Frömmel, C., & Nückles, M. (2014). Effects of visual feedback on medical students' procrastination within web-based planning and reflection protocols. *Computers in Human Behavior*, *41*, 120–136. doi:10.1016/j.chb.2014.09.022

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. doi:10.1037/0022-3514.54.6.1063

Webber, J., Scheuermann, B., McCall, C., & Coleman, M. (1993). Research on self-monitoring as a behavior management technique in special education classrooms: A descriptive review. *Remedial and Special Education, 14*(2), 38–56. doi:10.1177/074193259301400206

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review*, *92*(4), 548–573. doi:10.1037/0033-295X.92.4.548

Werth, S., Wagner, W., Ogrin, S., Trautwein, U., Friedrich, A., Keller, S., … Schmitz, B. (2012). Förderung des selbstregulierten Lernens durch die Lehrkräftefortbildung «Lernen mit Plan»: Effekte auf fokale Trainingsinhalte und die allgemeine Unterrichtsqualität. *Zeitschrift Für Pädagogische Psychologie*, *26*(4), 291–305. doi:10.1024/1010-0652/a000080

Wheelan, S. A. (2009). Group Size, Group Development, and Group Productivity. *Small Group Research*, *40*(2), 247–262. doi:10.1177/1046496408328703

Wild, K.-P., & Schiefele, U. (1994). Lernstrategien im Studium: Ergebnisse zur Faktorenstruktur und Reliabilität eines neuen Fragebogens. *Zeitschrift Für Differentielle Und Diagnostische Psychologie*, *15*(4), 185–200.

Winne, P. H. (2014). Issues in researching self-regulated learning as patterns of events. *Metacognition and Learning*, *9*(2), 229–237. doi:10.1007/s11409-014-9113-3

Winters, F. I., Greene, J. A., & Costich, C. M. (2008). Self-Regulation of Learning within Computer-based Learning Environments: A Critical Analysis. *Educational Psychology Review*, *20*(4), 429–444. doi:10.1007/s10648-008-9080-9

Wirth, J., & Leutner, D. (2008). Self-regulated learning as a competence. *Zeitschrift Für Psychologie / Journal of Psychology*, *216*(2), 102–110. doi:10.1027/0044-3409.216.2.102

Wise, A. F. (2014). Designing pedagogical interventions to support student use of learning analytics. In *Proceedins of the Fourth International Conference on Learning Analytics And Knowledge - LAK '14* (pp. 203–211). New York, New York, USA: ACM Press. doi:10.1145/2567574.2567588

Zhou, M., & Winne, P. H. (2012). Modeling academic achievement by self-reported versus traced goal orientation. *Learning and Instruction*, *22*(6), 413–419.

doi:10.1016/j.learninstruc.2012.03.004

Ziegler, C.-N., & Golbeck, J. (2007). Investigating interactions of trust and interest similarity. *Decision Support Systems*, *43*(2), 460–475. doi:10.1016/j.dss.2006.11.003

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist*, *25*(1), 3–17.

Zimmerman, B. J. (2000). Attaining Self-Regulation: A Social Cognitive Perspective. In M. Boekaerts, M. Zeidner, & P. R. Pintrich (Eds.), *Handbook of Self-Regulation* (pp. 13–39). London, UK: Elsevier Academic Press. Retrieved from http://doi.apa.org/psycinfo/2001-01625-001

Zimmerman, B. J., & Campillo, M. (2003). Motivating self-regulated problem solvers. In J. E. Davidson & R. J. Sternberg (Eds.), *The Psychology of Problem Solving* (pp. 233–262). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511615771

Zimmerman, B. J., & Kitsantas, A. (2014). Comparing students' self-discipline and self-regulation measures and their prediction of academic achievement. *Contemporary Educational Psychology*, *39*(2), 145–155. doi:10.1016/j.cedpsych.2014.03.004

Zimmerman, B. J., & Schunk, D. H. (2011). *Handbook of self-regulation of learning and performance*. New York, NY; London: Routledge : Taylor & Francis Group.

Appendices

9 Appendix A: Description of the Training

9.1 Lesson 1 – Before Learning

The first lesson contains the three chapters *Introduction*, *Setting Goals*, and *Time Management*.

The chapter *Introduction* presents an overview of the whole training and establishes the relevance of self-regulated learning in general. In an animated video (created with GoAnimate, http://www.goanimate.com) the virtual trainer Tom welcomes the virtual participant Lisa and gives her a synopsis of the content of the first lesson (see Figure 14). The following presentation (created with Prezi, http://www.prezi.com) explains the process model of self-regulated learning (Schmitz & Wiese, 2006) by means of one of three examples chosen by the user (see Figure 15).

Figure 14. Screenshot from video created with GoAnimate

In the chapter *Setting Goals* participants are instructed to set goals and to formulate goals using the SMART technique (Doran, 1981). In a little online game (created with Adobe Flash Professional CS5.5, http://www.adobe.com/de/products/flash) participants are told to imagine a spontaneous travel with a friend without knowing the destination (see Figure 16). The task is then to pack their bags with a variety of clothes to choose from. Depending on the user's choice the travel destination is determined dynamically so that the clothes are not appropriate, e.g. if the user chose primarily sporty clothes the destination is an opera. The following video deals with the frustration that participants might have experienced and explains that without knowing one's goals it is not possible to choose the right means. Users are then asked to set goals for their online preparation course and for their academic studies afterwards. In the next presentation (created with Microsoft Powerpoint and distributed via Slideshare, http://www.slideshare.com), the SMART technique is introduced and participants are asked to refine their former goal setting using this technique (see Figure 17).

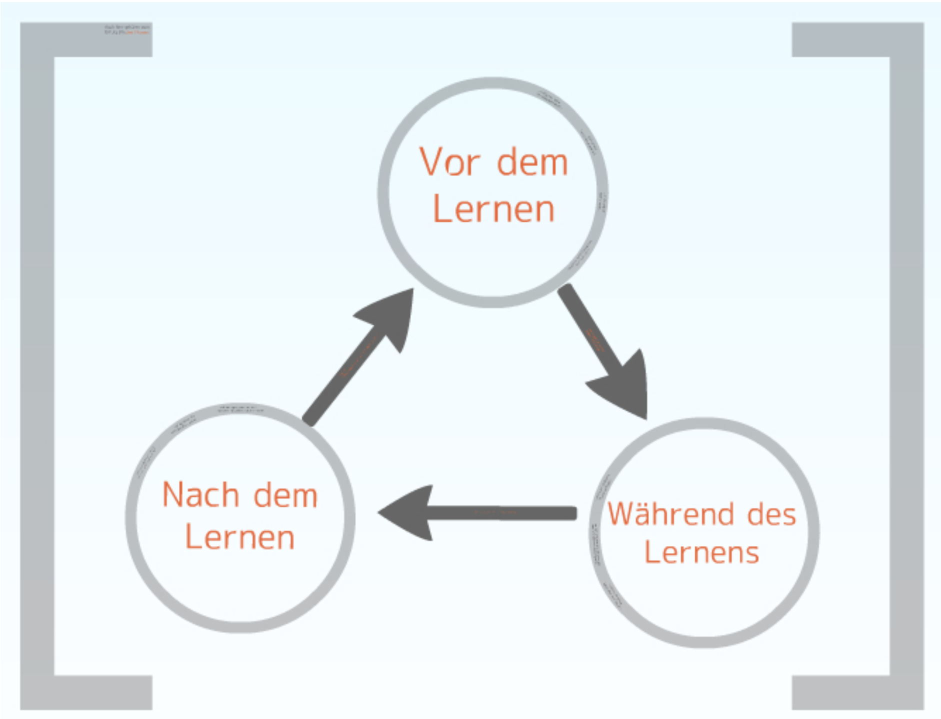

Figure 15. Screenshot from presentation created with Prezi

The chapter *Time Management* helps users to derive action plans from their goals, to reflect their own time management and to create a learning plan for their online preparation course. Participants are guided to create a mind map of their own activities and chores, including length and priority of each of those activities. They are then asked to post activities that they found inefficient to an online forum and to discuss them with their peers. In the following presentation well-established recommendations of time management are presented and transferred to the conditions of the online preparation course. The final task is to create a detailed time schedule for the four weeks of the online preparation course.

At the end of lesson 1 the virtual trainer summarized the content in a video and encourages participants to write down all strategies that they found helpful in their personal strategy manual in order to implement them within the next days.

Figure 16. Screenshot from game created with Adobe Flash Professional CS5.5

9.2 Lesson 2 – During Learning

The second lesson contains the chapters *Procrastination, Dealing with Distractions, Volition,* and *Learning Strategies*.

The chapter *Procrastination* starts with a picture story of virtual participant Lisa that postpones learning for her exams repeatedly but in the end reproaches herself for not having started earlier. Users are led to identify with this situation and to describe their own experiences with procrastination. After exploring similarities between the different situations and reflecting assets and drawbacks of delaying tasks in general, participants view a presentation with helpful clues like rewarding oneself or committing oneself in front of others.

In the chapter *Dealing with Distractions* users performed the Stroop color word interference test with and without background music (Cassidy & MacDonald, 2007) in order to experience for themselves whether their personal performance would be enhanced or diminished by music. After that a check list is presented which participants can use to identify potential external distractions (e.g. telephone calls) and internal distractions (e.g. tiredness). A presentation gives hint on how to deal with such distractions.

The chapter *Volition* starts with a video about children performing the marshmallow test (Mischel, Shoda, & Rodriguez, 1989). The following presentation explains the relevance of delay of gratification for learning and how volition can be trained. In a short physical exercise participants try the effect of self-motivation on themselves by thinking about a positive picture and repeating a positive motto while exercising in the first trial and comparing it to a second trial with a negative picture in mind and repeating a negative motto. Users are then encouraged to formulate a personal motto for their online preparation course.

Figure 17. Screenshot from presentation created with Microsoft Powerpoint and Slideshare

In the last chapter *Learning Strategies* both cognitive, metacognitive and resource-oriented strategies are dealt with. All learning strategies (e.g. elaboration as one cognitive learning strategy, monitoring as one metacognitive strategy, and help seeking as one resource-oriented strategy) are explained and transferred to the situation of the online preparation course with hints on how to implement them. A discussion forum serves to encourage users to share their experiences with different strategies with their peers.

The lesson ends with a short summary and a reference to the strategy manual as in the first lesson.

9.3 Lesson 3 – After Learning

The third lesson contains the chapters *Dealing with Success and Failure, Reflection,* and *Motivation.*

The chapter *Dealing with Success and Failure* focuses on attribution and reference standards. A video shows virtual participant Lisa dealing with different situations of failure. The following presentation explains attribution theory (Weiner, 1985) and advocates an internal and unstable attribution for both successful and unsuccessful learning situations (e.g. “I was successful because I made enough effort.”). Afterwards the concept of social and individual frame of reference (Festinger, 1954) is established and an individual frame of reference is explained to be particularly motivating (e.g. comparing one’s current knowledge with one’s prior knowledge before learning). In an exercise users are guided to calculate their mean time investment in the online preparation course to date and to set a goal to surpass their individual frame of reference.

In the chapter *Reflection* the process model of self-regulated learning (Schmitz & Wiese, 2006) is revisited with a focus on the cyclical character of this model. A presentation advises participants to reflect whether a learning situation was successful or not and to infer intentions for the next learning situation. This principle is applied to three time levels: short-term (e.g. reflection after one particular mathematical problem), medium-term (e.g. reflection at the end of one learning day), and long-term (e.g. reflection after examination period). Participants are advised to recall their learning goals previously set in lesson 1 and to reflect about whether they have achieved their goals.

The last chapter *Motivation* is intended to help participants to understand how they can actively improve their own motivation. Motivation being important in all phases of the process model of self-regulated learning, this chapter also serves as a summary of the entire training. Starting with an imagination exercise, users are guided to think about how they will feel when they will have reached their goals. Afterwards they are asked for obstacles that might prevent them from doing so. By switching the perspective repeatedly, motivation is supposed to increase (Oettingen, Pak, & Schnetter, 2001). Implementation intentions (Gollwitzer, 1999) are then used to prepare participants for coping with obstacles (e.g. “If the weather is nice and I don’t feel like learning, I close the curtains and reward myself for learning afterwards with ice cream.”). A presentation explains the difference between intrinsic and extrinsic motivation and proposes strategies to foster intrinsic motivation (e.g. to recall successful moments). In a discussion forum users are asked to describe possible rewards for achieved daily goals.

The lesson ends with the participants writing a letter to their future self in which they state the insights they have got from the training. Participants were told the letters would be sent back to them in a non-specified future by the experimenter with the intention of reminding them of the strategies learnt in the training.

10 Appendix B: Examples from Learning Diary

As an illustration of answers given in the learning diary we chose two exemplary participants (one from group TD and one from group D) at three different days (one at the beginning of the preparation course, one after the first week, and one at the end of the preparation course), each diary entry consisting of one part before learning and one part after learning. Answers to open questions are presented in

Table 8 and Table 9.

Table 8

Exemplary diary entries from participant 3247 (Group TD)

Day	Part	Entry
3	pre-learning	**What are your learning goals for today? Which strategies do you plan to apply in order to achieve your goals?** Understanding - we only dealt with these topics superficially in school, therefore I probably need to work intensely on them
3	post-learning	**How well did you achieve your learning goals? Which difficulties did you experience? What do you want to change tomorrow?** I have to admit that I only learnt reluctantly today. But I was aware that I had to do it in order not to fall behind. I need to improve my concentration tomorrow.
7	pre-learning	**What are your learning goals for today? Which strategies do you plan to apply in order to achieve your goals?** Primarily understanding. But secondly also to work more consequently and to judge the importance of topics: what can I just scan briefly in order to save time for more important topics? According to the SMART model I have chosen three chapters for today because I have fallen behind my schedule a bit. There will probably be no time for lawn mowing this afternoon.
7	post-learning	**How well did you achieve your learning goals? Which difficulties did you experience? What do you want to change tomorrow?**

		I achieved my goals within the given time, my schedule was almost 100% correct. But halfway through I was heavily distracted by the internet. I regret that I did not try to learn one more chapter. For tomorrow I intend to start earlier and to catch up - after today I need to be more disciplined tomorrow.
22	pre-learning	**What are your learning goals for today? Which strategies do you plan to apply in order to achieve your goals?** As I don't remember much from school about the topic "Integration of Rational Functions" I need to repeat and understand this chapter. The chapter on "Vectors" on the other hand shouldn't be a big issue so that I won't need much time for that. I have set my goals, created a time schedule, tidied up my workplace and motivated myself. I will finish the preparation course tomorrow which is a big motivation as well because I complied with my plan very well!
22	post-learning	**How well did you achieve your learning goals? Which difficulties did you experience? What do you want to change tomorrow?** There were no unusual problems today: I have worked quite efficiently! Tomorrow I will have a look into my books from school concerning the topic "Vectors" because I think the preparation course does not cover all aspects of it. Furthermore I will think about which topics I need to repeat one more time, that is: which topics I had difficulties with.

Table 9

Exemplary diary entries from participant 3744 (Group D)

Day	Part	Entry
2	pre-learning	**What are your learning goals for today? Which strategies do you plan to apply in order to achieve your goals?** My goal is to work through the chapters attentively and to do well on the tests. I also want to have a look at the supplementary materials of the chapters. My strategies are to repeat by practicing and to enhance my understanding through new kinds of tasks and perspectives.
2	post-learning	**How well did you achieve your learning goals? Which difficulties did you experience? What do you want to change tomorrow?** I achieved my goals today. Tomorrow I want to start earlier to be fitter.
8	pre-learning	**What are your learning goals for today? Which strategies do you plan to apply in order to achieve your goals?** To brush up my prior knowledge and to learn something new. My strategies are repeating and practicing.
8	post-learning	**How well did you achieve your learning goals? Which difficulties did you experience? What do you want to change tomorrow?** I worked through the chapters I intended to but struggled with my motivation and my lack of interest in the topics. Tomorrow I want to work through more chapters.
24	pre-learning	**What are your learning goals for today? Which strategies do you plan to apply in order to achieve your goals?** To work through the chapters attentively and to do well on the tests. My strategy is to brush up my knowledge by working through the chapters and to repeat them if I notice deficits in the tests.
24	post-learning	**How well did you achieve your learning goals? Which difficulties did you experience? What do you want to change tomorrow?** I achieved my goals, but discipline and motivation were issues today. Tomorrow I want to work on less chapters but more in detail instead.

Curriculum Vitae

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PROFESSIONAL EXPERIENCE

since 04/2016	Research Assistent at Department of Educational Psychology, Johannes Gutenberg University, Mainz
2011-2016	Research Assistent at Working Group for Educational Psychology (Prof. Bernhard Schmitz) TU Darmstadt
2010-2011	PhD-Student in the Interdisciplinary Research Training Group on „Feedback Based Quality Management in Learning"; Scholarship holder of the German Research Foundation (Deutsche Forschungsgemeinschaft; DFG)
2004-2009	Study of Psychology at Gutenberg-University Mainz, Germany
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FELLOWSHIPS, GRANTS, AND AWARDS

08/2016 – 03/2017	"Online-Selbstregulationstraining für Studierende – ein wissenschaftlich fundiertes Instrument zur Verbesserung von Lernstrategien"; Grant of the Gutenberg Lehrkolleg, University Mainz (15.000€)
08/2016 – 12/2016	"Differentielle Effekte von Online-Selbstregulationstrainings: Begleitforschung zu einem GLK-Lehrprojekt"; Grant of the Zentrum für Bildungs- und Hochschulforschung, University Mainz (15.000€)
10/2014 – 05/2016	„MoodlePeers – Learning Group Formation and Peer Feedback (Lerngruppenunterstützung und Peer Feedback)"; Grant for Quality Improvement in Study Conditions and Teaching (134.343€). Applicants: Dr. Johannes Konert, Dipl.-Psych. Henrik Bellhäuser, Prof. Dr. Ralf Steinmetz, Prof. Dr. Bernhard Schmitz & Prof. Dr. Regina Bruder
11/2012	E-Teaching-Award of the Carlo and Karin Giersch-Foundation at the TU Darmstadt (9.000 €)

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04/2007 – 09/2007	Research Grant of Johannes Gutenberg-Universität Mainz
08/2006 – 11/2006	Leonardo da Vinci Student Mobility Project (EU Funding)
12/2005 – 02/2006	Foundation Fellow of the Association of German Professional Psychologists (Berufsverband Deutscher Psychologen e.V.)

INTERNSHIPS

08/2006 – 11/2006	Neuropsychological Ambulance of Karolinska Institute, Danderyds Sjukhus, Stockholm (Dr. Aniko Bartfai)
03/2006 – 04/2006	Pratice for Neuropsychology, Saarbrücken, Germany (Dr. Gilbert Mohr)
03/2005 – 04/2005	Max Planck Institute for Brain Research (MPI für Hirnforschung, Frankfurt, Germany; Dr. Lars Muckli)

PUBLICATIONS

Fellgiebel, A., Keller, I., Marin, D., Müller, M.J., Schermuly, I., Yakushev, I., Albrecht, J., **Bellhäuser, H.**, Kinateder, M., Beck, M., Stoeter, P. (2009). Diagnostic utility of different MRI and MR angiography measures in Fabry disease. Neurology, 72(1), 63-68.

Bellhäuser, H. (2009). Strukturelle Integrität der weißen Hirnsubstanz und kognitive Leistungsfähigkeit depressiver Patienten – eine DTI-Studie. Unveröffentlichte Diplomarbeit, Johannes Gutenberg-Universität, Mainz.

Bellhäuser, H., & Schmitz, B. (2013). Förderung selbstregulierten Lernens für Studierende in mathematischen Vorkursen: ein Web-Based-Training (WBT). Mathematische Vor-und Brückenkurse: Konzepte, Probleme und Perspektiven (S. 343–358). Wiesbaden: Springer Spektrum.

Roth, A., **Bellhäuser, H.**, & Schmitz, B. (2015). Selbstreguliertes Lernen im Jurastudium – eine Schlüsselkompetenz. In: Bleckmann, F. (2015). Selbstlernkompetenzen im Jurastudium: Bedeutung – Praxis – Perspektiven. Stuttgart: Richard Boorberg Verlag.

Konert, J., Bohr, C., **Bellhäuser, H.** (2016). PeerLA - Assistant for individual learning goals and self-regulation competency improvement in online learning scenarios. Proc. of the 16th IEEE International Conference on Advancing Learning Technologies (ICALT). IEEE (2016).

Butz, S., Hertel, S., **Bellhäuser, H.**, Karlen, Y., Spinath, B., Maag Merki, K. & Schmitz, B. (2016). Vermittlung von Selbstreguliertem Lernen in der Studieneingangsphase: Wie wirksam sind Präsenz-Kurse und E-Learning-Kurse? *Lehren und Lernen,* 42 (6), 11-17.

Bellhäuser, H., Lösch, T., Winter, C. & Schmitz, B. (*in press*). Applying a web-based training to foster self-regulated learning – Effects of an intervention for large numbers of participants. doi:10.1016/j.iheduc.2016.07.002

Bellhäuser, H., Liborius, P. & Schmitz, B. (*under review*). Fostering Self-Regulated Learning Online: Effects of Web-Based Training and Peer Feedback on Mathematics Performance.

CONFERENCE PRESENTATIONS

Bellhäuser, H., Lösch, T. & Schmitz, B. (2010). Fostering Self-Regulated Learning Online - Concept of a Web-Based Training. Poster auf der 1. KLEE Konferenz (Kreativity, Learning Strategy and Efficiency in E-Learning) in Darmstadt, 7.9.2010.

Bellhäuser, H. & Schmitz, B. (2011). Evaluation eines Online-Trainings zur Förderung selbstregulierten Lernens für angehende Studierende. Vortrag auf der 75. AEPF-Tagung (Arbeitsgruppe für empirische pädagogische Forschung) in Bamberg, 28.2.-2.3.2011.

Bellhäuser, H., Lösch, T. & Schmitz, B. (2010). Fostering Self-Regulated Learning Online. Vortrag auf der 14. EARLI Conference (European Association for Research on Learning and Instruction) in Exeter, 29.8.-3.9.2011.

Bellhäuser, H. & Schmitz, B. (2011). Evaluation eines Online-Trainings zur Förderung selbstregulierten Lernens für angehende Studierende. Poster auf der 13. Fachgruppentagung Pädagogische Psychologie der DGPs (PAEPS) in Erfurt, 14.-16.9.2011.

Bellhäuser, H. & Schmitz, B. (2011). Förderung selbstregulierten Lernens für Studierende in mathematischen Vorkursen: Entwicklung und Evaluation eines Web-based Trainings (WBT). Poster auf der Arbeitstagung „Mathematische Vor- und Brückenkurse" in Kassel, 3.-5.11.2011.

Bellhäuser, H. (2012). Applying a Web-Based Training to Foster Self-Regulated Learning. Poster auf der Konferenz „American Educational Research Association (AERA)" in Vancouver, Kanada, 13.-17.04.2012

Bellhäuser, H. & Schmitz, B. (2012). Intraindividuelle Variabilität in Affekt und Selbstregulation zur Vorhersage von interindividuellen Unterschieden im Trainingserfolg bei Studierenden. Vortrag auf dem 48. Kongress der Deutschen Gesellschaft für Psychologie (DGPs) in Bielefeld, 23.-27.09.2012.

Bellhäuser, H. & Schmitz, B. (2013). Variabilität und Inkonsistenz der Selbstregulation – neue Outcome-Maße für Interventionsstudien? Vortrag auf der 1. Tagung der Gesellschaft für empirische Bildungsforschung (GEBF) in Kiel, 11.-13.03.2013.

Bellhäuser, H. & Schmitz, B. (2013). Fostering Self-Regulation Online - Effects of a Web-Based Training on Mathematics Performance. Vortrag auf der 15. EARLI Conference (European Association for Research on Learning and Instruction) in München, 27.-31.08.2013.

Bellhäuser, H. & Schmitz, B. (2014). Effekte eines web-basierten Trainings zum selbstregulierten Lernen auf objektive Verhaltensmaße: Logfile-Analysen. Vortrag auf der 2. Tagung der Gesellschaft für empirische Bildungsforschung (GEBF) in Frankfurt, 03.-05.03.2014

Bellhäuser, H. & Schmitz, B. (2014). Logfile-Analysen zur objektiven Untersuchung selbstregulierten Lernens in einem web-basierten Mathematik-Vorkurs. Vortrag auf dem 49. Kongress der Deutschen Gesellschaft für Psychologie (DGPs) in Bochum, 21.25.09.2014.

Bellhäuser, H., Roth, A. & Schmitz, B. (2015). SRL@U: Validierung des Fragebogens zur Erhebung des selbstregulierten Lernens an der Universität. Vortrag auf der 3. Tagung der Gesellschaft für empirische Bildungsforschung (GEBF) in Bochum, 11.-13.03.2015.

Bellhäuser, H. & Schmitz, B. (2015). Log File Analysis as Objective Measure of Self-Regulated Learning in a Web-Based Mathematics Course. Vortrag auf der 16. EARLI Conference (European Association for Research on Learning and Instruction) in Zypern, 25.-28.08.2015.

Bellhäuser, H. & Schmitz, B. (2015). Logfile-Analysen zur objektiven Untersuchung selbstregulierten Lernens in einem web-basierten Mathematik-Vorkurs. Poster auf der 15. Fachgruppentagung Pädagogische Psychologie (PAEPS) in Kassel, 14.-16.09.2015.

Bellhäuser, H., Stahlmann, A. & Schmitz, B. (2016). Effekte eines web-basierten Selbstregulationstrainings auf Mathematikleistung, Zeitinvestment und selbstreguliertes Lernen. Vortrag auf der 4. Tagung der Gesellschaft für empirische Bildungsforschung (GEBF) in Berlin, 9.-11.03.2016.

Bellhäuser, H. & Schmitz (2016). Effects of Web-Based Training, Learning Diaries and Peer-Feedback on Self-Regulated Learning, Self-Efficacy and Mathematics Performance. Vortrag auf der 7. International Biennial Conference of EARLI SIG 16 Metacognition in Nimwegen, Niederlande, 23.-26.08.2016.

Hertel, S., Butz, S., **Bellhäuser, H.** & Karlen, Y. (2016). Approaches in Fostering Self-Regulated Learning at University: Effectiveness of Web-Based Classes as Compared to Regular Attendance-Based Classes. Vortrag auf der 7. International Biennial Conference of EARLI SIG 16 Metacognition in Nimwegen, Niederlande, 23.-26.08.2016.

Bellhäuser, H., Hertel, S., Karlen, Y., Butz, S., Spinath, B., Maag Merki, K. & Schmitz, B. (2016). Förderung des selbstregulierten Lernens von Studierenden: Effektivität von webbasierten Kursen und Präsenzveranstaltungen. Vortrag auf dem 50. Kongress der Deutschen Gesellschaft für Psychologie (DGPs) in Leipzig, 18.-22.09.2016.

Konert, J., **Bellhäuser, H.,** Röpke, R., Gallwas, E. & Zucik, A. (2016). MoodlePeers: Factors relevant in learning group formation for improved learning outcomes, satisfaction and commitment in E-learning scenarios using GroupAL. In: Springer: Proc. of 11th Euopean Conference on Technology Enhanced Learning (EC-TEL 2016), Lyon, Frankreich, September 2016.

Röpke, R., Gallwas, E., Konert, J. & **Bellhäuser, H.** (2016). MoodlePeers: Automatisierte Lerngruppenbildung auf Grundlage psychologischer Merkmalsausprägungen in E-Learning-Systemen. Proc. of the DeLFI 2016: Die 14. E-Learning Fachtagung Informatik. Potsdam, September 2016.

INVITED TALKS

Bellhäuser, H. (2015). Selbstreguliertes Lernen in mathematischen Vorkursen fördern durch web-based Training und Gruppenformation. Eingeladener Vortrag am Lehrstuhl für Didaktik der Mathematik an der Universität Paderborn (Prof. Rolf Biehler), 27.05.2015

Bellhäuser, H. (2015). Selbstreguliertes Lernen fördern durch web-based Training. Eingeladener Vortrag am Lehrstuhl für Personale Kompetenzen im schulischen Kontext am Institut für Bildungswissenschaft an der Universität Heidelberg (Prof. Silke Hertel), 01.06.2015.

Bellhäuser, H. (2016). Intra-individual variability in an online course. Eingeladener Vortrag des Network on Intrapersonal Research in Education (NIRE) an der University of York, UK (Prof. Robert Klassen & Prof. Lars-Erik Malmberg), 17.03.2016.

Obligatory Declaration

I declare that I have developed and written the enclosed doctoral thesis entitled "Fostering Self-Regulated Learning Online – Development and Evaluation of Interventions for E-Learning Scenarios" completely by myself, and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are clearly marked. This thesis was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere.

Mainz, July 28th, 2016

Dipl.-Psych. Henrik Bellhäuser