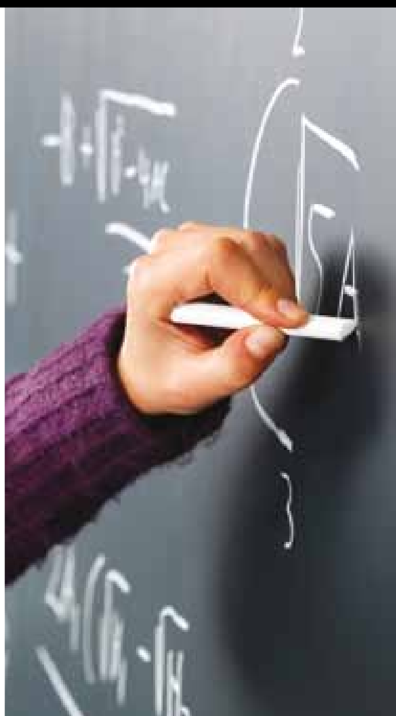
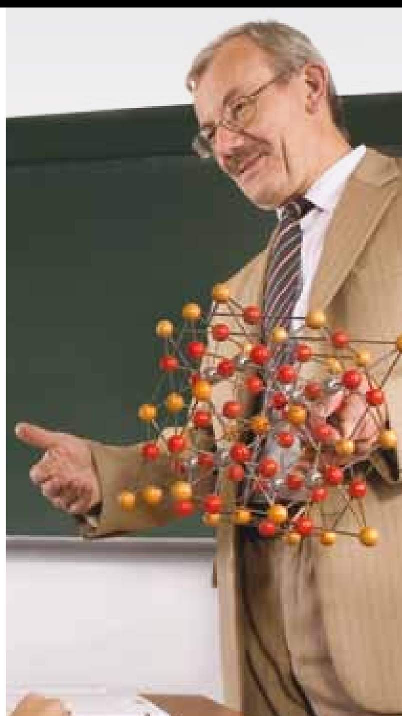
Education Research International

New Perspectives on Integrating Self-Regulated Learning at School

Guest Editors: Bracha Kramarski, Annemie Desoete, Maria Bannert, Susanne Narciss, and Nancy Perry



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Editorial Board

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Editorial

New Perspectives on Integrating Self-Regulated Learning at School

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1. Introduction

In recent years the role of self-regulated learning (SRL) in education has garnered considerable attention from educators, researchers, and policy makers [1, 2]. Though there are several SRL models proposing different constructs, they still share basic assumptions about self-regulation in learning [3, 4]. Specifically, SRL is an active process, which relates to "self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals" [4, p. 14]. Learners are self-regulated to the extent that they are cognitively/metacognitively, motivationally, and behaviorally active participants in their own learning process (e.g., [3–5]).

SRL is an important interdisciplinary competence that leads to improved learning and helps individuals cope with the challenges of life-long learning in a knowledge society [2]. It is widely accepted that SRL has a crucial role in school achievement. Children and young people with higher levels of SRL are more likely to succeed academically than students with low SRL (e.g., [6–8]).

So far, the research supports a few general conclusions: SRL is *teachable* in the classroom, SRL must be *explicitly* taught and intensively practiced, and interactive *learning environments* are effective for implementing SRL instruction (e.g., [9, 10]). The activities required to promote SRL strategies (including planning, monitoring, and evaluation) are naming the strategy, explaining the *what, why,* and *how,* and modeling the strategy's application (e.g., [10–13]). Finally, the teacher's role must include being able to cultivate self-regulated learners. But if teachers are not equipped to self-regulate their own learning, how can they develop SRL in their students? Learners depend on *teachers*, *teaching methods*, and *learning conditions* to acquire SRL (e.g., [6, 14–16]).

This special issue brings together a series of papers on some of the theoretical, methodological, and practical issues in SRL and discusses various new perspectives for integrating it into schools. The issue hopes to add greater depth to the broader subject of the contribution of SRL in schools, by analyzing the features and conditions in schools that can support SRL development in teachers and students in key areas, including the following.

(a) *Subjects: mathematics* (M. Leidinger and F. Perels; G. Papantoniou et al.; J. Roelle et al.); *science* (T. J. Cleary and P. Platten; S. Eggert et al.; K. Schmidt et al.), and *reading* (D. L. Butler et al.).

(b) *Ages: primary school* (M. Leidinger and F. Perels; J. Roelle et al.), *secondary school* (K. Schmidt et al.), and *high school* (T. J. Cleary and P. Platten; S. Eggert et al.).

(c) *Type of prompt: self-questions*; (e.g., S. Eggert et al.); relating to *different phases* (Zimmerman model; M. Leidinger and F. Perels); relating to *objects* (generic/personal reflection; e.g., K. Schmidt et al.).

(d) *Learning materials:* problem solving examples (e.g., J. Roelle et al.) focusing on interactive learning environments such as CBLE (I. Glogger et al.), collaborative learning (S. Eggert et al.) for students, and teachers development.

The issue contributes significantly to SRL assessment by exploring ways of evaluating SRL as a dynamic process in real-time situations and by combining different kinds of measures for assessing such processes [1, 5, 17, 18]. The articles describe a variety of methodologies such as, using *reflective* learning journals (e.g., M. Leidinger and F. Perels); *observations* (D. L. Butler et al.); *interviews* (e.g., T. J. Cleary and P. Platten); *multi-dimensional assessment* with a variety of research designs, for example, the quasi-experimental combination of pre-/postcontrol-group design and time series design (e.g., M. Leidinger and F. Perels); *case studies* (T. J. Cleary and P. Platten), *meta-analysis* type of literature review (D. C. Moos and A. Ringdal), and *path analysis models* (G. Papantoniou et al.).

We have divided the issue into two parts with 5 papers in each. Part 1 examines the learner's role while Part 2 examines the teacher's role in integrating SRL in the school.

1.1. Part 1: Studies about the Learner's Role in Integrating SRL at School. (a) M. Leidinger and F. Perels have developed mathematics learning materials based on Zimmerman's self-regulated learning model [4]. The purpose of the materials is to develop core cognitive, metacognitive, and motivational components of self-regulated learning within a natural primary school learning environment. Evaluation of the SRL-training materials is based on a quasi-experimental pre-/postcontrol-group design with a time series design. Intervention was evaluated using a self-regulated learning questionnaire, standardized mathematics test, and process data consisting of structured paper-and-pencil diaries that students recorded for six weeks. The evaluation reveals that when fourth graders (age 9-10) are given these SRL-training materials in regular mathematics lessons, they can maintain their self-reported self-regulated learning activities not only for the 6-week training phase, but for the next year as well. However, fourth graders who did not receive the training materials demonstrated a significant decline in their SRL-activities between the pre- and posttest. Despite several limitations, the study illustrates that self-regulated learning can be integrated at primary schools by asking teachers to use SRL-training materials in their regular mathematics lessons.

(b) J. Roelle et al. examined the use of solved example problems for fostering strategies of self-regulated learning in journal writing. In a quasi-experimental field study, 5th grade students (ages 11-12) were given examples of solved math problems and prompts, either from the start of their journal writing, or after they had written two entries. The results suggested that when fifth grade students are given solved example problems with prompts from the time they start keeping their journals, it can effectively support them in overcoming deficits in their SRL strategies in mathematics.

(c) In a quasi-experimental field study, K. Schmidt et al. investigated the effects of personal-utility reflection prompts in journal writing on 7th grade (ages 13-14) students' learning motivation and comprehension in biology education. Previous research on journal writing, focusing on supporting the application of cognitive and metacognitive strategies in learning journals, has shown that prompting cognitive and metacognitive strategies are not enough to sustain student motivation over time. In order to support student motivation, K. Schmidt et al. used personal-utility prompts, cognitive prompts, and metacognitive prompts in the students' learning journal assignment. The results showed that prompting reflection about the personal relevance of the learning contents in the learning journals strongly influences learning motivation and that these motivational effects were positively correlated to learning outcomes as measured by a curriculum-based comprehension test. Thus journal writing which involves reflection on the utility and value of learning can be effective in supporting student motivation and comprehension in secondary science education.

(d) S. Eggert et al. examined the effect of embedded metacognitive instructions on senior high school students' (age 17) socioscientific decision making in the science classroom. Participants studied either in a cooperative learning setting (COOP), a cooperative learning setting with embedded metacognitive questions (COOP + META), or a nontreatment control group. Results show that the students in both the training conditions outperformed students in the control group regarding both processes of socioscientific decision making. However, students in the COOP + META condition did not outperform students in the COOP condition. The authors discuss these surprising findings and the shortcomings of the study.

(e) T. J. Cleary and P. Platten examined the correspondence between self-regulated learning and academic achievement using case study analysis. Four high school students (9th graders, age 14) received 11 weeks of a self-regulated learning (SRL) intervention, called the Self-Regulation Empowerment Program (SREP), which sought to improve their classroom-based biology exam scores, SRL, and motivated behaviors. This mixed model case study examined the correspondence between shifts in students' strategic, regulated behaviors, and performance on classroom-based biology tests. This multidimensional assessment approach was used to establish convergence among the assessment tools and facilitate interpretation of trends in students' biology test performance relative to their SRL processes.

1.2. Part 2: Studies on the Teacher's Role in Integrating SRL at School. (a) D. C. Moos and A. Ringdal offer a meta-analysis literature review of the teacher's role in promoting SRL in the classroom. They systematically consider the following research questions.

How does the literature endorse SRL in teacher education programs? What does the literature say about the use of

SRL and different kinds of teachers? How does research that examines self-regulation in the classroom measure SRL? The review concludes with the theoretical, methodological, and practical implications of the studies reviewed.

(b) C. D.-van Ewijk and G. van der Werf investigated teachers' beliefs, knowledge, and behavior in the context of self-regulated learning in primary schools. The authors assessed primary school teachers' knowledge and beliefs regarding two aspects of promoting SRL: strategy instruction and the constructivist learning environment. A randomized sample of forty-seven Dutch teachers' (ages 24–63 years) who taught grade 5 or 6 were selected for the study. The teachers answered open-ended questions regarding their understanding of SRL and on their implementation of SRL in their classrooms. Teachers were found more positive towards a constructivist learning environment than towards SRL (i.e., strategy instruction). However, teacher beliefs towards SRL are the only predictor of teacher behavior. The results show how teacher education can support teachers in learning how to promote SRL effectively to their students.

(c) G. Papantoniou et al. examined the links between effect, self-regulated learning strategy use, and course attainment in the didactics of mathematics (teaching mathematics) subject matter domain, at the School of Early Childhood Education. The sample consisted of 180 student teachers (aged 19–23). Pearson's correlations and path analysis revealed that negative effect was positively related to cognitive interference, whereas positive effect positively influenced the use of almost all the SRL strategies. The only SRL strategy which predicted the didactics of mathematics course attainment was elaboration.

(d) I. Glogger et al. developed and evaluated a computer-based learning environment for teachers: "*Assessment of learning strategies in learning journals.*" Though it is important to train teachers to assess key SRL components such as learning strategies, this area is a somewhat neglected in efforts to support teachers' use of SRL at school. Learning journals can assess learning strategies in line with cyclical process models of self-regulated learning, allowing for rich formative feedback. In light of this, the authors developed a computer-based learning environment (CBLE) for training student teachers (ages 20–26) to assess learning strategies with learning journals. They found high levels of satisfaction, interest, and good usability, as well as satisfactory assessment skills after working with the CBLE.

(e) D. L. Butler et al. investigated what happens when teachers work collaboratively to support self-regulated Learning Through Reading (LTR) in adolescents. They report the findings of a longitudinal project in which secondary school teachers worked collaboratively to support adolescents' self-regulated LTR in subject-discipline classrooms. More specifically, the authors investigated whether and how teachers working within a community of inquiry had mobilized research to shape classroom practice and advance student learning. To link practice changes to student outcomes, they related pre- and postshifts in students' self-regulated LTR for 364 students (grades 7–9) in relation to practices employed by 12 teachers in 20 humanities classrooms.

2. Final Remarks and Implications for Future Work

This special issue contributes importantly to enriching the literature on self-regulation in learning for students and teachers in diverse conditions and learning environments. However, more attention needs to be paid to the ability of SRL to meet the diverse learning needs of individual students in mixed ability classrooms. This suggestion concurs with the researchers' proposals for the teaching curriculum to address the often major gaps between students with different intellectual needs trying to learn in the same classroom, such as high achievers and gifted students (e.g., [19]) and students with learning disabilities (e.g., [20]). Future research needs to evaluate the efficacy of adapted SRL prompts in challenging high achievers to acquire a sophisticated understanding of the core curriculum in an advanced learning environment and, equally important, to support the low achievers in monitoring and regulating their learning as well.

And as for teachers, if it is our aim to promote the widespread adoption of SRL in the classroom, then our focus should be on improving teachers' understanding of SRL and on supporting them in developing and adopting self-regulated teaching practices. Our goal should be to empower experienced teachers and student teachers to be self-regulated learners themselves and to in turn cultivate successful self-regulated learners of all achievement levels within their classrooms [14, 21, 22]. To this end, some of the most relevant issues for future research are developing, introducing, and evaluating SRL-training in teacher education programs.

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Research Article

Development and Evaluation of a Computer-Based Learning Environment for Teachers: Assessment of Learning Strategies in Learning Journals

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Training teachers to assess important components of self-regulated learning such as learning strategies is an important, yet somewhat neglected, aspect of the integration of self-regulated learning at school. Learning journals can be used to assess learning strategies in line with cyclical process models of self-regulated learning, allowing for rich formative feedback. Against this background, we developed a computer-based learning environment (CBLE) that trains teachers to assess learning strategies with learning journals. The contents of the CBLE and its instructional design were derived from theory. The CBLE was further shaped by research in a design-based manner. Finally, in two evaluation studies, student teachers ($N_1 = 44$; $N_2 = 89$) worked with the CBLE. We analyzed satisfaction, interest, usability, and assessment skills. Additionally, in evaluation study 2, effects of an experimental variation on motivation and assessment skills were tested. We found high satisfaction, interest, and good usability, as well as satisfying assessment skills, after working with the CBLE. Results show that teachers can be trained to assess learning strategies in learning journals. The developed CBLE offers new perspectives on how to support teachers in fostering learning strategies as central component of effective self-regulated learning at school.

1. Introduction

This paper describes the development of a computer-based learning environment (CBLE) that aims to support teachers in promoting learning strategies as a central component of self-regulated learning. More specifically, the CBLE aims to train teachers to assess learning strategies with an instrument suitable for the school context, namely, the learning journal. The CBLE was based on theoretical principles derived from the self-regulated learning literature on the one hand (with respect to the learning contents) and multimedia design on the other hand (with respect to the instructional design). In line with design-based research principles, we carried out formative research to test and refine the design of our CBLE [1, 2].

New perspectives on fostering self-regulated learning in school are provided in this paper in two respects. First, training teachers to assess important components of self-regulated learning such as learning strategies is an important, yet somewhat neglected, aspect of the integration of self-regulated learning at school. Actually, teachers need skills to assess the processes of learning [3–6] in order to foster students' strategies for learning, for example, by giving helpful specific feedback [7, 8]. Thus, we developed, revised, and tested a CBLE that aims to enhance teachers' skills to assess learning strategies in school.

Second, we used learning journals as method to foster and assess cognitive and metacognitive learning strategies. Recent models of self-regulated learning look at self-regulated learning as a process embedded in its ecological setting [5].

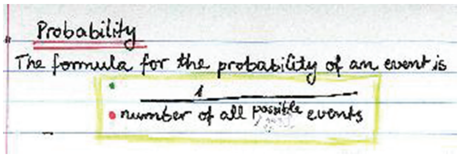
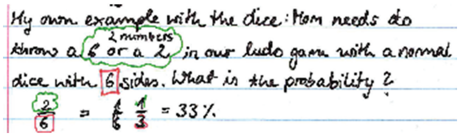
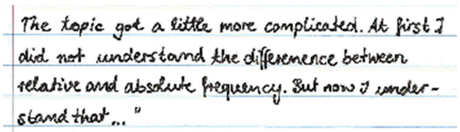
Learning journal passage	Learning strategies
A Student writes. . .	
	Organization: headings Rehearsal Organization: highlight what is most important
[· · ·]	
	Elaboration: example Organization: show connections (here by color coding)
[· · ·]	
	Metacognition: monitoring Remedial strategy

Figure 1: Examples of learning strategies in a ninth-grader's mathematics learning journal. Glogger et al. [9] APA, reprinted with permission.

Learning journals, embedded in naturally occurring events in the classroom, are an ecologically valid way of assessing students' learning and self-regulated learning [9]. Teachers can use learning journals to assess self-regulated learning in a way that allows for rich formative feedback. Thus, in the CBLE, we introduced the assessment of self-regulated learning using learning journals. In the following, we describe the conceptual framework of self-regulated learning underlying learning journals as assessment for learning strategies and then deduce the training contents of the CBLE.

2. Conceptual Framework and Contents of the Computer-Based Learning Environment: Assessment of Learning Strategies in Learning Journals

In self-regulated learning, students control and influence their own learning processes towards their learning goals. Cyclical interactive process models [10, 11] presume that self-regulated learning proceeds in several phases. The learners define their learning goal in a forethought phase (phase 1), apply powerful cognitive strategies in a performance phase (phase 2), and monitor their understanding in a self-evaluation phase (phase 3) in order to identify and eliminate possible comprehension problems or adapt their cognitive strategies to better approach their goals. Planning adapted cognitive strategies can be already seen as the transition into the forethought phase of a next cycle [11]. Although different models of self-regulated learning emphasize different components (e.g., motivation or overarching goals derived from students' self [12, 13]), the components most directly related to knowledge acquisition and understanding are cognitive strategies and metacognitive strategies [12]. Metacognitive strategies are used by learners to monitor and controll their cognitive strategies. Cognitive and metacognitive strategies are focussed in the present work. Focusing on strategies that contribute directly to understanding and retention, we can use the broad categories of Weinstein and Mayer's [14] frequently cited taxonomy: rehearsal, organization, elaboration, and metacognitive learning strategies (on the usefulness of these categories, see also [15]).

Recent efforts to measure self-regulated learning based on process models [5, 10, 16–18] use instruments that try to capture (self-regulated) learning processes *close* to the learning behavior or *as they happen* (*online measures*; see [18], or event measures; see [5, 16]). One such instrument is the learning journal. It can well be used in school contexts [9, 19, 20]. The task of writing learning journal can be assigned to all students of a classroom as follow-up course work in order to reflect on the learning contents and on their own understanding. The learning journal can be introduced to students in a way that lets them follow a cyclical-interactive process of self-regulated learning, focusing on cognitive and metacognitive learning strategies (see Figure 1, for students' examples; [7, 9, 19–22]). Students are encouraged to plan what learning contents they need to address in writing (forethought phase), to apply cognitive strategies in order to deepen understanding and retention (performance phase), and to monitor their understanding (self-evaluation phase) as well as remediate their learning if necessary (transition into the next cycle).

For example, students choose a topic they need to understand better (metacognitive planning). Then, students might simply write down (rehearse) some information about that topic (see Figure 1, [14]). On the basis of rehearsed information, students can identify main ideas, relations, or hierarchies within the new learning contents (organization strategies), for example, by highlighting or color coding them, or drawing a map that includes the main concepts in their learning journal. Furthermore, they can link new learning contents to prior knowledge or experiences (elaboration strategies); for example, they explain new concepts with concrete examples. Organization and elaboration particularly deepen understanding. Rehearsal, organization, and elaboration strategies are summarized as cognitive learning strategies [12]. Metacognitive strategies get visible if students write down where they have difficulties in understanding (metacognitive monitoring) and how they plan to overcome difficulties in understanding (transition in a further cycle).

Learning strategies are "materialized" in learning journals (i.e., written down) as they happen ("online" process). Teachers thus can assess those strategies and give specific feedback if they know how to differentiate categories (types) of learning strategies. Teachers should be able to identify types (categories) of learning strategies because they have different functions in understanding and retention ([14, 23], e.g., elaboration integrates new information in prior knowledge structures, thereby creating associations; organization sorts out important from unimportant contents). Thus, in a conceptualization of the CBLE, a section with four interactive learning modules about rehearsal, organization, elaboration, and metacognitive learning strategies was planned. This section should teach in detail which learning strategies should be applied in writing learning journals according to the theoretical and empirical backgrounds, how they improve comprehension, and how to identify and evaluate them in learning journals. Teachers should learn to categorize learning strategies as the broader main categories (rehearsal, organization, etc.) and to identify subcategories as belonging to the broader categories. For example, underlining, highlighting, and summarizing main points of a topic belong to organization strategies. Planning (setting goals), monitoring understanding, and planning remedial strategies belong to metacognitive strategies [12, 14].

Cognitive and metacognitive strategies are closely related to learning outcomes, especially if measured close to the learning behavior [24, 25]. For an assessment of self-regulated learning related to learning outcomes, a teacher could just sum up the number of one type of these described strategies (quantity) in a learning journal entry. However, it is crucial that students not only use learning strategies but that they use the learning strategies appropriately, so that they actually fulfill their specific function in a strong way [9, 24]. For example, a high quantity of note-taking can mean that students are not selective in recording information [5]. Only if students select the most important (instead of marginal) information for their notes, they apply this organization strategy so that it strongly fulfills its function. Such a strategy application is of high quality. Schwamborn et al. [25] found correlations from .57 to .82 between the quality of an elaboration strategy (learner-generated drawings) and learning outcomes. Glogger et al. [9] found that both the quantity and quality of learning strategies correlated significantly with learning outcomes. Therefore, the CBLE was planned to train teachers in differentiating quantity and quality of learning strategies so that they can assess and foster learning strategies referring to (a) how often a student applied learning strategies (quantity) and also (b) how well the learning strategies were applied (quality).

The training to identify different learning strategies and to evaluate their quality in learning journals was seen as the core aspect of the CBLE. If teachers hold well-organized and networked schemata about general categories of learning strategies (e.g., elaboration, organization; [14]) and related subcategories (e.g., creating examples as elaboration strategy), linked to related instances of those categories in learning journals they should be able to apply them to assess students' learning strategies in learning journals [26, 27].

However, we assumed that teachers additionally need (a) to be informed about the idea of writing learning journals, and (b) to be supported in summarizing data, for example, to create diagrams to get an overview of a class. In order to get qualitative information about needed contents and functionalities, we conducted interviews with teachers.

3. Interviews about Teachers' Needs

With a small sample of five teachers, we conducted half-structured interviews. We were interested in the teachers' prior knowledge and understanding about learning strategies and learning journals, and which (planned) contents and functionalities the teachers perceived as helpful and necessary for their work. This information was supposed to help us select contents and functionalities of the CBLE in line with teachers' needs. Five in-service teachers (3 females and 2 males) from several secondary schools were interviewed (3 teachers of lower track classrooms within the German three-track system, grades 5 to 9; 2 teachers of middle-track classrooms, grades 5 to 10). We first explained to the teachers how we define learning strategies, and learning journals, and we explained the basic goal of the CBLE. We then asked open questions about learning journals, learning strategies and how teachers have assessed them in school so far. After that, we asked teachers what features and functionalities they would prefer in the CBLE in one open question and in more closed questions about specific features and functionalities. The specific features and functionalities had been conceptualized in the research team including one in-service teacher. The questions asked whether teachers would use this functionality on a 6-point scale (1 = *no, never*; 6 = *yes, always*) and what perceived (dis-)advantages of a specific functionality motivate their answer.

4. Results and Consequences for the Design of the Computer-Based Learning Environment

The half-structured interviews first revealed one surprising result. Teachers' conceptions of learning strategies can differ profoundly from the scientific conception (e.g., a teacher mentioned a kind of problem-solving strategy instead of strategies which are applied in order to understand and learn: "I use brainteasers, which are also about strategies"). In addition, teachers lacked ideas of how they can assess learning strategies in general (e.g., "Good question, I think I have never really consciously assessed learning strategies"). The learning environment thus has to start at a quite basic point: define what learning strategies are and explain how learning journals can be implemented in classroom teaching as medium to foster and assess learning strategies (self-regulated learning). On this background, the first section of the preliminary CBLE was created. In Section 1, teachers learn how learning strategies are defined, what learning journals are and how the application of learning strategies can be encouraged during journal writing. Instructional goals and potential positive effects of the application of learning journals are outlined. These contents are presented by a professional speaker with slides illustrating the verbal information.

According to the teachers themselves, besides a brief introduction in the application of learning journals and the categorization of learning strategies, a collection of materials for in-classroom use of the learning journal method should be given. The material should allow for effectively introducing the students into journal writing and the application of learning strategies while writing. Thus, materials from previous studies [9] were slightly adapted for teachers and made available in a second section of the CBLE. That is, in Section 2, teachers find material of how to implement writing learning journals in classrooms. The materials' implementation is explained briefly.

In order to evaluate the written learning journals, teachers suggested a learning module introducing a category system of learning strategies. They stressed the importance of (real) students' learning journal examples. These suggestions could well be aligned to the theoretically deduced conception of four learning modules about rehearsal, organization, elaboration, and metacognitive strategies (cf. [14]; see the paragraph about the instructional design of the CBLE). These four modules constitute Section 3 of the CBLE.

When teachers apply the category system to assess their students' learning journals, this assessment should not take longer than about 10–15 minutes per student. All teachers stated they would (always or often) use a database functionality to administer data by classroom and individual student (over time) and a functionality that allows for displaying a graphical overview of the results of a whole classroom. All five teachers emphasized that they would appreciate readily available feedback suggestions for fostering strategy application in students. These features were thus selected and provided by a forth section of the CBLE. Section 4 of the CBLE, a cognitive tool, provides a learning journal management tool which is thought to help teachers to evaluate hand-written learning journals in a time-efficient way, administer student data, and formulate feedback to students. A simplified rating catalogue was developed so that the assessment of one student's learning journal only takes about 10–15 minutes. Section 3 was supposed to train teachers in categorizing learning strategies in learning journal examples and apply quality criteria to the examples. With this background knowledge, the rating catalogue of Section 4 can not only be used to assess the learning strategies in a time-efficient way, but also in a way that is well grounded in theory. Section 4 also helps to analyze and compare students' use of learning strategies within or across courses by displaying graphical overviews of the results of whole classrooms. Finally, it helps teachers to formulate supportive formative feedback for students. Text blocks are given as feedback suggestions, (e.g., "You have linked new learning contents with something familiar by an example from our lesson. It would be great for your own learning if you tried to find an *own* example next time. If you think about the learning content intensively by finding own examples, you will be able to memorize it better").

A functionality that the teachers would not or rarely use would be to exchange ideas or pose questions online about strategy assessment or the application of the program. Therefore, this (initially planned) feature was not realized. In addition, teachers preferred an offline version over a version that could be accessed online because not all teachers would have the possibility to work with constant internet connection, and many colleagues would be afraid about the security of the students' data. Teachers do not have their own personal computer work station at school. Therefore, the CBLE was developed as an offline version based on Adobe Flash CS2. Flash made the CBLE platform independent; that is, it potentially runs with different systems (Mac, Linux, and Windows) without needing an installation. If teachers or student teachers need to use the CBLE on computers in school or university, they do not need administration rights, because an installation is not needed.

Altogether, the interviews gave us the following important hints: introduce contents at a quite basic level, give ready-to-use material for introducing students, give a lot of examples, and provide a way to assess learning strategies and give feedback in a time-efficient way.

5. Summary of Contents of the Computer-Based Learning Environment: Assessment of Learning Strategies in Learning Journals

In summary, in line with the interview results, the first preliminary CBLE had four main sections (Figure 2): (1) an introductory video about learning journals as assessment method for learning strategies, (2) materials for introducing the students in writing learning journals (e.g., PowerPoint presentations and example lesson-plans), (3) four interactive learning modules about rehearsal, organization, elaboration, and metacognitive learning strategies, and (4) a cognitive tool, that is, a database-driven learning journal management tool with a simplified rating scheme for the fast assessment of learning journals ("assessment tool" in Figure 2). In the following, we will report how we considered important multimedia principles and approved instructional support procedures in the design of the CBLE.

6. Applying Multimedia Principles and Approved Instructional Support Procedures

We considered important design principles for multimedia learning when developing the CBLE [28–30]. These principles were especially important for the development of the core part of the CBLE, the interactive learning modules about rehearsal, organization, elaboration, and metacognitive

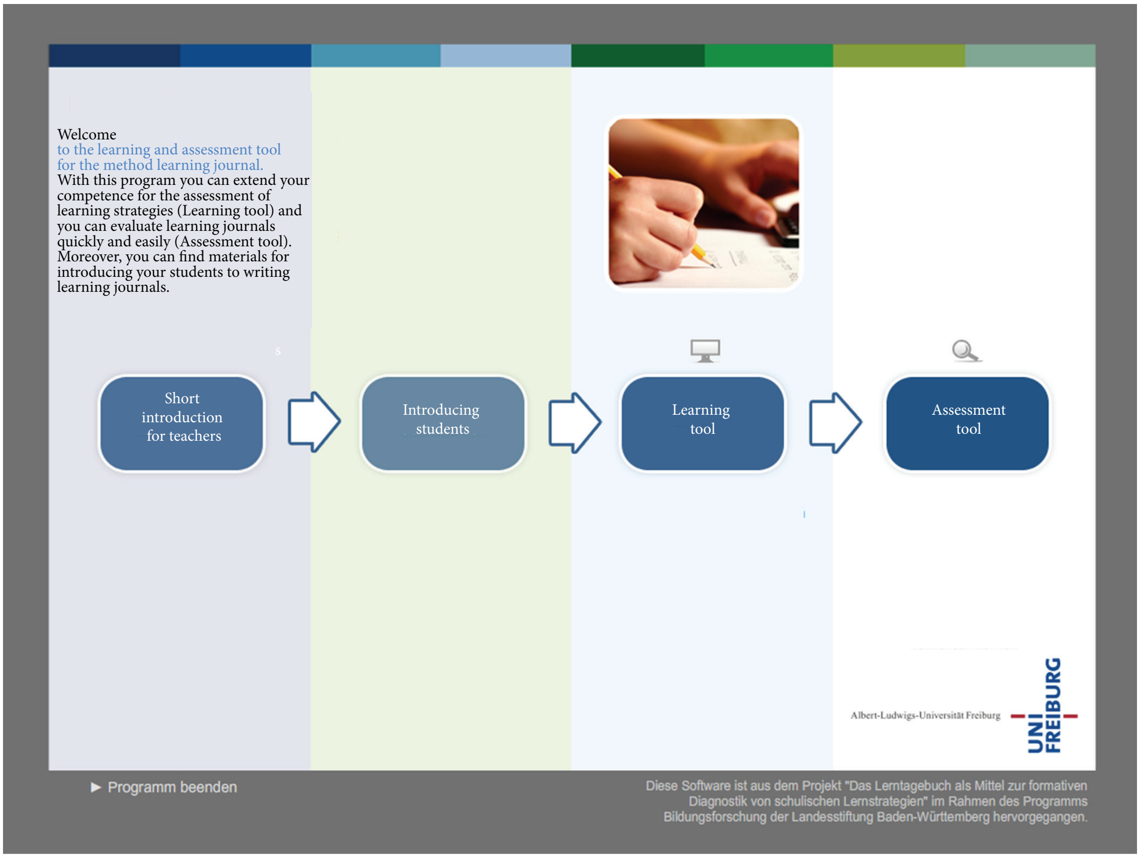


FIGURE 2: Start menu of the CBLE with four sections: "short introduction for teachers," "introducing students," "learning tool," and "assessment tool." Short descriptions about what can be expected in the sections appear when learners mouse over the four boxes.

learning strategies (Section 3; see Figure 3). This part aimed to teach (prospective) teachers well-organized, networked schemas, linked to concrete examples, which should enable them to apply this knowledge to students' learning journals [26, 27].

6.1. Multimedia Principles. The underlying software Flash allowed us to realize Mayer's [28] *multimedia principle* by including pictures, sound files, and videos and by creating animations. According to the *modality principle*, we combined visualizing elements and spoken text. An example of the modality principle is shown in Figure 4. Another example is a student's visualization that is presented with a spoken explanation of how this visualization is an elaboration strategy.

In addition, we aimed to present pictures and texts that belong together in spatial or temporal contiguity (*contiguity principle*). We avoided presenting irrelevant information such as decorative illustrations or marginal information in texts (*coherence principle*). We also avoided presenting redundant information simultaneously (*redundancy principle*). We realized the *personalization principle* by addressing learners directly in spoken and written texts.

Several functionalities address the *control-of-processing principle*. Whenever there is spoken text, learners can pause and/or start the sound by clicking on the play button (Figures 5 and 1). They can navigate freely within the audio file, that is, jump to a specific time of the audio file by clicking on the time line (2) too. These options allow some learner control as formulated by Schnotz [30]. Learners can control the speed of processing the given information. To avoid the "fleetingness" of acoustic explanations, learners can view the textual version of the spoken text (by clicking on "show audio as text" (4) in Figure 5).

6.2. Approved Instructional Support Procedures

6.2.1. Transition Principle of Instructional Support. According to this principle formulated by Hilbert et al. [31], each strategy module starts with an expert's explanation (direct instruction) about the according strategy (rehearsal, elaboration, organization, or metacognition). Then, students' journal examples are presented, and an explanation of the expert can be clicked and started. The expert explains how the journal passage exemplifies the explained learning strategy category. Partly, such passages consist of contrasting examples from students' learning journals (see Section 6.2.2). Using a lot of real students' examples (adapted from the [9] studies) was in line with interviewed teachers' suggestions. Each module ends with tasks that ask the learners to self-explain why journal example passages represent one kind of learning strategy.

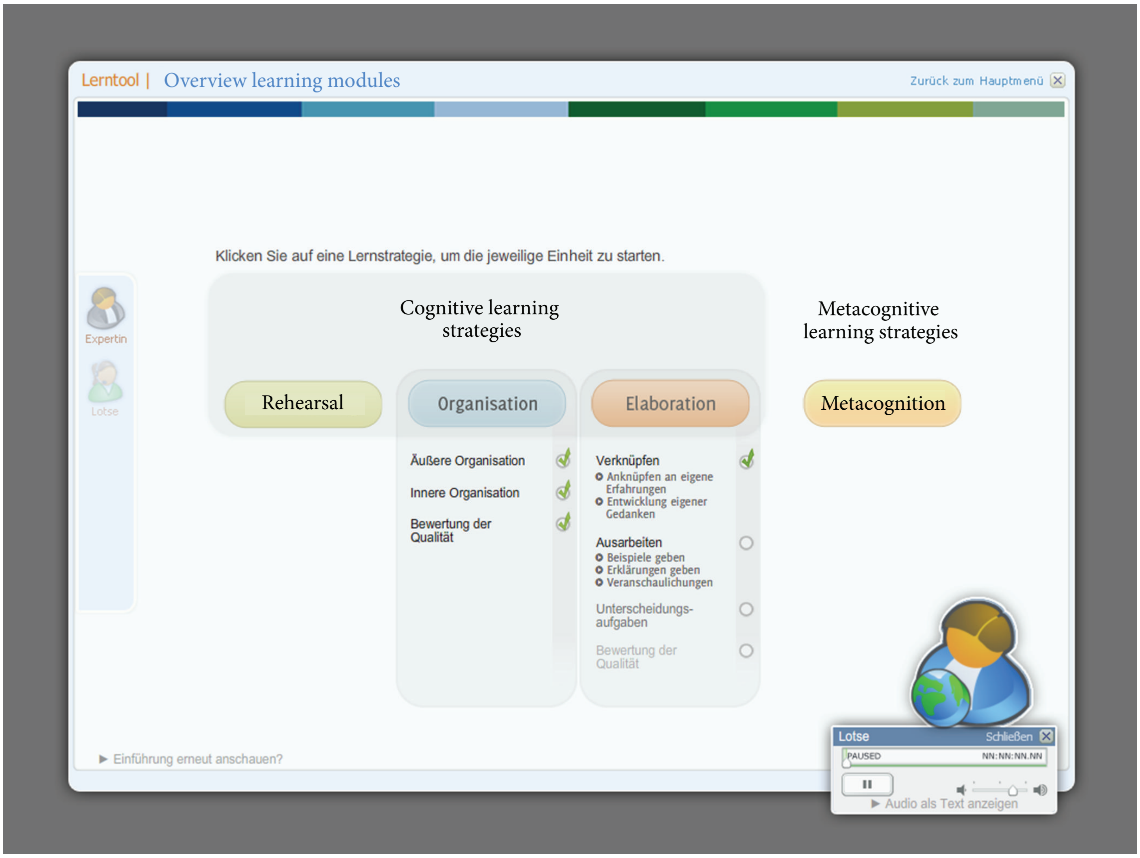


Figure 3: Overview site of the interactive learning environment (Section 3 of the CBLE) with three modules about cognitive learning strategies (rehearsal, organization, and elaboration) and one module on metacognitive strategies. Here, the organization module was finished (green check marks), and the elaboration module was started.

6.2.2. The Contrasting Examples Principle. Comparing two or more instances of a subject is a successful method of making underlying differentiation principles salient [32–34]. This principle was used when differentiating different kinds of strategies within one strategy module (e.g., different elaboration strategies are contrasted in examples). We also applied the contrasting examples principle in the quality part of each module. Each of the four strategy modules ends with a part about the quality aspect of the learning strategy. In order to sensitize for the underlying criteria of evaluating the quality of the strategy, we contrasted examples that differ in their level to which the strategy's specific function is fulfilled (i.e., their quality).

6.3. Interactive Learning Tasks. The computer-based learning environment was developed for teachers to work on their own, without further support by a trainer or by peer learners. Therefore, all the learning activities can be accomplished without further instructional support or additional material. Basically, the following two kinds of learning tasks were implemented.

6.3.1. Self-Explanation. A learning journal passage with one realized learning strategy was given with the right categorization. The learners were prompted to explain why this learning strategy can be categorized in this way (e.g., "*This is an elaboration strategy. Why?*") [35].

6.3.2. Practice with Classification Tasks. In order to train differentiating different levels of quality (high, middle, or low) at the end of the quality sub-modules, teachers had to classify journal passages of different quality by dragging and dropping them to three quality levels (see the boxes in Figure 6: (1) high, (2) middle, or (3) low quality; see also contrasting example principle).

6.3.3. Elaborated Feedback. After completing (all) the classifications of one task or after choosing one of the strategy categories, feedback on the correctness is provided, and learners can read an explanation for why an answer is correct or incorrect (cf. [8]).

7. Formative Evaluation of the Computer-Based Learning Environment

Formative evaluation of preliminary versions of the CBLE was conducted by (1) asking experts for feedback and (2) walkthroughs by the research team whenever a new version was finished. Additionally, in line with design-based research principles, we used the CBLE in a small student teacher class

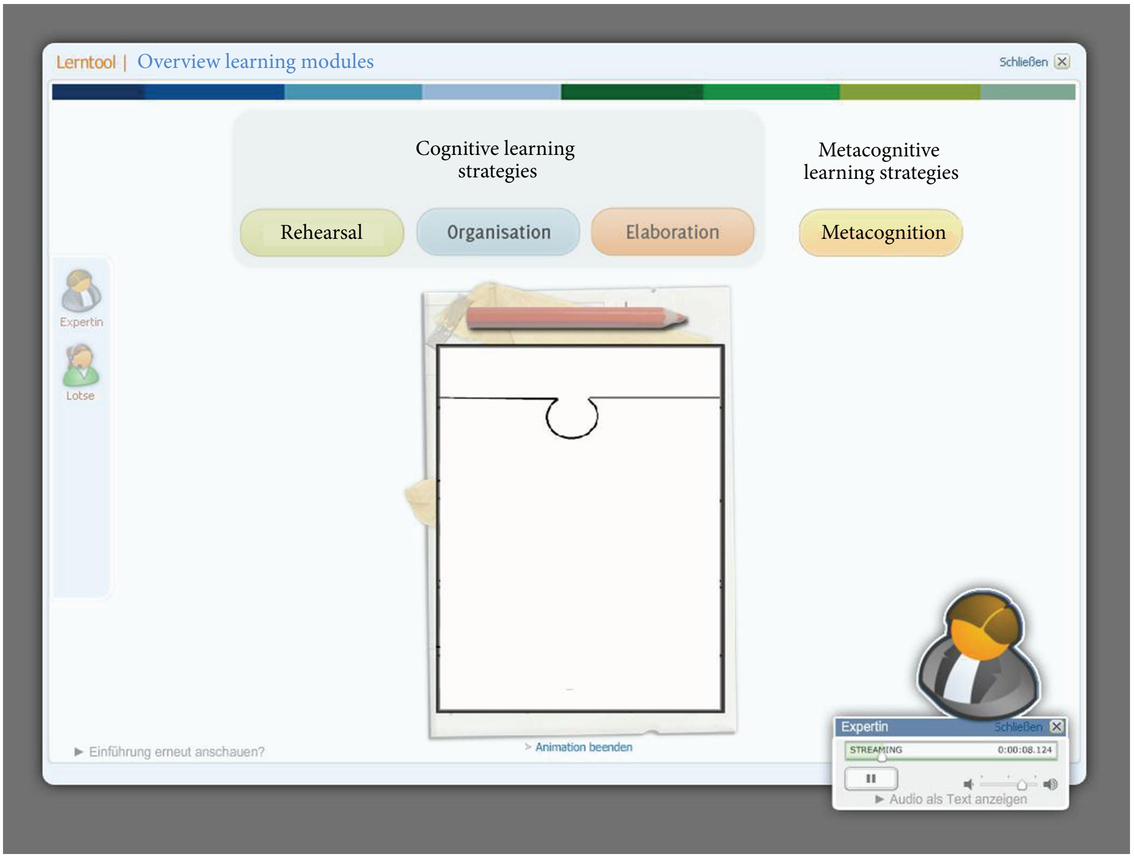


Figure 4: Example of the "modality principle." Expert speaks (on the lower right) while related visual elements appear step by step (middle).

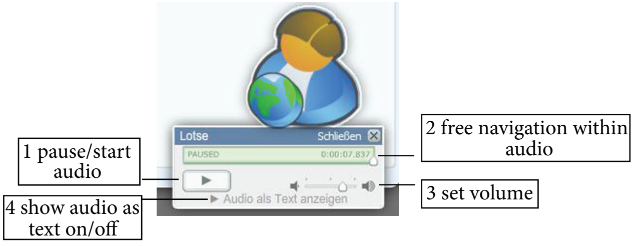


Figure 5: Audio control.

and asked for feedback (3). Finally, two evaluation studies were conducted.

7.1. Expert Sessions. Altogether, six experts worked with a prototype including the module about organization strategies. We asked for written feedback about usability aspects, comprehensibility of the contents, and multimedia principles before we collected open oral feedback. Important refinements in reaction to the expert sessions were (a) adding extra sites with overviews or with short introductions in order to give the learner more orientation within learning contents; (b) refinements referring to multimedia principles; for example, when graphics (journal passages or "illustration" of explanations) included too much text, experts recommended to avoid simultaneous audio. Thus, in the case that journal passages contain primarily textual information, we prompted learners to first read the journal example carefully and then activate the spoken instructional explanations by clicking a button.

7.2. Research Team. The research team consisted of the authors (including one in-service teacher who also worked in teacher education) and five student research assistants who either studied educational psychology, instructional design, or teaching. Within the research team, we continuously conducted *cognitive walkthroughs,* documented feedback and systematically incorporated it into the software.Important refinements comprised highlights in graphics in order to guide attention, and also highlighting navigation in order to show the learner where s/he is and what else is coming. Refinements that were done after almost each feedback cycle concerned coherence and comprehensibility of texts (e.g., optimizing wording; using the same words for a concept throughout a module; leaving off irrelevant information).

7.3. Student Teacher Session. Then, we evaluated the prototypical CBLE with a small teacher education class of nine student teachers. They answered questions about motivation and satisfaction positively on average. Again, we asked for written feedback about usability aspects, comprehensibility of the contents, and selected multimedia principles before

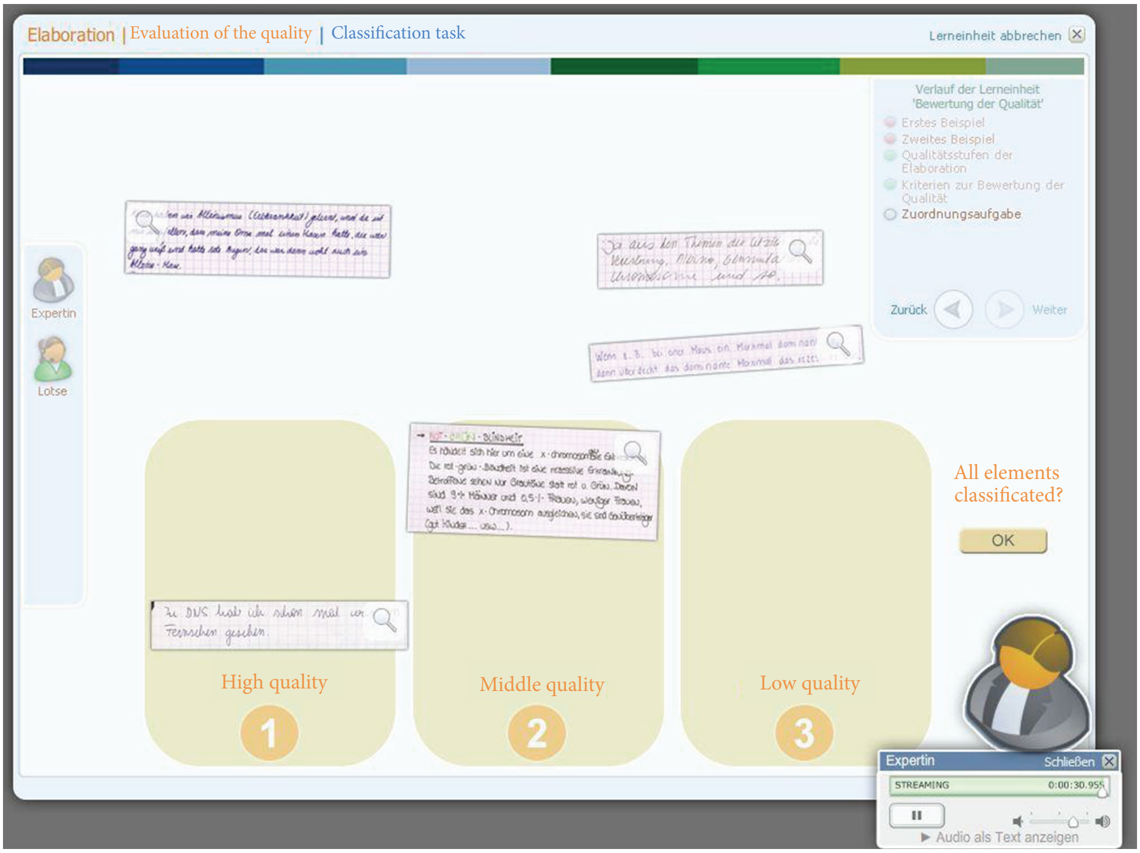


Figure 6: Classification tasks. In order to train to differentiate different levels of quality (high, middle, and low), teachers had to classify journal passages by dragging and dropping them to the three boxes (1), (2), and (3).

we collected open oral feedback. Important refinements in reaction to the student teacher session were (a) adjustment of tasks (e.g., some self-explanation tasks had to be more difficult; feedback in classification tasks should not be given until the learner asks for it by clicking a button); (b) more text was changed to audio; (c) texts were structured by more underlining or highlighting of important aspects; (d) the orientation in the learning environment, partly being a matter of usability, still had to be enhanced. Therefore, we added the figure of a *pilot* to support the navigation and orientation in the interactive learning environment. When a learner enters a new part of the learning environment (or a new kind of task), the pilot describes which activities are expected from or offered to the learner. It is explained, if applicable, how specific functionalities of the program can be used. On the left, there is a pilot button where this information about the specific part of the program can be recalled (Figures 3, 4, and 6, at the left margin, “Lotse”).

The latter refinement prompted us to also insert an *expert button*. The expert button (above the pilot button) allows to reread instructional explanations about every learning strategy (rehearsal, elaboration, organization, and metacognition), no matter in which module the learner is.Finally, the formative evaluations and refinements ended in the version of the CBLE that was used in the evaluation studies described in the next paragraphs.

8. Evaluation Study I of the Computer-Based Learning Environment

The aim of this evaluation study was to test whether (prospective) teachers learn to assess learning strategies in learning journals efficiently and effectively by working with the CBLE. Additionally, we regarded a high acceptance of the CBLE as favorable precondition for its use in later “real” practice. The CBLE should be attractive so that (preservice) teachers actually put time and effort in working with the environment [36–38]. Therefore, the study tested whether (prospective) teachers are interested in the learning content, motivated while working with the environment, evaluate the contents as comprehensible, find the environment easy to use (usability), and, in the end, learn to assess learning strategies in authentic learning journal passages.

8.1. Method. Forty-four German student teachers (25 females and 19 males; age: $M = 23.93$, $SD = 3.16$) from a German University participated in this laboratory study. They worked through one learning module of the CBLE that introduced several subcategories of organizational strategies (20 minutes). They were then asked to rate their satisfaction with the CBLE (e.g., “*I would recommend this learning environment*”), their interest in the contents (e.g., “*I find it important to learn about a scheme for assessing learning strategies*”), the usability (e.g., "*Operating the learning environment was easy*"), and their motivation to keep on working in the CBLE ("*I would like to work through the other parts of the learning environment (assessment of rehearsal, elaboration, and metacognitive learning strategies)*"). All items were rated on a 7-point scale (1: *not at all true*; 7: *absolutely true*). A posttest with 14 items including authentic learning journal passages assessed participants' assessment skills. They had to identify learning strategies, to evaluate the quality of applied learning strategies, and to provide reasons for their judgments. One third of the posttests was rated by two independent raters using a 6-point scale for each item (6: *all central aspects, coherently related to each other*). As interrater reliability was very good ($ICC = .87$), the remaining tests were only rated by one rater.

8.2. Results. We found high satisfaction ($M = 5.83$, $SD = 0.70$; scale from 1 to 7) and high topic-specific interest ($M = 5.91$, $SD = 0.77$). For example, the student teachers rated the item "*I find it important to learn about a scheme for assessing learning strategies*" on the 7-point scale (7: *absolutely true*) at 6.11 ($SD = 1.06$) on average. That is, student teachers perceived the learning contents of the CBLE were very important.

Results regarding the usability of the CBLE showed that student teachers did not report difficulties using the CBLE ($M = 5.81$, $SD = 1.42$). Student teachers perceived the environment as, for example, not unnecessarily complex and its structure understandable.

Additionally, motivation to keep on working in the CBLE was rated 6.55 on average ($SD = 0.70$). Assessment skills after the short learning phase were satisfying. On average, student teachers achieved half of the maximum score on most items (overall score on the scale from 1 to 6: $M = 3.66$, $SD = 0.55$). That is, after 20 minutes of learning, they were able to identify and evaluate learning strategies in authentic learning journal passages that they had not seen before.

Important refinements in the CBLE in reaction to Study 1 were (a) adding or changing keywords or symbols that communicated to the learners how or where they can close a window (e.g., when working in a specific submodule, the whole window has to be closed in order to get back to the overview site. In order to make that clear, we replaced "close window" by "back to overview"); (b) adding saving functions (e.g., answers to a task were saved for the user as well as which modules had been finished). Results suggested that the theoretically deduced contents and the instructional design of the module could serve as model for the other modules. Thus, we finished a second module *elaboration* which was studied in the second evaluation study.

9. Evaluation Study II in Student Teacher Courses

In this evaluation study, we had a twofold research question. Student teachers worked with and evaluated our CBLE during their School of Education courses. We were again interested in their satisfaction with the CBLE, interest in the presented contents, motivation to keep on working in the CBLE, usability, and learning outcomes. In addition, we tested a simple variation which can be realistic for in-service teachers and helpful for teacher education. We expected that the mere exposure to an authentic problem prior to working with the CBLE (without attempts to solve it) enhances motivation and learning outcomes. The authentic problem consisted of passages from students' learning journals. Student teachers were asked to give those students feedback after learning how to evaluate learning strategies in learning journals with the CBLE.

Approaches that try to optimize receptive forms of learning and direct forms of instruction by prior problem-oriented activities were the theoretical background for this variation (e.g., [39, 40]). Such approaches typically use generative group activities that are quite time consuming. These activities are thought to generate forms of prior knowledge that allow for subsequent elaborative processes. Simply knowing about target problems might, however, already sufficiently prepare for learning from direct instruction, as the goal of learning, knowledge deficits, and the application context become salient.

9.1. Method. Eighty-nine student teachers (71 females and 18 males) from two equivalent seminars at a German School of Education participated in the study (title of the seminars: "Selected topics of mathematics instruction"). Two weeks prior to the intervention, they all worked on a pretest during their seminar. The pretest measured assessment skills regarding learning strategies by two open questions about learning strategies and how student teachers would identify and evaluate them in school.

At the intervention, participants were randomly assigned to two conditions: (a) they either received the authentic problem prior to learning with the CBLE and had 5 minutes to familiarize themselves with the problem (problem-first group, $n = 42$); or (b) they received the same problem after learning (problem-after group, $n = 47$). The problem consisted of learning journal passages and a description of a situation ("Here you see two learning journal passages of two students. Your challenge is the identification of learning strategies and the formulation of a feedback to the students. Use the information from the learning environment."). All participants learned in the module of the CBLE that introduces the assessment of elaboration strategies for 30 minutes. Providing feedback was not specifically taught.

After learning, all participants answered the items on satisfaction with the CBLE, their interest in the contents, the usability, and their motivation to keep on working in the CBLE. The items were the same as in the first evaluation study (see Study 1 for examples). Then, the problem-first group had 10 minutes to solve the problem, that is, to identify learning strategies in the learning journals and to write feedback to the students. The problem-after group now received the problem, read it carefully (5 minutes), and worked on it for 10 minutes; that is, time-on-task was equal across groups. The posttest contained three items that measured assessment skills. Student teachers had to evaluate the quality of elaboration strategies in learning journal passages as low, middle, or high and to explain their assessment by completing the sentence "I evaluate the quality of the elaboration strategy in passage 1 as ... [low, middle, high], because..." The items were rated on a 6-point scale. Transfer was measured by coding student teachers' feedback on two learning journal passages. Scores were (1) the number of sections coded as "learning strategy use", where student teachers pointed out which learning strategies the student uses in the learning journal and in which quality ("You found an own example which you explained very nicely and in detail"); (2) the number of sections coded as "suggestions for improving learning strategies" ("Next time, you could improve your example by additionally drawing an illustration of the example problem"). Two independent raters rated and coded the test items (ICCs > 0.80).

9.2. Results and Discussion. With regard to the satisfaction about the CBLE, we again found high values ($M = 5.58$, $SD = 1.20$; scale from 1 to 7). The motivation to work with the CBLE and the interest in the learning contents was very high ($M = 6.23$, $SD = 0.79$). For example, the student teachers rated the item "*I find it important to have learned about a scheme for assessing learning strategies*" on a scale from 1 to 7 (as in Study 1, i.e., 7: *absolutely true*) at 6.41 ($SD = 0.80$) on average. The item "*I would like to work through the other parts of the learning environment (assessment of rehearsal, organization, and metacognitive learning strategies)*" was rated at 6.35 ($SD = 0.94$) on average.

Results regarding the usability of the CBLE showed that student teachers find the CBLE easy to use ($M = 5.84$, $SD = 1.42$). Most items were rated at the second highest point on the scale from 1 to 7 (7: *absolutely true*). Thus, student teachers perceived the learning environment as, for example, easy to operate ($M = 6.46$, $SD = 0.93$) and its structure understandable ($M = 5.95$, $SD = 1.31$).

Assessment skills after the short learning phase were again satisfying. On average, student teachers achieved at least half of the maximum score on all items (overall score: $M = 3.91$, $SD = 1.01$). That is, they were able to efficiently learn and transfer their acquired knowledge on learning strategies to the evaluation of (new) authentic journal passages.

With regard to the experimental variation, we found that student teachers who first familiarized themselves to the authentic problem achieved higher scores in the assessment skill measure ($F(1, 87) = 5.04$, $p = .014$, $\eta^2 = .06$), as well as in the feedback transfer score "learning strategy use" ($F(1, 87) = 4.03$, $p = .024$, $\eta^2 = .05$). Suggestions, however, were made more often by the problem-after group ($F(1, 87) = 11.88$, $p = .001$, $\eta^2 = .13$). This is surprising and can be seen as problematic, because student teachers told students how to improve their learning strategy use even though they were less successful than the problem-first group in identifying the students' learning strategies and explaining why the learning strategies were suboptimal. However, well-grounded, specific, and, thereby, helpful [8] suggestions can scarcely be made without detailed identification of learning strategies and their quality. Prior knowledge was considered in the previous results and was not significantly related to the learning outcome scores. Motivation did not differ significantly between groups prior or after the learning phase which can be explained by ceiling effects; almost all student teachers were highly motivated (all $M > 6$ on the scale from 1 to 7; pre: $F(1, 87) = 0.18$, $p = .672$, $\eta^2 = .002$; post: $F(1, 87) = 0.82$, $p = .369$, $\eta^2 = .01$).

In summary, receiving an authentic problem prior to learning prepared student teachers to learn and transfer their knowledge to giving feedback that was based on specific observation. In contrast to research about preparation to learn from direct forms of instruction, it is not necessary to use time-consuming instructional methods. Instead, the mere exposure to a problem taken from their professional context can prepare student teachers to learn from direct instruction. Satisfaction, interest, and usability of the CBLE were high, which is an important precondition for its use in practice. These results served as further evidence that the remaining modules of the CBLE could be finished on basis of the two studied modules.

10. Conclusion

This paper has introduced a CBLE that, in the end, can support teachers to promote self-regulated learning in school by training their skills to assess learning strategies. We reported on the theoretical deduction of contents as well as of instructional design features, on further shaping the conception of contents and design by teacher interviews, and formative evaluation cycles. The reported evaluation studies suggest that teachers can learn to assess learning strategies in learning journals efficiently and effectively by working with the CBLE. In fact, learning and transfer scores were mostly in the middle of the scales. This achievement could seem moderate; however, two points have to be considered. First, student teachers only worked with one of the four strategy modules for 20–30 minutes. Second, the posttest items all required the application of learned principles to learning journal passages; that is, they required some transfer. Therefore, the participants' achievements on identifying learning strategies (quantity) and on evaluating the strategies' quality after such a short learning phase can indeed be regarded as substantial.

Exposing student teachers to an authentic problem prior to learning, that is, expecting them to give feedback on learning strategy use to students after working with the CBLE, enhances the feedback student teachers give. Motivational variables as well as usability were rated very high in both evaluation studies.

Especially, the evaluation Study 2 suggests that the CBLE is of practical use as it was conducted in regular teacher education courses. Results suggest that student teachers would benefit from and enjoy working through the CBLE during regular teacher education courses similar as in the study. Working with the CBLE as homework might also be effective if, for example, authentic problems are discussed in the courses. The high acceptance of our CBLE is a favorable precondition for its use in later practice.

To date, our approach to develop the computer-based learning environment has taken first successful steps. Nevertheless, there are open questions to be addressed in the future. The benefits of our CBLE should be analyzed in more depth by studies that assess the teachers' learning processes more carefully. Interventions (e.g., a pretraining as in [41]) prior to learning with the CBLE could be of additional value because we observed mistakes (apparently based on incoherently organized knowledge pieces) in the pretest that were repeated in the posttest. Furthermore, studies on how students' self-regulated learning is affected by the teachers' use of the CBLE would be sensible. We will keep on offering courses using the CBLE to (student) teachers. Thus, many (student) teachers will have the opportunity to learn more about assessing learning strategies in learning journals, which can enable them to better promote self-regulated learning in school.

Acknowledgments

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Research Article

Layers of Self- and Co-Regulation: Teachers Working Collaboratively to Support Adolescents' Self-Regulated Learning through Reading

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This paper reports findings from a longitudinal project in which secondary teachers were working collaboratively to support adolescents' self-regulated *learning through reading* (LTR) in subject-area classrooms. We build from prior research to "connect the dots" between teachers' engagement in self- and co-regulated inquiry, associated shifts in classroom practice, and student self-regulation. More specifically, we investigated whether and how teachers working within a community of inquiry were mobilizing research to shape classroom practice and advance student learning. Drawing on evidence from 18 teachers and their respective classrooms, we describe findings related to the following research questions: (1) While engaged in self- and co-regulated inquiry, what types of practices did teachers enact to support LTR in their subject-area classrooms? (2) How did teachers draw on research-based resources to inform practice development? (3) What kinds of practices could be associated with gains in students' self-regulated LTR? In our discussion, we highlight contributions to understanding how teachers can be supported to situate research in authentic classroom environments and about qualities of practices supportive of students' self-regulated LTR. We also identify limitations of this work and important future directions.

1. Introduction

In this paper, we present findings from the second year of a longitudinal project in which secondary teachers in Western Canada were working collaboratively with researchers to better understand and support adolescents' self-regulated *learning through reading* (LTR) in subject-area classrooms. In this project, a central goal has been to advance understanding about students' self-regulated LTR as situated in classroom contexts [1]. However, if we are to make a meaningful difference for students, also essential is studying how teachers can be supported to embed practices supportive of students' self-regulation into authentic classroom environments. To that end, in the longitudinal project, we have been studying *teachers'* engagement in self- and co-regulated inquiry as they work together to develop practices supportive of students' self-regulated LTR [2–4].

Extending from prior work, in this paper we "connect the dots" between teachers' engagement in self- and co-regulated inquiry, associated shifts in classroom practice, and student outcomes. More specifically, we investigated whether and how teachers working within a community of inquiry were mobilizing research to shape classroom practice and advance student learning. Drawing on evidence from 18 teachers and their respective classrooms, we addressed the following research questions: (1) While engaged in self- and co-regulated inquiry, what types of practices did teachers enact to support LTR in their subject-area classrooms? (2) How did teachers draw on research-based resources to inform practice development? (3) What kinds of practices could be associated with shifts in students' self-regulated LTR?

2. Self- and Co-Regulated Inquiry in Teachers' Professional Development

It is increasingly recognized that improving student outcomes in classrooms is dependent on teachers' professional learning (e.g., see [5–8]). As a result, research is being called for that both associates qualities of professional development with teachers' contextualized use of promising literacy practices and traces how practice shifts that emerge through professional learning are associated with gains in adolescents' literacy performance [9–11]. In response to this call, we have been investigating how teachers' professional development supports not only teacher learning and practice revisions, but also more positive outcomes for students.

More specifically, in the research reported here, we studied whether and how teachers working within a "community of inquiry" were mobilizing research to inform practice and achieve positive outcomes for learners. Critics of transmission or prescriptive approaches to professional development have suggested they are particularly ineffective in supporting contextualized and sustained shifts in classrooms [5, 12–14]. As an alternative, newer initiatives are embedding professional development within communities of inquiry wherein individuals work together to co-construct and situate emerging knowledge and beliefs [3, 4, 15–21]. Building from these initiatives, in this research, we studied whether and how an inquiry-oriented approach to professional development might support teachers in making research-practice connections.

To inform our study, we applied a socioconstructivist model of self- and co-regulation to characterize teachers' inquiry processes (see [3, 4, 22]). Models of self- and co-regulation are most often applied to understanding students' engagement in learning, (e.g., [23–30]). Students are described as self-regulating when they deliberately orchestrate learning so as to achieve goals, by planning and enacting strategies, monitoring progress and outcomes, and adjusting activities as needed. However, in Figure 1, we depict how we have described *teachers'* working to set goals, plan, enact, and monitor classroom *practices* as something that they also "self-regulate" [4, 12]. In a community of inquiry, teachers are typically supported to identify and set goals for practice and student learning, plan practices to achieve goals, situate those practices meaningfully in classroom settings to meet students' needs, monitor challenges and benefits for learners, and adjust approaches as needed. By engaging in these kinds of self-regulating strategies in a sustained way over time, teachers have opportunities to engage in iterative cycles of practice refinement so as to advance students' learning.

As is referenced in Figure 1, our layered model of self- and co-regulation also suggests that when teachers participate in professional development (formal or informal), they can also deliberately advance their own professional *learning* in/through practice [2, 4, 15]. Indeed, to inform understanding about teachers' professional development, we have found

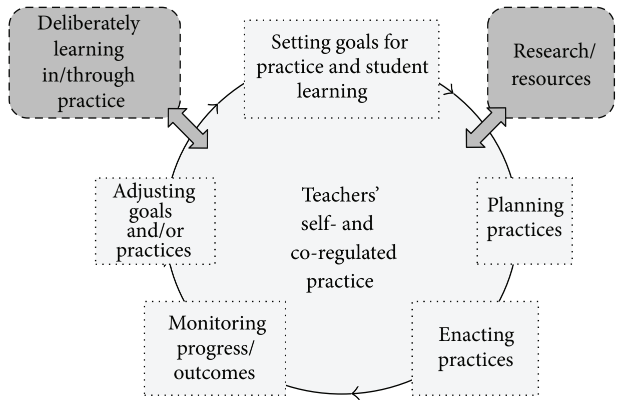

Figure 1: Teachers' engagement in cycles of self- and co-regulated inquiry (see also [4]).

it useful to distinguish teachers' self-regulation of *practice* (i.e., SRP) from their self-regulation of their own *learning* (i.e., SRL) [2–4]. When self-regulating practice, teachers strategically orchestrate their work in classrooms so as to advance student learning. When self-regulating their own learning, teachers might extend their professional competence deliberately by setting learning goals (e.g., to learn more about SR and how to support it in their classroom), planning for learning (e.g., to join a study group), self-monitoring (e.g., their progress in learning), and making adjustments as needed (e.g., to access other kinds of resources). To advance professional learning, our past research has suggested that the ideal is for teachers' deliberate engagement in SRL to be intimately connected to their reflective and iterative engagement in cycles of SRP [2, 4, 15].

We would note that a particular benefit in a *community* of inquiry is that teachers have opportunities to engage in inquiry processes together [4, 6, 15, 20, 21, 31–33]. In the theoretical model applied here, we therefore extend the concept of "co-regulation" to describe teachers' collaborative inquiry within professional development initiatives. Models of self-regulation do not just focus on "in-the-head" processes of individuals; instead, they characterize the complex interplay between individual and social processes [34–37]. For example, research suggests how teachers can structure activities, instruction, or assessment so as to "co-regulate" students' engagement in activities as a way of developing self-regulation in reading, writing or other forms of academic work (e.g., [38–43]). In past projects, we have built from this theoretical perspective to conceptualize and study teachers' engagement in collaborative inquiry. For example, we have examined the depth and quality of teachers' co-regulated practice and professional learning when teachers work with colleagues (e.g., peers, mentors) to set goals, plan for teaching, enact classroom practices, monitor outcomes, and revise practices accordingly [4, 15, 22].

In previous reports, we demonstrated the heuristic value of this theoretical framework for conceptualizing teachers' engagement in inquiry [2–4]. We also documented how when teachers engaged in collaborative inquiry, they experienced significant gains in professional learning and classroom practice [2, 4, 15, 44]. To advance this line of research, in this study, we focused on whether and how teachers were drawing on research-informed resources to shape practices developed in inquiry cycles. Building from our layered model of professional learning as depicted in Figure 1, we hypothesized that research could have an impact on practice to the extent that it informed teachers' iterative engagement in goal-directed cycles of self- and co-regulated inquiry (see also [45]). This perspective motivated this investigation of how the availability of research-based resources within a community of inquiry could be associated with teachers' practice development.

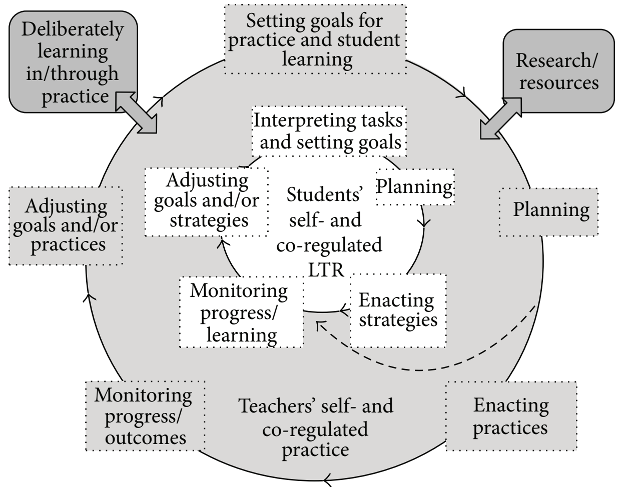

Figure 2: Layers of self- and co-regulation (see also [4]).

3. Students' Self-Regulated Learning through Reading

The community of inquiry studied here formed with the common goal of refining classroom practices so as to advance adolescents' *learning through reading* (LTR) within subject-area classrooms. At the secondary level, subject-area teachers rely heavily on students' ability to engage in reading as an important vehicle for learning. The result is that to thrive in today's classrooms, adolescents must navigate complex LTR tasks, often involving multiple types of text (e.g., narrative and expository: textbooks, primary source documents, websites) [46–51].

LTR provides a good example of a kind of academic work that requires effective self-regulation. LTR activities challenge students to recognize the demands in particular settings (e.g., LTR in history or science), coordinate multiple types of knowledge, beliefs, perceptions, and conceptions (e.g., about a topic; LTR tasks; fields of study; themselves as learners) and plan and manage use of multiple reading and learning strategies [52–56]. Expectations in LTR include not just "comprehending," but also engaging actively with information (e.g., drawing inferences, applying ideas), participating in discipline-specific discourses (e.g., in history or science), and adapting reading and learning strategies to match task requirements and teacher expectations [53, 56, 57]. Ample research has documented the importance of students' SR and higher-level thinking if they are to construct meaning and learn from reading [58, 59].

In this project, researchers and teachers worked again from a socioconstructivist model of self- and co-regulation to inform their efforts to better understand and support students' engagement in LTR (see [60, 61]; see also [23–30]). A version of this model is depicted in Figure 2, which is designed to illustrate how, in this research, teachers' engagement in self-regulated and co-regulated inquiry was centered on enhancing students' self-regulated LTR. Teachers in this study worked from a more elaborated model that added attention to how students bring to bear knowledge (e.g., in a given subject area; about strategies), beliefs (e.g., self-perceptions of competence and control), conceptions (e.g., about learning in science), and emotions (e.g., stress or worry) that mediate their engagement in activities. Figure 2 represents the importance of students' enacting reading and learning strategies well matched to the demands of a particular LTR activity (e.g., to learn from particular texts in a given humanities classroom). It also depicts how strategy use is best situated within cycles of self-regulation [38, 57]. As outlined previously, self-regulating learners ideally engage in iterative learning processes that include interpreting tasks and setting goals, planning, selecting, and enacting task-relevant strategies, monitoring progress and learning (e.g., self-assessing), and adjusting goals and/or strategies as needed (to manage motivation and emotions; to improve learning).

Unfortunately, in spite of the centrality of LTR to adolescents' school success, research has documented that secondary-level students often experience significant challenges when self-regulating their performance in LTR activities, (e.g., [55, 62]). Consistent with that research, formative assessment data collected by teachers as part of this project revealed important strengths and gaps in students' self-regulated LTR (see also [1]). For example, at the start of the academic year, students reported relatively high self-perceptions of competence and control. While teachers have mostly been encouraged by these positive self-perceptions, which can be associated with strategic engagement and persistence through difficulty (see [63]), in some cases, students' self-perceptions were clearly inflated. Teachers were also concerned that students were paying little attention to self-regulating strategies such as planning or self-monitoring. Equally troubling was that, while students reporting using strategies for working with text (e.g. pay attention to bold words) and building meaning (e.g., think about what I know), they were much less likely to report using more active meaning-making strategies (e.g., find links; think of examples; apply ideas; summarize). Consistent with self-reports, performance-based assessments also revealed how students struggled to engage in richer, meaning-making activities such as drawing inferences, analyzing information, and relating main ideas and details when making notes. It was overcoming these kinds of challenges that in large part motivated teachers' decision to focus on supporting self-regulated LTR in their classrooms.

Fortunately, research has identified classroom practices with potential to support more effective self-regulation (e.g., see [44, 57, 64–66]) and/or LTR (e.g., see [46–49, 55, 56, 59, 67]). Essential then is to study how teachers can be assisted to draw on research-informed resources to inform their practice development. To that end, in this research, teachers were supported to draw on a rich array of resources, from workshops, research reports, professional articles, mentors, and peers, to consider how they might refine practices to support their students' self-regulated LTR. In this paper, we trace how practices teachers enacted could be related to those resources. We also identify the types of practices that were most closely associated with gains in student outcomes.

4. Methodology

Case study designs are particularly useful for advancing understanding about self- and co-regulation as situated in authentic classrooms [68–70]. For example, by creating a frame for collecting and juxtaposing multiple forms of data on both individuals and environments, case study designs support investigating self- and co-regulation as multidimensional, dynamic activities inextricably wedded to context.

In prior reports, we have described our overall research design as "encompassing multiple, context-dependent case studies at the classroom level, each of which preserved meaning in context" (see [1, page 79]). Our approach has involved creating descriptive portraits of secondary students' engagement within particular LTR activities in subject-area classrooms, and then moving "upwards" and "downwards" across levels of aggregation (e.g., individual, class, grade, school) to consider how patterns observed at the classroom-level relate to patterns at other levels (i.e., whether a grade-level pattern in a given school was common across classes or masked between-class differences). Through this approach, we have identified both common patterns and important variances in students' LTR across classrooms, consonant with a situated view of SR that locates the meaning of action in context.

Taking this approach has also enabled us to associate practices enacted within and across classrooms with learning outcomes for students working in particular contexts. In other words, our case study methodology has enabled us to "connect the dots" between teachers' activity and student learning in naturalistic settings. In the research reported here, we extended our case study methodology to investigate how teachers drew on research-informed resources within cycles of self- and co-regulation (see also [2–4]). We report findings in which we examined links between resources, qualities of practices, and outcomes for students.

4.1. Research Context. This project overall involved 18 teachers from three secondary schools located within an urban, multicultural school district within Western Canada who had been working over time in a community of inquiry to better understand and promote students' self-regulation in LTR activities (see [1] for detailed information on the inquiry community). An important contextual influence was that the Ministry of Education in the province had instituted an accountability cycle requiring school districts to develop goals, implementation plans, and assessment strategies (see [71]). For their adolescent literacy project, the participating district supported the collaborative development of assessment tools that could be used, not just for reporting on outcomes (for their accountability contract), but also for guiding and monitoring practice within and across classrooms and schools. A role of the research team in the inquiry community has been to support teachers in their construction and interpretation of assessments in ways that they might find meaningful for supporting students' self-regulated engagement in LTR.

The district participating in this research had established a culture of ongoing inquiry as a means of fostering teachers' ongoing practice improvements. Interpreted in relation to our theoretical framework, we considered this as an example of an overall environment where social practices favored and encouraged teachers' engagement in cycles of self- and co-regulated practice and learning.

We considered too that the resources made available in the project would provide language and tools that would inform but also delimit how teachers engaged in collaborative inquiry. Notable here was that teachers had access to two kinds of resources: (1) theoretical frameworks that articulated important instructional goals (i.e., about self-regulation in LTR; provincial curricula), along with associated guidelines for constructing assessments, and (2) ideas and support from resources (research articles or professional resources; literacy leaders; colleagues). Thus, what we looked for in our analyses was whether and how these resources informed teachers' efforts to improve student learning (see also [15]).

A relatively complete overview of resources available to teachers is provided in Figure 3. District-level resources are explained in more detail in Table 1. These figures show how professional development activities took place at both the district and school levels. In addition to support provided to teachers' collecting, interpreting, and setting goals based on formative assessment data, professional development activities also assisted teachers to identify practices supportive of LTR (e.g., literacy practices described in research or in use by peers) and to collaborate productively (e.g., planning collaboratively on how to achieve goals). At the school level, literacy leaders supported teachers through co-planning, co-teaching, and/or hosting team meetings where idea sharing and/or collaborative partnerships could emerge. In this work, part of literacy leaders' role was to help mediate their colleagues' engagement with ideas drawn from research. Thus, in important respects, the structure of the district's professional development initiative was designed to cue and scaffold teachers' interweaving of cycles of self- and co-regulated inquiry and, in that context, to support their drawing on a range of research-based resources to inform practice development.

4.2. Data Collection. Figure 4 overviews the multiple forms of data collected as part of our overall case study design. Taken together, these displays show collection strategies have afforded examining students' thinking about and performance in LTR activities in relation to teachers' engagement

Table 1: Professional development activities available to participants at the district level.

Activities	Fall	Winter	Spring
Assessment to Instruction Workshops (teams)	One day workshop (Sept 26) Explored formative and performance based assessment and reading performance standards Modeled goal setting from PBA data Elements of effective adolescent literacy programs (i) Instructional improvements (Reading Next) (ii) Infrastructure improvements (Reading Next) Introduced strategic teaching (a few thinking strategies targeted and integrated into the curriculum over time) Teams goal set and planned at the instructional and school organization level	One day workshop (Jan 13) Assessment to instruction cycle revisited Reflected on current goals and related activities Discussed the notion of sustainability continuing to work on plans throughout the year Discussed using formative assessment throughout the year Open ended teaching reviewed and modeled Cross-school sharing of goals, plans, strategies enacted and student samples Teams goal set and planned at the instructional and school organization level	Morning workshop (May 19) Reviewed focus of the project (grade level teams, formative assessment, setting goals for student learning, working together to develop and implement practices, summative assessment and reflection) Teams shared and discussed successes and challenges, ways to work between elementary and secondary schools Discussed integrating planning, assessment and instruction Teams goal set and planned regarding their professional development needs for next year
Partner workshops (literacy leader and partner)	One day workshop (Dec 13) Assessment to instruction cycle revisited Reflected on current goals and related activities Co-teaching models introduced Examined unit planning approaches to build reading strategies into content teaching Reviewed reading comprehension research (Duke and Pearson 2002 [93]) Modeled open ended teaching to help kids connect to, actively process, and transform content Partners goal set and planned classroom activities Professional readings distributed	One day workshop (Feb 14) Partners reflected on student learning, plans enacted, and possible next steps Shared implementation stories and student samples Introduced approaches to organizing for collaboration Modeled open-ended teaching that helps kids connect to, actively process and transform/personalize content Introduced inquiry groups as an instructional approach Partners goal set/planned classroom activities Professional readings distributed	One day shared leadership workshop (April 12) Superintendent spoke about IRI as epicenter of learning plan as a district Reviewed goal of supporting student transition to secondary schools (awareness of kids at risk) Related adolescent learning theory to reading initiative Examined opportunities to link reading/learning foci to new curricula (assessing kids' thinking processes) Reviewed formative assessment and strategic teaching Discussed building teaching practices that help kids achieve standards and accommodate differences Discussed, shared and distributed learning and leadership at the classroom and school level
Literacy leaders meetings	Literacy leader meetings afternoon (Sept 15) Examined vision for schools and literacy leader role Reviewed and discussed 6 strategies for people work (McAndrew 2005 [94]) Discussed reading performance standards and PBA protocol Reviewed and discussed Pro D initiatives for the year, professional resources in schools and IRI funding Action planning (vision, collaboration, instruction, and own learning and reflection)		Literacy leader meetings afternoon (June 20) Discussed instructional coaching Examined principles of assessment for learning Reflected on ways to work with full school staff around literacy Discussed PBA format and group problem solved Reviewed new professional resources in schools Goal set and planned regarding professional development needs for next year

Table 1: Continued.

Activities	Fall	Winter	Spring
Second shot program development (second shot teachers and literacy leaders)	Morning meeting/workshop (Sept 15) Reviewed development process to date Shared progress to date Reviewed role of second shot course within schools Shared assessment practices and goals set for students Shared instructional plans to date Reviewed unit planning, lesson planning, comprehension and metacognition strategies and instructional approaches Reviewed unit/lesson planning, strategies, and instructional approaches Goal set and planned classroom activities	After school 3 hour meeting (Feb 21) Reviewed structure of IRI initiative Reviewed second shot course goals Reviewed reading comprehension research Brainstormed and discussed challenges and questions Shared implementation stories, student samples and units and lessons Goal set and planned classroom activities	Morning meeting (June 28) Reviewed Deschler's content literacy curriculum Reviewed Allington's research on struggling readers Reviewed second shot course goals and outcomes Reviewed instructional approaches (gradual release, strategic teaching, four blocks, open ended teaching) Examined engaging and accessible texts Goal set and planned regarding groups professional development needs for next year

in professional learning and practice development. As is depicted in this figure, participating teachers gathered data for all of their students at the start (Fall) and end (Spring) of the academic year, to aid them in understanding student needs, planning for instruction, and monitoring outcomes. Note here that we only accessed data for research purposes with consent/assent from parents and students, respectively. We analyzed data collected on teachers' learning and practice development for 18 teachers across a full year. To evaluate connections between practice changes and student outcomes, we drew on data from 20 humanities classes taught by 12 teachers, including 364 students.

To afford understanding of students' self-regulated engagement in academic work, in prior research, we have developed and validated an array of data collection strategies (e.g., interviews; questionnaires; think-alouds; think-pair-share activities; learning logs; structured classroom observations; performance traces; achievement measures) (e.g., [38, 43, 68, 72–76]). For this project, teachers drew on two of those tools: the *Learning through Reading Questionnaire* (LTRQ) and the *Performance-Based Assessment* (PBA).

First, teachers employed the LTRQ to tap into how students were thinking and feeling about their engagement in self-regulation within LTR activities as situated in classrooms (see Figure 5). A unique quality of the LTRQ [60, 61] is that it is situated within a given learning activity and context (i.e., "read this text to learn about this topic within this subject area"). To date, versions of this tool have been created to study students' engagement in *Learning through Reading* (the LTRQ; see [1, 60, 61]), *Inquiry Learning in Science* (the ILQ; see [77]), and *Engineering Design* (the EDQ; see [75]). It is critical to stress that the contribution of this tool (in all variants) is to assess, not actual behavior, but how students think and feel about academic work and their engagement within it, as situated within particular contexts [60, 61]. For this research, we drew on LTRQ data to consider how students' perceptions about themselves as learners and their participation in LTR activities could be related to practices enacted by teachers in their particular classrooms.

Second, to create a more complete portrait of students' self-regulation that juxtaposed their thinking about LTR tasks (i.e., on the LTRQ) with a measure of actual performance, we also worked with teachers to construct and interpret situated PBAs following guidelines provided by Brownlie et al. [78]. The PBA assesses how students build meaning from text during a given LTR activity within a given subject area (see Figure 5). In this research, we linked administration of the LTRQ to the PBA to allow relating data between the two measures. Specifically, students completed the LTRQ while referring to the texts and tasks they would complete as part of the PBA, then they completed the PBA shortly thereafter. In this year of the project, teachers coordinated PBA development within and across subject areas and grade levels (i.e., students in the same grade and subject completed the same PBA; PBA versions were parallel in format/style across contexts). Each PBA variant required students to read one or more texts and then respond to open-ended questions. Teachers also conferenced with students as they were working to ask questions about strategy use and meaning making. Teacher teams scored PBAs collaboratively, with researchers' assistance, in relation to provincial performance standards for reading informational text.

Across the year, we also traced the professional learning and practice development of teachers. For this paper, data collection methods included Fall and Spring interviews, observations, and documents/artifacts gathered to assess (1) how teachers drew on resources to inform their practice development and (2) the quality of practices teachers engaged to promote literacy by their students. Again, to describe literacy practices as associated with teachers' use of resources, we reviewed data for 18 teachers across three schools sites, three of whom were literacy leaders (one per site) (see Table 2 for data available for each of these teachers). To link practice changes with student outcomes, we related pre-post

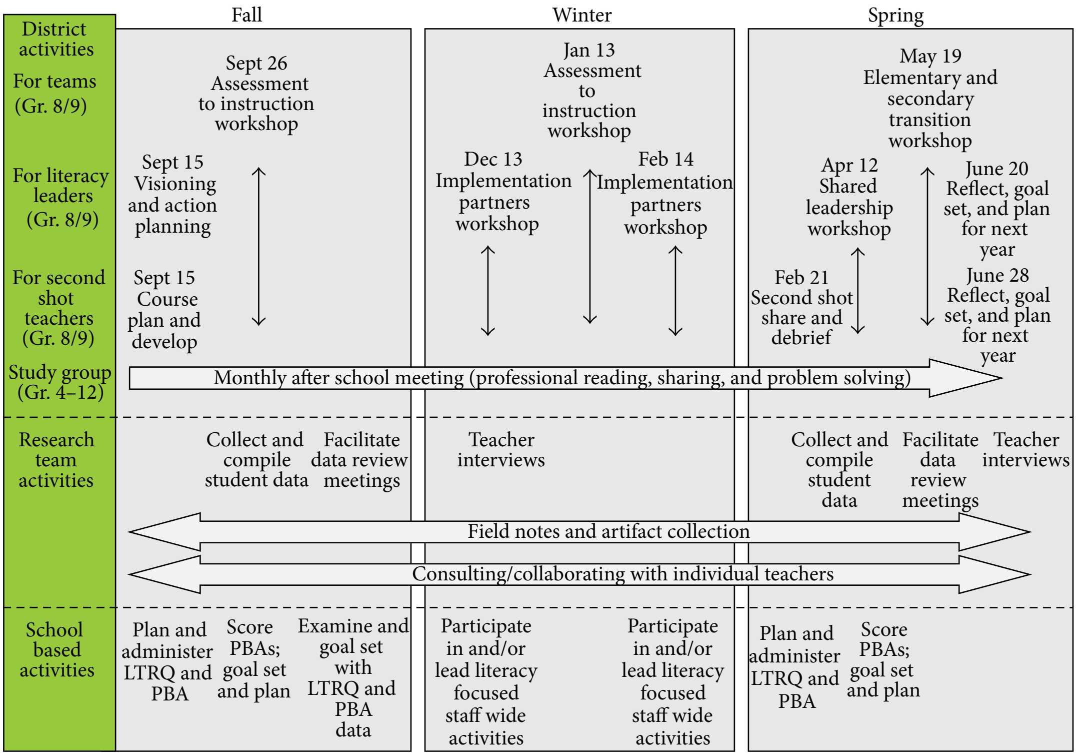

Figure 3: Professional development activities available to project participants at the district and school levels.

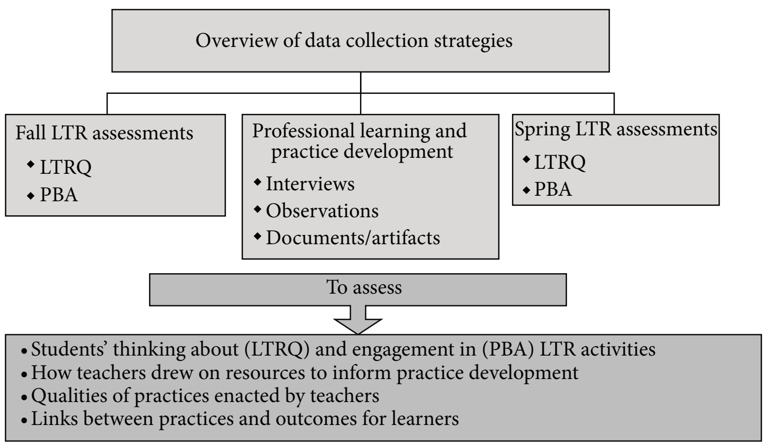

Figure 4: Overview of data collection strategies.

shifts in students' self-regulated LTR for 364 students in relation to practices enacted by 12 teachers in 20 humanities classrooms.

4.3. Data Analyses

4.3.1. Students' Engagement in LTR. We scored and summarized LTRQ and PBA data following processes described more completely elsewhere [1, 3, 79]. In brief, to support teachers' instructional decision-making, we used frequency analyses to create classroom-level LTR portraits. For the PBA, frequency distributions represented the number of students within and across classrooms who were achieving at different levels, overall (in "snapshot" scores) and for each of the PBA dimensions. For the LTRQ, we visually displayed the distribution of students' responses within and across classrooms for each of the main constructs associated with our model of self-regulation (e.g., students' perceptions of competence and control; task interpretation; reported strategy use). We also used factor analyses to define stable and reliable dimensions underlying LTRQ responses (summarized in Figure 5). We used repeated-measures, multivariate analyses of variance to assess Fall to Spring changes.

Table 2: Data sources available for each teacher.

Teacher	LTRQ Fall data	PBA Fall data	Interview fall	Field notes Fall PBA scoring meeting	Field notes Fall LTRQ debriefing meeting	Classroom artifacts	E-mail	LTRQ Spring data	PBA Spring data	Interview Spring
AA	✓	✓	✓	✓	✓			✓	✓	✓
MB	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DC	✓	✓		✓	✓	✓	✓	✓	✓	✓
SC	✓	✓		✓	✓	✓	✓	✓	✓	✓
MD	✓	✓		✓	✓	✓	✓	✓	✓	✓
EG	✓	✓		✓	✓	✓	✓	✓	✓	✓
DM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
WP	✓	✓	✓	✓	✓	✓				✓
RR		✓		✓	✓	✓			✓	✓
BT		✓		✓	✓	✓			✓	✓
ST	✓	✓	✓	✓	✓	✓		✓	✓	✓
MV	✓	✓		✓	✓	✓		✓	✓	✓
LW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
GF	(✓)	(✓)		✓		✓		(✓)	(✓)	✓
DS	(✓)	(✓)		✓	✓	✓	✓	(✓)	(✓)	✓
AG	N/A	N/A	✓	N/A	✓	✓	✓	N/A	N/A	✓

Notes: Initials for teachers refer to pseudonyms; LTRQ: Learning through Reading Questionnaire; PBA: Performance-Based Assessment.

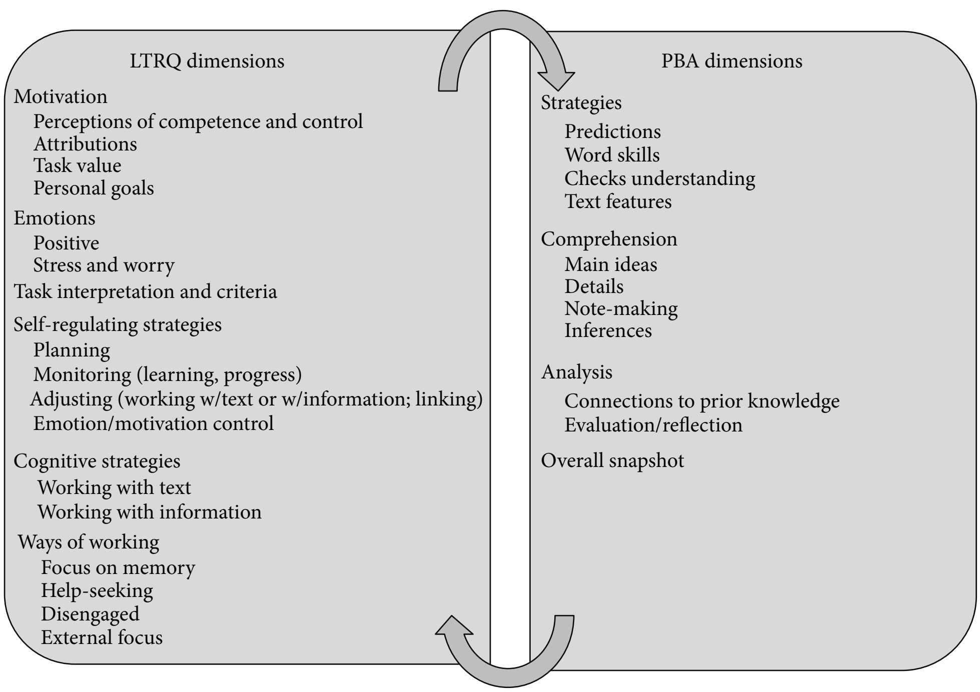

Figure 5: Dimensions captured in the Learning through Reading Questionnaire (LTRQ) and the Performance-Based Assessment (PBA).

Table 3: Goals teachers set for improving students' LTR engagement based on situated assessment data.

Teacher	Main ideas	Details	Note-making	Making connections	Making inferences	Visualizing	Text features	Reasoned judgements
AG	✓		✓		✓			
AA	✓							
BT	✓	✓	✓	✓	✓			
CM	✓		✓	✓	✓	✓	✓	✓
DC	✓	✓	✓		✓			✓
DM	✓	✓		✓	✓	✓		✓
DS	✓	✓	✓	✓	✓	✓		
EG	✓	✓	✓					
GF	✓		✓					
LW	✓	✓	✓	✓	✓	✓		✓
MB	✓	✓	✓		✓			
MD	✓	✓	✓	✓		✓		
MV	✓	✓	✓		✓	✓		
NW	✓	✓		✓			✓	
RR	✓	✓	✓	✓	✓		✓	✓
ST	✓	✓	✓		✓			
SC	✓	✓	✓	✓			✓	
WP	✓	✓		✓		✓	✓	✓

Notes: Initials for teachers refer to pseudonyms; columns refer to main goals set by teachers.

4.3.2. Teachers' Engagement in Self- and Co-Regulated Practice. To trace teachers' professional learning and practice development, we used a combination of qualitative analysis techniques to interpret and coordinate multiple forms of data. We analyzed interview transcripts in an iterative process to construct, test, revise, and coordinate codes (for details, see [3, 4, 69, 80, 81]). We mined documents and field notes for confirming or disconfirming evidence. Following recommendations from Miles and Huberman [81], we created data displays (e.g., tables; visual representations) to reveal patterns for interpretation. For example, for analyses of practices reported here, we started by creating low-inference "level one" displays that collected evidence related to goals teachers set and practices enacted. Next, building recursively between an inductive derivation of themes from data and consideration of relevant theory, we developed codes to describe goals and practice qualities that might be associated with students' development of SR. Finally, in "level two" displays, we co-related coded data to surface patterns and warrant conclusions (as in Tables 3 and 5).

4.3.3. Relating Teachers' Practices to Outcomes for Students. We used a variety of analytic tools (see later) to cross-reference analyses of instructional practices with LTR gains for students. Consistent with our situated approach to studying self- and co-regulation, we anticipated gains for students as a function of (a) goals teachers worked on and (b) qualities of instruction as implemented in classrooms.

5. Results

5.1. Research Question 1. While Engaged in Self- and Co-Regulated Inquiry, What Types of Practices Did Teachers Enact to Support LTR in Their Subject-Area Classrooms? To address our first research question, we analyzed data from interviews, observations (e.g., of team planning meetings), and related documents/artifacts (e.g., e-mails, lesson plans) to identify the goals teachers set for students and the practices they enacted to achieve those goals.

5.1.1. Goals Teachers Set. First, case study analyses allowed us to identify goals teachers set for students in their classrooms. Apparent in Table 3 is that teachers targeted goals focused on finding main ideas (all 18 teachers), finding details or supporting note-making (14 teachers each), inferencing (11 teachers), making connections (10 teachers), visualizing (7 teachers), making reasoned judgments (6 teachers), and using text features (5 teachers).

5.1.2. Qualities of Practice Changes. To trace the qualities of practices enacted by teachers, we systematically coded case study data (interviews, field notes from meetings, and artifacts). Following Agar [82], our coding proceeded abductively, cycling between deductive and inductive reasoning. We first categorized practice changes descriptively by kind (e.g., "gradual release"). Then, at a next level of abstraction, we found that practices could be described as reflecting more or less of the following four qualities: *sustained attention to goals*; *integrating LTR goals into the curriculum*; *explicit attention to reading, thinking, and/or learning processes*; *promoting/fostering student independence*. Definitions and coding criteria for these qualities can be found in Table 4.

5.2. Research Question 2. How Did Teachers Draw on Research-Based Resources to Inform Practice Development? Our case study analyses suggested how both the goals teachers set

Table 4: Coding criteria for instructional qualities evident in teaching practices as represented in interviews and artifacts.

Dimension	Quality of teachers' instruction 1 Little or no focus	2 Some focus	3 Multiple attempts/efforts	4 Thorough, focused effort
Sustained attention to goals	Teacher gave little attention to goals, may be one shot	Teacher worked on goal in more than one instance, but seems to be little sense of maintaining or building efforts over time	Teacher made multiple attempts to work on goal(s) with a sense of building over time	Evidence of teacher's very focused and sequential work on goal(s) over an extended period of time
Integrating goals into curricula	Teacher focused on learning skill(s)/process(es) but not how curriculum is linked to learning processes	Teacher says they focused on learning skill(s)/process(es) as linked to curriculum, but there is minimal evidence	Teacher describes/shows how goal(s) was integrated into curriculum with explicit attention to how content and learning processes are interwoven	Teacher describes/shows how goal(s) was deeply and/or consistently integrated into curriculum as part of learning in content area(s) and may describe how this was uniquely addressed in different content areas and/or texts
Explicit attention to reading, thinking, and/or learning processes	Teacher talked about seeking to work on learning process goal(s) but does not make learning process goals or strategies apparent to students	Teacher talked about attempts to help students understand and use learning process goal(s), but does so in a way that just has students do things (e.g., answer a question), rather than making learning processes transparent to students	Teacher talked about how they made efforts to address learning process(es) goals, with specific attention to defining/explicating learning processes (e.g., what a process looks like)	Teacher talked very specifically about ways in which he/she used specific methods to make the what and how of learning process goal(s) explicit and apparent to students
Promoting/fostering student independence	No mention and/or little evidence of efforts to build student independence	Talked about methods that might support student independence (e.g., practicing a skill learned), but not with student independence or SRL explicitly as a goal	Talked about using specific methods designed to foster student independence but without moving to level of promoting active self-directed learning (e.g., student mastery of specific processes/strategies but not necessarily choosing strategies, self-monitoring, adapting, etc.)	Talked about fostering independence in a way that also fosters student self-direction and managing of learning

and the practices enacted were shaped by resources available to inform their engagement in cycles of self- and co-regulated inquiry.

5.2.1. Goals Teachers Set. Teachers in this project were free to set goals associated with their students' unique needs. That they did so is apparent in the diversity of goals targeted by teachers (see Table 3). That said, many teachers also set common goals for their students. We suggest that this commonality was a function of the teachers having drawn on shared frameworks, jurisdictional performance standards, and assessment tools to assess where students were experiencing challenges and define priorities. As described earlier, Fall data on students' self-regulated LTR revealed that many students were neither prioritizing nor enacting the kinds of active reading and learning strategies essential to successful LTR and articulated as goals in provincial curricula. Thus, it was not surprising that so many teachers identified goals for students in areas such as note-making, inferencing, and making connections.

It is significant that in this project all teachers set goals focused on supporting LTR processes, even though these were subject-area teachers. Prior research has shown that, at the secondary level, instructors often assume students already know how to construct new knowledge through reading in a variety of subject areas [83–87], so that attention in subject-area classrooms does not often focus on supporting adolescents' LTR processes. Thus, it was encouraging that teachers here targeted learning processes as an instructional focus. Consistent with this observation, in final interviews, many teachers explained that they had shifted in how they were balancing attention to teaching content and supporting learning processes within their instruction (see also [3, 4]). Thus, data from the LTRQ and PBA and associated theoretical

Table 5: Implementation quality (1–4) for each teacher for each targeted goal.

Teacher	Main ideas	Details	Note-making	Making connections	Making inferences	Visualizing	Text features	Reasoned judgments
AG	1	1	2	1	2	1	1	1
AA	1	1	1	1	1	1	1	1
BT	1	2	2	2	2	1	1	1
CM	4	1	4	3	2	2	2	1
DC	2	2	2	1	2	1	1	2
DM	2	2	1	3	2	2	1	2
DS	3	2	2	3	2	2	1	1
EG	2	3	3	1	1	2	1	1
CF	1	1	2	1	1	1	1	1
LW	4	2	4	4	4	2	1	2
MB	3	2	4	1	2	1	1	1
MD	2	2	3	3	1	2	1	1
MV	3	2	2	1	2	1	1	1
NW	3	3	1	4	1	1	2	1
RR	2	2	2	2	2	1	2	2
ST	3	3	4	1	2	1	1	1
SC	2	2	2	2	1	1	2	1
WP	3	2	1	2	1	2	2	2

frameworks appeared to direct teachers' attention to important instructional goals that they might not have explicitly targeted.

5.2.2. Qualities of Practice Changes. Case study data also suggested how participating in the district's literacy project shaped the practices teachers enacted. Earlier, we described how theoretical frameworks and assessment tools influenced the goals teachers set in their classrooms. Similarly, the practices teachers enacted were very consonant with research-based recommendations apparent in resources available at the district and school levels (e.g., in workshops; through mentoring). While the specific form of practices varied across classrooms based on topics addressed and other contextual factors, clear family resemblances were still apparent across practices implemented to achieve teachers' priority goals. For example, many teachers described how the practices they tried enabled them to "gradually release" responsibility for learning to students. These themes, apparent in available resources and echoed across teachers' descriptions of practices, were correspondingly prominent in our qualitative coding of practice qualities (i.e., as sustained, integrated into curricula, explicit, or focused on supporting independence).

While definite themes were apparent across teachers' descriptions of practices, how teachers took up practices in pursuit of goals varied considerably across classes. Reports from teachers suggested that rather than trying to tackle too many goals at one time, they generally decided to focus on the highest priorities for their students first, based on Fall data, and then build to tackle a wider range of issues over time. Consistent with teachers' descriptions, Table 5 reveals the diversity in goals and practices for the 18 teachers for whom we tracked practice changes. In this table, we cross-reference an overall implementation score (across all four practice qualities) with teachers' attention to different LTR goals (e.g., CM's practices reflected the highest level of intensity across all four practice qualities when working on main ideas and note-making). Apparent in this display is that teachers invested different kinds and amounts of effort to achieve different kinds of goals.

Thus, to conduct a fair evaluation of how practice changes were associated with student outcomes, we needed to associate the goals and practices *actually taken up by teachers* in classrooms with gains for students *in those particular areas*. While "messy," adopting this approach allowed us to track the complexity of how practice change was unfolding (iteratively; dynamically) to address students' needs in particular settings.

5.3. Research Question 3. What Practices Could Be Associated with Gains in Students' Self-Regulated LTR? Table 5 describes how teachers' classroom practices reflected four important qualities with promise to support students' self-regulation in LTR activities. In this section, we link these practice qualities to observed outcomes for students. To begin, we describe Fall to Spring changes on the PBA for students in 20 humanities classrooms. Then, we consider how variations in outcomes, both on the LTRQ and the PBA, could be linked to the goals and practice qualities within different classrooms.

5.3.1. Pre-Post Gains in LTR Performance. Analyses of pre-post gains for the 364 students working in 20 humanities classrooms revealed statistically reliable gains on the PBA, when data were aggregated across classes. Table 6 presents mean scores and standard deviations overall for the entire sample. For example, pre-post PBA "snapshot" scores for 360 students showed a gain from an average of 2.76 (SD = 1.16) to 3.90 (SD = 1.31) between the beginning and end of the year.

Findings showed that the greatest mean shifts on the PBA across classrooms were on these overall performance scores and on four more specific dimensions: text features, main idea, inferences, and connections, corresponding with the goals most heavily emphasized by teachers. Note here that the difference in *N's* across dimensions resulted both from missing data (e.g., from absenteeism) and from slightly different PBA forms being used across grade levels. Specifically, as is represented using "n/a" in the table, predicting, checks understanding, and accuracy/completeness were not assessed at the Grade 9 level.

The findings from multivariate analyses summarized in Table 6 reveal that the main effect of "time" was statistically reliable across all measured dimensions (suggesting Fall-Spring gains). But our analyses also revealed statistically reliable interactions between time and classrooms (see Table 6). We concluded that, while on average students increased in LTR performance, changes in performance were mediated by the classrooms in which students were working.

5.3.2. Relating Qualities of Instruction to Pre-Post Gains for Students on the LTRQ. Further analyses revealed significant correlations between the qualities of teachers' practices and gains on LTRQ dimensions associated with the goals on which teachers were working (see Table 7). Building from this, we suggest that our methodological logic established internal validity (i.e., relating practice changes to outcomes) by anticipating changes only in relation to the qualities of practice changes teachers made to target particular goals, in comparison to areas where they had not yet focused attention. Consistent with this assertion, we noted in field notes how in Spring data review meetings teachers did not expect improvements in all aspects of students' performance (viewing education as a longer-term process). But they were very disappointed if gains were not observed in areas where they had chosen to invest concerted effort (as reflected in Table 5).

What stood out as important in our quantitative analysis was that instruction that combined the four qualities we observed (*sustained, integrated, and explicit instruction focused on supporting student independence*) was most highly related to gains on the LTRQ, particularly when teachers focused instruction on achieving the following goals (see Table 7): (1) making inferences, which was most highly related to gains for students across LTRQ dimensions, including motivation, emotion, cognition, and metacognition; (2) reasoned judgments; (3) main ideas; (4) note-making. In contrast, a sustained focus on details was associated with greater stress and worry and greater use of motivation and emotion control strategies. A focus on visualizing was negatively related to strategies for working with text. A focus on text features was negatively related to attributions for success to controllable factors (effort, strategies) and to positive emotions. Overall, findings combined to suggest that gains were greatest when teachers invested sustained effort in fostering students' engagement in higher-level reading, learning, and thinking processes.

We also used regression analyses to relate particular goals and implementation qualities (i.e., *sustained*; *integrated into curricula*; *explicit*; *supporting student independence*) to gains on the LTRQ. When taken together, implementation quality variables predicted up to 70% of the variance on LTRQ gains. Note again that the strongest relationships between practice qualities and LTRQ gains across components (including the most active learning ones) happened when teachers selected making inferences as a goal and, to a much lesser extent, main ideas. Based on these data, we concluded that SRL-supportive practices focused on active learning goals achieved the greatest gains in students' perceptions about LTR activities and their engagement within them. Also notable was that gains were most evident when teachers' practices moved towards promoting independence. For example, gains were greater when teachers moved beyond just scaffolding or guiding students' learning to supporting students' reflective, deliberate decision-making (e.g., about which strategies might help them in achieving a given goal).

5.3.3. Relating Qualities of Instruction to PBA Gains for Students. We did not find direct positive relationships between practice qualities and gains for students on the PBA. However, as described earlier, we did find that practice qualities strongly predicted gains on the LTRQ, suggesting that teachers' instruction could be related to how students thought about their engagement in LTR activities. Further, findings suggested that pre-post gains on the LTRQ were strongly associated with gains on the PBA (see Table 8). This latter finding suggests that students' perceptions about their engagement in LTR may have mediated shifts in actual performance. Further research is needed to test this possibility.

6. Discussion and Conclusions

This research investigated relationships between teachers' engagement in cycles of self- and co-regulated inquiry, practice change, and the promotion of students' self-regulated engagement in what is a ubiquitous requirement in educational settings, namely, LTR. Over time, our findings have converged with other research to suggest that secondary students experience significant challenges with LTR in subject-area classrooms [46, 83, 87]. More encouragingly, our research also suggests that subject-area teachers can be inspired and supported to modify instructional practices to support adolescent literacy within an inquiry-based professional development framework (see also [3, 4]).

One way in which the research reported here extends previous research is by advancing understanding about practice qualities with promise to advance students' engagement in self-regulated LTR. In particular, findings reported here suggest that practices that push students to deliberately learn from classroom activities (i.e., by fostering independence) are most highly associated with gains in self-regulation (see also [44, 66]). As we reflected on these findings in relation to prior research on challenges to students' self-regulated LTR, we started to wonder whether it might be productive to extend the SRP/SRL distinction we have found

Table 6: Pre- to posttest changes on performance-based assessments (PBA).

PBA dimension	N	Means (St Dev) Pre	Means (St Dev) Post	Time × classroom MANOVA[1]	Grade 7/8 (16 classes; $N = 280$)	Grade 9 (4 classes; $N = 84$)	All grades (20 classes; $N = 364$)
Snapshot	360	2.76 (1.16)	3.90 (1.31)	Time	$F = 113.20$, eta$^2 = .42^{***}$	$F = 93.38$, eta$^2 = .64^{***}$	$F = 264.55$, eta$^2 = .52^{***}$
				Time × classroom	Yes***	N.S.	Yes***
Word skills	351	2.99 (1.41)	3.83 (1.32)	Time	$F = 33.75$, eta$^2 = .18^{***}$	$F = 14.57$, eta$^2 = .22^{***}$	$F = 80.47$, eta$^2 = .25^{***}$
				Time × classroom	Yes***	N.S.	Yes**
Predicting	276	3.00 (1.11)	4.01 (1.32)	Time	$F = 6.125$, eta$^2 = .28^{***}$	n/a	n/a
				Time × classroom	Yes***		
Checks understanding	255	2.99 (1.33)	3.97 (1.35)	Time	$F = 45.62$, eta$^2 = .23^{***}$	n/a	n/a
				Time × classroom	Yes**		
Text features	340	2.94 (1.45)	4.19 (1.41)	Time	$F = 78.40$, eta$^2 = .33^{***}$	$F = 63.39$, eta$^2 = .55^{***}$	$F = 155.72$, eta$^2 = .39^{***}$
				Time × classroom	Yes***	Yes*	Yes***
Accuracy/completeness	237	3.53 (1.62)	3.91 (1.33)	Time	$F = 8.50$, eta$^2 = .05^{**}$	n/a	n/a
				Time × classroom	N.S.		
Main idea	351	2.86 (1.60)	4.06 (1.59)	Time	F = 62.63, eta$^2 = .29^{***}$	$F = 56.359$, eta$^2 = .52^{***}$	$F = 131.67$, eta$^2 = .35^{***}$
				Time × classroom	Yes***	Yes*	Yes***
Details	353	2.70 (1.42)	3.63 (1.55)	Time	$F = 35.83$, eta$^2 = .19^{***}$	$F = 46.85$, eta$^2 = .47^{***}$	$F = 95.67$, eta$^2 = .28^{***}$
				Time × classroom	N.S.	N.S.	Yes**
Note-making	340	2.37 (1.63)	3.24 (1.83)	Time	$F = 9.63$, eta$^2 = .06^{**}$	$F = 16.71$, eta$^2 = .24^{***}$	$F = 39.173$, eta$^2 = .14^{***}$
				Time × classroom	Yes**	N.S.	Yes***
Inferences	349	2.60 (1.60)	3.63 (1.67)	Time	$F = 35.31$, eta$^2 = .19^{***}$	$F = 26.56$, eta$^2 = .34^{***}$	$F = 83.40$, eta$^2 = .25^{***}$
				Time × classroom	N.S.	Yes*	Yes**
Connections	351	2.67 (1.57)	3.91 (1.71)	Time	$F = 76.38$, eta$^2 = .33^{***}$	$F = 35.00$, eta$^2 = .40^{***}$	F=135.07, eta$^2 = .35^{***}$
				Time × classroom	Yes***	N.S.	Yes**
Evaluation	349	2.91 (1.63)	3.95 (1.62)	Time	$F = 21.92$, eta$^2 = .12^{***}$	$F = 40.31$, eta$^2 = .44^{***}$	F = 73.18, eta$^2 = .23^{***}$
				Time × classroom	Yes**	N.S.	Yes***

$^{***}P < .001$, $^{**}P < .01$, $^{*}P < .05$. [1]Results from multivariate repeated measures analyses of variance conducted with PBA dimensions as the dependent measures, and with time (pre-post) and class as independent variables. Follow-up univariate tests were then conducted for each PBA dimension separately.

Table 7: Correlations between implementation quality and LTRQ gains for goals selected by teachers.

LTRQ dimensions	Goals selected by teachers							
	Main ideas	Details	Note-making	Connections	Inferencing	Visualizing	Text features	Reasoned judgments
Perceptions of competence and control	.30	−.26	.11	.01	.29	−.06	−.14	−.00
Controllable attributions	.32	.06	**.43 (.06)**	−.16	**.46***	.09	**−.59****	.10
External attributions	−.21	.12	−.28	.21	−.06	.14	−.03	.18
Task value	**.46***	.14	.28	−.02	.32	.12	−.20	−.06
Positive personal goals	**.50***	−.18	.27	.22	**.46***	.16	.14	.21
Positive emotions	.24	.06	.13	.09	**.52***	.13	**−.55***	**.41 (.07)**
Stress and worry	−.26	**.43 (.06)**	−.18	.06	−.13	−.14	−.03	.07
Positive task interpretation	.41	.08	**.41 (.07)**	−.16	.21	−.15	.14	−.14
Positive criteria	.23	−.23	.15	−.30	.36	−.40	−.28	−.04
Planning	.26	.07	−.03	.22	**.51***	.10	−.30	**.45***
Monitoring: learning	**.46***	−.00	.04	.06	**.49***	−.12	−.19	.26
Monitoring: work progress/methods	.33	.03	−.10	−.02	.30	−.23	−.16	.08
Adjusting: working with text and rereading	.22	.12	.07	−.24	.24	−.17	−.26	.08
Adjusting: linking information	.37	−.21	.12	.14	**.57****	.06	−.23	**.40 (.08)**
Adjusting: work management	.34	−.08	.18	.01	**.57****	.01	−.35	**.42 (.06)**
Emotion/motivation control	.38	**.41 (.07)**	.18	.08	.28	−.03	−.05	.07
Self-evaluating	**.47***	−.03	.14	−.09	**.46***	−.16	−.11	.20
Working with information	.33	.06	.04	.09	**.59****	−.07	−.27	**.47***
Working with text	.22	−.36	.07	−.26	.28	**−.53***	−.04	.10
Focus on memory	.33	−.26	.08	−.22	.33	−.08	−.25	−.01
Help seeking	.23	.11	−.31	.27	.08	.02	.27	−.02
Disengaged	**−.50***	−.05	−.31	.13	−.20	.10	.04	.26
External focus	.04	−.16	−.18	.36	**.40 (.08)**	.18	−.27	**.48***

$^{***}P < .001$, $^{**}P < .01$, $^{*}P < .05$; parens are used to flag effects that suggest a trend, but do not achieve a .05 level of significance (e.g., $P < .07$).

useful in understanding teachers' professional development to conceptualizing students' self-regulated engagement in classrooms.

For example, in classrooms, students are also engaged in a particular kind of socially constructed *practice*, namely, academic work as constituted in schools [88, 89]. Teachers typically engage students in these forms of academic work in hope that they will deliberately learn in/through those experiences. But students cannot be expected to just "know" how to engage in academic practices. Instead, teachers' roles in part need to be demystifying the demands of academic work as constituted in particular contexts (i.e., communities, disciplines, and classrooms). Adopting this perspective affords a richer, sociocultural analysis of where and why SRP/SRL might break down in schools, as might be the case if students fail to appreciate discipline-specific norms for constructing and communicating knowledge (e.g., in science and in history). Similarly, students assigned activities that primarily involve learning facts from textbooks may come to define science or history as fields of practice that involve memorizing facts established by experts [77]. Moves towards more inquiry-oriented or problem-based approaches can be conceptualized as attempts to engage students in more "authentic" forms of *practice* (e.g., designing an experiment like a scientist) as a foundation on which they can anchor both content and process learning [90, 91].

Table 8: Predicting PBA scores from LTRQ dimensions.

	Snapshot	Word skills	Predict	Checks under.	Text features	Accuracy	Main ideas	Details	Note-making	Inference	Connect	Eval
Overall R-square	$.27^{***}$	$.17^{***}$	.12	$.25^{***}$	$.16^{***}$	$.30^{***}$	$.18^{***}$	$.19^{***}$	$.15^{***}$	$.20^{***}$	$.13^{**}$	$.16^{***}$
First-order correlations with items that predicted each dimension ($P < .05$) and significance of those correlations												
Perceptions of comp/control	$.39^{***}$	$.31^{***}$	$.24^{***}$		$.26^{***}$	$.40^{***}$	$.26^{***}$	$.33^{***}$	$.29^{***}$	$.33^{***}$		
Controllable attributions												
Task value						$.14^{***}$		$.12^{*}$				
Positive personal goals		$.28^{***}$		$.30^{***}$		$.32^{***}$						
Positive emotions	.05			.02				.00				
Stress/worry				$-.29^{***}$								$-.21^{***}$
Motivation/emotion control												
Disengaged					$-.23^{***}$							
Positive task interpretation												
Positive criteria							$.13^{*}$					
Planning				$.14^{*}$								
Monitoring: progress										.00		−.03
Adjusting: working with text												
Adjusting: linking	$.25^{***}$	$.19^{***}$		$.24^{***}$	$.17^{***}$	$.20^{***}$		$.22^{***}$	$.22^{***}$	$.21^{***}$		$.21^{***}$
Adjusting: work												
Self-evaluating					.04		−.02					
Strategies: working with text					.03		.00		.04			
Strategies: working w/info								$.16^{**}$				
Focus on memory	$-.16^{**}$				$-.17^{***}$	$-.20^{***}$	$-.15^{**}$	−.10		−.09	$-.17^{**}$	

$^{***}P < .001$, $^{**}P < .01$, $^{*}P < .05$.

Further, drawing on an SRP/SRL distinction, it could be argued that if students are to learn actively, they need to deliberately shift from "getting through teacher-assigned tasks," or just learning incidentally through that experience, towards deliberately *learning* about, during, or from classroom activities. For example, many students seem to derive strategies for achieving good grades by working mechanically through assignments to fulfill expectations (e.g., to answer end-of-the-chapter questions), without self-regulating their learning from or through that activity (e.g., by connecting what they know with prior knowledge, forming opinions they can defend, or testing their understanding). In classrooms, SRL may be enabled when students are supported to deliberately plan for and monitor how they are constructing knowledge or skill while engaged in activities (i.e., practices) designed to promote active learning [66]. Connecting SRP and SRL for students may require constructing academic work in ways that encourage students to deliberately manage their *learning* in/through meaningful *practice* (e.g., deliberately learning from and through LTR activities). Our findings that gains in LTRQ scores were associated with teachers' push for independence are consistent with this suggestion.

Considering our contributions more broadly, what we have achieved in this research has been to take up the challenge to study SR as a complex, multicomponential, dynamic, and layered process as it unfolds for students and teachers within schools and classrooms. Here, we would highlight the heuristic value of the theoretical framework we have been drawing on to guide our research into self- and co-regulation as situated in practice (see Figure 1). Theoretically speaking, our model of self- and co-regulation as situated in activity has afforded drawing useful distinctions, for example, between SRP and SRL, and uncovering important dependencies, for example, in how forms of self- and co-regulation are supported and delimited in the context of social practice. From a practice perspective, we have found that teachers value the model and associated assessment tools for how they draw attention to highly important instructional goals and inform directions for practice. We have also contributed by advancing knowledge about how teachers can be supported to construct practices supportive of self-regulated LTR in authentic classroom settings.

Another main contribution offered by this research program overall has been in defining innovative methodological strategies for the study of self- and co-regulation. There are certainly many exciting methodological designs and tools being developed with great potential to advance understanding about self-regulation as a complex, multicomponential, dynamic, and situated event (see [92]). A limitation of this research study is that we did not take full advantage of some of these other approaches as part of our methodological tool kit (e.g., more online microanalyses of students' self-regulation while actually engaged in LTR). But what we have contributed are ways of thinking about and studying self- and co-regulation that preserve meaning in context. For example, our self-report and performance-based tools assess important components implicated in self-regulation (i.e., motivation, emotion, cognition, and metacognition) in ways that reference the demands of activities and environments. Our case study methodology can be productively applied to investigate interconnections between teachers' and students' self- and co-regulated learning and practice. In so doing, we have highlighted how investigating self- and co-regulation requires attending to how learning is constituted within and by the kinds of social practices through which individuals work and learn.

While results from this line of research have been promising, it is important to acknowledge important limitations to this work that should be taken up in future research. First, our sample here was limited to just three schools located within one school district in Western Canada. Further, when linking practice shifts to learning outcomes, we focused just on practices enacted by 12 teachers working across 20 humanities classrooms with just 364 students. Clearly, additional research is needed to consider how findings generated in this context might be meaningful in other settings. Further, while we employed a variety of methodological lenses to study how goals and practices taken up in classrooms were related to students' learning in those settings, either broadening or narrowing the sampling strategy could extend understanding about how practices are related to students' learning. On one hand, including a larger, more diverse sample in the research frame might enable a more multilayered assessment of how student learning gains can be accounted for by variables at the student, classroom, school, and even district levels. On the other hand, more fine-grained microanalyses at the individual level could afford tracing shifts in students' learning processes and achievement with more specificity.

An interesting puzzle presented by our findings was that the qualities of practices we coded, while strongly related to gains in LTRQ scores for students, were not directly associated with gains on the PBA. One potential explanation is that the practice qualities teachers "added" in this research were closely focused on improving self-regulation (e.g., students' deliberate orchestration of learning processes). The kinds of changes these subject-area teachers made in their practices did tend to integrate attention to learning processes with more content-focused instruction. It is perhaps not surprising, then, that the most notable direct effects of teachers' practice changes were on students' thinking about LTR activities and their engagement within them. It is possible that the gains observed here in students' literacy performance were mediated by gains in self-regulation. That said, it is also possible that we missed cataloguing qualities of practices in our coding scheme that were more directly related to PBA gains. Thus, further research is certainly needed into how practice qualities are directly and/or indirectly related to gains in self-regulation and/or achievement.

In conclusion, in the research reported on here, we traced how teachers' practice revisions can and do emerge from their reflective engagement in cycles of self- and co-regulated inquiry (see [2–4]). Extending from previous reports focused on students' self-regulated LTR or on teachers' professional development, this paper contributes by connecting the dots between teacher learning, practice development, and outcomes for learners. Based on findings reported here, we conclude that when student and teacher self- and co-regulation are considered and nurtured in relation to one another, desired links can be achieved between practice changes and positive outcomes for students.

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Research Article

Examining the Correspondence between Self-Regulated Learning and Academic Achievement: A Case Study Analysis

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Four high school students received 11 weeks of a self-regulated learning (SRL) intervention, called the Self-Regulation Empowerment Program (SREP), to improve their classroom-based biology exam scores, SRL, and motivated behaviors. This mixed model case study examined the correspondence between shifts in students' strategic, regulated behaviors with their performance on classroom-based biology tests. The authors used traditional SRL assessment tools in a pretest-posttest fashion (e.g., self-report questionnaires, teaching rating scales) and gathered SRL data during the intervention using field note observations and contextualized structured interviews. This multidimensional assessment approach was used to establish convergence among the assessment tools and to facilitate interpretation of trends in students' biology test performance relative to their SRL processes. Key themes in this study included the following: (a) the close correspondence between changes in students SRL, biology exam performance, and SREP attendance; (b) individual variability in student performance, SRL behaviors, and beliefs in response to SREP; and (c) the importance of using a multi-dimensional assessment approach in SRL intervention research. Furthermore, this study provided additional support for the potential effectiveness of SREP in academic contexts.

1. Introduction

The importance and positive impact of self-regulation learning (SRL) processes on the academic achievement of students have been consistently demonstrated over the past couple of decades across a multitude of research methodologies and contexts [1–6]. Of particular relevance to educators, however, is research evaluating the impact of SRL intervention programs on the basic academic skills, such as reading, math, and writing [2, 3, 5]. This line of research is important because it underscores the potential utility of infusing SRL principles into academic intervention programs or authentic classroom instructional contexts. Another emergent applied SRL issue involves the discrepancy between the perceptions of teachers and school-based professionals regarding the importance and utility of SRL and the extent to which they directly infuse this concept into their professional activities [7–9]. In a series of recent surveys, for example, teachers and school psychologists identified SRL as a critical determinant of student success [7–9]. Interstingly, these school-based personnel also expressed poor personal knowledge in motivation and SRL processes, a lack of experience incorporating these principles into their teaching or professional activities, and a strong desire to receive professional development training regarding implementing SRL assessment tools and interventions. Such individuals may benefit from research that closely examines how SRL interventions afford opportunities for students to become more empowered and regulated learners in specific contexts and how shifts in students' regulatory and motivation processes are often linked to these intervention practices.

In recent years there has also been increased interest in studying the impact of SRL interventions with adolescent populations and in content area domains, such as science [10–14]. Sinatra and Taasoobshirazi [14] have argued that

SRL is closely intertwined with science education because many activities within this domain, such as inquiry, conceptual change, and problem solving, often necessitate the use of metacognitive and strategic skills, two key components of self-regulated learning. On a more general level, the link between science education and SRL in the United States is bolstered when considering the recent emphasis placed on teaching students to become self-directed learners in literacy and specific content areas (e.g., science and social studies) [15] and the fact that secondary school students continue to lag internationally in science achievement [16]. Although some progress has been made in infusing SRL principles into science education or tutoring programs to enhance science achievement [12, 17, 18], there remains a paucity of available interventions specifically designed to help high school students become more successful in navigating increasingly complex science courses.

Developing SRL interventions specifically targeting high school students is important for a variety of reasons. At the high school level, classroom-based exams often represent a key performance outcome and an integral component of students' report card grades. Thus, the skills necessary for effectively studying for exams represent a critical academic skill that needs to be taught, practiced, and refined, particularly for students who struggle academically. Although there is much information in the literature about effective test preparation skills and effective learning strategies [19–21], there remains a dearth of comprehensive, applied intervention programs devoted to helping students effectively manage and overcome authentic learning challenges as they naturally arise over extended periods of time (e.g., several months). In secondary school contexts, students are often faced with many challenges or demands as they prepare for exams, most notably the need to organize and integrate large volumes of information presented within class lessons, homework assignments, and/or readings from relevant texts and resources [22]. Given that these activities often occur outside the supervision of teachers and necessitate the use of efficient regulatory strategies and processes, attention devoted to how students regulate and use such strategies as they prepare for exams is critical. The primary focus of this paper is to investigate, through four case studies, the correspondence between shifts in high school students' strategic and regulated behaviors during test preparation and their overall test performance and attendance to an SRL intervention program, called the Self-Regulation Empowerment Program.

1.1. Definition and Conceptualization of Self-Regulated Learning (SRL). Self-regulation has been described as a multidimensional process that integrates a myriad of related yet distinct motivation beliefs and strategic and metacognitive skills [5, 23–25]. Although researchers from various theoretical backgrounds have developed innovative models of self-regulation, SREP is largely grounded in social-cognitive theory and research [18, 25, 26]. In general, social-cognitive theory emphasizes that in order to understand student learning and behavior it is critical to examine the reciprocal interactions between the social environment and various student-related processes (e.g., beliefs, attitudes). Central to this paradigm is the premise that humans have the capacity to self-regulate and to actively manage their environment, behaviors, and beliefs. Zimmerman [25] explicitly defines self-regulation as a process operationalized in terms of a contextualized, cyclical feedback loop. That is, individuals proactively plan and initiate learning attempts and then use self-generated or externally provided feedback to modify and adapt their learning methods to optimize performance.

In general, this cyclical loop has been described as a three-phase process including forethought, performance, and self-reflection. *Forethought phase* processes precede efforts to learn or perform and include students' goal setting, strategic planning, and motivational impetus to act. Students are more likely to engage in learning when their self-motivation beliefs are adaptive. Adaptive motivational beliefs include maintaining high self-efficacy during difficult tasks, viewing tasks as enjoyable, and believing that certain behaviors will lead to specific outcomes. Collectively, forethought processes are hypothesized to impact *performance phase* processes that are most prominent during learning. These latter processes include self-control (e.g., directing one's attention, structuring learning environments, and using regulatory tactics) and self-observation (e.g., tracking the quality of their learning). Self-observation is a general process that includes metacognitive monitoring (e.g., maintaining an awareness of one's thoughts and knowledge) and self-recording (e.g., writing down specific aspects of behavior or performance). These self-observational processes are critical in the cyclical loop because they generate information that students use to reflect on the quality of their skills or performance levels. In the final phase, *self-reflection*, individuals evaluate whether they reached their goals (i.e., self-evaluation), reflect on the causal factors of their performance (i.e., attributions), and identify specific things that need to be modified or sustained to optimize future performance (i.e., adaptive inferences; [25]).

Many theorists also argue that SRL is a teachable process that can vary across contexts and situations [4, 5, 27, 28]. Research has supported this premise by showing that student motivation beliefs and regulatory actions will often differ across academic domains (e.g., science, math) and across distinct tasks within the same domains or contexts [29–31]. As will be discussed in subsequent sections, "context specificity" and "cyclical self-regulation" are two fundamental principles that guide SREP.

1.2. Core Characteristics of SREP. A few applied academic self-regulation training programs have been developed to help students engage in recursive cycles of self-regulatory thought and action [5, 19, 28, 32, 33]. Although these programs often differ in their theoretical underpinnings and instructional format, most of them are designed to enhance students' repertoire of task-specific learning strategies as well as their skills in managing and regulating their use of these strategies during learning. Collectively, these programs, including SREP, emphasize that instruction and/or tutoring support should be grounded in specific course material or curriculum to maximize the effectiveness of the intervention.

SREP, however, possesses several unique features. First, SREP was specifically designed to help at-risk students in middle school and high school improve their performance on authentic distal outcomes, such as preparing for monthly unit exams in science. Unlike intervention programs that are of relatively short duration or target a relatively narrow skill set or strategy, SREP seeks to enhance students' knowledge and proficiency in dynamically using a myriad of learning strategies. Additionally, SREP is designed to improve students' skill in adapting and refining their use of strategies based on course demands or obstacles that are naturally encountered during an academic semester. During this intervention, students also learn how to cope with and manage the quality of their learning and to overcome the individual-specific obstacles or challenges that may inhibit effective test preparation. By providing a highly structured environment for students to learn and practice various types of cognitive strategies (e.g., concept maps) and regulatory strategies (e.g., self-reinforcement, time management, help seeking) with feedback from a tutor or self-regulated learning coach (SRC), students can learn to independently use these skills outside the presence of tutors or teachers (e.g., studying alone at home). During sessions, students receive consistent feedback about the use of strategies and their performance on important academic outcomes, such as test scores.

SREP is also unique because it represents one of the few applied, comprehensive self-regulation intervention programs specifically designed to target test preparation in science content areas. As indicated by Schraw et al. [13], research in science education has focused on metacognition (i.e., thinking about thinking), but much less is known about how the broader concept of self-regulation can be applied to such contexts [13]. Rather than simply improving self-regulation and metacognition, SREP operates on a strong empirical and theoretical foundation from which changes in students' behavior can be understood and explained [24, 25]. By applying the three-phase model of SRL highlighted previously, SREP affords students the opportunity to engage in recursive cycles of thinking and action while independently learning science course material and preparing for unit exams. That is, students learn to engage in a feedback loop that directly parallels or mirrors the forethought, performance, and self-reflection phases as described by Zimmerman ([25]; see Section 2).

1.3. Purposes of Study. We used individual case studies to investigate the relationship between SREP instruction, observed shifts in students' strategic and regulated thoughts and behaviors, and changes in their biology test grades. Unlike most SRL intervention research studies, which are more time-limited in nature and typically evaluate change in terms of pretest-posttest analysis [3, 34], this study combines a pretest-posttest framework with qualitative descriptions of shifts in students' regulatory processes *during* the course of the intervention. These shifts included how deeply students engaged in SREP discussions, how often they attended SREP sessions, and how frequently they reported using key strategies taught during SREP sessions. This methodological approach provides a context to examine trends between shifts in students' behaviors and changes in their biology exam scores. Researchers have recognized the need to illustrate how SRL might unfold during an intervention as well as how shifts in SRL processes and behaviors of academic strugglers, whether learning disabled or those who simply perform below expectations, are linked to more adaptive academic outcomes [4, 18]. To capture the complex and multifaceted nature of SRL, researchers have also advocated for using a multidimensional SRL assessment approach [35]. Methodologically, a multidimensional approach facilitates convergence of multiple data sources which then can be used to strengthen interpretive statements about changes in students' SRL behaviors during an intervention.

To date, only one study has examined the relationship between SREP instruction and science performance using a multidimensional SRL assessment approach [18]. The authors implemented SREP with a small group of academically at-risk urban high school students who exhibited below average performance on biology tests during the first semester of a school year. In general, the authors reported a clinically significant increase in biology test grades, as illustrated by improvements in all students' test scores from below average to the average or above average range. Additionally, reliability change index (RCI) procedures were used to detect statistically significant changes in students' motivation beliefs and regulatory behaviors as measured with both self-report questionnaires and teacher rating scales. Furthermore, the authors included some methodological controls to strengthen claims regarding the relation between SREP instruction and the observed changes. However, to strengthen the premise that an intervention relates to observed achievement and behavioral changes in case study research, replication of findings is essential [36, 37]. With this latter point in mind, a secondary objective of the current study was to replicate the finding that students who receive SREP show improvement in classroom-based biology test scores relative to class norms.

2. Method

2.1. Participants. All participants were ninth grade students enrolled in an urban high school located in a large public school district in the Midwestern region of the US. The authors used a multiple criteria screening process to select students: (a) enrollment in a ninth grade Honors biology course, (b) teacher ratings of poor student engagement and regulatory behaviors, and (c) teacher concerns about test performance [18]. Students who are enrolled in Honors classes in this high school typically exhibit stronger academic skills than their same-district peers and receive nominations from their middle school teachers. However, their overall skill levels when compared to state or national norms are average. For this study, we were primarily interested in including students with average achievement (as determined by state or national level) but who were struggling to perform

Table 1: Demographic information and prior achievement data for SREP participants.

Participant name[a]	Gender	SES[b]	Ethnicity	WKCE science	WKCE reading	WISC-IV screener[c]
Vince	M	FRL	Hispanic	Proficient	Proficient	9.0
Pauline	F	NS	Asian	Proficient	Basic	9.7
Eric	M	NS	White	Advanced	Advanced	11.7
John	M	FRL	Black	Proficient	Proficient	NA

WKCE: Wisconsin Knowledge and Concepts Examination. There are four performance categories on the WKCE, ranging from lowest to highest: minimal, basic, proficient, and advanced. WISC-IV: Wechsler Intelligence Scale for Children—Fourth Edition. NA: not available. All information was obtained from student records provided by the participating high school.

[a]All names are fictional. [b]Lunch status was used as an indicator of SES. FRL: free-or-reduced lunch. NS: no financial support.

[c]Average scores across three subtests ($M = 10$; SD = 3).

well in a high school science course. Hence, ninth grade students enrolled in an Honors biology class in the target high school were recruited for this study. Fourteen students were nominated by a team of teachers (biology, mathematics, English, social studies) to receive SREP. Nine of the 14 students returned parental consent forms, with five agreeing to participate in a Fall SREP training and four students agreeing to begin in a Spring session. Data is only presented for the four Spring participants (see Table 1), as the Fall semester served as a pilot program to refine the implementation procedures. None of the participants had been previously identified as having a learning disability.

2.1.1. Vince. Vince, a fourteen-year-old, Latino male, performed in the proficient range on the science and reading sections of a state standardized exam and exhibited average intellectual skills (see Table 1). He displayed an adaptive profile of cognitive and academic skills. A review of his educational records, however, showed that Vince exhibited interest and motivation to learn, but his grades were highly inconsistent in middle school. His eighth grade science teacher noted that Vince's course grades reflected low test scores. His ninth grade biology teacher expressed similar concerns, particularly with regard to the consistency of his test grades. In terms of demographics, Vince came from a lower SES background and he self-reported receiving English Language Learner (ELL) services from the first through the sixth grade (SREP session observation, April 21, 2008). Vince also reported several personal interests typical of adolescence, including playing sports and participating in Tae Kwon Do.

2.1.2. Pauline. Pauline, a fourteen-year-old, Asian female, performed in the proficient range in science and the basic range (i.e., category below proficient) in reading on a state standardized exam and displayed average intellectual skills (see Table 1). Based on high school and middle school teacher reports, Pauline typically displayed adequate motivation and effort in school. However, a review of her middle school report cards showed that Pauline struggled to attain proficiency in writing as well as on tasks requiring independent research and inquiry. These types of tasks are often linked with science classrooms. Her ninth grade teachers supported this latter finding, suggesting that her struggles with independent learning was a prime reason for referring Pauline to participate in SREP. Pauline did not qualify for free-or-reduced lunch. In terms of leisure interests, she reported playing tennis for her high school.

2.1.3. Eric. Eric, a fourteen-year-old, Caucasian male, displayed advanced academic skills in science and reading as well as strong intellectual skills (see Table 1). Based on his middle school records, Eric typically displayed adequate effort in school and earned mostly B grades in his academic subjects. However, a couple of his teachers indicated that Eric did not always work up to this potential in middle school and thus displayed inconsistent motivation. His ninth grade teachers supported this claim, highlighting that his inconsistent effort and poor organization were the primary reasons for nominating him to receive SREP. Eric was not eligible for free-or-reduced lunch and his leisure interests were not available.

2.1.4. John. John, a fourteen-year-old, African American male, performed in the proficient range in both science and reading. Although John did not complete the cognitive ability screener (based on parental request), his teachers in both middle school and high school reported that he possessed strong potential to perform well in school. However, several of John's middle school teachers indicated that he often exhibited issues with regulation and self-management, including poor self-control and attention focusing skills. Collectively, his ninth grade teachers highlighted these weaknesses along with poor motivation as the primary reasons for referral to SREP. Based on school records, John received free-or-reduced lunch in ninth grade.

2.2. Measures

2.2.1. Biology Test Scores. The authors used teacher-developed class tests covering specific units in biology as the primary measure of academic achievement. A total of eight unit exams were administered throughout the school year. The first five science exams occurred prior to SREP training and thus were considered pretest or baseline scores. However, we did not include the first exam of the school year in the pretest average score due to teacher reports that this exam differed substantially in format, structure, and content from all other exams. The remaining four pretest and three intervention exams adhered to a similar format (i.e., multiple choice, short answer, diagrams, and essay questions) and ranged from 0% to 100%.

2.2.2. Self-Report and Rating Scales. A variety of self-report questionnaires were administered to examine student perceptions regarding their use of regulatory strategies and their self-efficacy perceptions. Multiple SRL strategy questionnaires were used to examine shifts in students' perceptions of strategy use because SREP instruction entailed frequent modeling and teaching of such strategies. Although there are several types of motivation beliefs that we could have examined, such as goal orientation and task values, we elected to comprehensively focus on self-efficacy (i.e., two separate measures) due to its central role in social-cognitive theoretical models of motivation and SRL. Moreover, prior research has established self-efficacy as one of the strongest predictors of motivated and strategic behaviors [25].

2.2.3. Self-Regulation Strategy Inventory—Self-Report (SRSI-SR). The SRSI-SR is a 28-item self-report scale designed to assess students' use of various self-regulation strategies during studying and homework completion [38]. Factor analysis indicated that the SRSI has a three-factor structure: Environment and Behavior Management ($\alpha = 0.88$), Seeking and Learning Information ($\alpha = 0.84$), and Maladaptive Behaviors ($\alpha = 0.72$). The Environment and Behavior Management scale is a 12-item subscale assessing the frequency with which students report using strategies to manage their study environment (e.g., "I try to study in a quiet place") and examines whether they engage in self-control during studying (e.g., "I tell myself to keep trying hard when I get confused"). The eight-item Seeking and Learning Information subscale measures the frequency with which students report seeking help or using specific study tactics during studying. The Maladaptive Regulatory Behavior scale includes eight items and measures the extent to which students engage in maladaptive regulatory behaviors, such as forgetfulness and avoidance (e.g., "I give up or quit when I do not understand something"). All items were worded in relation to biology class and used a five-point Likert scale ranging from 1 (almost never) to 5 (almost always) with specific anchors for each scale unit. These scales have been shown to differentiate high and low achievers in urban [38] and suburban contexts [39].

2.2.4. Self-Regulation Strategy Inventory—Teacher Rating Scale (SRSI-TRS). The SRSI-TRS is a 13-item teacher rating scale designed to assess teachers' perceptions of students' regulatory behaviors and engagement in specific classroom contexts [40]. This scale was developed as a parallel measure to the SRSI-SR. All items were worded in relation to biology class and used a five-point Likert scale ranging from 1 (almost never) to 5 (almost always). Example items include "The student asks questions in class when he or she does not understand something" and "The student monitors how well he or she learns class material." The scale has demonstrated adequate internal consistency ($\alpha = 0.96$) and predictive validity with high school students in urban contexts [40].

2.2.5. Self-Efficacy for Self-Regulated (SRL) Learning. A 10-item self-efficacy for self-regulated learning measure was employed to examine students' confidence in regulating learning, such as planning and organizing schoolwork, motivating themselves to study, and structuring their study environments [18, 41]. The self-efficacy stem phrase, "How confident are you that you can…," was followed by 10 efficacy phrases, including "Get yourself to study when there are other interesting things to do" and "Arrange a place to study without distractions." Students responded to all items using an 11-point Likert scale ranging from 0 (not confident at all) to 10 (completely confident). In addition, one item was reworded to ensure compatibility with the nature of the target school (e.g., item pertaining to library use). Different versions of this scale have been shown to exhibit adequate internal consistency, with α levels ranging from 0.82 to 0.85 [18, 42].

2.2.6. Self-Efficacy for Outcomes. A six-item self-efficacy scale adapted from the Patterns of Adaptive Learning Scale (PALS) was used to assess students' confidence for learning and performing in biology class [31]. The authors worded all items to reflect performance in biology class and included an 11-point Likert scale ranging from 0 (not confident at all) to 10 (completely confident) to be consistent with the other self-efficacy measure. The self-efficacy stem phrase, "How confident are you that you can…," was followed by the six items. An example item included "Understand the most difficult topics in biology if you try hard." The internal consistency of different versions of this scale has been shown to range from 0.70 to 0.88 in middle school and secondary school populations [18, 31].

2.2.7. Qualitative Measures. Qualitative information about students' strategy use and self-reflection processes as well as students', teachers', and parents' perceptions of social validity of SREP (i.e., acceptability, importance) were also gathered. The inclusion of social validity measures in SRL intervention research is a relatively rare phenomenon. However, it is an important type of measure that can provide supplementary information regarding the implementation and potential effectiveness of an intervention. That is, social validity measures generate information about whether direct consumers (i.e., students) and indirect consumers (i.e., teachers and parents) perceive the intervention procedures, outcomes, and goals to be valuable and/or acceptable. These types of perceptions are critical because they often determine whether interventions will be rejected or embraced during future iterations of an intervention program [43, 44].

2.2.8. Field Notes. As part of each session, the second author, who was an advanced doctoral student trained extensively in multidimensional assessment techniques, used a behavioral checklist to document students' verbalizations and behaviors pertaining to various aspects of SRL. This checklist was aligned with Zimmerman's [25] model of self-regulation to focus on key processes underlying each of the three phases of self-regulated learning. For example, the checklist listed self-motivational beliefs as one category for behavioral documentation, such as statements indicative of self-efficacy ("I can do this") or outcome expectations ("This will help me do better"). Verbal reports of using cognitive or self-regulated learning strategies at home were recorded as performance control behaviors, such as using concept maps, self-quizzing, studying in a quiet place or rewarding oneself with a snack after studying. Self-reflection processes, such as affective reactions ("I am happy that I did better on the exam") were also recorded. For each of these general categories, specific definitions derived from theoretical definitions along with example behaviors were included to facilitate accurate recording. Ample writing space for additional recording of specific behaviors and verbalizations was also provided. The second author was provided with the opportunity to ask questions and to confirm the meaning of the student behaviors and verbalizations on a weekly basis with the primary author.

2.2.9. SRL Microanalysis. SRL microanalysis is a structured interview protocol that uses highly contextualized questions targeting specific regulatory processes as students engage in particular tasks or activities [45, 46]. In this study, questions targeting two self-reflection phase processes, attributions ("What is the main reason(s) for my exam performance?"), and adaptive inferences ("What do I need to do to improve my next test performance?") were administered following the first and second intervention biology exams. These questions provided qualitative information about how students perceived and reacted to test performance. Prior research has shown these two questions typically elicit maladaptive or nonstrategic responses in low achieving students [46, 47]. Thus, in this study, student responses to these questions were used by the self-regulated learning coach (SRC) to formally engage students in reflective discussions about the quality of their strategic thinking and approaches for subsequent biology exams (i.e., during the self-reflection module).

2.2.10. Social Validity. A nine-item social validity questionnaire was administered to students, parents, and the biology teacher (see the appendix for individual items; [18]). The measure was designed to target two aspects of social validity as defined by Wolf [44]: (a) social acceptability of procedures, and (b) social importance of effects. This scale utilized a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores representing greater acceptability and consumer satisfaction.

2.3. Research Design. This mixed model case study design emphasized the use of a comprehensive array of quantitative and qualitative measures to examine shifts in students' regulatory and motivation process during and following the intervention. The authors administered self-report questionnaires and a teacher rating scale at pretest and posttest, the social validity survey at posttest only, and the qualitative assessment tools *during* SREP sessions. The use of this multidimensional-assessment approach allowed us to examine whether students' perceptions of their regulatory behaviors and beliefs converged with teacher and SRC observations and ratings.

We also incorporated methodological controls to reduce the likelihood that extraneous variables impacted the observed changes in students' biology test scores. In terms of achievement, we used four biology exams administered over a four-month period as the index of pretest achievement. Given that participant test scores were relatively stable over a long period of time, it is highly unlikely that changes in test performance observed during the intervention were due to maturational changes. Second, we reduced the likelihood that teacher behaviors or instruction, difficulty level of biology unit, or exam difficulty served as confounding variables by using classroom test average as a benchmark against which to evaluate changes in students' exam performance. In addition, given that all participants were instructed by the same teacher and were administered identical exams, the observed test score changes could not have been due to variability in teacher expertise or to differences in the complexity of individual tests. Finally, interviews at the end of the intervention with the teacher and students revealed that students did not receive any additional academic services during the intervention to support their learning in biology, minimizing the risk that supplementary instruction impacted changes in test grade.

2.4. General Procedures. All assessment and SREP training sessions were conducted by the self-regulated learning coach (SRC) prior to the school day in a large classroom at the target high school. The school administrators were not comfortable in allowing SREP to occur during the school day because of potential scheduling conflicts and missed classroom instruction. Trained graduate students administered the pretest and posttest measures and a cognitive screening tool (i.e., Wechsler Intelligence Scale for Children—Fourth Edition). The social validity questionnaires were administered at the conclusion of SREP, with student demographic data being provided by the school at the end of the academic year. All participants had the opportunity to attend 17 SREP sessions over the course of 12 weeks. A total of 24 sessions were initially planned (two sessions per week) but school functions, school closings (snow), and other logistical issues resulted in seven sessions being cancelled. Sessions were approximately 45 minutes in length, highly structured, and organized around the format and protocols of the SREP manual.

2.5. SREP Instructional Principles and Procedures. Given that extensive details about SREP are provided elsewhere [18, 28], we will only briefly describe the instructional format and sequence. In general, the primary purpose of SREP is to embed content-specific cognitive strategy instruction within a self-regulation process of thinking and action. In general, students are taught to think and act in a cyclical, regulated way while studying and preparing for biology exams. More specifically, students are taught to (a) set process goals (e.g., use of strategy) and outcome goals (e.g., specific test grade) and develop strategic plans *prior* to learning or studying, (b) implement, use, and monitor learning and regulatory strategies *during* studying activities, (c) and reflect on the quality and effectiveness of the learning strategies *after* test performance. This instructional focus directly corresponds to Zimmerman's [25] three-phase cyclical feedback loop.

Using a series of instructional modules, the SRC taught students how to (a) set goals and develop strategic plans, (b) use cognitive learning strategies (e.g., concepts maps) and regulatory strategies (e.g., self-monitoring, self-control) when studying at home, and (c) evaluate and reflect on their biology tests (see [18] for specific module details). The most comprehensive aspect of SREP training, however, involved strategy instruction. Throughout the intervention program students were taught both cognitive strategies, such as concept maps and mnemonic devices, and regulatory strategies, such as self-monitoring, help seeking, time management, and environmental structuring. The strategy instruction entailed using a well-defined instructional sequence: explanation of strategies, modeling, and guided practice [25]. The memory tactics and concept map modules were implemented during the fourth and fifth weeks of SREP, respectively. Each strategy module was administered over two sessions. The first session involved strategic instruction, with the second session devoted to teaching students how to monitor their rate of learning using the learning strategies (e.g., self-quizzes). From week six through the completion of the SREP, the SRC led students through successive cycles of guided practice in using cognitive strategies (e.g., concept maps) and various self-control strategies (e.g., environmental structuring, time management) in a self-regulated manner as determined by students' self-expressed needs. It is important to note that these latter sessions were highly collaborative and individualized in that students were encouraged to express their specific challenges when learning biology content or when using a cognitive strategy during studying at home.

An underlying theme in the SREP instruction is the alternation between the highly structured SREP sessions (which included high levels of feedback and guided practice opportunities when using cognitive strategies) and the independent use and monitoring of these strategies at home. The SRC not only provided students with ample practice opportunities during SREP to apply strategies to course content but also how to practice and track how well they learned using these strategies at home. As will be discussed across the case studies, students varied in how well they were able to independently use these strategies outside the presence of the SRC.

Finally, the SREP self-reflection module is one of the most important components of the program because it explicitly guides student reflection on whether they reached their goals, the potential reasons for their performance, and what they need to do strategically to improve. It is during this module when the SRC provides individualized and customized feedback to best address students' specific maladaptive beliefs and behaviors. Following the first two biology tests during SREP, the SRC administered the brief SRL microanalytic protocol to examine student attributions and adaptive inferences. Although the primary function of this qualitative data was to help the SRC guide intervention activities and reflective conversations, in this paper we present examples of students' microanalytic responses to illustrate the quality of their reflective thinking during the course of the intervention.

3. Results and Case Study Analysis

Multiple assessment tools and sources were used to examine the level of correspondence between biology test score patterns exhibited by each of the participants and their SREP attendance as well as shifts in their use of cognitive and regulatory strategies and motivation *during* and immediately following the intervention. For the metric SRL measures (i.e., SRSI-SR, SRSI-TRS, self-efficacy), we calculated reliability change index (RCI) scores to examine pretest-posttest changes in SRL and motivation beliefs. RCI procedures involved dividing pretest-posttest differences by the standard error of the differences between the two test scores [48, 49]. One can interpret an RCI of 1.96 as a statistically significant difference at a $P < 0.05$ level, whereas an RCI of 2.33 or greater is significant at a $P < 0.01$ level and is viewed as having greater clinical significance. Qualitative information gathered from field observations, microanalytic questions, and social validity questionnaires were used to supplement the quantitative measures.

3.1. SREP and Biology Exam Performance. Using descriptive analysis, it was observed that, in general, each of the participants showed positive gains when comparing their average pretest exam score to their average intervention score. However, there was a high level of variability in the pattern of specific intervention test scores across participants (see Table 2). For example, both Pauline and Vince showed steady improvement during the intervention, whereas Eric and John showed initial progress but then displayed a sharp decline in performance on the final test of the semester.

To interpret these case studies, we discussed normative changes in student biology test performance and then illustrated whether these test score patterns closely corresponded to shifts in their regulatory and motivated behaviors, their SREP attendance and punctuality, and their perceptions and motivation beliefs. A series of quantitative and qualitative assessment tools were used to accomplish this objective. To structure the narrative sequence for each case, we highlighted students' regulatory behaviors and motivation when beginning SREP, specific challenges that they exhibited or encountered, and the evolution of the quality of their regulatory perceptions, beliefs, and strategic behaviors during the intervention. Within this narrative, we address three overarching themes: (a) shifts in motivation beliefs and strategic or regulatory behaviors, (b) degree of convergence among assessment tools to support interpretive conclusions, and (c) correspondence between motivated and regulatory behaviors and intervention biology exam scores.

3.1.1. Vince and Pauline. On the first intervention exam, Vince and Pauline performed substantially below the class average. However, they both showed substantial growth during SREP. Vince performed 0.95 (raw $\text{score}_{\text{exam}} = 85\%$) to 0.80 (raw $\text{score}_{\text{exam}} = 95\%$) standard deviations above

Table 2: Biology test performance of participants before and during SREP intervention.

Participant name	Baseline test score average[a]	Intervention test score average[b]	Gain score	Intervention test no. 1	Intervention test no. 2	Intervention test no. 3
	$M_{z\text{-score}}$ ($M_{\text{raw score}}$)	$M_{z\text{-score}}$ ($M_{\text{raw score}}$)	$M_{z\text{-score}}$ ($M_{\text{raw score}}$)	z-score (raw)	z-score (raw)	z-score (raw)
Vince	.26 (76.3%)	.42 (85.3%)	.16 (9.0)	−.50 (76%)	.95 (85%)	.80 (95%)
Pauline	−.31 (68.0%)	−.05 (79.7%)	.26 (11.7)	−1.0 (71%)	.17 (75%)	.68 (93%)
Eric	.14 (74.8%)	.43 (84.0%)	.29 (9.2)	.57 (87%)	.74 (83%)	−.02 (82%)
John	−1.63 (50.5%)	−.84 (67.3%)	.79 (16.8)	−.60 (75%)	−.71 (64%)	−1.22 (63%)
Group Avg	−.40 (67.4%)	−.02 (79.1%)	.38 (11.7)	−.40 (77.3%)	.29 (76.8%)	.06 (83.3%)

$M_{z\text{-score}}$: mean z-score. $M_{\text{raw score}}$: mean raw exam score.
[a]means biology test scores prior to SREP. [b]means biology test scores during SREP.

the class mean on the last two intervention exams, whereas Pauline performed 0.17 (raw $\text{score}_{\text{exam}} = 75\%$) and 0.68 (raw $\text{score}_{\text{exam}} = 93\%$) standard deviations above the class average on the last two exams. Both Vince and Pauline clearly improved their test performance during the intervention in comparison to their pretest exam scores.

3.1.2. Vince: Link between Motivation, Regulation, and Achievement. Based on a review of records and several assessment tools used in this study, Vince presented as a highly interested and eager learner who underperformed academically relative to his effort and motives for achieving success. Vince's motivation to improve was demonstrated in his SREP attendance; Vince attended the highest percentage of SREP sessions of the four participants (82%; see Table 3), arriving to most sessions on time and with classroom materials. In addition, at pretest, he exhibited relatively high perceptions of efficacy and reported that he frequently used different strategies when studying for biology tests (see Table 4).

Interestingly, Vince also displayed some awareness of specific areas of challenge for him. He self-reported that he struggled to consistently comprehend and understand biology course material, particularly technical vocabulary. During one of the initial sessions, the SRC noted that the technical vocabulary associated with biology represented a major hurdle for Vince and that he did not exhibit a strong repertoire of strategies for learning vocabulary. For example, Vince conveyed that his study plan consisted of looking over his notes and simply stating vocabulary words aloud to remember them (SREP field notes, March 5, 2008). At around the same time, Vince underperformed on a quiz of the skeletal system because he confused several anatomical terms (SREP field notes, March 17, 2008). He was disheartened by the results of this quiz because he had reportedly spent a considerable amount of time preparing. In short, despite exhibiting strong motivation and desire to perform well, Vince felt frustrated by his lack of success and struggles with learning key terms for tests. Vince's difficulty with vocabulary again surfaced during the SREP module devoted to teaching mnemonic strategies. During one particular session, Vince openly talked about his frustration when learning to pronounce complex or challenging technical vocabulary (SREP field notes, March 31, 2008).

It was not until the SRC began to explain and model specific tactics on how to learn key terms and to monitor how well he learned them when studying at home that Vince began to exhibit more strategic behaviors and improved test performance. Although he was initially resistant to using mnemonics to learn vocabulary words or to use self-quizzes to monitor his study approach, Vince gradually began to practice this tactic after receiving guided practice support and encouragement from the SRC (SREP field notes, April 2, 2008). Vince was similarly hesitant during the next session which focused on concept maps but, again, quickly embraced this strategy as the SRC systematically modeled and provided guided practice support (SREP field notes, April 4, 2008). His acceptance and application of these strategies were observed during a subsequent SREP session when both Vince and John began to refine their use of mnemonics, concept maps, and self-quizzing together (SREP field notes, April 16, 2008). Of particular interest is that Vince's desire to use concept maps is consistent with prior research showing that various types of graphic organizers often facilitate learning and comprehension with ELL students [50, 51]. It is possible that Vince experienced greater success in learning when using these strategies and thus was highly motivated to use and apply them.

As predicted by the three-phase model of self-regulation [25], changes in Vince's use of concept maps and mnemonic devices coincided with adaptive changes in his self-reflective thoughts following exam performance, suggesting that Vince began to think about exam performance in relation to the strategies taught during SREP. For example, as part of the self-reflection module administered following his second biology test, Vince reported that learning key vocabulary terms was the primary barrier to his success. In addition, he attributed his performance on the second intervention exam, which was a large improvement from his first intervention exam, to the perceived "large amount of time he studied" and the use of "easier ways to remember more information about all of the subjects" (SRL microanalysis, May 5, 2008). These latter statements were in reference to the mnemonic devices and concept maps taught during SREP.

It was during this discussion that Vince spontaneously revealed to the SRC that he had received ELL services from the first to sixth grade, which he associated with his difficulty learning biology terms (SREP field notes, April 21, 2008).

Table 3: Student attendance and tardiness during the SREP intervention.

Participant	Total SREP attendance ratio[a] (%)	Attendance before test no. 1 ratio[a] (%)	Attendance before test no. 2 ratio[a] (%)	Attendance before test no. 3 ratio[a] (%)	Total SREP lateness ratio[b] (%)	Lateness before test no. 1 ratio[b] (%)	Lateness before test no. 2 ratio[b] (%)	Lateness before test no. 3 ratio[b] (%)
Vince	14/17 (82.4%)	3/3 (100%)	6/7 (85.7%)	5/7 (71.4%)	0/14 (0%)	0/3 (0%)	0/6 (0%)	0/5 (0%)
Pauline	9/17 (52.9%)	1/3 (33%)	3/7 (42.8%)	5/7 (71.4%)[c]	1/9 (11.1%)	0/1 (0%)	0/3 (0%)	1/5 (20%)
Eric	13/17 (76.5%)	2/3 (75%)	6/7 (85.7%)	5/7 (71.4%)	4/13 (30.8%)	0/2 (0%)	0/6 (0%)	4/5 (80%)
John	11/17 (64.7%)	3/3 (100%)	5/7 (71.4%)	3/7 (42.8%)	6/11 (54.5%)	3/3 (100%)	1/5 (20%)	2/3 (66.7%)

Attendance ratios and percentages reflect whether students showed up to a session regardless of lateness. Lateness was defined as being late to an SREP session by more than 15 minutes.

[a]Ratio pertains to the number of sessions students attended divided by the total number of sessions offered.

[b]Ratio pertains to the number of times students were late to an SREP session divided by the number of sessions attended.

[c]Pauline missed the last session because she was on a family vacation.

Table 4: Reliability change index (RCI) scores across self-regulation and motivation measures.

Dependent measures	Vince			Pauline			Eric			John		
	Pretest	Posttest	RCI	Pretest	Posttest	RCI	Pretest	Posttest	RCI	Pretest	Posttest	RCI
SRSI-MBE	3.27	3.64	0.98	3.91	3.64	−0.72	2.73	2.91	0.48	3.36	3.45	0.24
SRSI-SLI	3.25	3.63	0.99	3.25	3.38	0.34	2.63	3.13	1.30	3.38	3.50	0.31
SRSI-MRB[a]	1.63	1.63	0.00	3.25	2.38	−2.00*	3.13	3.25	0.28	2.00	1.75	−0.58
SRSI-TRS	2.38	2.69	0.84	1.69	3.08	3.75**	1.85	3.00	3.10**	2.23	2.69	1.24
SE outcomes	8.83	9.17	0.53	9.0	6.33	−4.16**	10.0	6.83	−4.94**	6.83	5.67	−1.81
SE learning	7.2	8.7	1.76	6.6	6.4	0.23	6.1	6.1	0.00	6.7	4.5	−2.58**

MBE: managing behavior and environment. SLI: seeking and learning information. MRB: maladaptive regulatory behavior. TRS: teacher rating scale. SE: self-efficacy. RCI: reliability change index.

[a]Low scores represent fewer maladaptive regulatory behavior.

$^{*}P < .05$.

$^{**}P < .01$.

This reflection exercise marked an important shift for Vince because he began to attribute his exam outcomes to controllable factors (e.g., study strategies) that he could modify. Research has shown this type of attribution response to be quite adaptive in promoting more positive motivation and self-regulation [52, 53]. In fact, during this particular self-reflection discussion, Vince spontaneously elected to expand his strategy plan for the third intervention exam to include asking his sister to quiz him on key terms and concepts (SREP field notes, April 21, 2008).

Not only did Vince become more strategic with how he learned information, but he also explored ways to structure his study sessions and to regulate his motivation and studying behaviors, such as time management, environmental structuring, and self-reinforcement (all components of the performance phase of the three-phase cyclical model). SRC field notes showed that Vince experimented with self-reinforcement, whereby he would award himself with an afterschool snack only after he completed his homework. Vince deemed this strategy effective because, as he revealed in an earlier SREP session, he would get distracted most often after he ate (SREP field notes, March 19, 2008). Over the course of the SREP intervention, Vince also recognized the value of time management as he reported using intermittent breaks of soccer to help him structure his studying and to enhance his time management (SREP field notes, May 19, 2008).

Although many of the behaviors and strategies that Vince exhibited were prompted and guided by the SRC, there was also evidence that Vince began to proactively and independently adapt and use strategies taught during SREP. For example, after learning how to use concept maps and summarization techniques during an SREP session, Vince independently and spontaneously (i.e., without prompting from the SRC or teacher) developed a series of potential test questions to guide his studying at home the following weekend (SREP field notes, April 16, 2008). Vince brought these questions into the following SREP session to share with John and to receive feedback regarding their appropriateness and quality. Vince exhibited similar behaviors prior to the third intervention exam, as he generated additional questions to quiz himself as he studied for this final unit exam (SREP field notes, May 19, 2008). In short, by the end of SREP, Vince exhibited a profile of high achievement and adaptive motivated and self-regulatory behaviors. In fact, after SREP had ended, Vince met with the SRC to debrief about the program.

During this conversation he spontaneously revealed that prior to SREP he would typically gloss over difficult words because focusing on them elicited feelings of embarrassment and frustration. However, he reported that during SREP he recognized the value of using SREP strategies to deal with the problem as well as the use of alternative strategies to find definitions of unfamiliar words, such as using the Internet (SREP field notes, May 28, 2008). Theorists have described these types of proactive or self-generated behaviors as being reflective of adaptive levels of personal agency and regulatory sophistication [25, 54].

Another important theme involved the level of convergence between pretest-posttest changes in quantitative measures of SRL (i.e., self-report questionnaires and teacher rating scales), the field note observations, and data derived from microanalytic reflection questions. For Vince, there was poor convergence between most quantitative measures and the qualitative assessment tools. For example, RCI analysis of both the self-report and teacher version of the SRSI showed that there was no improvement in Vince's strategic approach to learning biology course content (see Table 4). That is, despite evidence for shifts in his strategic behaviors as noted previously, Vince did not perceive that he used strategies more frequently nor did his teacher report that he was more strategic during classroom activities. This lack of convergence may suggest that students may have difficulty accurately reporting their strategic behaviors, a premise consistent with prior research [55, 56] or that self-report questionnaires may often lack the sensitivity needed to capture specific shifts in students' use of cognitive or regulatory strategies.

In terms of Vince's profile of self-efficacy perceptions, he displayed relatively high efficacy perceptions at the beginning of SREP. These high levels of efficacy were consistent with his high level of motivated behaviors exhibited at the outset of the program and his strong SREP attendance. Unlike his SREP peer participants, however, Vince sustained these high beliefs throughout the program, with his change in efficacy for regulated learning narrowly missing statistical significance (see Table 4). By sustaining his belief in personal capability and through recognizing that learning study strategies were connected with his improved test grades, Vince displayed the most consistent pattern of SREP attendance and was rarely late to the intervention sessions.

3.1.3. Pauline: Link between Motivation, Regulation, and Achievement. As indicated in record reviews, Pauline displayed adequate achievement and intellectual skills, but struggled on tasks that involved self-directed or independent activities. She was a good candidate for SREP in this context because test preparation was the key task of interest that necessitated a high level of self-initiation and self-direction to perform well. Based on SREP field notes, Pauline was distracted, frustrated, and disorganized during the initial SREP sessions and often exhibited poor strategic behaviors and motivation beliefs. For example, when asked to describe her approach to studying at the beginning of SREP, Pauline related that she saved all her studying for the weekend (SREP field notes, March 5, 2008) and that her typical approach to learning and recalling key terms and course content was to "keep going over them until my brain hurts" (SREP field notes, March 17, 2008). Pauline expressed frustration during initial SREP sessions because she did not perform well on exams despite her efforts and often forgot to turn her assignments in on time, even when she had completed the assignments (SREP field notes, March 17, 2008). Pauline's difficulties with learning course material and time management appeared to impact her mood and thoughts, as the SRC noted that she was often tired, distracted, and confused during initial sessions. On one occasion, Pauline expressed a declining level of self-efficacy, stating "everything is difficult for me" (SREP field notes, March 31, 2008). Given this pattern of beliefs and behaviors, it made sense that Pauline attended only four out of the first 10 sessions and that her perceived efficacy to regulate her learning was only at a moderate level (see Tables 3 and 4).

Despite exhibiting maladaptive behaviors at the outset of SREP, Pauline evinced an important shift in regulatory thinking and behaviors immediately before the second exam. She also appeared to become more entrenched in strategic thinking during the self-reflection module administered following the second intervention test. When probed with an attribution question during the self-reflection module ("What is the main reason why you got this test grade?"), Pauline identified running out of time when taking the test and spending too much time studying a narrow set of topics as the key causes of her performance (SREP microanalysis, April 28, 2008). Thinking about her test outcomes in terms of specific strategies was highly adaptive because she recognized that, with the help of the SRC who had modeled such thinking during SREP sessions, she could improve her test performance if she modified her study plan (a type of controllable, internal, and unstable attribution). As part of the self-reflection session, Pauline also made effective adaptive inferences by identifying controllable actions she could take to improve her next exam grade. For example, she cited studying "equally on each section" as one method for ensuring that she did not neglect key test topics (SREP microanalysis, April 28, 2008). In addition, the specificity of her plan increased as she reported practical methods to better manage her time and quality of learning. For example, she determined a specific amount of time that she would devote to studying each night (rather than wait for the weekend) and planned to utilize specific tactics, such as, "thinking about questions and easier strategies" to help her remember key terms and content. Recognizing that anxiety was a self-reported area of concern, Pauline included the use self-talk in her strategic plan for the third test by reminding herself "the more I study the better my grade will be" (SRL microanalysis, May 6, 2008).

Of particular importance from a self-regulatory perspective was that Pauline increased how frequently she sought out support prior to the third intervention biology test, such as asking her older siblings for assistance (SREP field notes, April 21, 2008). This behavior was highly adaptive because it enabled her to clarify points of confusion and to receive support and confirmation regarding the appropriateness of her approach to her studies. Furthermore, help seeking is widely regarded as an essential regulatory skill that is used by highly effective learners [57, 58]. During subsequent sessions, Pauline also reported that she proactively researched mnemonic devices on the Internet to help her remember content prior to an exam on the circulatory system. It is important to note that these latter behaviors occurred immediately following an SREP session on help-seeking and information-seeking strategies. In other words, these anecdotal observations suggest that Pauline attempted to apply and adapt strategies that she learned during SREP to enhance her independent studying at home.

Another important shift for Pauline occurred following her second exam, when she recognized that attending SREP sessions on a more regular basis would help her improve her test performance by getting more practice and feedback from the SRC. In fact, Pauline attended five of the last seven SREP sessions that occurred prior to the third intervention exam, with one of those absences resulting from a family vacation rather than her decision to not attend. Consistent with her increased level of self-directedness and initiative, Pauline spoke with the SRC about how to prepare early for the third intervention exam given that she was going to miss the SREP session prior to her exam (SREP field notes, April 28, 2008). Despite beginning SREP with poor levels of organization and self-directed behaviors, Pauline gradually initiated her own attempts to learn and sought out the appropriate assistance when struggling.

Furthermore, Pauline's self-reported perceptions of strategy use, teacher ratings, and SRC observations during SREP showed a moderate amount of convergence. In general, Pauline perceived that she engaged in less maladaptive regulatory behaviors (e.g., lack of organization, forgetfulness) at the end of the intervention, (RCI = 2.00, $P < 0.01$). These self-reported behaviors were consistent with field note observations about Pauline's behaviors highlighted previously as well as teacher ratings showing a significant increase (pretest to posttest) in Pauline's regulatory and motivated behaviors during biology class, (RCI = 3.75, $P < 0.01$). Interestingly, no significant pretests to posttest change was found regarding Pauline's perceptions of how frequently she used adaptive cognitive and regulatory strategies during learning. This lack of correspondence between her perceptions of strategy use and the changes in strategies observed by the SRC and biology teacher is consistent with findings related to Vince. That is, significant changes on the SRSI adaptive subscales may not have been observed because either Pauline did not accurately report these behaviors due to overestimation at pretest or due to poor awareness of what she actually did to prepare for exams.

Analysis of Pauline's declining self-efficacy throughout the intervention further underscores the latter point about inaccuracies in student self-perceptions. Pauline began SREP with very high levels of self-efficacy to perform well in biology but displayed relatively lower levels of efficacy to manage and regulate her learning. Her low efficacy for regulation made sense given that organization and regulation were specific areas that Pauline and her teachers noted as personal areas of weakness. Her inflated efficacy for biology outcomes, however, suggested a lack of awareness on her part regarding being able to learn biology material well, particularly because her pretest biology test average was so low. In analyzing pretest-posttest differences across these two self-efficacy measures, her self-efficacy for attaining biology outcomes showed a significant *decline* whereas her efficacy for regulation did not change. The decline in her efficacy for biology outcomes can be understood from a calibration perspective. That is, as Pauline became more aware of her learning challenges or weakness, even with improved biology test scores, her perceived capabilities shifted. This is an important phenomenon because given the high level of monitoring and self-awareness enhancement that occurs during SREP, students will not only become more aware of progress that they make but also their personal limitations and specific areas of struggle.

3.1.4. Eric and John. Although Eric and John exhibited different pretest exam score averages, with Eric's pretest average slightly above the classroom mean ($z = 0.14$, $M_{\text{exam}} = 74.8$) and John's profile substantially below the mean ($z = -1.63$, $M_{\text{exam}} = 50.5$), they demonstrated a similar pattern of exam performance over the course of the intervention (see Table 2). That is, both students showed an initial increase in their biology exam scores relative to their pretest averages but struggled to sustain this performance over time.

3.1.5. Eric: Link between Motivation, Regulation, and Achievement. Eric exhibited strong performance on his first two biology intervention tests but exhibited slightly below average performance on his third exam. Interestingly, the majority of the data gathered from quantitative and qualitative methods supported the premise that Eric's behaviors during class time and during SREP sessions were adaptive, at least initially, but that he was unable to sustain these behaviors throughout the intervention and struggled to implement what he learned during SREP without external support.

Throughout SREP, Eric attended most of the sessions and was very engaged during the initial part of the training program. During the initial SREP sessions, students identified the reasons why they displayed inconsistent performance in biology. Eric expressed several controllable or modifiable factors, including difficulty with recalling information following studying, poor knowledge of test preparation strategies, and difficulty concentrating or avoiding distraction when doing work at home (SREP field notes, March 5, 2008). Prior to the first intervention exam, Eric expressed a strong desire to refine and extend his repertoire of strategies in preparation for upcoming exams, including rewriting notes and looking over labs as opposed to simply reading over notes (SREP field notes, March 12, 2008). His level of strategic engagement was also apparent in preparation for the second biology exam as he reported using self-quizzing tactics as a way to monitor his learning. He also demonstrated a strong interest and skill in being able to generate his own mnemonic strategies to address his self-reported problems with recall for exams (SREP field notes, April 2, 2008). His extremely positive attendance and punctuality to SREP, along with his interest in applying learning strategies to improve learning, was highly consistent with his strong performance on the first two biology exams (see Table 2).

Interestingly, following the second intervention exam, field note observations and self-reflection discussions revealed that Eric began to disengage from SREP. As part of the self-reflection module following this exam, Eric reported that he "did not study very specific material," and that this was the key factor affecting his grade (SREP microanalysis, April 28, 2008). In terms of what he believed he needed to do to improve (adaptive inference), Eric indicated that he needed to become "more detailed in studying and reviewing" (SREP microanalysis, April 28, 2008). However, during this self-reflection discussion, Eric conveyed that he would like to continue to improve his test grades, but he was unwilling to put forth the necessary effort to do so (SREP field notes, April 28, 2008). It was following this exam when Eric began to show signs of disengagement, characterized by excessive lateness to SREP sessions (see Table 3).

Many theorists argue that the motivation to engage in learning is largely determined by one's motivation beliefs, such as self-efficacy, task interest and value, and conceptions of ability [25, 59, 60]. In Eric's case, his declining motivation could be explained by several of these beliefs, including his tendency to perceive exam performance as a stable trait (i.e., conceptions of ability; [59]), his declining self-efficacy, and his devaluing of biology class (task value; [25]). Eric exhibited a large and statistically significant decrease in his efficacy beliefs for attaining positive biology outcomes (RCI = −4.94, $P < 0.01$) from pretest to posttest. Similar to Pauline, at pretest Eric's self-efficacy for biology outcomes was at the upper extreme (i.e., a raw score of 10) and plausibly overinflated relative to his average level of biology performance at pretest. Given that SREP sessions often included conversations centering on students' specific strategic weaknesses along with potential suggestions for improvement, it is highly probable that he became more aware of his personal weaknesses as well as the inherent obstacles to learning success. As a result, his perceptions about his ability to perform well were also adversely impacted. According to Bandura [61], students who begin to doubt their capabilities are much more likely to avoid work and to display poor effort. It is also noteworthy that towards the end of SREP, Eric began to exhibit behaviors suggesting that he did not place biology class as a priority in his life. For example, during one session prior to the third intervention exam, Eric doubted whether he would study for the third intervention exam as planned because he wanted to visit his brother, who was in college, since it was more enjoyable (SREP field notes, May 8, 2008).

Although it is difficult to ascertain whether Eric's value perceptions were directly influenced by his lowered self-efficacy (i.e., "*if* I cannot do something well, I do not value it"), there was also qualitative data suggesting that he possessed an entity conception of ability rather than a more incremental one [59]. Entity theorists tend to view ability as a fixed capacity whereas incremental theorists perceive it to be malleable with practice and effort. Entity theorists would perceive low levels of effort as reflecting high capability. During an SREP session, Eric talked about his older brother performing exceedingly well in high school and in college while also conveying his perception that his brother did not appear to try very hard to attain these grades (SREP field notes, April 28, 2008). Although Eric expected that he would experience similar success, it appeared that he displayed poor awareness about the level of effort that his brother probably put forth to maintain this high level of performance or the level of effort that he personally needed to sustain a high level of performance. As a result, Eric believed that he could experience the same success as his brother without much effort. However, when he realized during SREP that he might need to exert high levels of effort to learn challenging concepts or to be a consistent performer, he appeared to display avoidance and resistance for the remainder of SREP.

An alternative explanation as to why Eric may have disengaged and experienced lower self-efficacy was that he was unsure *how* to enact more strategic forms of studying without external support. This is an intriguing possibility because Eric's dwindling attendance and engagement in SREP may have limited the extent to which he effectively applied the study strategies taught during previous SREP sessions. That is, Eric received specific, performance-related feedback from the SRC on how to implement study strategies in a self-regulated manner. By modeling how learning strategies could be used in a self-regulated manner, the SRC demonstrated what could be done to better learn biology content. In the context of the SREP session, Eric felt confident about what strategies he could use and how these strategies could be adapted. However, in the absence of the feedback rich setting of SREP, Eric was unable to independently use the strategies he learned. Although speculative, it is possible that upon becoming aware of his struggle to do so at home, his interest and self-efficacy for learning declined. Whereas Vince and Pauline expressed excitement and enthusiasm at the prospect of independently altering their use of strategies to increase their grades, it appeared that Eric did not experience those positive feelings. It is possible that Eric did not know how to apply these strategies at home without the support of the SRC and was not willing to exert the effort needed to do so.

In terms of his self-perception of strategy use, RCI procedures revealed no significant changes from pretest to posttest (see Table 4), suggesting that his profile of regulatory skills did not improve during the intervention. The lack of positive change in strategy self-report questionnaires mirrored the declines in his SRL behaviors and motivation that were observed in his poor attendance record and his lowered levels of self-efficacy. Interestingly, the biology teacher reported that Eric had generally become more engaged and motivated during his participation in SREP, rating him in a significantly more positive way at posttest than pretest (RCI = 3.10, $P < 0.01$). This level of divergence was interesting because it suggested that while Eric's regulatory and motivated behaviors improved in biology class (i.e., a context whereby he could receive external support) his interest and motivation to perform independent studying activities at home declined. From an instructional perspective, it was clear that Eric needed additional supports to help modify his maladaptive thinking and to sustain his strategic efforts when studying at home.

3.1.6. John: Motivation Beliefs and Regulatory Behaviors. Despite possessing adequate academic and intellectual skills, a record review and teacher reports showed that John struggled with motivation, organization, and self-regulation at the beginning of SREP. For the first two sessions, John arrived approximately forty minutes late, effectively missing the entirety of the content presented (SREP attendance notes). Pulled aside by the SRC to inquire about his tardiness issues, John stated that he arrived late because he missed the bus (SREP field notes, March 12, 2008). The SRC discussed the importance of arriving on time and worked with John to identify how he could arrive on time. John attended the next SREP session on time, but struggled with attendance and punctuality for the remainder of the intervention (SREP attendance notes). In addition to routinely arriving late, John attended most SREP sessions without his materials and made comments regarding projects for other classes that he had not finished on time (SREP field notes, March 17, 2008). These behaviors were highly consistent with teacher reports of his poor organization skills. Given his extremely sporadic and infrequent attendance to SREP sessions and the high level of consistency in his weak self-regulatory processes and strategic behaviors, we will discuss a few key issues pertaining to John's deficient motivation and regulatory skills rather than providing a sequential account of his behaviors during SREP as was illustrated with the other cases.

First, John reported relatively low perceptions of efficacy at pretest, suggesting that prior to SREP, he did not possess a high level of confidence about regulating his learning in biology or performing well in the course (see Table 4). Although John improved his exam performance by about 0.79 standard deviations, his biology exam performance was still near failing and far below his classmates. Given his normatively weak performances in biology, it makes sense that he did not "see" his test score improvement; thus, he sustained low self-efficacy for biology outcomes and even exhibited significant declines in his self-efficacy for regulated learning (RCI = -2.58, $P < 0.01$). As stated earlier, research has shown that when students display poor levels of self-efficacy they become disengaged from learning [61].

There was also evidence that John possessed poor metacognitive skills regarding his knowledge and awareness of the nature and format of his biology exams. In discussions that occurred during the self-reflection module following intervention exam two, it was revealed that John erroneously interpreted attaining a 93 on a 150-point test as equivalent to the same score on a 100-point test (SREP field notes, April 28, 2008). Similarly, John believed preparing for a 150-point test did not require more effort than preparing for a 100-point test (SREP field notes, April 28, 2008). It was not until the SRC discussed these misinterpretations that John acknowledged the discrepancy between his perceptions and the demands of studying for biology tests of varying complexity and length. Self-regulation researchers have consistently found that students who demonstrate poor awareness of task demands or their own skill levels are typically those who underperform in school [62–64]. Although enhancing John's self-awareness and poor motivation (i.e., SREP attendance) became the primary instructional goal of the SRC, poor attendance and punctuality limited the opportunities for the SRC to impact John's strategic skills, motivational beliefs (self-efficacy, perceived instrumentality), and cognitive and metacognitive approach to studying for biology exams.

Finally, for John, there was complete convergence amongst SRL assessment tools and his performance on biology exams. In short, all measures demonstrated that John did not exhibit changes in his regulatory behaviors or strategies during the intervention nor did he substantially improve his exam grades. For example, based on both self-report (SRSI-SR) and teacher rating scales (SRSI-TRS), there were no significant changes in his perceptions of strategy use and regulatory behaviors from pretest to posttest (see Table 4). Similarly, John exhibited maladaptive behaviors that limited the extent to which he benefited from the SREP intervention, including poor time management and self-reflection, sporadic attendance, and poor punctuality to SREP sessions (see Table 3). John attended only 65% of the sessions (11/17) and was late more than 15 minutes for six of those sessions. Thus, he not only missed approximately half of the sessions, but also key instructional content on those days in which he did attend. In sum, John's consistent below average test performance clearly converged with his lack of growth in strategic and metacognitive skills, his poor motivation, and his low attendance of SREP sessions.

4. Conclusions and Areas of Future Research

This study examined the relationship between shifts in student SRL and motivation during an intervention and their test performance changes in a specific academic content area. In general, students who attended SREP sessions on a regular basis and practiced using the strategies taught during SREP exhibited substantial improvement. This paper also descriptively illustrated the association between students' motivation beliefs and self-reflection processes (e.g., attributions) with their enactment of regulatory and learning strategies; a finding that parallels the SRL literature [6, 38, 65, 66]. Of particular importance was the varied responsiveness of students to the SRL intervention, ranging from "steady improvement" (Vince and Pauline), to "progress with difficulty sustaining motivation" (Eric), to "slow or minimal progress" (John). The utility of a multidimensional SRL assessment approach for assessing the dynamic, context-specific nature of SRL was also underscored. That is, self-report questionnaires, teacher ratings, SRL microanalytic questions, and field observations can provide a robust foundation for interpreting and explaining student behaviors during an intervention.

4.1. Relation between SREP and Science Achievement. All four students who received SREP showed improved biology test scores relative to their individual pretest score averages. Based on findings from this study as well as those from Cleary et al. [18], SREP participants have demonstrated z-score changes ranging from 0.13 to 1.5 ($M = 0.55$; Median = 0.36), with most showing significant changes in their motivated and self-regulated behaviors (see Tables 2 and 5). In addition, social validity information gathered from parents, teachers,

Table 5: Biology test performance gain scores observed in Cleary et al. [18].

Participant name	Baseline test score average[a]	Intervention test score average[b]	Gain score
	$M_{z\text{-score}}$ ($M_{\text{raw score}}$)	$M_{z\text{-score}}$ ($M_{\text{raw score}}$)	$M_{z\text{-score}}$ ($M_{\text{raw score}}$)
Jamal	−.77 (67.2%)	.18 (83.0%)	.95 (15.8)
Jordan	−.47 (70.8%)	.09 (81.7%)	.56 (10.9)
Nancy	−.84 (66.2%)	.66 (90.7%)	1.50 (24.5)
Ronaldo	−.15 (75.2%)	.09 (81.7%)	.24 (6.5)
Tony	−.23 (74.2%)	.01 (79.7%)	.24 (5.5)

[a]Mean biology test scores prior to SREP. [b]Mean biology test score during SREP.

and students in the current study and prior research [18] indicated that SREP was deemed to be a highly acceptable, relevant, and important intervention that has great potential as an academic intervention in high school contexts.

The primary purpose of the present study, however, was devoted to examining how shifts in student SRL processes, motivation beliefs, and motivation-related behaviors corresponded to the instructional opportunities provided in SREP and to changes in students' in biology test grades. Our results showed that changes in these SRL processes were clearly linked to shifts in exam performance and SREP attendance. This relationship was strengthened through our use of a multidimensional assessment approach as well as the control of several extraneous variables. For example, using z-score transformations and selecting students from a biology course taught by the same teacher controlled for the impact of teacher skill, instructional approach, and exam difficulty. That is, if the teacher developed easier exams or enhanced the quality of her teaching during the same semester in which SREP was implemented, all students would have likely benefitted and thus one would probably not have observed normative changes in participant test scores. The fact that a couple of the students performed substantially above the class average also makes it less likely that regression to the mean accounted for improving test scores. Furthermore, each participant's pretest biology exam score was calculated from several exam grades obtained over an extended time period (5 months); the use of a relatively stable baseline over a long time period minimized the potential that typical development or maturation contributed to the observed effects. Finally, interviews with students towards the end of the SREP intervention revealed that they had not received any tutoring or supplemental instruction in biology besides SREP during the course of the intervention.

The analysis of individual cases suggested that SREP afforded or created structured opportunities for students to optimize their motivation and to enhance their SRL skills. That is, the SRC modeled and provided guided practice in using specific learning strategies, encouraged students to monitor their use and application of these strategies during test preparation outside of school, and engaged students in discourse about the link between the use of learning and regulatory strategies during most SREP sessions. Those students who consistently attended SREP sessions, such as Vince and Pauline, had greater opportunities to learn, refine, and adapt their use of strategies and to develop more positive motivation beliefs that enhanced their future learning efforts. In contrast, John exhibited extreme lateness and poor attendance to SREP sessions and did not provide any evidence of improved regulation or motivation during the intervention.

The primary implication from this analysis connects shifts in student SRL and motivation processes during the intervention (i.e., either increased or decreased) with changes in biology test grades. For both Pauline and Vince, practicing and applying specific cognitive and self-regulatory strategies while studying at home appeared to lead to substantial improvements in test performance. However, this improvement occurred in tandem with increased self-reflection on how their biology test scores related to the strategies they used to prepare for tests. Furthermore, Eric and John missed extensive instructional time during the last seven or eight SREP sessions, which collectively were devoted to guiding students to independently use the skills taught while studying at home. These sessions were devoted to shaping students' thought processes and behaviors by providing repeated guided practice opportunities for adapting and refining self-motivation beliefs and the use of cognitive and regulatory strategies. Eric and John would have clearly benefitted from these types of discussions as they showed either poor motivation or skill in independently using these strategies when studying at home.

At a more general level, it is important to realize that some students who exhibit the types of negative belief patterns illustrated by Eric and John will naturally display resistance to change and may actually disengage from learning. Consistent with response-to-intervention (RTI) models [67, 68], interventionists must recognize individual differences in how students respond to SRL interventions. Given that not all students respond similarly necessitates the use of a flexible service-delivery model that adapts sessions to most effectively address individual concerns and issues.

4.2. Patterns of SRL during SREP: Implications and Future Research. Self-regulation has been conceptualized as a multidimensional process that integrates forethought, performance, and self-reflection processes [23, 25]. Given the breadth and depth of the SRL construct, researchers have argued that multiple assessment tools should rely on a variety of sources to measure changes in students' regulatory beliefs and behaviors [35]. In this study, we illustrated that various assessment tools can be used to establish convergence regarding changes in self-regulatory processes and behaviors. However, there was a large disconnect between information generated from student self-report questionnaires and the data obtained through teacher and SRC observations and the contextualized student verbalizations *during* SREP. In general, no pretest-posttest differences were observed across any of the three subscales of the SRSI-SR for the four participants, except for the significant improvement displayed by Pauline on the SRSI-SR Maladaptive Regulation subscale. Collectively, these results suggest that student perceptions regarding the frequency with which they used cognitive and

Table 6: Student, parent, and teacher responses to social validity questionnaire.

Student version		Teacher version		Parent version	
Acceptability	*M* (SD)	Acceptability	*M* (SD)[a]	Acceptability	*M* (SD)
The strategies that the tutors taught me were very important	4.0 (.82)	The strategies that the tutors used in the program are very important for student success	4.0 (—)	The strategies that the tutors taught my child are very important for his/her success	4.0 (0.0)
I would recommend this program to a friend who was struggling in school.	4.0 (.82)	I would recommend this program to parents of other children who are struggling in school	5.0 (—)	I would recommend this program to parents of other children who are struggling in school	4.3 (.58)
The tutoring forced me to do a lot of extra unnecessary work[b]	3.3 (1.7)	The tutoring involved too much work for the students[b]	4.0 (—)	The tutoring involved too much work for my child[b]	4.3 (.58)
Going to the tutoring was a waste of my time[b]	4.3 (.96)	I am happy that the students participated in the program	4.0 (—)	I am happy that my child participated in the program	4.7 (.58)
Importance of outcomes	*M* (SD)	Importance of outcomes	*M* (SD)	Importance of outcomes	*M* (SD)
The tutoring helped me to become more aware of the reasons why I sometimes struggle in school	4.0 (0.0)	The tutoring helped the students recognize the reasons why they were having difficulty in school	4.0 (—)	The tutoring helped my child recognize the reasons why he/she was having difficulty in school	4.0 (0.0)
I think about myself in a more positive way because of the tutoring sessions	4.0 (0.0)	The students think about themselves in a more positive way because of the tutoring	4.0 (—)	My child thinks about him/herself in a more positive way because of the tutoring	4.0 (0.0)
I am more confident in my ability to manage things in school because of the tutoring	3.8 (.50)	The students seem to be more confident in school because of the tutoring	4.0 (—)	My child seem to be more confident in school because of the tutoring	4.3 (.58)
The tutoring helped me realize that I can change or improve my learning in school	4.0 (0.0)	The tutoring helped the students realize that they can change or improve their learning in school	4.0 (—)	The tutoring helped my child realize that he/she can change or improve his/her learning in school	4.3 (.58)
The tutor taught me strategies that will help me to manage things in school better	4.3 (.50)	The tutoring helped the students manage the demands of school more effectively	4.0 (—)	The tutoring helped my child manage the demands of school more effectively	3.7 (.58)
Total average	4.0	Total average	4.1	Total average	4.2

Student version ($N = 4$). Teacher version ($N = 1$). Parent version ($N = 3$). All measures were based on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).
[a]Standard deviation (SD) was not applicable because only one teacher completed the questionnaire.
[b]Items were reverse scored to reflect adaptive perceptions of satisfaction.

regulatory strategies did not change. However, information gathered from the SRSI teacher rating scale as well as from field note observations of students' verbalizations, regulatory behaviors, and work products, suggested that changes did occur, at least on some level, for all participants (John being the lone exception).

Although caution should be applied in drawing overly broad conclusions regarding the appropriateness or adequacy of self-report questionnaires, an interesting point is that if self-report questionnaires, which are typically the most common form of SRL assessment, was the only type of SRL measure used in this study our conclusions would have varied greatly from those generated by using our multidimensional-assessment methodology [35]. Along a similar vein, a limitation of this study was the use of only a single type of self-report motivational belief measure (i.e., self-efficacy measure). It would have been helpful to include multiple measures of motivation beliefs, such as task values and goal orientation, so that a more robust foundation could have been used to interpret shifts in students' effort and persistence.

In terms of the appropriateness of using self-report questionnaires, the present study corroborated previous research demonstrating that self-report surveys diverge from other measures of SRL; a finding that is consistent with the SRL assessment literature showing that what students say that they do (self-report questionnaires) is often not what they actually do [55, 56]. This measurement characteristic can be problematic or advantageous to researchers or interventionists, depending on their research goals and objectives. If a researcher is primarily interested in examining the efficacy of an intervention, self-report questionnaires can be particularly problematic because students tend to overestimate their skills, behaviors, and beliefs at pretest, thereby potentially obscuring any "true" gains that might occur. It is highly probable that this occurred for many of the students in our study.

Conversely, if the goal of an SRL assessment tool is to guide or inform instruction, then self-report measures are critical because they can potentially help to identify inaccurate student judgments and perceptions. The importance of student miscalibration was highlighted extensively in the present study. All participants, aside from John, provided extremely high pretest self-efficacy perceptions for attaining positive outcomes in biology class even though their biology pretest exam performance was not strong. Although overestimates of personal capability can be advantageous in sustaining effort and motivation [62], they can be problematic when they signify poor metacognition and awareness about their personal strengths and weaknesses. However, from the perspective of an interventionist or a practitioner, poor calibration or self-assessment skills can be used as a guide for instruction or intervention. Several researchers have discussed how interventions can be employed to enhance the accuracy with which students self-assess their performance capabilities and to help them become more aware of task demands and their own knowledge and skills [7, 69–71].

In terms of future research, alternative research methodologies, such as quasi-experimental or experimental designs, should attempt to more closely examine and strengthen the premise that SREP causes changes in science achievement and self-regulation. Issues pertaining to external validity and inter-rater agreement for behavioral observations are also important in examining SREP. Although the present sample was diverse in terms of gender and ethnicity, it is important to consider the effectiveness of SREP with students exhibiting disabilities, such as a learning disability and Attention Deficit Hyperactivity Disorder (given their well-documented struggles with strategy use and regulation), and across different areas within and outside of science education. It is also important for future researchers to carefully consider performance outcomes that occur on a more frequent basis. In the current study, students took class exams approximately once every three weeks. Hence, the number of opportunities for them to engage in the cyclical, regulatory process was restricted. From our vantage point, more frequent performance outcomes would allow students greater opportunities to evaluate and to recognize the strong link that exists between their strategic behaviors and academic outcomes. In addition, future research should explore transfer effects associated with providing multiple opportunities for students to learn and practice using strategies.

It is also important to consider the instructional context in which SREP tutoring sessions took place and how this context may have greatly impacted the frequency with which academically at-risk students attended the program. Due to school administrator stipulations, SREP was presented as a "before school program." Since it occurred outside of the typical school day, presenting this program to students created a challenge for engaging and enlisting students who displayed resistance (e.g., John) to coming to the program. From our perspective, it is critical to implement programs, such as SREP, during the regular school day and to perhaps offer this program as part of a package of remedial academic programs or Tier III intervention programs used in response-to-intervention service-delivery frameworks.

Finally, it is important for researchers to strongly consider how student developmental factors and the nature of contextual demands influence academic outcomes when implementing and evaluating SREP. For example, young children and those in the primary school years (e.g., Kindergarten to 5th grade) show the capacity to learn and adapt SRL skills [72]. However, it remains unclear at this point how SREP could be adapted and refined to best meet the needs of younger children. In addition, the nature of academic tasks and the demands for independence and self-sufficiency in the primary grades are much less intensive than those observed during the high school years. Researchers interested in employing SREP with younger children would benefit from considering how to infuse SRL principles within classrooms to optimize SRL and motivation and/or to include small group SREP sessions within the climate and culture of a typical classroom.

Appendix

For more details see Table 6.

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Research Article

Socioscientific Decision Making in the Science Classroom: The Effect of Embedded Metacognitive Instructions on Students' Learning Outcomes

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The purpose of the present study was to examine the effects of cooperative training strategies to enhance students' socioscientific decision making as well as their metacognitive skills in the science classroom. Socioscientific decision making refers to both "describing socioscientific issues" as well as "developing and evaluating solutions" to socioscientific issues. We investigated two cooperative training strategies which differed with respect to embedded metacognitive instructions that were developed on the basis of the IMPROVE method. Participants were 360 senior high school students who studied either in a cooperative learning setting (COOP), a cooperative learning setting with embedded metacognitive questions (COOP+META), or a nontreatment control group. Results indicate that students in the two training conditions outperformed students in the control group on both processes of socioscientific decision making. However, students in the COOP+META condition did not outperform students in the COOP condition. With respect to students' learning outcomes on the regulation facet of metacognition, results indicate that all conditions improved over time. Students in the COOP+META condition exhibited highest mean scores at posttest measures, but again, results were not significant. Implications for integrating metacognitive instructions into science classrooms are discussed.

1. Introduction

Over the past decades curriculum authorities as well as science educators and researchers worldwide have called for changes in the way science is taught at schools (e.g., [1–4]). Modern science education should not only foster the acquisition of scientific content knowledge but engage students in scientific inquiry, in lifelong learning and in discussions about modern science problems, their technological applications as well as their personal and societal implications [1–5]. In a similar vein, the implementation of socioscientific issues into the science classroom has been proposed for more than two decades (e.g., [6–10]). Socioscientific issues represent modern science problems, such as global climate change or the loss of worldwide biodiversity, that are tightly linked to social, political, and economical concerns (e.g., [11]). They are complex, real-world scenarios at the interplay between science and society and thus, can no longer be solved by relying on scientific knowledge only [8, 10, 11]. Consequently, they fundamentally challenge the aims and scope of traditional science instruction.

A growing body of research within the area of science education highlights the notion that the implementation of socioscientific issues into science classrooms can enhance students' learning outcomes with respect to conceptual scientific knowledge as well as reasoning and argumentation skills (e.g., [8, 12–15]). Ottander and Ekborg found that interest in socioscientific issues correlates with self-reported learning outcomes in science education [16]. In addition, they have the potential to prepare students' becoming literate citizens (e.g., [8, 10]). However, working with complex socioscientific issues also poses high cognitive demands on students, because students need to engage in various information search and evaluation processes as well as argumentation, reasoning, and problem solving processes. This also involves the ability to take perspectives and to integrate multiple perspectives into the development of solution strategies. Thus, implementation of learning settings that enable students to engage in peer interactions and motivate them to argue, to reason, and to negotiate how to solve these problems and hereby participate in discourse on modern science problems is crucial (e.g., [7, 11, 17, 18]).

Moreover, learning about complex issues needs to be carefully structured, as prior research also showed that students can easily be distracted when working on socioscientific issues where the outcome is uncertain [16, 19]. Embedded metacognitive guidance or self-regulated scaffolds have widely been regarded as one means to meet these ends. Among the most prominent approaches that use cooperative-metacognitive settings are Palinscar and Browns' reciprocal teaching method to enhance reading literacy, King and Kitcheners' reflective judgment model, or Kings' Guided Peer Questioning [20–22]. Based on the seminal work of Polya, Mevarech and Kramarski developed the IMPROVE method to activate students' metacognitive skills during mathematical problem solving to enhance students' mathematical achievement [23, 24]. Within science education, Mevarech and colleagues also used this method to enhance students' scientific inquiry skills [25]. Azevedo and colleagues could show that facilitation of self-regulated learning can improve student achievement on complex science topics [26]. However, still only few studies exist that analyse the effects of such metacognitive or self-regulated learning settings on students' socioscientific decision making and reasoning (e.g., [27, 28]). The present study aims to contribute to this research need. It analyses the effects of embedded cooperative-metacognitive trainings on senior high school students' reasoning and decision making about socioscientific issues.

1.1. Effects of Cooperative-Metacognitive Learning Settings on Student Achievement. Cooperative learning has been on the international agenda for more than half a century by now both in educational research and in educational practice (e.g., [29–32]). Research on the effects of cooperative learning is traditionally rooted either in social or cognitive psychology. While social psychologists take on a motivational or social cohesion perspective on cooperative learning, cognitive psychologists often refer to mental information processes that are stimulated by cooperative learning (e.g., [32]). From a constructivist point of view, new knowledge can only be attained if it is connected to and integrated into prior knowledge (e.g., [33]). While learners interact with each other, they provide explanations, engage in discussions, develop arguments about complex problems, and reflect upon the topic and tasks at hand. These peer-to-peer interactions can lead to deeper processing of information, facilitation of higher-order thinking skills, and construction of profound knowledge. Thus, they are likely to enhance individual achievement (e.g., [34, 35]).

Numerous research studies could actually show that cooperative learning has beneficial effects not only on student achievement, but also on student interest as well as social skills [30–32, 36, 37]. As a consequence, cooperative learning has often been euphorically advocated as the optimal learning strategy [34, 38]. However, empirical research also highlights the notion that cooperative learning is not per se more beneficial than other learning settings [34, 38]. Merely putting learners into small groups will not lead to interactive group work and meaningful learning (for an overview see [34]). Referring back to the works of Johnson and Johnson as well as Slavin, cooperative learning settings need to account for positive interdependence and individual accountability, promote face-to-face interaction, and foster interpersonal and social skills to be successful (e.g., [29, 32]). Moreover, cooperative groups need to be able to monitor and reflect upon their learning processes [29, 32]. Especially this last aspect has been identified as one crucial factor for successful collaboration (e.g., [20, 22, 23, 35]) Typically, these studies provide support measures in the form of metacognitive guidance or self-regulated learning trainings to support students' elaboration and learning processes [20, 22, 23, 35, 39].

Metacognitive guidance has been extensively used and analysed in the area of mathematics education (e.g., [40]). Mevarech and Kramarski developed the IMPROVE method to enhance students' mathematical reasoning [23]. Central to IMPROVE are metacognitive questions that can be differentiated into comprehension, connection, strategic and reflection questions [23]. Comprehension questions address the main idea of the problem or the task to be solved. Connection questions support students in analysing similarities and differences between the current task and tasks that were solved in the past. Strategic questions ask students to reflect on the specific strategy that might be appropriate to solve the task. Finally, reflection questions ask students to either monitor their learning or problem solving process during or at the end of the process. Mevarech, and colleagues showed in a series of studies that students who studied under the IMPROVE method outperformed students who studied under traditional, more individual instruction or under cooperative instruction that was not additionally structured by metacognitive guidance (e.g., [23, 24]). In addition, they could show that a metacognitive instruction using IMPROVE did not only have immediate but also delayed effects [41]. Furthermore, Mevarech and Fridkin showed that an intervention using IMPROVE did not only foster students' mathematical knowledge and reasoning but also their metacognitive skills [42].

Within the area of science education, fewer studies explicitly implement cooperative-metacognitive trainings or self-regulated learning in science classrooms. Zion and colleagues transferred the use of IMPROVE to an intervention study on scientific inquiry in microbiology [25]. They showed that students who studied under IMPROVE in a network technology environment outperformed those groups that had no metacognitive guidance. Moreover, Azevedo and colleagues showed that students who studied about complex scientific issues in self-regulated learning settings with embedded scaffolding outperformed students who studied in self-regulated learning settings without any additional scaffolding [26, 43].

Metacognition and self-regulation are often treated as two separate concepts in the literature [44, page 223]. However, this is not due to the fact that they are different concepts but that they originally stem from two research fields: developmental psychology and educational psychology [44]. There are still ongoing discussions about defining the relations between metacognition and self-regulation, but a common ground seems to be that metacognition can be seen as a part of self-regulation in that self-regulation can be described as the dynamic interaction of cognitive, metacognitive and motivational aspects of learning [44–46]. Metacognition is typically defined by two components: knowledge of cognition and regulation of cognition (e.g., [44, 47]). The former is described as knowledge about one's own cognitive functions and is often differentiated into declarative, procedural, and conditional knowledge (e.g., [44, 47]). The latter is typically regarded as control of one's own cognitive activities and typically refers to processes such as planning, monitoring and evaluation [44, 47, 48]. As the present study aims to enhance students' learning outcomes by using the IMPROVE method, the theoretical basis of the present study refers more to the concept of metacognition than to the concept of self-regulation.

1.2. Enhancing Students' Socioscientific Reasoning and Decision Making. Socioscientific issues represent controversial issues of modern science that involve social, political, economical, and ethical considerations [8, 10, 49, 50]. Examples for socioscientific issues are loss of worldwide biodiversity, but also bioethical dilemmas or biotechnology issues such as genetic engineering. They often represent issues of first frontier science or "science in the making" [49, page 294]. They have their basis in science, but can no longer be solved by relying on scientific evidence only [8, 11]. Instead, they are factually and ethically complex and do not have a clear-cut solution (e.g., [8, 10, 15, 51, 52]). Moreover, multiple solutions exist that all have their drawbacks [8, 10, 15, 52, 53]. New solution strategies have to be developed by integrating multiple, often competing, perspectives. In addition, socioscientific issues and solution strategies are subject to ongoing inquiry and are often based on uncertain, fragile and conflicting evidence [8, 10, 50, 53].

Working with socioscientific issues in the science classroom poses high processing demands on students because they are engaged in various information search and evaluation processes as well as argumentation and reasoning processes (e.g., [12, 15, 52, 54]). As socioscientific issues cannot be solved on the basis of "simple cause and effect reasoning" [10, page 375], students first need to understand and describe a socioscientific issue in its complexity. Second, they need to be able to generate solutions that account for multiple perspectives on the issue, and third they have to be able to critically evaluate developed or existing solutions (e.g., [55]).

There is empirical evidence that students can be promoted with respect to socioscientific decision making and reasoning. Several studies focused on the quality of argumentation and reasoning processes while dealing with socioscientific issues (e.g., [7, 12–15, 27, 54, 56]). Results showed that students can be trained in developing pro and contra arguments, in using trade-offs to compare possible solutions and in weighing arguments or decision criteria to reach an informed decision [7, 12–15, 27, 54, 56].

Few studies exist that analyzed the effect of embedded metacognitive or self-regulated trainings on students' socioscientific decision making and reasoning. Gresch and colleagues showed in a pre-post-follow up control-group design that a web-based training program with additional metacognitive prompts to support task analysis enhances students' socioscientific decision making with respect to "evaluating solutions" [28]. Labuhn and colleagues showed again in a pre-post-follow up control-group design that self-regulated learning elements can be successfully integrated into science classrooms. In addition, they showed that students who studied in a self-regulated learning condition outperformed students who studied under traditional instruction on a knowledge test about decision-making processes [57]. Eggert and colleagues used the IMPROVE method in an intervention study among seventh graders to enhance socioscientific decision making ("evaluating solutions") with respect to the issue of river assessment and renaturation [27]. Results showed positive effects in both training groups. Students in the IMPROVE condition performed better at posttest measures, but the effect was not statistically significant. However, results from this study are promising that metacognitive guidance can have a positive impact on students' socioscientific reasoning and decision making.

1.3. Objectives of the Current Study. On the basis of existing research, we aimed to investigate the effect of two cooperative training strategies on students' socioscientific reasoning and decision making. As described above, working on socioscientific issues is a complex endeavor. We assume that cooperative learning settings will provide learners with multiple opportunities to engage in peer-to-peer interactions that are needed to reason and argue about complex socioscientific problems. This may than lead to deeper information processing as well as elaboration processes and eventually to better individual performance. Referring to Kirschner and colleagues [34] who postulate that cooperative groups are most successful in terms of effective learning when task complexity is high, we assume that cooperative learning settings are especially adequate for working on socioscientific issues. As socioscientific issues are not only complex, and solutions need to be developed by integrating multiple perspectives, individuals might benefit from the advantage to distribute information processing and thus, to reduce cognitive load (cf. [34]).

In more detail, we hypothesize that students who study in cooperative learning settings will produce better learning outcomes with respect to socioscientific reasoning and decision making than students who study under more traditional, individual instruction.

Similar to existing research that highlights the importance of metacognitive guidance to support group processing, we also assume that individual student achievement will be enhanced through an additional metacognitive training that explicitly supports students in formulating and answering questions. Referring to Mevarech and Kramarski's work on mathematical problem solving [19, 23], we assume that students who work on metacognitive questions will gain a deeper understanding of the problems they work on. In more detail, we assume that students who learn in a cooperative-metacognitive setting will produce better learning outcomes with respect to socioscientific reasoning and decision making than students who study in a cooperative learning setting.

2. Method

2.1. Participants. Participants included 360 senior high school students (151 males and 209 females, mean age: 17.35 years; SD = 1.06) from nine high schools in Germany. All participants were from grades 11–13 (last three years of senior high school in Germany). Students studied in three different conditions: cooperative learning (COOP), cooperative learning with embedded metacognitive instruction (COOP+META), and a nontreatment control group with traditional instruction. Due to restrictions concerning school and classroom settings, participants could not be randomly assigned to the different conditions, but assignment took place at the class level. In total, 112 students from 7 classes were assigned to the COOP condition, 129 students from 8 classes to the COOP+META condition, and 119 students from 8 classes to the control group. 21 teachers (12 females) participated in the study (mean age = 43 years; age range from 29 to 63 years; mean teaching experience = 13.2 years).

2.2. Training Conditions and Learning Material. Both training conditions (COOP and COOP+META) were identical in terms of lesson structure and time as well as context and tasks. They only differed with respect to the presence or absence of metacognitive instruction. While students in the COOP+META condition spent time on the metacognitive guidance, students in the COOP condition had time to elaborate on the socioscientific issue of palm oil production in Indonesia (see below). Both, the COOP as well as the COOP+META condition used the same set of cooperative learning methods such as the jigsaw and the fishbowl method. In addition, think-pair-share processes were included in all of the lessons [29].

The COOP+META condition was developed using the IMPROVE method [23, 24]. On the basis of IMPROVE we integrated comprehension, connection, strategic, and reflection questions into the learning material. These questions were given to students prior to and during learning activities as well as after having finished learning activities. Appendix A shows an example for the implementation of these metacognitive questions into one of students' group work.

The socioscientific issue addressed in both training conditions was the issue of palm oil production in Indonesia. There is an increasing demand on palm oil worldwide as an ingredient for cosmetics and food, but especially with respect to its potential as a biofuel. Palm oil is typically produced on monocultures within the Indonesian rainforest. Due to the increasing demand, more and more plantations emerge. Many people on Sumatra, one of the main islands in Indonesia, work on these plantations to earn their living. As a consequence, the Indonesian rainforest decreases. In addition, indigenous people who traditionally live in and subsist on the rainforest are negatively affected. The described problem represents a typical socioscientific issue. It is factually and ethically complex and needs to be addressed by incorporating ecological, economical, and social aspects and perspectives [51]. Various social groups play a role within this problem situation such as workers on the plantations (representing nonsustainable users), indigenous people (representing sustainable users) who live in the rainforest, but also external stakeholders such as governments and the consumer in general. With respect to the problem, students need to understand the situation in its complexity. They need to understand the interdependence between the nonsustainable users and the decrease of the rainforest as a natural resource. The indigenous people in turn suffer from the overuse of the rainforest. Thus, both social groups are interrelated. Often, such problem situations are described as socioecological dilemmas [58].

Students in the nontreatment control group received traditional, individual instruction. They studied according to their regular school curriculum, which did not include the specific socioscientific issue of palm oil production in Indonesia. However, working on socioscientific issues is mandatory according to the national educational standards and all training conditions were obliged to teach to these standards [4].

Teachers in both training groups received an introductory training on the learning material. All teachers were familiar with cooperative learning and implemented it regularly in their classrooms. Teachers in the COOP+META condition received a one day introductory training on the IMPROVE method. The training was designed in the biology education research group and administered to the teachers by the researchers themselves. Teachers were first introduced to the theoretical construct behind the IMPROVE method and then worked on exemplary student tasks that included the four different metacognitive questions. Teachers in the control group received no specific training.

2.3. Measures

2.3.1. Socioscientific Decision Making. Students' learning outcomes were measured using two 45 min paper-and-pencil tests on socioscientific decision making prior to and after the intervention. The pre- as well as the posttest consisted of three socioscientific issues (SSI) that were identical in structure but used different contexts in order to keep students motivated at the posttest. In addition, different contexts were used to counteract increases in students' learning outcomes at the posttest that are only due to training effects on the questionnaire (Appendix B shows two example socioscientific issues from the pretest questionnaire). Table 1 shows the distribution of the different contexts in the pre-and posttest.

All test items to these socioscientific issues were presented in an open-ended format. With respect to the first two socioscientific issues, students had to describe the problem as well as to develop sustainable solutions to the problem.

Table 1: Contexts for the different SSIs used in the pre- and posttest questionnaire on socioscientific decision making.

	Pretest	Posttest
Describing socioscientific issues	Issue no. 1: Uncontrolled Collection of Rattan in the Indonesian Rainforest	Issue no. 1: Overfishing of Tuna around Tonga in the South Pacific
Developing solutions to socioscientific issues	Issue no. 2: Oil Production and its Side Effects in the Siberian Tundra	Issue no. 2: Soy Production in Rainforest Areas in Paraguay
Evaluating solutions to socioscientific issues	Issue no. 3: Shrimp Aquaculture in Mangrove Areas in Indonesia	Issue no. 3: Collection of Hoodia for Medicine Production in the Kalahari Desert in Southern Africa

With respect to the third socioscientific issue, students were asked to evaluate presented solutions in terms of their sustainability and to suggest improvements to these solutions. Students' responses to the open-ended questions were coded independently by two of the researchers. The final scoring guide consisted of 10 items (Table 2). Interrater-reliability was found to be sufficient (Cohen's Kappa: $\geq .88$). In case of disagreement, discussions took place until agreement on the score could be reached.

The socioscientific decision making questionnaire (pre- and posttest version) includes two scales. Scale 1 consists of four items that represent the description of SSIs (items 1-2 for issue no. 1, items 3-4 for issue no. 2; Table 2). Scale 2 consists of six items that represent the development and evaluation of sustainable solutions to SSIs (item 5 for issue no. 1, item 6 for issue no. 2, items 7–10 for issue no. 3; Table 2). Both scales for the pre- and posttest were analysed in terms of reliability in previous studies. Reliability indices were found to be acceptable ($\alpha = .50 - .74$). In addition, item difficulties were checked to allow comparisons between pre- and posttest scores. With respect to the present study reliability indices for the pretest were $\alpha = .63$ (scale 1) and $\alpha = .51$ (scale 2) and for the posttest $\alpha = .53$ (scale 1) and $\alpha = .61$ (scale 2).

2.3.2. Metacognition. To assess general metacognition a questionnaire developed by A. Kaiser and R. Kaiser [59] was used. The original questionnaire consists of 19 items. Seven of these items refer to the regulation of cognition (planning, monitoring, and debugging), the facet of general metacognition that is relevant for the instructional approach addressed in the present study. Exemplary items were "I check my knowledge in detail that can be helpful to work on the assigned task" or "If I realise that I'm stuck, I will check whether another strategy will be more successful". Each item was scored on a four-point Likert type scale ranging from "I completely agree" to "I completely disagree". Cronbach's Alpha was found to be $\alpha = .56$ for the pretest and $\alpha = .66$ for the posttest.

3. Results

3.1. Socioscientific Decision Making. With respect to the socioscientific decision making scales, data were analysed as follows. Concerning "Describing Socioscientific Issues", we conducted a one-way ANOVA to examine group differences between the control group and the two experimental groups at the pretest. Results indicated no significant differences prior to the beginning of the intervention with respect to scale 1 ($F_{(2,357)} < 1.00$, $P > .05$). This legitimated us to conduct a 3 × 2 (treatment × measurement points) repeated-measures ANOVA with "Describing Socioscientific Issues" (scale 1) as the dependent variable. Table 3 presents the mean scores and standard deviations with respect to scale 1 by time and treatment.

The repeated measures ANOVA indicated a significant main effect for time ($F_{(1,357)} = 243.72$, $P < .001$, $\text{eta}^2 = .406$) and a significant main effect for treatment ($F_{(2,357)} = 13.44$, $P < .001$, $\text{eta}^2 = .070$). The interaction effect between treatment and time was also significant ($F_{(2,357)} = 15.09$, $P < .001$, $\text{eta}^2 = .078$). Post hoc Tukey tests revealed that students in both experimental groups (COOP and COOP+META) performed significantly better than the control group (both *P*s <.001). However, the two experimental groups did not differ significantly, thus, indicating that the COOP+META group did not benefit from the embedded metacognitive instruction.

With respect to "Developing and Evaluating Solutions" we also conducted a one-way ANOVA to check group differences on the pretest scores. Results indicated that there was a significant difference between groups ($F_{(2,357)} = 3.60$, $P < .03$). Post hoc Tukey tests revealed that the control group differed significantly from the COOP group on pretest scores at the 5% level of significance. Consequently, we used a multiple regression analysis with prior knowledge (pretest score) and treatment conditions as independent variables and the posttest score of scale 2 as dependent variable. Concerning treatment conditions, two contrast variables were coded. Contrast one examined the difference between the control group and both experimental groups (Control versus COOP and COOP+META). Contrast two examined the difference between the two experimental groups (COOP versus COOP+META). Predictor variables were entered blockwise into the regression analysis. Table 4 shows the mean and standard deviations on "Developing and Evaluating Solutions" (scale 2) by time and treatment.

Results from regression analyses showed that prior knowledge as well as both contrasts predict students' learning outcomes at posttest measures. Table 5 shows the unstandardized beta values and their standard errors as well as standardized beta values with respect to the different

Table 2: Scoring guide for the assessment of students' socioscientific decision making (pre- and posttest).

	No.	Item description	Score 0	1	2	3	4
Scale 1: describing socioscientific issues	1, 3	Sociosocial relation (sustainable and nonsustainable users)	No response or describes either the role of nonsustainable or sustainable users	Describes both social groups but not the relation between the two	Describes both social groups and their relation		
	2, 4	Socioecological relation (nonsustainable users and resource)	No response or describes either the role of nonsustainable users or the resource	Describes the nonsustainable users and the resource but not the relation between the two	Describes the nonsustainable users and the resource and their relation		
Scale 2: developing and evaluating solutions to socioscientific issues	5, 6	Developing solutions	No response	Develops a solution on the basis of one solitary aspect (ecological, economical, or one of the social aspects)	Develops a solution on the basis of 2–4 solitary aspects	Develops a solution on the basis of two aspects and their relation	Develops a solution on the basis of two or more relations
	7, 8	Evaluating solutions	No response	Evaluates a presented solution by referring to one solitary aspect (ecological, economical, or one of the social aspects)	Evaluates a presented solution by referring to 2–4 solitary aspects	Evaluates a presented solution by referring to one or more relations between aspects	
	9, 10	Suggesting improvement to solutions	No response	Makes a sensible suggestion but not on the basis of relevant aspects	Makes a suggestion on the basis of one aspect (ecological, economical, or one of the social aspects)	Makes a suggestions on the basis of 2-3 solitary aspects	Makes a suggestion on the basis of one or more relations between aspects

Table 3: Mean scores and standard deviations on "describing socio-scientific issues" (scale 1) by time and treatment.

	COOP	COOP+META	Control
Pretest			
M	2.59	2.80	2.60
SD	1.87	1.82	1.70
Posttest			
M	5.04	4.88	3.53
SD	1.61	1.64	1.66

Table 4: Mean scores and standards deviations on "developing and evaluating solutions" (scale 2) by time and treatment.

	COOP	COOP+META	Control
Pretest			
M	9.54	8.72	8.59
SD	3.08	2.91	2.82
Posttest			
M	11.98	10.69	9.05
SD	3.33	3.46	3.34

regression models. The final statistical model accounted for 27% of the variance with prior knowledge accounting for 19%, the first contrast variable accounting for 7% percent of the variance and the second contrast variable accounting for 1%. Interestingly, the second contrast variable, which represented the difference between the COOP and the COOP+META condition, exhibited a negative relationship with posttest performance.

3.2. Metacognition. With respect to the regulation facet of general metacognition, a one-way ANOVA was conducted to examine possible differences between groups at the pretest. Results indicated no significant differences prior to the beginning of the intervention ($F_{(2,357)} < 1.00$, $P > .05$). Thus, data were analysed using a 3 × 2 (treatment × measurement points) repeated-measures ANOVA. Table 6 presents the mean scores and standard deviations by time and treatment.

The repeated-measures ANOVA indicated a significant main effect for time ($F_{(1,352)} = 58.76$, $P < .001$, $\text{eta}^2 = .14$), but no significant main effect for the treatment ($F_{(2,352)} = 2.062$, $P = .13$). The interaction effect between treatment and time was significant ($F_{(2,352)} = 4.090$, $P < .02$, $\text{eta}^2 = .023$). Post hoc Tukey tests revealed no significant differences between the groups.

4. Discussion

The major purpose of the present study was to examine the effects of two cooperative training settings (COOP and COOP+META) on students' socioscientific decision making and metacognition. Socioscientific decision making refers to the description of socioscientific issues as well as to the development and evaluation of solutions to socioscientific issues. Findings show that both training groups outperformed the nontreatment control group on both scales. This is in line with a large body of research that identified beneficial effects of structured cooperative learning settings on students' learning outcomes (for an overview, e.g., [30]). It also reflects findings from studies that used the IMPROVE method in mathematics education [23, 24, 35, 41].

However, with respect to the COOP+META treatment condition, findings did not meet our expectations. Students who studied in the COOP+META condition did not benefit from the embedded metacognitive training, as there were no differences on "Describing Socioscientific Issues" (scale 1) between the COOP and the COOP+META condition. With respect to "Developing and Evaluating Solutions" (scale 2), findings even exhibited a negative relationship between the corresponding contrast variable and students' performance on the scale at the posttest. This, at first side astonishing, negative impact raises several questions. Why did students not benefit from the additional embedded metacognitive training and in more detail, which factors can be identified that lead to the decline in posttest measures when compared to the COOP condition? What can we deduce with respect to future research?

Empirical research on the effects of cooperative learning settings on student achievement suggests that students benefit most from collaboration if task complexity is high because individuals are more willing to distribute information processing among group members to reduce cognitive load [34]. These beneficial effects were found mostly in highly structured cooperative groups (e.g., [34, 60]). On the basis of these findings, we assumed that the COOP+META condition would outperform the COOP condition. However, this was not the case. One possible explanation might be that cooperation between group members in the COOP+META condition was overly structured so that natural cooperation was disturbed or even disrupted. Students were not able to cooperate naturally but were forced into a script that they felt was artificial or too detailed (cf. [60]). While students worked on complex socioscientific issues, overly structuring their group processes may even have hindered them from employing higher-order thinking skills and being creative (cf. [36]).

When confronted with socioscientific issues students have to perform a variety of information search and evaluation processes as well as reasoning and argumentation processes. Students may likely have experienced cognitive overload during group work as they had to solve a complex socioscientific issue, collaborate with their peers, and understand and work with the metacognitive instructions (cf. [60]). Thus, they may have concentrated more on solving the socioscientific issues or on working with the metacognitive instruction. As posttest measures on "Developing and Evaluating Solutions" were lower compared to the COOP condition, metacognitive guidance may even have hindered students from dealing with the socioscientific issue. Consequently, for future research, we need to carefully reconsider the design of the metacognitive guidance to ensure an adequate balance between group autonomy and provision of additional support measures.

Table 5: Multiple regression predicting posttest performance on "developing and evaluating solutions" (scale 2) by prior knowledge and treatment condition.

	B	SE	β
Step 1			
Prior knowledge (pretest scores)	0.53	0.06	$.44^{***}$
Step 2			
Prior knowledge (pretest scores)	0.51	0.06	$.42^{***}$
Contrast 1 (control versus COOP and COOP+META)	0.66	0.12	$.26^{***}$
Step 3			
Prior knowledge (pretest scores)	0.49	0.06	$.41^{***}$
Contrast 1 (control versus COOP and COOP+META)	0.67	0.12	$.27^{***}$
Contrast 2 (COOP versus COOP+META)	−0.44	0.20	$-.10^{*}$

Note: $R^2 = .19$ for step 1, $\Delta R^2 = .07$ for step 2, $\Delta R^2 = .01$ for step 3. $^{*}P < .05$, $^{***}P < .001$.

Table 6: Mean scores and standards deviations on metacognition (regulation facet) by time and treatment.

	COOP	COOP+META	Control
Pretest			
M	16.66	17.23	16.86
SD	4.08	3.87	3.73
Posttest			
M	18.63	19.17	17.59
SD	4.75	4.32	4.54

Another important aspect addresses the issue of successful implementation of metacognitive trainings into the science classroom. Referring to existing research three fundamental principles have to be acknowledged: ensuring connectivity, being explicit about the function of metacognitive guidance, and extensive and prolonged metacognitive training [61, page 9], [62, page 85]. Possible explanations to the unexpected results refer to a combination of these three principles. Although the metacognitive questions were integrated into teaching materials at various stages in the teaching unit and contextualised with respect to the issue taught, students did probably not make use of these questions to their full extent. Although teachers in the COOP+META condition explained the metacognitive questions and their function, students may not have acknowledged their usefulness. Thus, they did not invest the extra effort that is needed for successful metacognitive instruction [61, page 9]. This is in line with findings from Hogan, who argues that "simple immersion" of metacognitive guidance in the task is not sufficient to build students' metacognitive knowledge [56, page 1101]. Instead, an intervention that explicitly focuses on the use of metacognitive guidance and its functions seems to be more successful [56].

Moreover, written comments on lesson plans from teachers who taught in the COOP+META condition revealed that the use of reflection questions especially at the end of lessons often fell short. This has two possible reasons. On the one hand, lesson plans were quite packed with respect to learning goals on socioscientific decision making, the socioscientific issues taught as well as the extra metacognitive guidance. Although teachers aimed faithfully to implement the lessons according to our instructions, it is only reasonable that they considered the curricular requirements with respect to socioscientific decision making first.

On the other hand, teachers in the COOP+META condition had no prior experience with metacognitive instruction, which might have led to difficulties during the intervention. Although they were trained in using the metacognitive questions, a shortcoming of the present study is that teachers were not additionally supported during the intervention in their classrooms.

With respect to posttest measures for metacognition, results indicate that all groups, including the control group, improved on the metacognition scale at posttest measures. Although the COOP+META condition had the highest mean score, differences between groups were not statistically significant. Thus, one has to be cautious about interpreting these results. However, they might still contribute to the discussion described above that students either concentrated more on solving the socioscientific issues or on working with the metacognitive questions. Given the highest mean scores on the posttest measures, one might argue that students who studied under the COOP+META condition focused more on working with the metacognitive guidance.

Another explanation to this finding is that the intervention itself aims to enhance students' critical thinking and reflection on socioscientific issues and possible solutions strategies. While developing and evaluating solution strategies, students need to engage in critical thinking to be able to identify nonsustainable solutions, to incorporate multiple perspectives and to monitor and regulate their own problem-solving processes, especially during group work. Developing solutions to a socioscientific issue can be described as a special problem solving process, which can be divided into three main aspects. First, students need to understand and describe the problem situation, second they need to develop possible solutions on the basis of relevant information, and third, they need to evaluate possible solutions in order to reach an informed decision [8, 52, 55]. Especially with respect to the second and third aspect students need to monitor their information search as well as their decision making process as a whole. The described phases were also taught and discussed with students in both training groups. In line with existing research, this may likely have enhanced performance on the metacognition scale at posttest measures (e.g., for an overview see [45]).

Implications for future research are diverse, but one major aspect refers to the improvement of teacher support during the intervention. Apparently, the introductory training to the metacognitive guidance was not sufficient to enable teachers to implement both socioscientific decision making and metacognitive instruction into their science classrooms as we had wished. In future research, we need to be even more aware of the "teachers' dilemma" [56, page 1104] to teach according to curricular requirements as well as to focus on the metacognitive instruction and especially become aware of the potential benefits of such instruction for students' learning processes. In terms of biology education, it is highly important that the teachers themselves conduct the training and not the researchers, although the latter might lead to better results with respect to student achievement [63].

With respect to the methodological limitations of the present study, a mixed-method approach should be applied in future research that converges both product and process data (e.g., [43]). The analysis of process data would have given deeper insights into possible difficulties with respect to the instruction of metacognitive guidance on the teachers' side as well as the actual learning outcomes on the students' side.

In addition, research needs to be done to shed more light on the relationship between the two concepts of socioscientific decision making and metacognition. As described above, dealing with socioscientific issues can be described as a problem solving process. Consequently, students are already engaged in reflection and monitoring processes. Thus, it would be extremely important to analyse in depth which processes with respect to the regulation of cognition are being promoted by socioscientific decision making in the science classroom. Therefore, process data are absolutely vital (cf. [64]).

Appendices

A. Metacognitive Guidance

Note. The following questions were given to students in the COOP+META condition during one of their group works. The overall task was to develop a solution to the problem of palm oil production in Indonesia and its side effects with respect to the rainforest and the indigenous people who live in the forest. Each group took up the perspective of one of the groups that are part of the problem. A panel discussion, which succeeded this group work, aimed to integrate all the different perspectives and solutions developed.

Here are some questions that can help you before you actually start your task.

(i) What are the goals of our task?

(ii) Can we describe the current situation of the person we are dealing with? Take some notes.

(iii) Which aspects are essential to develop a good solution from the perspective of ...? Take some notes.

(iv) How should we proceed to develop a solution and in which way can we apply the strategies from previous lessons? Quote some.

Here are some questions that can help you while working on your task.

(i) Are we still on task or are we running off the track?

(ii) Are we incorporating all essential aspects?

Here are some questions that you should consider just before completing your task.

(i) From the perspective of ..., did we consider all important aspects for our solution?

(ii) If our solution to the problem was implemented, how would the situation improve from our perspective? Take some notes.

(iii) Anticipate the consequences that our solution would have for the other social groups! Take some notes.

B. Examples for Socioscientific Issues from the Pretest Questionnaire

B.1. Abbreviated Version of Issue No. 1: Uncontrolled Collection of Rattan in the Indonesian Rainforest

Note. The description of this socioscientific issue is based on research and findings from Koch and colleagues [65].

B.1.1. Rattan from Indonesia. Rattan is a very popular material for the production of chairs, armchairs, or outdoor furniture. In the 1980s furniture that was made out of Rattan became popular in Europe and North America and has been popular ever since. 90% of the Rattan that is used in the furniture industry stems from Indonesian Rattan. [...].

In Sulawesi, one of the Indonesian islands, indigenous people, who live in and subsist on the rainforest, collect Rattan. They use Rattan to make ropes for fishing or for farming. They also use Rattan for building their houses. [...]. When collecting Rattan, they take care that some of the shoots will not be harvested, so that the Rattan plants are able to resprout.

Other Sulawesian people also collect Rattan. They do not only need it for their own supply but they collect and sell it to agents who in turn sell it to the furniture industry. These people also depend on collecting Rattan to assure their livelihood. The money that they get depends on the amount as well as the weight and diameter of the harvested Rattan stems. They harvest Rattan in large groups so that they can collect a large amount of Rattan per day. Often, they collect all of the Rattan shoots in one area. The harvest is being collected and then transported out of the rainforest.

Rattan is a palm that climbs through and over other vegetation. Depending on the Rattan species, it takes about

5–25 years to harvest Rattan for the first time. It grows 0.2–1.5 meters per year. For resprouting, it is important that enough Rattan shoots remain in the forest. Otherwise, Rattan species will likely decline within the area.

Although it is forbidden to collect Rattan within the national park on Sulawesi, illegal harvesting still takes place as park rangers often cannot control the whole area. As a consequence, Rattan species are also under threat in the national park.

Tasks are mentioned below.

(i) Describe the problem situation and explain the interrelations of central aspects.

(ii) Develop a possible solution to this problem that acknowledges these interrelations.

B.2. Abbreviated Version of Issue No. 3: Shrimp Aquaculture in Mangrove Areas in Indonesia

B.2.1. Shrimp Aquaculture in Southeast Asia

B.2.2. Introductory text to the problem. Due to the high demand for shrimps in Germany and worldwide, shrimp farming in mangrove areas of Southeast Asia is steadily increasing. Shrimp farms provide jobs for many people but also have negative side effects on mangrove areas as well as on the people who live in these areas and subsist on the mangroves.

Solution A: Shrimp production in Europe. Shrimp production will be moved to shrimp farms in Europe. Existing shrimp farms in Southeast Asia will be closed and no new aquacultures will be built. Thus, mangrove areas in Southeast Asia and the people living in mangrove areas won't be affected any longer.

In Europe, indoor shrimp aquacultures will be built that simulate conditions of mangrove areas, in particular marine water conditions. In such aquacultures, shrimps can be raised up to their requested size and then be sold to the food industry.

Solution B: Installing sustainable shrimp production in Southeast Asia. Shrimp farming in Southeast Asia will be shifted towards sustainable production. The overall aim is to receive a certified label for shrimp production in these shrimp farms. To receive such a label, shrimp farms have to meet a variety of requirements: At least half of the farming area needs to be covered with mangroves. Existing mangroves must not be cut down, otherwise new mangroves need to be planted. To assure sustainable production permanent controls need to be put through. Due to these new-less intensive-working conditions, less workers will be needed on shrimp aquacultures.

Tasks are mentioned below.

(i) Evaluate both solutions with respect to their sustainable development. Consider positive and negative outcomes in case these solutions would be considered for implementation.

(ii) Develop suggestions for improvement for both solutions. Explain!

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Research Article

Affect and Cognitive Interference: An Examination of Their Effect on Self-Regulated Learning

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The present study examined the relationships among affect, self-regulated learning (SRL) strategy use, and course attainment in the didactics of mathematics (teaching mathematics) subject matter domain. The sample consisted of 180 undergraduate students attending a didactics of mathematics course (mean age = 21.1 years) at the School of Early Childhood Education. The participants were asked to respond to the Positive and Negative Affect Schedule (PANAS) and the Cognitive Interference Questionnaire (CIQ). They also completed the Learning Strategies Scales of the MSLQ. Examination grades were used as the measure of course attainment. Pearson correlations and path analysis revealed that negative affect was positively related to cognitive interference, and positive affect influenced positively the use of almost all of the SRL strategies. Elaboration was the only SRL strategy found to predict the didactics of mathematics course attainment. Finally, cognitive interference was found to negatively predict course attainment.

1. Introduction

Self-regulated learning (SRL) is a notion that emphasizes the active role of the learner in setting one's goals to learning and ensuring that the goals set is attained [1–4]. Self regulated learning in academic settings is assumed to consist of skills that are learned, rather than being unchangeable or genetically rooted [2]. As a result, various aspects of SRL have often been conceived as being situational and context dependent, while less attention has been devoted to the connection between SRL and individual trait-like characteristics [5, 6].

It is generally accepted in SRL research that self-regulation comprises different systems and processes that monitor and control behavior, such as cognition, metacognition, motivation, affect, and volition [1, 7, 8]. According to Efklides [1] and Winne [3] the interactions between different components of SRL can be described either at a macrolevel or at a microlevel. The level of functioning of SRL processes is important because metacognition, motivation, and affect at a macro-level are represented by relatively stable or trait-like person characteristics (e.g., metacognitive knowledge, positive and negative affect, ability beliefs, etc.) [2] that function across tasks or situations. In other words, SRL is conceived as domain-specific but at a generalized level (e.g., self-efficacy in mathematics, emotions raised in a specific course, etc.) rather than at the task-specific or micro-level. The macrolevel, or "Person" level according to Efklides [1], comprises cognitive, metacognitive, motivational, affective, and volitional person characteristics. In extant research in SRL there has been a lot of emphasis on motivational person characteristics but less so on affective. The "metacognitive and affective model of self-regulated Learning" (the MASRL model) [1] posits that there are interrelations between person characteristics and between them and micro-level processes as well. Specifically, affect and motivation are assumed to interact with metacognition, both metacognitive knowledge (MK) and metacognitive strategies (MSs).

Taking into account that there is no exhaustive list of affective person characteristics in the MASRL and that, despite the remarkable progress in the concept of self-regulated learning, there are still several unanswered questions about the role of affect (general moods and specific emotions), which—with the exception of test anxiety [9]—is not yet fully comprehensible [10, 11], this study conceptualized affect in terms of positive affect, negative affect, and cognitive interference (as one of the cognitive components of test anxiety). Focusing on affect is important because there is a need to clarify its role in SRL.

The interest in this study was also in SRL in terms of the proposed model by Pintrich [12] of self-regulated learning comprising three general categories of strategies: cognitive learning strategies, metacognitive control or self-regulatory strategies, and resource management strategies like managing and controlling one's own time, effort, study environment, and so forth. The importance of academic self-regulation is well established in college students, since it has been shown that self-regulated learners' attributes are positively related to their academic achievement and their quality of learning [13–15].

In the following positive affect, negative affect, and cognitive interference are considered in more detail and findings concerning their relations with SRL strategies and performance in academic contexts are reviewed. An empirical study is then reported that tested the interrelations between trait positive affect, trait negative affect, state test anxiety (state cognitive interference), self-reported strategy use, and course attainment in the didactics of mathematics (mathematics teaching) in a School of Early Childhood Education student sample.

1.1. Positive and Negative Affect. Different emotions and moods often compose the more general constructs of positive affect (PA) versus negative affect (NA) as in recent research these two broad and largely uncorrelated factors have emerged reliably as the dominant dimensions of emotional experience [16]. They also emerge consistently across diverse descriptor sets, time frames, response formats, languages, and cultures [17]. As regards the question whether it is appropriate to regard the constructs of PA and NA as relatively independent, Watson et al. [16] have reported low to moderate correlations between the Positive Affect and the Negative Affect Scales of the 20-item Positive and Negative Affect Schedule (PANAS), ranging from $-.12$ to $-.23$, with other studies reporting similar results [18]. Moreover, using CFA, two nearly orthogonal dimensions of positive affect and negative affect were reported for a 10-item short form of the PANAS ($r = -.10$) as well as for the 20-item form of the PANAS ($r = -.30$) [18]. Although, to date, only few studies involving the 20-item PANAS in nonclinical samples have employed CFA, the results from the CFA modeling are consistent with the results of the of EFA and have shown that the positive affect and the negative affect are distinct and largely independent dimensions [19].

In most prior research on achievement goals and emotions, these more general constructs have been used, with PA being measured as an omnibus variable comprising emotions such as enjoyment, pride, and satisfaction, and NA as an omnibus variable comprising emotions such as anxiety, frustration, and sadness [2, 17].

1.1.1. Affect, Learning Strategies, and Academic Achievement. In spite of the limited research, there are some findings about the ways affect is involved in self-regulation. First of all, affective factors suit the individual's ability to orientate themselves towards the goals' accomplishment process [11]. In other words affect plays a guiding and regulatory role in our cognitive, as well as in our motivational system [10]. In addition, affect may increase or decrease working memory load by using cognitive resources that could be devoted to the academic task. Emotion has also been used less in mathematics education research, and, despite the different approaches in mathematics education, there is some measure of agreement: emotions affect cognitive processing in several ways. They bias attention and memory. They activate action tendencies and are seen to be functional, with a key role in human coping and adaptation [20].

There are two research trends which support that students' emotions influence academic achievement [10]. Particularly, the experimental mood research has shown that affective states influence cognitive and motivational processes relevant to cognitive achievement. Specifically, it has been found that moods and emotions make the mood-congruent memory processes easier [21] that is, positive affect can increase motivation to approach tasks, while negative affect can increase the mood-congruent avoidance motivation.

Furthermore, emotions can affect some of the self-regulation constituents, such as the selection of a strategy [11]. In particular, in the frame of the experimental mood research, there are findings supporting that negative affect may lead to more analytical, detailed, careful, and inflexible ways of processing information, whereas positive affect promotes the creative, flexible, and holistic way of thinking which has more beneficial effects for more heuristic processing [10, 22, 23].

However, a significant restriction of the above research is the fact that most of it has focused on attitudes and social judgments and not on the academic content of learning. Surely, there is a second research trend which attempts to analyze students' emotions in academic situations. Yet, most of the research of this trend has concentrated on test anxiety [9] and has shown that anxiety hinders achievement in complex or difficult tasks which call for available cognitive resources. This is due to the fact that affective factors—and consequently test anxiety—can increase or decrease, accordingly, the load of the working memory when they consume available cognitive resources, which could be used in the solution of academic tasks. According to a large number of data, when test anxiety is high, it actually influences learning and achievement negatively, along different age groups and academic fields [24] and the existence of this influence is also reinforced in the mathematics domain [25–30].

Students studying science are also not exempt from the negative effects that test anxiety can have on achievement. Garcia [31] and Obrentz [32] reported that by the end of a semester test anxiety negatively predicted final course grades in chemistry. In a study with undergraduates that included biology students, Lin et al. [33] found that those who earned the highest final course grades had low test anxiety. Finally, in a large study with 4.000 undergraduate including nearly 22% science majors, Chapell and his colleagues [34] found a significant negative relationship between test anxiety and college GPA.

The negative relation between anxiety and academic achievement has been also verified in Pekrun and his colleagues' research [35, 36], who looked into the relationships of specific test emotions with academic achievement. Research about the relation of emotions, apart from anxiety, with achievement is limited. Although the relation between general positive affect and achievement is found to be rather inconsistent [37], specific positive test emotions are found to affect achievement in a positive way [28, 35], due to the fact that they reinforce motives, strategy use, cognitive resources, and self-regulation.

The relations between negative affect and achievement happen to be more complex, since except for the negative connection of the general negative affect with achievement [35, 36, 38] and the low, but significant, negative effect of the general negative affect on self-regulated learning strategies [39], especially anxiety has been found to be positively related to the self-reported use of rehearsal [35, 36].

1.2. Cognitive Interference as a Cognitive Facet of Test Anxiety. Emotion constructs can be linked to momentary emotional episodes and moods or to dispositional tendencies of experiencing momentary emotions and moods. The terms trait emotions and trait affectivity are used to signify dispositional tendencies of the individual towards the experience of either specific emotions or even positive versus negative emotions in general [35, 36]. From this perspective, to say someone is a test-anxious person implies that he or she has a tendency to see the testing situation in a manner that generally results in feeling anxious. On the other hand, state test anxiety refers to the momentary context-specific appraisals, emotions, and strategies that emerge during a person-environment transaction [11].

Test anxiety is a multidimensional construct that consists of cognitive, affective, and behavioral components. Each facet is construed as representing a distinct response channel through which test anxiety may be expressed to test taking situations. Worry, self-preoccupation, and cognitive interference compose the cognitive facet of test anxiety [9]. Cognitive interference refers to intrusive thoughts—thoughts that are unwanted, undesirable, and disturbing.

Although intrusive thoughts can occur in almost any kind of situation, the bulk of research on cognitive interference has examined their role in test taking situations [40]. Intrusive thoughts occurring in academic situations are hypothesized to be a function of test anxiety and these thoughts can disrupt task performance in anxious individuals. Cognitive interference gets in the way of effective performance because it is the opposite of cognitive accessibility. It diminishes attention to the task the individual is performing [41]. Cognitive interference refers to thoughts that intrude and pop into one's mind during exams, but have no functional value in solving the cognitive task at hand. When high-test-anxious subjects are confronted with difficult or challenging tasks, they are prone to experiencing interfering cognitive responses, dividing attention between the self and the task. Therefore, researchers who study cognitive interference face the challenge of discriminating between on- and off-task thoughts—thoughts which reflect task involvement and are directed towards task completion and thoughts which are not [40]. In addition to being distracted by task-irrelevant thoughts, test anxious students may also be distracted by task-generated thoughts and other irrelevant task-related parameters (e.g., time left to complete exam, task difficulty, level of ability).

1.2.1. Cognitive Interference and Academic Achievement. However, all types of thoughts do not have the same effects. Task-related worries, when have been measured as state cognitive interference, are more predictive of performance than are task-irrelevant thoughts. This is consistent with other evidence demonstrating that generalized tendencies to have task-related worries are negatively related to task performance under test-like conditions. This relationship has been found to vary as regards its strength and to be, either direct, or indirect between task-related worries, measured as state cognitive interference, and performance on mathematics' tasks [9, 26, 27, 40]. As test-anxious examinees become preoccupied with task irrelevancies, they may employ less efficient strategies with which to solve the task at hand.

Furthermore, there is some research evidence that task generated interference is positively related to test anxiety scores [9]. Often test-anxious students at all levels of education perform more poorly on standardized tests and receive poorer grades [34] than the grades they ought to because anxiety and other test-taking deficiencies interfere with their performance, either directly or indirectly. These effects of test anxiety and cognitive interference on achievement have been confirmed in math problem solving as well [26, 27, 42].

1.2.2. Cognitive Interference and Negative Affect. Research has shown that task-irrelevant thoughts are also highly correlated with negative affect [38, 39]. According to the resource allocation theory proposed by Ellis and Ashbrook [43], negative affect leads to the increase of task-irrelevant thoughts, which overload working memory, thereby reducing the available cognitive capacity [38].

To sum up, given the emphasis of the resource allocation model in both negative affect and task-irrelevant thoughts, there is a good reason to expect that negative affect as trait can predict cognitive interference as state in the mathematics teaching course attainment in university. Furthermore, the question is if the effects of negative affect on performance are, firstly, distinct and, secondly, mediated by task-irrelevant thoughts.

1.3. Self-Regulated Learning Strategies and Achievement in Mathematics. Self-regulation as an event suggests that self-regulated learning unfolds within particular contexts and that associations between SRL (cognitive, metacognitive, and resource management) strategy use and achievement vary with respect to subject area and should therefore be studied at the course level, that is, for an individual discipline or study subject [44, 45]. Pintrich [2] stated that there is no self-regulatory strategy working equally for all individuals and for all tasks, and according to Duncan and McKeachie [46] students' strategy use depends on the nature of the academic task.

Specifically, the cognitive component of SRL, such as cognitive strategy use, seems to depend on cues of the learning task and environment [47]. Research has shown that mathematics classes were more structured, sequential and less engaging than was the case for social study classes [48]. Mathematics tasks were often cognitively less engaging than the more open-ended and diverse tasks found in social studies. These findings indicate that the context in which the learning task is embedded determines the kind of cognitive strategy that needs to be activated. However, other researchers have reported a significant negative correlation between deep learning strategies (such as organization, elaboration and critical thinking) use and students' final statistics, geometry, and mathematics course grades [49–51]. Furthermore, although high course performers were often found to report using more deep SRL cognitive strategies than low performers, the use of these strategies did not always predict college science course success [29, 32, 52, 53].

Similarly, while students who employ metacognitive and resource management SRL strategies generally perform better academically [5, 6, 14, 49, 54], metacognitive strategies were found either to be a moderately negative predictor of achievement in mathematics [50] or not to be significant predictors of science success in courses such as mathematics [29].

As regards the resource management SRL strategies, effort regulation and time and study environment management are two of the most salient predictors of academic achievement [5, 6, 14, 54]. Contrary to the aforementioned studies, however, Ozturk et al. [29] found no significant contribution of effort regulation to the variance in high school students' mathematics achievement.

In summary, the literature review regarding SRL strategies reveals an inconsistent pattern of relations of SRL strategy use with achievement in the mathematics subject matter domain. However none of the above studies included mathematics teaching tasks. Thus the question is if SRL strategy use is related to university students' course attainment in the didactics of mathematics subject matter.

1.4. Aim: Hypotheses. The present study aimed to examine the effect of affect (i.e., trait positive affect and trait negative affect) on cognitive interference (i.e., task-oriented worries as state), SRL strategies use (i.e., cognitive, metacognitive, and resource management), and academic performance in university students.

According to the MASRL model [1], interrelations between each of the above person characteristics and the SRL strategies are expected: both positive and negative affects and cognitive interference, as affective characteristics, are assumed to be related to metacognition in the form of metacognitive strategies (MSs) and learning strategies, which constitute the person's usual strategies for the control of cognition and learning.

Specifically, with respect to affect, it was hypothesized that trait positive affect and trait negative affect will be associated with the use of cognitive, metacognitive, and self-regulatory strategies (Hypothesis 1). Based on the studies of Bless et al. [22], Fiedler [23], Malmivuori [28], and Pekrun et al. [35, 36], we hypothesized that trait positive affect will be positively associated with the use of learning strategies (Hypothesis 1a); since the relations between negative affect and the SRL strategies happen to be more complex, based on Magno's [39], Pekrun et al.'s [35, 36], and Wolters and Pintrich's [30] findings, we expected either no associations or low negative associations between trait negative affect and use of self-regulated learning strategies, except for the use of lower order cognitive strategies, such as rehearsal, for which we expected their associations with trait negative affect to be positive (Hypothesis 1b).

As trait characteristics are more distal from performance than the use of learning strategies, it was hypothesized that the effects of positive and negative affect on academic performance will be mediated by learning strategies. Specifically, since several studies [5, 32, 49] have shown that various aspects of each one of the three general categories of SRL strategies (cognitive, metacognitive, and resource management) emerged as good predictors of performance in mathematics, trait positive and negative affects were expected to have an indirect effect on course attainment mediated by use of cognitive, metacognitive, and resource management strategies (Hypothesis 2).

According to Ellis and Ashbrook's [43] resource allocation model and to Linnenbrink et al.'s [38] and Magno's [39] findings, negative affect as a trait was expected to be positively associated with cognitive interference as a state (Hypothesis 3a). As trait characteristics are more distal from performance than state characteristics, we hypothesized that the effects of negative affect on academic performance will be mediated by cognitive interference (Hypothesis 3b).

With respect to cognitive interference as a cognitive facet of test anxiety, it was hypothesized that it will be negatively related to course attainment (Hypothesis 4), either directly [24, 25, 28–30] (Hypothesis 4a) or indirectly [25–27] via learning strategy use [1, 9] (Hypothesis 4b).

Finally, based on the studies of Crawford and Henry [18], Tellegen et al. [19], and Watson et al. [16], we expected either no associations or low negative associations between the distinct constructs of positive affect and negative affect (Hypothesis 5).

2. Method

2.1. Participants. The sample consisted of 180 undergraduate students (6 male, 174 female, mean age = 21.1 years, SD = 2.3) attending a didactics of mathematics course at the School of Early Childhood Education at the University of Ioannina in Greece. Participation in the study was voluntary and 78.26% of the students in the course participated in the study.

2.2. Instruments

2.2.1. The Positive and Negative Affect Schedule (PANAS). The PANAS [16] is a self-report questionnaire which consists of two 10-item scales for positive affect and negative affect, respectively. For the purposes of a previous study the PANAS was translated into Greek and tested for its construct validity by Moraitou and Efklides [55]. Participants had to answer to what extent in general they feel what was described by each item. Responses were on a Likert-type scale from 1 (very few times or not at all) to 5 (too many times).

The internal consistency for the two factors of PANAS, namely, *Trait Positive Affect* and *Trait Negative Affect*, was satisfactory: Cronbach's $\alpha = .81$ and .86, respectively.

2.2.2. The Cognitive Interference Questionnaire (CIQ). The CIQ [41] provides an index of intrusive thinking in a specific situation and consequently it might be regarded as a state measure of cognitive interference. The CIQ is a 22-item questionnaire designed to measure, following performance on a task, the degree to which people experienced various types of thoughts while working on it, and the degree to which these thoughts are viewed as interfering with concentration. According to its constructors [41], the CIQ measures two types of thoughts, task-oriented worries and off-task thoughts. The *task-oriented worries* dimension was used in the present study. Participants were asked to indicate the frequency of occurrence of task-related thoughts that intruded while they were working on their examination in the didactics of mathematics course on a 5-point scale from 1 (never) to 5 (very often). Cronbach's α was acceptable: .77.

For the purposes of a previous study, the first 10 items of the CIQ, providing post-performance reports of the frequency of occurrence of task-oriented worries, had been translated into Greek by the first author and the single factor structure of the Greek version of the *task-oriented worries* dimension of the CIQ was verified with CFA [56].

2.2.3. The Motivated Strategies for Learning Questionnaire (MSLQ). The MSLQ was developed by Pintrich et al. [57] as a measure of self-regulated learning. The MSLQ has two sections, a motivational and a learning strategies section. In this study the learning strategies section was used to assess college students' use of various learning strategies in college courses. The learning strategies section of the MSLQ consists of 50 items, divided into nine subscales measuring: *rehearsal, elaboration, organization,* and *critical thinking* (representing the cognitive aspect of self-regulated learning); *metacognition* (representing the metacognitive aspect of self-regulation); and *environment and time management, effort regulation, peer learning,* and *help seeking* (representing the management component of self-regulation). Responses are given on a 7-point Likert-type scale anchored by 1 (not at all true of me) and 7 (very true of me). An example from the subscale used to measure elaboration is "when reading for this class, I try to relate the material to what I already know." An example from the subscale used to measure metacognition is "when I study for this class, I set goals for myself in order to direct my activities in each study period." An example from the subscale used to measure study environment management is "I usually study in a place where I can concentrate on my course work."

For the purposes of a previous study the learning strategies section of MSLQ was translated into Greek by two of the authors and an independent bilingual person. The two versions of the translated questionnaire were then compared and modifications were made. Confirmatory factor analysis verified the nine-factor structure of the Greek version of the learning strategies section of MSLQ [6].

Cronbach's alphas, for the sample of the present study, were also comparable to those of Pintrich et al. [57] (given in parenthesis): $\alpha = .56$ (.69) for *rehearsal*, $\alpha = .68$ (.76) for *elaboration*, $\alpha = .76$ (.64) for *organization*, $\alpha = .65$ (.80) for *critical thinking*, $\alpha = .69$ (.79) for *metacognition*, $\alpha = .75$ (.76) for *environment and time management*, $\alpha = .76$ (.69) for *effort regulation*, $\alpha = .68$ (.76) for *peer learning*, and $\alpha = .57$ (.52) for *help seeking*.

2.2.4. Course Attainment. Course attainment in the didactics of mathematics was measured with students' final course grade, which was converted to a 10-point scale ($M = 4.62$; SD = 2.30). Final course grade was assessed with (a) an essay (maximum score: 3) and (b) an exam, which required recall of information from textbooks and was administered at the end of the semester (maximum score: 7).

2.3. Procedure. Institutional permission for conducting research with human subjects was obtained. All participants gave informed consent, they were assured confidentiality, and they were provided code numbers in order their anonymity to be preserved. Questionnaires were administered in the classroom. The PANAS was administered at the beginning of the semester. Participants also provided demographic information, including age, gender, and class level prior to completing the questionnaire. The MSLQ was administered during a session at the end of the semester, while the CIQ was administered after their final examination in the didactics of mathematics course.

2.4. Statistical Analyses. In order to examine the relationships between the various constructs of the study, Pearson correlations were computed in addition to the use of path analysis—a structural equation modeling (SEM) technique for analyzing structural models with observed variables. Sum scores were used for the various scales. Specifically, to examine the model depicting the hypothesized relationships between the subscales of positive and negative affects, cognitive interference, SRL strategies, and course attainment in didactics of mathematics, a path analysis with manifest variables was computed. Although it is undoubtedly true that the attainment of specific goals (e.g., passing an exam) may enhance one's level of trait positive affect and trait negative affect, the general rule is that personality traits are relatively enduring, and so when an association is found between a trait (such as positive and negative affect) and a specific behavior (such as reaching one's goal), it is plausible to assume that the trait caused the behavior rather than the other way round. Consequently, the two components of affect were treated as trait-like variables, while the graded performance, the state cognitive interference, and the nine self-regulated learning strategies were treated as domain-specific variables.

Path analysis was conducted in EQS Version 6.1 and performed on covariance matrix using the Maximum Likelihood estimation procedure [58]. Initially, in the structural part of the model, the two affective independent variables incorporated in the path model were allowed to correlate between them and predict the nine latent variables of self-regulated learning strategies, the cognitive interference, and the dependent variable of course attainment. Simultaneously, the latent self-regulation learning strategies variables and the cognitive interference were allowed to correlate and predict the dependent variable of course attainment as well. Modifications suggested by the Wald test were used to test the necessity of the regressions included in the model and to ensure a theoretically plausible and statistically restricted model. The chi-square (χ^2), the chi-square/degrees of freedom (χ^2/df) ratio, the Comparative Fit Index (CFI), the standardized root mean squared residual (SRMR), and the root mean squared error of approximation (RMSEA) were used as indices of the model.

3. Results

Correlation matrix between positive and negative affect, cognitive interference, SRL strategies, and mathematics teaching course attainment is shown in Table 1.

The path model that was confirmed is displayed in Figure 1. The dotted lines indicate the direct effects of the domain specific variables on course attainment. The overall fit of the model was good, χ^2 (33, N = 173) = 34.31, P = .40, χ^2/df = 1.04, CFI = 1.00, SRMR = .05, and RMSEA = .02 ($\mathrm{CI}_{90\%}$ .00 to .06) [59].

As hypothesized in (H1) and (H1a), trait positive affect was related to the use of several cognitive, metacognitive, and resource management strategies. Specifically, it was positively related to the use of all of the cognitive, metacognitive, and resource management strategies, except for critical thinking. That is, the higher the trait positive affects the more the use of the SRL strategies.

Furthermore, since all of the cognitive, metacognitive, and resource management strategies, except for rehearsal and peer seeking, were positively correlated with course attainment, it seems that a student's trait positive affect could be beneficial to performance (H2). However, this noteworthy finding of Pearson correlations was not observed in path analysis where elaboration was the only SRL strategy found to be positively related to course attainment (explained variance: 11-12%) (H2).

Contrary to (H1) and (H2), trait negative affect was not related, either directly to the SRL strategy use, or indirectly to performance via regulation of the use of SRL strategies. It seems that trait negative affect neither facilitates nor inhibits the SRL strategy use in the mathematics teaching subject matter domain (H1b).

As hypothesized in (H3a) and (H3b), trait negative affect was positively related to cognitive interference and, through this, negatively to course attainment. It seems that a student's trait negative affect explains state cognitive interference (the degree to which a student experienced task-oriented worries, while working on the examination tasks, and the degree to which these thoughts are viewed as interfering with concentration) (explained variance: 18-19%), which in turn is translated into lower graded performance.

As hypothesized in (H4a) state cognitive interference was found to be directly and negatively related to course attainment (explained variance: 4%). Contrary to (H4b), however, cognitive interference was not found to be indirectly related to performance via regulation of the use of SRL strategies, since, except for a positive correlation with rehearsal, there was a lack of relationships between SRL strategies and task-oriented worries.

Finally, as hypothesized in (H5), no association was found between positive and negative affects. This finding is consistent to the PANAS constructors' findings that positive affect and negative affect are distinct and largely independent dimensions of the instrument.

4. Discussion

The aim of this study was to examine the effect of prospective kindergarten teachers' affect and cognitive interference on their SRL strategy use and academic performance in a didactics of mathematics course. The present study focused on three of the students' characteristics, namely, positive affect, negative affect, and cognitive interference as affective constructs, and their potential impact on self-regulated learning. Specifically, this study found that SRL strategies and course attainment are linked to important trait-like characteristics, such as trait positive and trait negative affect, and domain-specific characteristics, such as state cognitive interference.

Without discounting the claim that SRL skills, in general, are learnable, the results of the present study suggest that personality predispositions impact SRL strategy use and academic achievement in specific situations [1, 5]. Affect and cognitive interference can lead to decisions regarding top-down self-regulation as both of them appear to be associated with metacognitive knowledge in the form of strategies (the SRL cognitive, metacognitive and resource management strategies) that one tends to use when dealing with a task (e.g., a didactic of mathematics course examination essay) [1]. These findings are in accordance with the MASRL model's predictions for the person characteristics and support the importance of affective factors in self-regulated learning.

4.1. Effects of Positive Affect on SRL Strategy Use and Course Attainment. As regards the predictive ability of positive and

TABLE 1: Zero-order correlations among negative affect, positive affect, cognitive interference, self-regulated learning strategies, and course attainment in the didactics of mathematics subject matter.

	Negative affect (NA)	Positive affect (PA)	Cognitive interference (CI)	Organization (ORG)	Rehearsal (REH)	Elaboration (EL)	Critical thinking (CT)	Metacognition (MET)	Time and study environment management (TSEM)	Effort regulation (ER)	Peer learning (PL)	Help seeking (HS)	Course attainment (CA)
NA	1.00												
PA	−.12	1.00											
CI	.43**	−.08	1.00										
ORG	.00	.18*	.07	1.00									
REH	.09	.25**	.18*	.60**	1.00								
EL	.00	.19*	.03	.50**	.46**	1.00							
CT	−.03	.10	.03	.27**	.26**	.60**	1.00						
MET	.05	.34**	.08	.48**	.56**	.59**	.49**	1.00					
TSEM	−.10	.26**	−.04	.39**	.50**	.36**	.12	.45**	1.00				
ER	−.11	.29**	−.04	.38**	.42**	.38**	.19**	.51**	.64**	1.00			
PL	.09	.28**	.06	.21**	.24**	.37**	.30**	.36**	.09	.10	1.00		
HS	.11	.18*	.03	.08	.11	.22**	.20**	.26**	.11	.04	.60**	1.00	
CA	−.11	.10	−.20**	.16*	.09	.34**	.20**	.19*	.25**	.24**	.20**	.02	1.00

Note: $^{*}P = .05$ (2-tailed), $^{**}P = .01$ (2-tailed).

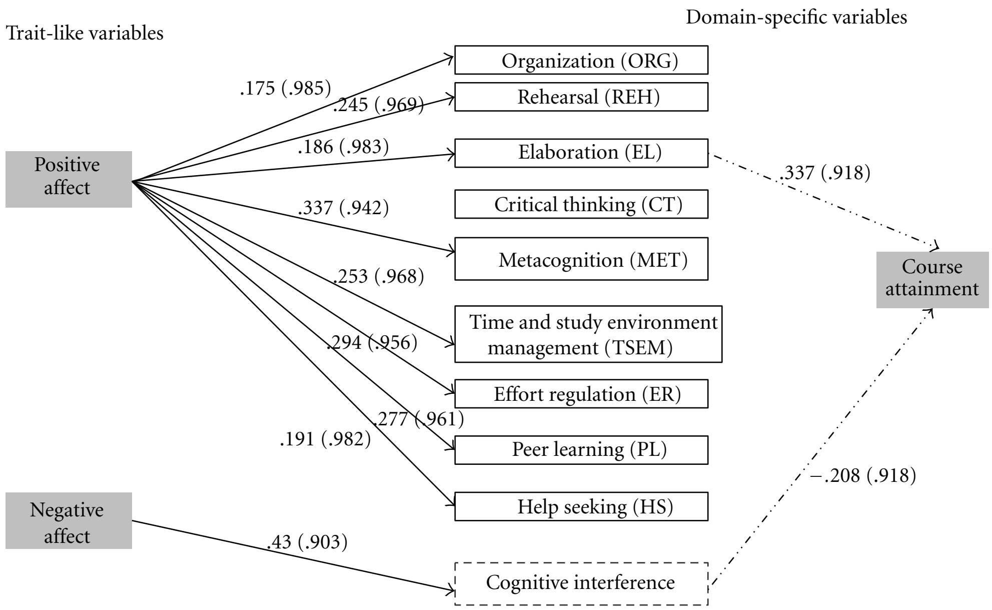

Figure 1: The final path model displaying the relationships among negative affect, positive affect, cognitive interference, self-regulated learning strategies, and course attainment in the didactics of mathematics subject matter. *Note* 1. All paths drawn indicate significant associations ($P < .05$). *Note* 2. Doted lines indicate direct effects on course attainment. *Note* 3. Errors are given in parenthesis. *Note* 4. Correlations of SRL strategies: REH-ORG: .584, EL-ORG: .475, MET-ORG: .450, TSEM -ORG: .362, ER-ORG: .338, PL-ORG: .148, EL-REH: .417, MET-REH: .495, TSEM -REH: .465, ER-REH: .344, PL-REH: .137, MET-EL: .567, TSEM -EL: .316, ER-EL: .331, PL-EL: .313, HS-EL: .175, TSEM -MET: .400, ER-MET: .448, PL-MET: .276, HS-MET: .206, ER-TSEM : .619, HS-PL: .588.

negative affect for SRL strategy use, positive affect clearly stands out as a powerful predictor. Specifically, positive affect was found to positively affect the use of the most cognitive, metacognitive, and resource management strategies in the didactics of mathematics subject matter domain. It seems that students who have positive affect are likely to employ more a variety of self-regulated learning strategies in order to learn new and advanced material and apply concepts to problem solving and scientific inquiry in a didactics of mathematics undergraduate course compared to their counterparts lacking positive affect.

Since elaboration—which is a higher order cognitive strategy—was found to be positively associated with course attainment in mathematics teaching, the above finding is consistent with the literature showing that positive affect benefits students' achievement in a significant test, such as a test in the didactics of mathematics course, reinforcing the effective use of self-regulated learning strategies [28, 35, 36]. Therefore, the encouraging effect of the positive affect on the SRL strategy use should be taken into account at the interventions planned to teach college students to be self-regulated learners.

4.2. Effects of Negative Affect on SRL Strategy Use and Course Attainment. Contrary to positive affect, negative affect was not found to be associated with any SRL strategy use. Since in the present study the negative affect was appointed as a general variable, which consists of emotions such as anxiety, frustration—which is one of the reasons of anger—and shame, its influence on performance, via the use of SRL strategies, was found to be neutral. These findings are reinforced by Pekrun et al.'s [35, 36] opinion who claims that the influence of anger and shame on achievement, as well as the effect of anxiety [9], does not always need to be negative. It may be proved neutral or even positive for achievement in some projects, for specific individuals and under specific circumstances.

4.3. Effects of SRL Strategy Use on Course Attainment. Although almost all of the SRL strategies were found to be positively correlated with mathematics teaching graded performance, elaboration was the only SRL strategy found to predict it. This finding is consistent with previous research indicating that although high course performers were often found to report using more deep SRL cognitive strategies (such as organization, elaboration, and critical thinking) than low performers [60, 61], the use of these strategies did not always predict college science course success [29, 32, 52, 53].

It seems that early childhood education students who tend to paraphrase and summarize effectively the learning material are likely to perform better in a didactics of mathematics undergraduate course compared to their counterparts lacking these qualities. In addition, the finding that elaboration was the only SRL strategy predicting graded performance in the didactics of mathematics course is possible to be due to the composition of the sample, as regards gender, as 97,7% of the participants were female students. Wolters and Pintrich [30] demonstrated that while academic success and self-regulatory (metacognitive) strategy use were similar in mathematics, social sciences, and English for both male and female, female students employed higher levels of cognitive strategy use than male students in all three subject areas. These findings can be associated with test anxiety: students with higher levels of test anxiety were more likely to employ cognitive strategies but less likely to employ self-regulatory (metacognitive) strategies and more likely to get lower scores [30]. Similarly, students who participated in the present study employed higher level of elaboration; they got rather low final course grade (converted to a 10-point scale, $M = 4.62$) and their course attainment was found to be negatively predicted by state cognitive interference (explained variance: 4%).

This finding might indicate that female students, who compose the majority at the Greek Early Childhood Education Schools, lack the skills needed to be able to be themselves self-regulated learners (the learner's perspective in SRL) in the didactics of mathematics subject matter. Therefore, as preservice kindergarten teachers, it is possible that they will continue to lack the skills and knowledge needed to be able to teach mathematics successfully and to understand how to help their students achieve SRL (the teacher's perspective in SRL) [62, 63]. Since the ability to self-regulate learning is highly useful for preservice teachers' professional growth during their entire career and for promoting these processes among students [62, 63], the above indication reinforces Kramarski's and Michalsky's [63] suggestion that teachers' SRL may be developed through participation in training programs that provide opportunities to the teachers to control their learning and, consequently, their teaching.

4.4. Relations between Negative Affect and Cognitive Interference. An interesting finding of the present study concerns the positive relationship of trait negative affect with state cognitive interference. As it has already been mentioned, negative effect as disposition has been appointed and measured as a general variable, which includes emotions such as anxiety and frustration [2, 35, 36]. Seeing that state cognitive interference as a cognitive facet of test anxiety is appointed as instant emotional state, experienced before or during a particular test [9], it is presumable that a great part of its variance is explained by more general dispositions such as the trait negative affect and/or test anxiety as personality characteristic. Furthermore, the specific finding, as well as the finding of the indirect (through state cognitive interference) negative effect of trait negative affect on attainment in the didactics of mathematics course, falls within the frame of the resource allocation theory [43], according to which trait negative affect leads to the increase of intrusive thoughts, which overload working memory, decreasing the available cognitive resources [35, 36, 38].

To conclude, except for the aforementioned direct effect of state cognitive interference on the didactics of mathematics course attainment, the present study also reveals a lack of relations between SRL strategies and cognitive interference, except for a low correlation ($r = .18$) of cognitive interference with rehearsal, which is reinforced by Pekrun's [35, 36] opinion who claims that the effect of anxiety [9], does not always need to be negative. It may be proved neutral or even positive for achievement in some projects, for specific individuals and under specific circumstances. Moreover, even in the frame of the experimental research for moods, there are findings which support that negative affect can lead to more analytical, detailed, but also inflexible ways of processing data, such as the lower order strategy of rehearsal.

Generally speaking, the lack of relations between SRL strategies and cognitive interference is consistent to the cognitive-attentional (interference) model, which associates test anxiety with deficits in retrieval of previously learned information [9].

4.5. Limitations of the Study. A limitation of this study is the less validity of the used self-report measure of self-regulatory skills, since the MSLQ does not accurately measure the participants' actual use of SRL strategy. Self-regulated data collected during learning is a more accurate measurement of processes related to SRL [64, 65]. Thus, more rigorous designs are needed to establish the validity of the relationship between academic self-regulation and trait-like characteristics using behavioral and observational measures of self-regulation (i.e., real-time measurements of learning strategies, think-aloud protocol data, or video-based assessment of strategy use) [66, 67]. The restricted nature of the sample should also be noted, especially with regard to age and gender. It is also not known whether the same pattern of results would be obtained, if college students of other disciplines, other than early childhood education, were involved.

In conclusion, our findings suggest that affect as general disposition influences in distinct ways students' SRL strategy use and course attainment in the didactics of mathematics subject matter domain. Future research should further clarify, in different college student groups and in different age groups, how affective factors predispose individuals to employ SRL (how affective factors encourage or discourage individuals to become self-regulating learners) and how these dispositions interact with learning situations in developing relevant self-regulation strategies. It will also be helpful for future research to examine the variety of specialized emotions, such as hope, pride, anger, and shame, which arouse in the academic environment, and to evaluate the role that they may play in self-regulated learning.

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Research Article

Writing about the Personal Utility of Learning Contents in a Learning Journal Improves Learning Motivation and Comprehension

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Reflecting on the personal utility and value of learning contents is important for motivation building and engagement in high quality learning processes. We investigated the effects of a personal-utility prompt in journal writing on students' learning motivation and comprehension in biology education. 40 students of a German secondary school took part in a quasi-experimental field study. The students kept a weekly learning journal over six weeks. For writing their journal entries, the students received a brief instruction that either did or did not include a personal-utility prompt. Results showed that the personal-utility prompt successfully supported the students in reflecting about the personal utility of the learning contents. Consequently, students in the personal-utility prompt condition reported higher degrees of learning motivation and achieved better comprehension scores as compared to students who had no personal-utility prompt available. Evidently, using journal writing to reflect upon the utility and value of learning contents is a beneficial method to support students' learning motivation and comprehension in secondary science education.

1. Introduction

The ability to self-regulate one's learning processes effectively is important at almost all levels of education. Self-regulated learning involves the ability to use cognitive, metacognitive, and motivational learning strategies effectively [1]. One important motivational learning strategy a self-regulated learner should possess is the ability to explain to oneself why it is worthwhile to learn a particular topic and what the personal utility of a topic could be [2]. Far too often, however, students find it difficult to see the personal utility of the contents discussed, especially in secondary science education, for example [3]. Consequently, students show little identification with the learning contents and are weakly motivated to invest substantial effort in high quality learning processes [4]. On the contrary, they seem to limit their effort to the minimum defined by classroom requirements. As a result, students tend to use superficial learning strategies and accordingly focus on rehearsing and memorizing the contents as "isolated facts" [5]. Therefore, deep understanding and long-time retention can hardly be achieved because the students fail to engage in intentional and meaningful learning [6].

Learning journals are a medium which can help students reflect on the relevance of a particular topic. In a learning journal, students typically write down their thoughts on previously presented learning contents. They try to articulate what they found personally interesting and important and how the new information relates to what they already know about the subject. The aim of the current study was to investigate whether the reflection about the relevance of a topic can increase students' learning motivation and their comprehension of the subject matter.

Reflective journal writing can be regarded as a medium to foster self-regulated learning [7]. Journal writing promotes deep processing of the learning contents as students are encouraged to apply cognitive as well as metacognitive and motivational learning strategies [7–10]. In contrast to essays or scientific articles, learning journals do not have a fixed rhetorical structure. Therefore, they are especially beneficial for learners with comparatively little writing expertise [7]. Learning journal instructions are used to encourage students to use beneficial learning strategies via prompting. Prompts are strategy activators in the form of questions or hints that trigger students' application of corresponding strategies [11]. Previous research provided ample evidence that journal writing can be an effective medium to promote self-regulated learning. Positive effects of journal writing on learning behavior and learning outcomes were found both in lab and field studies in such diverse domains as biology, math, and psychology ([7–9, 12–14]; see [10] for an overview). Berthold et al. [8] and Nückles et al. [7], for example, investigated the effects of cognitive and metacognitive prompts on the application of learning strategies in journal writing as well as on learning outcomes. The results of their studies showed that prompting a combination of cognitive and metacognitive learning strategies in journal writing resulted in large effects on learning outcomes with regard to the acquisition of deep comprehension and retention of the acquired knowledge (see [13]). However, despite the promising short-term results of cognitive and metacognitive prompts in those experimental studies, Nückles et al. [15] also found a decrease in students' learning motivation over a longer period of time that was associated with a decrease in learning outcomes. Thus, prompting cognitive and metacognitive strategies in journal writing apparently was not sufficient for maintaining effort and interest in the learning contents over a longer period of time. Theoretically, the regulation of motivation is regarded as an essential subprocess in current models of self-regulated learning as well [16, 17]. Hence, prompting motivational strategies, which was not realized in the above-mentioned studies, seems to be equally as important as cognitive and metacognitive strategies. Thus, it is an interesting and open question whether the prompting of motivational strategies in journal writing will promote learning motivation. Accordingly, in our present study on journal writing, we introduced and systematically varied a motivational prompt—in addition to a combination of cognitive and metacognitive prompts. In the following, we discuss in a theoretical context the role of motivation in self-regulated learning and how learning journals can support the regulation of motivation and thereby learning successfully.

To describe the processes involved in self-regulated learning and the interrelations between different components, several models of self-regulated learning have been suggested (e.g., [17–20]). The perhaps most well-known one is the model developed by Zimmerman [20], which describes self-regulated learning as a cyclical and interactive process. According to this model, the coordination and regulation of cognition is realized by the metacognitive strategies of planning, monitoring, and evaluation of the learning process [1]. Furthermore, the learner should employ motivational strategies to initiate the learning process, to shield it against interruptions, and to invest a sustained effort in meaningful cognitive learning activities [16]. In order to maintain learning motivation, it is particularly important that learners experience the learning tasks and topics as personally valuable [21]. The more the learners perceive the learning contents as personally relevant, useful, and interesting [22], the more they will engage in effortful and persistent intentional learning [6, 22–24]. For example, by reflecting and writing about the relevance of a well-functioning immune system, learners could learn to regard this topic as also being relevant for their own health. As a consequence, they would more easily identify with the learning contents. They would develop a desire to acquire as much knowledge about the topic as possible and explore it for their own interest. Accordingly, we provided the students in our study with a personal-utility prompt in order to help them discover and articulate the personal relevance of the learning contents by writing a learning journal. In doing so, we expected to improve students' motivation to engage in meaningful leaning.

Prior research on motivation and learning provided evidence that students with higher learning motivation tend to choose more challenging learning goals [25, 26], apply more self-regulatory strategies [27], and show greater strategic flexibility [27, 28], more meaningful cognitive engagement [29, 30], and greater academic achievement [30, 31]. However, students also seem to have problems in motivating themselves [32]. Especially novices in a discipline may find it difficult to motivate themselves [16] and therefore are at risk to lose their learning motivation [32]. One strategy to increase students' learning motivation is to help them perceive the value and personal relevance of a topic [1, 17, 33]. In this regard, learning journals seem to be a particularly promising medium because they offer students ample freedom for reflecting on the meaning and purpose of a particular topic.

Such reflection is especially important in science education, as students are expected not only to acquire factual knowledge but also a thorough conceptual understanding of the subject matter [34]. In this regard, previous research in biology education demonstrated the benefits of learning journals [9, 12]. McCrindle and Christensen, for example, compared reflective journal writing with the writing of a scientific report in undergraduate biology courses. They found that—in comparison with the students in the scientific report condition—students who wrote regular learning journal entries as a follow-up course work reported using more sophisticated cognitive and metacognitive learning strategies and showed a more complex and better integrated understanding in a test at the end of the course. Such an integrated and flexible understanding is necessary to successfully apply the acquired knowledge to real-life situations and to participate in social discourses about science and the role of science in society [2]. For this reason, it is important that students engage in exploring the meaning and value of the contents discussed in science classes at school. Learning journals offer an ample opportunity for such reflection. For example, students who reflect on the meaning and purposes of immunology in a biology class could learn to consider this knowledge as valuable because it helps to prevent illness or to understand the signals of the body and medical advice. In this way, journal writing in science education may contribute to increases in students' learning motivation and improve their learning behavior in science classes, such as in biology.

2. Research Questions and Hypotheses

Based on these theoretical considerations, we addressed the following research questions. First of all, we were interested in whether a personal-utility prompt would lead the students to reflect about the meaning, purpose, and relevance of the learning contents in the learning journals. Second, related to this research question, we tested whether the personal-utility prompt would improve students' motivation for learning biology as well as their learning outcomes as measured by a comprehension test.

Accordingly, we predicted that students who received a personal-utility prompt would show a greater amount of statements about the meaning, purposes, and relevance of a topic in their learning journals as compared with students who did not receive such a prompt (Hypothesis 1). Writing about the relevance of a topic could help to make the value of a topic explicit and in this way increase students' learning motivation. As higher learning motivation should entail more effortful and persistent engagement in the exploration of a topic, we expected that providing students with a personal-utility prompt for journal writing would also have a positive effect on learning outcomes, that is, comprehension of the topic. Thus, we predicted that students who received a personal-utility prompt would report higher levels of motivation after journal writing (Hypothesis 2) and also show higher scores in a comprehension test as compared with students who wrote their learning journals without this prompt (Hypothesis 3).

3. Method

3.1. Participants and Design. 40 high school students (seventh grade, 13-14 years old) participated in the quasi-experimental field study. They were members of two biology classes of a German secondary school and taught by the same biology teacher. During the surveyed timespan of six weeks, the students reflected on the learning contents of their biology lessons by writing regular learning journal entries. The lessons were about basic concepts and issues in immunology (e.g., the functioning of white blood cells or the functioning of the Human Immunodeficiency Virus). Students in both classes were asked to write a learning journal entry once a week, that is, six entries in total. As the students' accomplishment of the journal writing assignment was not checked by the teacher, about one-third of the students in both classes (23 out of $N = 63$) did not comply with the assignment and did not write any learning journal entries. We therefore excluded these students from the data analyses. To support the students' journal writing, we provided them with a combination of cognitive and metacognitive prompts that had repeatedly been shown to foster learning processes and learning outcomes in our previous research (see [7, 13, 15]). We used a one factorial between-subject design comprised of two experimental conditions. The students of one class were assigned to the experimental condition while the students of the other class were assigned to the control condition. Given that the students belonging to a particular class as a whole were assigned to either the experimental or control condition, random assignment was somewhat restricted. Therefore, our design was rather quasi experimental than experimental in a strict sense. To nevertheless keep both conditions as comparable as possible, the same teacher taught the same contents in both classes during the intervention. She also used the same didactic methods and learning materials in both classes. All participating students had received biology instruction for two years. Their prior knowledge and also their motivation in learning biology were comparable across conditions (for details on statistical tests regarding prior knowledge and motivation prior to the journal writing intervention, see Section 4).

The students in the experimental condition received a personal-utility prompt in addition to our standard combination of cognitive and metacognitive prompts (personal-utility prompt condition, $N = 19$, 7 boys, 12 girls). The students in the control condition received the same combination of cognitive and metacognitive prompts but no additional personal-utility prompt (standard prompts condition, $N = 21$, eleven boys, ten girls). The distribution of boys and girls did not differ significantly between the experimental conditions, $\chi^2(N = 40) = 0.97$, ns. On average, students who complied with the journal writing task wrote 4.63 (SD $= 0.98$) out of 6 possible learning journal entries. Dependent variables encompassed students' comprehension of biological concepts as well as their learning motivation assessed by a learning motivation questionnaire. In addition, we analyzed measures of learning strategies elicited in the learning journals.

3.2. Instruments and Coding

3.2.1. Measures of Acceptance. To assess the students' acceptance of journal writing, we used 10 items translated and adapted from the Intrinsic Motivation Inventory (IMI; [35]). The IMI is a multidimensional questionnaire. The items that we chose assessed the students' interest and enjoyment (e.g., "journal writing was fun for me"), their effort (e.g., "I spent much effort in journal writing"), and perceived usefulness of the performed task (e.g., "journal writing was helpful for better understanding of the learning contents"(see Appendix A for the complete sample of items). Students estimated their degree of agreement for each item on a 7-point rating scale ranging from 1 (very low degree of agreement) to 7 (very high degree of agreement). Based on the students' answers to the items, we computed an average score of journal writing acceptance for each student. The internal consistency measured by the Cronbach's alpha was very good, $\alpha = .93$.

3.2.2. Measures of Learning Motivation. To assess the students' learning motivation related to biology, we used adapted items for interest (e.g., "I enjoyed tricky tasks and puzzles in biology very much."), effort (e.g., "I tried hard while solving problems in biology."), and perceived competence (e.g., "I could solve my tasks pretty well in biology.") from the Intrinsic Motivation Inventory (IMI; [35]) related to biology tasks. In total, the questionnaire included 18 self-report items to be rated on a 7-point rating scale, ranging from 1 (very low degree of agreement) to 7 (very high degree of agreement). As the internal consistency measured by Cronbach's alpha was good, Cronbach's $\alpha = 0.79$, we computed an average motivation score. High motivation scores indicated self-efficient students that were interested in the topic and willing to invest effort in biology tasks. We assessed students' learning motivation related to biology topics before and after the period of journal writing.

3.2.3. Comprehension Test. To assess the students' comprehension of immunology, we designed a comprehension test based on the guidelines for the biology curriculum of German high schools (see Appendix B for the test items). To ensure validity, the test was assessed by two experienced teachers of biology. We asked the students to answer the five questions in the comprehension test before and once again after the 6-week period of journal writing. Between these points of measurement, the teacher instructed both classes in immunology using the same teaching methods and materials. As the guidelines in the curriculum focus on the ability to explain biological phenomena scientifically, we primarily designed explanation tasks that measured comprehension (see Appendix B). Thus, the students had to apply their acquired knowledge in order to generate explanations. Recalling facts would not have been enough to answer the questions appropriately. Two trained research assistants evaluated each question of the comprehension test. They compared students' answers with reference answers given by the teacher and counted the number of correct statements. A maximum of 22 points could be reached when answering the five test items completely correct. The maximum scores, as well as the means and standard deviations students reached on average on each item in the pre- and posttest, are presented in Appendix B. Interrater reliability as determined by Cohen's kappa was very good, $\kappa = 0.95$. Students reached an average comprehension score of $M = 5.07$ ($SD = 1.86$) in the pretest and $M = 11.47$ ($SD = 3.28$) in the posttest.

3.2.4. Writing Assignment. As the participating 7th-grade students were inexperienced in journal writing, we provided them with a brief instruction (300 words) on how to write a learning journal. Students in both experimental groups were asked to reflect on the topics discussed in class by writing about the most important contents of a lesson, about their own understanding of concepts, and questions that still remained open to them after class discussion. The students were told to write about one page per journal entry. To facilitate the journal writing, the instruction

Table 1: Prompts used in the writing instructions.

Prompts
Cognitive prompts (organization and elaboration)
How can you structure and summarize the contents in a meaningful way?
Which examples can you think of that illustrate, confirm, or conflict with the learning contents?
Metacognitive prompts (monitoring and planning of remedial strategies)
Which main points have you understood yet, and which points do you need to elaborate?
What possibilities do you have to overcome the comprehension problems?
Personal-utility prompt
Why is the learning material personally relevant for you at present or in future out of school?

Note. Students in the standard prompts condition received only the cognitive and metacognitive prompts. Students in the personal-utility prompt condition additionally received the personal-utility prompt.

included two cognitive prompts stimulating elaboration and organization strategies and two metacognitive prompts stimulating monitoring and planning of remedial strategies (see Table 1). Students in the personal-utility prompt condition additionally received a personal-utility prompt that asked them to think about the personal relevance of the topic. The instruction ended by encouraging the students to consider personal needs, to develop their own ideas, and to design their learning journal however they wished.

3.2.5. Coding of the Learning Journals. Apart from the pre- and posttests, we also assessed the students' learning processes and strategies elicited in the learning journals. For this analysis, we used the coding scheme developed by Nückles and colleagues [7], see also Glogger et al. [12]. We aimed to identify learning strategies triggered by the corresponding prompts. Two independent raters, who were blind to the experimental conditions, coded the learning journals on the granular level of individual statements. As preparation for the coding, we first segmented the texts into single statements. We split longer sentences into smaller units on the basis of grammatical and organizational markers (e.g., and, or, because, etc.; see [36]). Based on this segmentation, the raters categorized single statements as organization, elaboration, metacognition, or personal-utility statements. For example, statements that highlighted the main points of the topic and their interrelations were coded as indicators of organization (e.g., students underlined important terms or highlighted them with different colors). As elaboration, we coded statements in which students associated the new content with their prior knowledge, for example, by generating examples, analogies, or illustrations (e.g., "the human immune system can be compared with the protective walls of a castle."). We coded statements related to comprehension monitoring (e.g., "I have difficulties in understanding the differences in active and passive immunizations.") and planning of remedial strategies (e.g., "I will rework the course materials and ask the teacher if I cannot understand everything.") as metacognitive strategies. Finally, we analyzed to what extent the students articulated considerations regarding the personal relevance and importance of the topic or their own interest in the topic (e.g., "it is important for me to know how I can prevent the transmission of HIV infection."). We coded these statements as personal-utility statements. Interrater reliabilities as determined by Cohen's kappa were very good (between $\kappa = 0.84$ and $\kappa = 0.93$).

3.3. Procedure. The whole intervention lasted eight weeks. In the first week, we asked the students to take part in a pretest. The students took the pretest in their class. They estimated their motivation in learning biology by using the learning motivation questionnaire described above. To assess the students' prior knowledge in immunology, they tried to answer the questions of the comprehension test (see Appendix B). Afterwards, they were given the above-described brief instruction on why and how to write a learning journal. The instruction was handed out to the students on a sheet of paper and was also orally explained to them by a preservice teacher, who served as the experimenter in this study. The instruction was identical for all students except for the personal-utility prompt. The students in both experimental conditions received two cognitive and two metacognitive prompts. However, the students in the personal-utility condition additionally received a personal-utility prompt. The students read the instruction together with the experimenter, who emphasized the relevance of using the prompts. The students were asked to write a learning journal entry once a week after the two biology lessons that were taught en bloc. The students were asked to show their biology teacher the journal entries but they received no feedback by the teacher. We decided against providing feedback on the journals to keep the implementation of the intervention as objective and comparable as possible across individual students. The students wrote a maximum of 6 journal entries during the intervention period. The students were asked to put the learning journal entries together into a small booklet, which was collected by the experimenter at the end of the journal writing period prior to the posttest. In the last week, all students took part in the posttest in class. The students again assessed their motivation in learning biology using the same questionnaire as in the pretest. They answered the explanation questions of the comprehension test and, finally, rated their acceptance of journal writing using the acceptance questionnaire mentioned above. All tests were administered as paper-pencil tests. Students completed the tests in their regular biology lesson in week eight of the overall intervention. After the end of the study, the students in the control condition also received the instruction with the personal-utility prompt to enable them to benefit as well from this enhanced instruction when writing future learning journals.

Table 2: Means and standard deviations for the experimental conditions.

Measures	Experimental condition			
	Personal-utility prompt condition		Standard prompts condition	
	M	(SD)	M	(SD)
Pretest				
Comprehension[a]	5.00	(2.05)	5.13	(1.73)
Learning motivation[b]	4.92	(0.46)	4.66	(0.49)
Elicited strategies[c]				
Elaboration	0.51	(0.18)	0.46	(0.16)
Organization	2.48	(1.21)	2.66	(1.22)
Metacognitive strategies	0.25	(0.21)	0.22	(0.16)
Personal-utility statements	0.54	(0.61)	0.08	(0.21)
Posttest				
Comprehension[a]	13.11	(2.81)	10.00	(3.00)
Learning motivation[b]	5.11	(0.49)	4.42	(0.64)
Acceptance[b]	5.61	(1.09)	4.68	(1.34)

Note. The different numbers of students in pre- and posttest were owing to the illness of students. [a]Scores in the comprehension tests in which a maximum of 22 points was achievable. [b]Rating scores from 1 (low value) to 7 (high value). [c]Average number of strategy indicators elicited in one learning journal.

4. Results

Table 2 presents the mean scores and standard deviations separately for the experimental conditions and thus provides an overview of the variables of interest. In the following sections, we first analyzed the pretest scores, then the measures of the learning strategies elicited in the learning journals, and finally the posttest scores. As an effect size measure for group differences, we used partial η^2 qualifying values < 0.06 as small effect, values in the range between 0.06 and 0.13 as medium effect, and values > 0.13 as large effect (see [37]).

4.1. Investigating Pretest Scores. First, we investigated whether students in the experimental conditions had similar prior knowledge related to immunology as well as comparable learning motivation. We conducted a one-factorial analysis of variance with prior knowledge as dependent variable and treatment condition (personal-utility prompt condition versus standard prompts condition) as independent variable. The results indicated no significant differences for the experimental conditions regarding prior knowledge, $F(1, 35) = 0.04$, ns. (Small differences regarding the degrees of freedom are due to the fact that three students missed the prior knowledge test and four students failed to complete the motivation questionnaire in pretest session. In the posttest, two students were ill and failed to complete both the comprehension test and motivation questionnaire.) An analysis of variance with the motivation scores as the dependent and treatment condition as the independent variable was also not significant, $F(1, 34) = 1.00$, ns. Thus, the students in both experimental conditions had comparable prior knowledge and also comparable motivation in learning biology prior to our treatment.

4.1.1. Hypothesis 1: Personal-Utility Prompt Stimulates Reflections about the Personal Utility of Immunology in the Learning Journals. First, we investigated whether the students in the personal-utility prompt condition produced more statements about the meaning, purpose, and personal relevance of immunology than the students in the standard prompts condition. To test this hypothesis, we conducted a one-factorial analysis of variance with the two experimental conditions (personal-utility prompt condition versus standard prompts condition) as the independent and the number of personal-utility statements as the dependent variable. The results indicated that the treatment was successful, $F(1, 38) = 10.42$, $p < 0.01$, partial $\eta^2 = 0.21$. Students in the personal-utility prompt condition produced significantly more statements regarding the personal relevance of immunology in their learning journals than the students in the standard prompts condition. Indeed, the students in the standard prompts condition hardly articulated any thoughts regarding the utility and personal value the topic of immunology had for them (see Table 2).

As both treatment groups received the same cognitive and metacognitive prompts, we did not expect any significant differences in cognitive and metacognitive strategy use between the groups. Inline with this assumption, a multivariate analysis of variance with the frequencies of elaboration, organization, and metacognitive strategies as dependent variables and experimental condition as independent variable clearly failed to reach statistical significance, Pillai's trace = .03, $F(3, 36) = 0.37$, ns. Table 2 shows that the students in both conditions produced only a few metacognitive statements indicating monitoring or planning of remedial strategies (around one statement in four journal entries). The application of elaboration strategies was also low (around one statement in two journal entries). In contrast, the use of organizational strategies was relatively high (2.5 statements per journal entry). To investigate these differences in strategy use in more detail, we conducted a repeated measures analysis of variance with the different kinds of strategies as a within-subjects factor. This MANOVA indicated significant differences between the frequencies of students' strategy use, Pillai's trace = 0.84, $F(2, 37) = 96.04$, $p < 0.01$, partial $\eta^2 = 0.84$. Pairwise comparisons showed that the students used significantly more organization strategies than elaboration strategies, $F(1, 39) = 104.87$, $p < 0.01$ partial $\eta^2 = 0.73$, and significantly more elaboration strategies than metacognitive strategies, $F(1, 39) = 60.37$, $p < 0.01$ partial $\eta^2 = 0.61$. Overall, the application of cognitive and metacognitive strategies in the learning journals was rather low, with the exception of organization strategies.

4.1.2. Hypothesis 2: Reflecting about the Personal Utility of the Topic Immunology Increases Students' Motivation in Learning Biology. To test this hypothesis, we computed an analysis of variance with the posttest motivation scores as the dependent and the experimental condition (personal-utility prompt condition versus standard prompts condition) as the independent variable. The pretest motivation scores were included as a covariate. The ANCOVA showed a significant effect of the pretest on the posttest scores, $F(1, 32) = 14.55$, $p < 0.01$, partial $\eta^2 = 0.31$, indicating the relative stability of individual differences in students' motivation in learning biology. Nevertheless, as predicted, the students in the personal-utility prompt condition had significantly higher motivation posttest scores than the students in the standard prompts condition, $F(1, 32) = 14.76$, $p < 0.01$, partial $\eta^2 = 0.32$. Thus, irrespective of the apparent interindividual differences in students' motivation in biology, reflecting about the personal utility of the topic of immunology through journal writing evidently helped the students to substantially increase their motivation for learning biology.

We further conducted an analysis of variance to test for differences between the experimental conditions regarding the students' acceptance of journal writing. The ANOVA indeed proved to be significant, $F(1, 36) = 5.44$, $p < 0.05$, partial $\eta^2 = 0.13$. Students who had received a personal-utility prompt were more likely to perceive journal writing as a beneficial learning method that they would like to use in future learning than students who had received only cognitive and metacognitive prompts.

4.1.3. Hypothesis 3: Reflecting about the Personal Utility of Immunology Increases Students' Comprehension of this Topic. To investigate the students' comprehension regarding immunological concepts, we conducted an analysis of variance with the individual posttest comprehension scores as the dependent variable and the experimental condition (personal-utility prompt condition versus standard prompts condition) as the independent variable. The pretest comprehension scores were included as a covariate. The results indicated a significant effect of the pretest on the posttest scores, $F(1, 33) = 6.59$, $p < 0.05$, partial $\eta^2 = 0.17$. Over and above these interindividual differences, the students in the personal-utility prompt condition evidently achieved higher scores in the comprehension posttest than the students in the standard prompts condition, $F(1, 33) = 11.93$, $p < 0.01$, partial $\eta^2 = 0.27$. Thus, reflecting about the personal utility of the topic of immunology in a learning journal not only increased the students' motivation for learning biology, but also spurred them to achieve superior comprehension than the students in the standard prompts condition.

To explore this result in more detail, we conducted a multiple regression analysis (backward method) to identify predictors of posttest comprehension scores. As potential predictors, we included the frequency of personal-utility statements as well as statements indicating elaboration, organization, and metacognitive strategies. The pretest comprehension scores and the posttest motivation scores were also included. The only predictor of posttest comprehension that proved to be significant was the posttest motivation score, $\beta = 0.38$, $p < 0.05$; $R^2 = 0.14$. In the next step, we investigated whether the posttest motivation score could be predicted by the frequency of statements representing different types of strategies (personal utility, organization, elaboration, and metacognition) elicited in the learning journals. Accordingly, we conducted a multiple regression analysis with the posttest motivation scores as criterion and the frequency of personal utility, elaboration, organization, and metacognitive statements as predictors. The pretest scores of motivation were also included as predictor. This regression analysis showed that the posttest motivation scores were predicted by the pretest motivation scores, $\beta = 0.52$, $p < 0.01$, $\Delta R^2 = 0.30$, and by the frequency of statements reflecting personal utility in the learning journals, $\beta = 0.44$, $p < 0.01$; $\Delta R^2 = 0.19$. Together, the regression analyses indicate, first, that it was especially the students learning motivation at the end of the intervention that predicted learning outcomes in the comprehension test. Second, the analyses show that the students' post-intervention learning motivation could in fact be traced back to the intensity in which they reflected in their learning journals about the personal relevance of the learning contents.

5. Discussion

The aim of the current study was to investigate (1) whether a personal-utility prompt would lead students to reflect about the personal relevance of the learning contents in their learning journals and (2) whether such reflection would increase students' learning motivation as well as their comprehension of the topics. To answer these questions, we conducted a quasi-experimental study with two conditions, a personal-utility prompt condition and a standard prompts condition. Students in both conditions received a combination of metacognitive and cognitive prompts that had proved to be successful in previous research [7, 13]. In the personal-utility prompt condition, students additionally received a prompt that encouraged them to think about the personal relevance of the topic. The results can be summarized as follows.

Students who received a personal-utility prompt included more statements about the meaning, purpose, and relevance of the topic in their learning journal entries than students who did not receive such a prompt (Hypothesis 1). Thus, the students in the personal-utility prompt condition used their learning journals to reflect on their personal stance by self-explaining the relevance of a topic related to their own experiences and personal examples. Students' personal-utility statements indicated that they related the learning content, immunology, to real-life situations by discussing its relevance for these situations in their learning journals.

Regarding learning motivation, we found that students who received a personal-utility prompt evaluated journal writing as more valuable to them than was the case for students who received cognitive and metacognitive prompts only. More importantly, as predicted by Hypothesis 2, the students in the personal-utility prompt condition not only evaluated journal writing more positively but also reported a greater motivation for learning biology after the journal writing period as compared with the students in the standard prompts condition. Thus, writing about the meaning, purpose, and relevance of a particular topic had considerable positive effects on students' motivation for studying this topic. The higher posttest motivation scores in the personal-utility prompt condition suggest that, as a result of journal writing, these students became more interested in biological topics, such as immunology, and were more willing to expend effort in learning about this subject. Such improved effort, engagement, and persistence [16, 23, 38] are important preconditions for meaningful learning [5]. Furthermore, being able to recognize and articulate the personal relevance of a topic also is important for developing a commitment to life-long learning. Life-long learning in general is imperative to the modern knowledge-based society; it is especially important in subject domains where scientific knowledge accumulates and changes rapidly, such as in biology [39]. Accordingly, students who were explicitly prompted to think and write about the personal utility of a biological topic were more likely to engage in the topic with a higher learning motivation.

Reflecting on the personal relevance of the topic not only increased the students' learning motivation but also helped them to better comprehend the learning contents. Accordingly, the students in the personal-utility prompt condition clearly outperformed the students in the standard prompts condition with regard to the level of comprehension (Hypothesis 3). The regression analyses suggest that the students' improved comprehension of immunology was apparently mainly due to the increase in learning motivation, which itself resulted from students' reflecting about the personal relevance of immunology in their learning journals. Hence, a major benefit the students drew from journal writing was motivational. The way they wrote about immunology in the personal-utility prompt condition raised their motivation for learning about this topic and thereby may have also improved their topic-specific learning behavior *beyond* the journal writing. For example, students may have built a strong intention to understand immunology and consequently increased the application of deep-level comprehension strategies in and out of class. Given that the motivational effects of journal writing apparently reached beyond the learning journal and generally affected students' ways of dealing with the subject, future research should explore how students' learning behavior changes as a result of journal writing. For this purpose, it is necessary to observe students' learning activities related to biology more comprehensively, for example, by assessing and observing students' engagement and strategy use during the lessons as well as during homework and class preparation.

What are the theoretical implications of the present study? Previous research on journal writing concentrated on supporting the application of cognitive and metacognitive strategies in the learning journals in order to foster self-regulated learning [7, 8, 10]. Although this cognitive approach proved to be successful in several short-term laboratory studies, a longitudinal study on journal writing by Nückles et al. [15] found, in the long run, a decrease in students' learning motivation that was associated with a decrease in learning outcomes. Hence, prompting cognitive and metacognitive strategies was not sufficient for maintaining effort and interest in the learning contents over a longer period of time. In the present study with relatively young high school students (compared to the university freshmen of [15]), cognitive and metacognitive strategy use in the learning journals was low and did not predict learning outcomes. Nevertheless, prompting reflection about the personal relevance of the learning contents in the learning journals evidently yielded strong effects on learning motivation which was positively related to learning outcomes as measured by a curriculum-based comprehension test. Thus, an important benefit of journal writing has also to be seen in the potential to foster learning motivation, in particular, appreciation of and interest in a topic, and therefore learning outcomes. It is beyond controversy that learning motivation is important for the depth of students' comprehension, but also especially for effort and persistence [16, 38]. However, learning motivation was not explicitly promoted in previous studies on journal writing. The present study therefore extends this research by providing evidence that learning journals can be used to promote learning motivation as well. The finding that the rather infrequent cognitive and metacognitive strategies in the learning journals of our 7th grade students did not predict posttest comprehension requires further research. One possible explanation is that thinking about the relevance of a topic could have supported students' deep examination of the topic beyond journal writing. Thus, students could have regarded journal writing as the initiator rather than as the medium for high quality learning. Another possible explanation refers to the competency to apply cognitive and metacognitive strategies in the written texts. The students in our previous studies (see [7, 8, 13, 15]) were at least 9th graders and often university students. Thus, it is possible that the comparatively younger students in our present study were not able to use the cognitive and metacognitive strategies implied by the prompted strategies to improve their task performance, because they did not possess the necessary cognitive requirements (mediators) to benefit from the strategies. In this case, they would have suffered from a mediation deficiency with regard to the application of cognitive or metacognitive strategies during writing (see [13, 40]). The low frequency of most types of these strategies (except organizational strategies) in the learning journals, despite the explicit introduction, may support this tentative conclusion.

The empirical results presented in this paper can be easily applied to schools. Previous studies showed that journal writing is a beneficial form of a follow-up course work [7–9, 12]. Results of the present study showed that learning journals are also a promising medium to improve students' learning motivation. Including a personal-utility prompt in the writing instruction invited the students to think about the meaning and purpose of a topic in real-life situations. As a consequence, they were more willing to expend effort in learning biology. As one cannot assume that all students are intrinsically motivated per se and willing to invest substantial effort in exploring a new topic, learning journals offers a promising approach to stimulate and to maintain students' learning motivation.

According to the biology curriculum in German high schools, understanding human biology should help students understand the functioning of their own body and its systemic relations to the social and ecological environment [2, 34]. This might enable them to act responsibly in order to protect one's own and others' health, for example, with regard to preventing infection with HIV. The relevance of the topic of immunology to students and to their own lives seems to be obvious. Nevertheless, the present study shows that in order to get students to reflect about the personal relevance of this topic, they had to be prompted to do so. Thus, even if the topics to be discussed in the science class are relatively close to the students' realm of experience, it might nevertheless be necessary to support them in reflecting about the value and personal utility of the topics by prompts. As the present study demonstrated, supporting even young students in this way yielded large effects on their learning motivation and thus on their comprehension of the topic.

Appendices

A. Motivation Questionnaires

A.1. Journal Acceptance Questionnaire

(1) Journal writing was useful.

(2) Journal writing was helpful for better understanding of my own way of studying.

(3) Journal writing was helpful to find out what topics I should rework.

(4) Journal writing was helpful for better understanding of the learning contents.

(5) Journal writing was fun for me.

(6) Journal writing was boring.^{R}

(7) Journal writing was beneficial for learning.

(8) I spent low effort in journal writing.^{R}

(9) Journal writing was an important experience for me.

(10) I would like to write learning journals more often as homework.

Note: ^{R}reverse-coded items.

A.2. Intrinsic Motivation Questionnaire. Please think about your class preparation for biology lessons in the last week. How much do you agree with the following statements?

(1) I enjoyed tricky tasks and puzzles in biology very much.

(2) I could solve my tasks pretty good in biology.

(3) I put a lot of effort into preparation of biology lessons.

(4) It was important for me to do well in biology.

(5) I tried hard while solving problems in biology.

(6) Solving problems in biology was fun.

(7) Pretending to be a scientist of biology who explores problems was very interesting.

Table 3: Means, standard deviations, and item difficulties of the comprehension test.

Item	Maximum score	Pretest			Posttest		
		Mean	SD	ID	Mean	SD	ID
Please explain the differences between HIV and AIDS.	6	1.53	0.57	.26	3.59	0.83	.60
Why is "AIDS" so life threatening for humans? Provide two reasons.	2	0.83	0.39	.41	1.79	0.62	.90
Please name the different components of blood and their functioning.	6	1.68	1.03	.28	2.55	2.10	.43
Put yourself in the position of a red blood cell and run through the entire circulatory system. Start in the heart and explain each station you run through. What is happening to you?	4	0.47	0.72	.12	1.50	1.28	.38
Please explain why humans get childhood diseases (e.g., measles, mumps) only once.	4	0.57	0.72	.14	2.00	1.31	.50

Note. SD: standard deviation; ID: item difficulty.

(8) I was satisfied with my performance in biology lessons and exams.

(9) I felt tense while performing difficult tasks in biology.[R]

(10) I felt anxious while solving tasks in biology.[R]

(11) I felt pressured while doing my biology homework.[R]

(12) I did not try hard when preparing for biology lessons.[R]

(13) While preparing for biology, I thought how much I enjoyed it.

(14) I feel pretty competent related to biology tasks.

(15) I was relaxed while preparing biology lessons.

(16) I am proud of my abilities in biology.

(17) The biology tasks did not hold my attention.[R]

(18) I worried about solving biological tasks.[R]

Note: [R]reverse-coded items.

B. Item Statistics for the Comprehension Test

For more details see Table 3.

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Research Article

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

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The aim of the intervention based on the self-regulation theory by Zimmerman (2000) was to promote a powerful learning environment for supporting self-regulated learning by using learning materials. In the study, primary school teachers were asked to implement specific learning materials into their regular mathematics lessons in grade four. These learning materials focused on particular (meta)cognitive and motivational components of self-regulated learning and were subdivided into six units, with which the students of the experimental group were asked to deal with on a weekly basis. The evaluation was based on a quasiexperimental pre-/postcontrol-group design combined with a time series design. Altogether, 135 fourth graders participated in the study. The intervention was evaluated by a self-regulated learning questionnaire, mathematics test, and process data gathered through structured learning diaries for a period of six weeks. The results revealed that students with the self-regulated learning training maintained their level of self-reported self-regulated learning activities from pre- to posttest, whereas a significant decline was observed for the control students. Regarding students' mathematical achievement, a slightly greater improvement was found for the students with self-regulated learning training.

1. Introduction

According to Boekaerts et al. [1], the concept of self-regulation is used in a variety of psychological fields (see also [2]). In research on educational settings, *self-regulated learning* [3] is classified as an important factor for effective (school-based) learning and academic achievement (e.g., [4–6]).

Regarding theories and models of self-regulation, there are different approaches to describe the construct. Some models regard self-regulation as consisting of different layers (e.g., [7]), while other models emphasize the procedural character of self-regulation and describe different phases (e.g., [8–10]). In our study, we refer to the self-regulation model developed by Zimmerman [8], who defines self-regulation as a cyclical process that "refers to self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals" (page 15). The model distinguishes between three learning phases: the forethought or planning phase, the performance or volitional control phase, and the self-reflection phase. For each of these phases, two components are uniquely characterized which are again represented by specific processes.

As components of the *forethought phase*, both the analysis of the given task (task analysis) and self-motivation beliefs are relevant variables in the beginning of the learning process. Task analysis includes processes of goal setting and strategic planning. According to Locke and Latham [11], goal setting has been defined as a decision upon specific outcomes of learning or performance. Highly self-regulated students organize their goal systems hierarchically and tend to set process goals in order to achieve more distal outcome goals [8]. Furthermore, strategic planning is a process relevant to the forethought phase—and closely related to goal setting—because after selecting a specific goal, students engage in planning how to reach it [9, 12]. Indeed, these processes are quite useless if students are not motivated or cannot motivate themselves to use corresponding strategies. Therefore, self-motivation beliefs, such as self-efficacy, outcome expectations, intrinsic value, and goal orientation, are relevant motivational variables of the forethought phase and they affect direction, intensity, and persistence of students' learning behavior [13, 14]. Self-efficacy refers to "personal beliefs about having the means to learn or perform effectively" [15, page 17], whereas outcome expectations refer to the judgments of the consequences that behavior will produce [16]. In line with Deci and Ryan [17], intrinsic value is defined "as the doing of an activity for its inherent satisfaction rather than for some separate consequences" (page 56). Regarding goal orientation, there is a first distinction between a mastery goal construct and performance goal construct (e.g., [18]): whereas mastery goals (also called mastery orientation) are focused on learning and self-improvement, performance goals (also called performance orientation) represent a more general concern with demonstrating ability and trying to do better than (or to not appear worse than) others [19, 20]. There is a distinction between two different types of performance goals: performance-approach goals and performance-avoidance goals [18]. Students can be motivated to try to outperform others in order to demonstrate their competence (performance-approach) or to avoid failure in order to avoid looking incompetent (performance-avoidance). With respect to self-regulated learning theory, a positive influence of mastery goals on the different components of self-regulated learning was found [10]. In addition, these motivational variables are important components of self-regulated learning as they initiate the learning process and affect students' performance [14].

In the next phase—the *performance or volitional control phase*—self-regulated learning is determined by processes of self-control and self-observation. In this regard, self-control strategies—or volitional strategies—are necessary when disturbances occur while performing a task [21, 22]. In his model, Zimmerman [8] differentiated between self-instruction, task strategies, imagery, and attention focusing as important strategies of self-control. Corno [23] emphasized that a flexible use of volitional strategies assists self-regulated learning because it enables students to shield their goal-related behavior from distractions. In the framework of our study, we concentrated on attention focusing as an effective self-control strategy in avoiding distractions and speculations of irrelevant matters [24].

Another important component of the performance phase concerns the ability of self-observation, which is described as the systematic observation and documentation of thoughts, feelings, and actions regarding goal attainment [25]. Regarding self-regulated learning, students cannot adequately engage in self-regulatory behavior without self-observation because they are only able to modify their behavior if they are attentive to relevant aspects of it [26]. As for the processes of self-observation, Zimmerman [8] adduced the processes of self-recording and self-experimentation. Self-recording has the advantage of retaining personal information at the point when it occurs and includes the possibility of altering or modifying the behavior. Self-experimentation offers the possibility of systematically varying different aspects of behavior. As a common self-recording technique, Zimmerman [8] argued for diaries to support self-observation processes because of the reactivity effect [27].

Subsequent to the performance phase, the completion of a task is the initial point of the *self-reflection phase*. This phase is characterized by the components of self-judgment and self-reaction. Zimmerman [8] describes self-judgment as consisting of two processes: self-evaluation and causal attributions, which includes the comparison of one's behavior with one's goals [28]. Students evaluate their learning results and draw conclusions concerning further learning behavior. In this context, there are different types of criteria to evaluate one's performance. In line with Zimmerman [8], we distinguished between normative criteria and self-criteria. In this context, self-criteria are regarded as being more effective for self-regulated learning [29] because they involve the comparison of current performance with earlier levels of performance and allow judgments about the learning progress. Self-evaluative judgments are related to causal attributions. Students attribute their behavior by considering the results. There is evidence that in cases of poor performance, attributions to insufficient effort or a poor task strategy can be beneficial to motivational aspects; in cases of successful performance, attributions to one's ability are beneficial to motivation [30, 31]. The comparisons of results to goals, as well as causal attributions, are linked to the students' affect or self-reactions. In this context, Zimmerman [8] described perceptions of satisfaction or dissatisfaction (called self-satisfaction) and distinguished between adaptive or defensive interferences that modify a person's self-regulatory approach during subsequent efforts to learn or perform. Thereby, the feedback resulting from current performance influences prospective performance. Zimmerman [8] designated this procedural nature of self-regulation as a feedback loop. The theoretical model is depicted in Figure 1.

As self-regulated learning has become a key construct in education in recent years because of its importance in influencing learning and achievement in school and beyond [33], there are many studies on enhancing students' self-regulatory abilities by training them either during or after their regular classes (e.g., [34–36]). Leopold et al. [37] fostered text understanding by the intervention of text highlighting and self-regulation strategies. Souvignier and Mokhlesgerami [38] focused on the enhancement of cognitive, motivational, and metacognitive aspects of self-regulated learning with respect to reading comprehension. Regarding science lessons, Labuhn et al. [39] trained seventh graders in cooperation with teachers. The target groups of these studies were students at the secondary school level (ranging from fifth to eleventh grade). As the development of self-regulation begins in early childhood [40, 41], and in line with the results of a meta-analysis by Dignath and

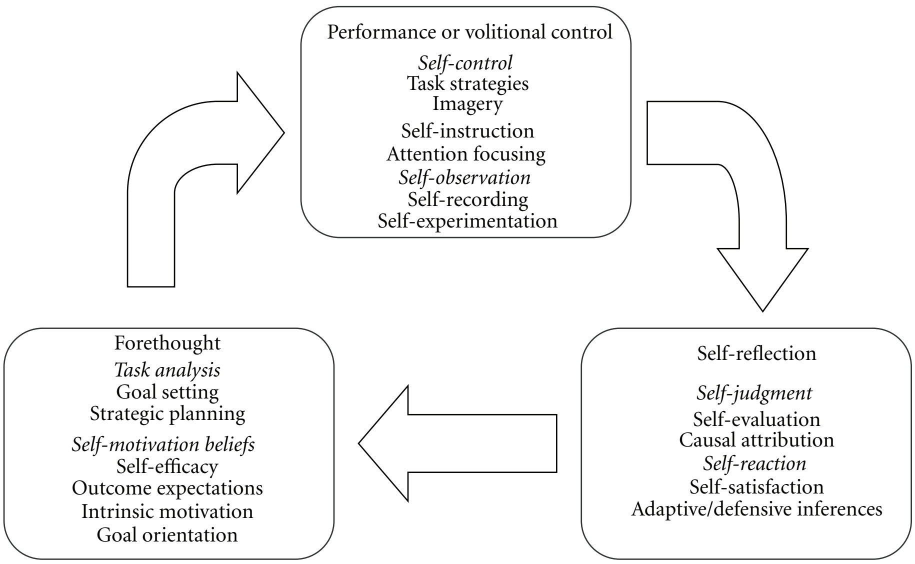

Figure 1: Phases and processes of self-regulation [32].

Büttner [42], interventions have been developed to foster self-regulated learning of students in primary school [43, 44] or even kindergarten [45]. Dignath et al. [46] pointed out that improving the self-regulated learning of primary school students has positive effects on learning outcomes, strategy use, and motivation (see also [47]). Otto [43] trained primary school students, as well as their teachers and parents, and was able to compare direct and indirect effects of self-regulation training. Rozendaal et al. [48] followed a similar approach. In the framework of their study, they trained significant reference persons (teachers) on how to improve students' self-regulated learning abilities [49].

The abovementioned studies represent different approaches to enhance self-regulated learning by training either students themselves or other relevant persons, such as teachers or parents. Thereby, self-regulated learning was combined with different academic subjects such as reading comprehension, text understanding or mathematical modelling, and problem-solving. This approach is in line with the results of a meta-analysis conducted by Hattie et al. [50], which pointed out that the direct and isolated instruction of self-regulated learning strategies had turned out to be less effective regarding its transferability on students' learning behavior. Instead, the authors argued that direct instruction of strategies ought to be linked to factual content in order to apply these strategies in a natural setting. With regard to mathematical learning, De Corte et al. [51] argued that "self-regulation constitutes a major characteristic of productive mathematics learning" because the main goal of learning and teaching mathematics concerns "the ability to apply meaningfully learned knowledge and skills flexibly and creatively in a variety of contexts and situations" (page 155). There are a few studies (e.g., [47, 49]) that combine the instruction of mathematical problem-solving strategies with multidisciplinary self-regulated learning strategies. The presented study was designed with regard to the approach of De Corte et al. [52], who promoted the conception of the powerful learning environment, which fosters the application of self-regulatory learning strategies. Therefore, the teachers received teaching materials that included instructions to train their students in their natural learning environment at school. Following the processual character of Zimmerman's model [8], these materials focused on particular strategies of each of the three phases. In detail, the forethought phase was represented by strategies of goal setting, strategic planning, and intrinsic value. With respect to the following phases, the learning materials focused on attention focusing as a strategy of the performance or volitional control phase and on causal attribution as a strategy of the self-reflection phase. In order to enhance their transferability, the learning materials were related to the current mathematics curriculum. As self-regulated learning strategies are transferable to different situations and areas [53], students should be thus enabled to use these strategies in different contexts.

2. Hypotheses

As the intervention was designed in order to improve self-regulated learning strategies of fourth grade students, the purpose of the study dealt with the influence of self-regulated learning interventions on students' self-regulated learning. In addition, an effect was expected on students' mathematics achievement because the intervention was conducted with respect to mathematical contents and conducted during regular mathematics lessons. In the framework of the study, a training to improve self-regulated learning was developed and implemented into regular mathematics lessons for a period of six weeks. In this process, the teachers received learning materials and instructions on how to train their students. It was expected that training particular self-regulatory processes could have an effect on students' self-regulated learning. Longitudinally, there should be an increase in self-regulated learning strategies in the trained group compared to the control group. In detail, the variables goal setting, strategic planning, intrinsic value, attention focusing, and causal attribution, as well as self-regulated learning, should be enhanced in the experimental group. As the training was linked to the contents of the mathematics curriculum, an effect of the intervention on the mathematical achievement of the trained students was expected, too. There should be found a stronger increase in mathematics achievement in the trained group compared to the control group. As the training effects were expected to be stable, there should be no significant changes of variables between posttest and follow-up measurement in the experimental group.

Beyond the pre/posttests, the students of the experimental group were also asked to complete a structured diary task addressing their self-regulated learning. Therefore, process data could be analyzed by means of interrupted time series analyses. With regard to the trained variables goal setting, strategic planning, intrinsic value, attention focusing, and causal attribution, intervention effects were assumed. In addition, it was expected that variables, which were not part of the training but dealt with within the diary, improved over the intervention period. This should be the case for the variables self-efficacy, self-recording, and self-evaluation as well as for self-regulated learning in general.

3. Method

3.1. Participants. The study was conducted in seven German primary schools with altogether 135 fourth graders. The participation was voluntary and the students' legal guardians were asked for their consent. In the experimental group (EG), 63 students took part, whereas 72 students were assigned to the control group. The mean age of the participants was 9.26 (SD = .56), and 50.40% were female. There were no significant differences between the experimental and control group concerning students' mathematics marks ($t = -1.56$, $P = .12$), and the mathematics marks on their report card ($t = -0.44$, $P = .66$). The students of the experimental group were involved in training carried out by their teachers. The control group did not receive any training.

3.2. Design. The study was evaluated by a time series design combined with a longitudinal design, including pretesting and posttesting of an experimental group (EG) and a control group (CG). The experimental group was trained in self-regulated learning and each student was asked to fill out a learning diary for the duration of the training. The control group was a group receiving neither training nor diaries.

3.3. Intervention. Based on the study of Perels et al. [49], learning materials to foster self-regulated learning strategies were developed with respect to fourth grade students' learning abilities. The learning materials were addressed to (meta)cognitive strategies, such as goal setting, and strategic planning, as well as to volitional/motivational strategies, such as intrinsic value, attention focusing, and causal attribution. On the one hand, these strategies were selected with respect to the (meta)cognitive abilities of primary school students because it had to be taken into account that students of this age have a growing (metacognitive) awareness of their own thinking processes and have the opportunity to control them [40]. As Bronson pointed out, primary school students "can learn to consciously set goals, select appropriate strategies to reach the goals, monitor progress and revise their strategies when necessary, and control attention and motivation until a goal is reached" [40, page 213]. On the other hand, the learning materials focused on the abovementioned strategies in order to represent the different phases of Zimmerman's self-regulation model [8]. Therefore, goal setting, strategic planning, and intrinsic value were selected according to the forethought phase, while the strategy of attention focusing represented the performance and volitional control phase. As a strategy belonging to the self-reflection phase, causal attribution was selected.

Table 1: Overview of the contents of the different units.

Session/unit	Content
1st unit	Introduction of Kalli Klug/learning diary
2nd unit	Goal setting
3rd unit	Strategic planning
4th unit	Intrinsic value
5th unit	Attention focusing
6th unit	Causal attribution

The learning materials focused on the abovementioned strategies and were differentiated between six units. Each of these units—excluding the first—referred to one particular self-regulated learning strategy. In order to impart these self-regulatory contents to the students in a playful and child-oriented manner, a fictitious character named Kalli Klug was developed with which the students could identify themselves, and which guided them through the different units. The first unit aimed to introduce the fictitious character to the students; therefore, a one-page profile of Kalli Klug was handed out to the students. The students learned that the character was an endearing bear of the age of nine, which had learned several strategies that helped him to improve his learning behavior and who wanted to relay this information to the students. In this context, a learning diary was introduced as one method to optimize learning behavior. The contents of units 2 and 3 were related to cognitive and metacognitive strategies. In detail, the third unit of the learning materials includes cognitive and metacognitive strategies because the students were asked to apply particular cognitive learning strategies such as organizing as well as metacognitive strategies like comprehension monitoring. The units 4 and 6 dealt with motivational strategies, such as self-motivation and favorable attributional styles. The fifth unit focused on volitional strategies, such as attention focusing. Table 1 gives an overview of the contents of the units.

Every unit was designed for the duration of one lesson (45 minutes). The teachers received the learning materials in the form of units according to the number of students in the classroom and the instruction plans on how to impart the

Table 2: Overview of the scales of the self-regulated learning questionnaire regarding the sources, authors, and changes.

Scale	Changes	Source	Author
Goal setting	Simplified formulation of the items	SELVES	Otto [43], Schmidt [54]
Strategic planning	Simplified formulation of the items One additional item	SELVES	Otto [43]
Intrinsic value	Simplified formulation of the items		Otto [43], Gürtler [55], Pekrun et al. [56]
Attention focusing	Simplified formulation of the items Three additional items	SELVES	Otto [43]
Self-recording	Simplified formulation of the items	SELVES	Otto [43]
Self-evaluation	Simplified formulation of the items	SELVES	Otto [43]
Causal attribution	Simplified formulation of the items One additional item		Bruder [57]

Table 3: Reliabilities of the self-regulated learning questionnaire.

Phase	Scale	N	Cronbach's alpha		
			Pretest	Posttest	Followup
Forethought phase	Goal setting	4	.54	.61	.74
(e.g. "Before I start with a mathematics task, I plan how to begin")	Strategic planning	3	.58	.71	.65
	Intrinsic value	6	.80	.85	.79
Performance or volitional control	Attention focusing	6	.76	.79	.74
(e.g. "When doing a complex mathematics task, I control whether my proceeding is reasonable")	Self-recording	3	.65	.76	.81
Self-reflection	Self-evaluation	4	.56	.80	.71
(e.g. "If I failed a mathematics task, I reflect on what to change next time")	Causal attribution	5	.67	.65	.58
Overall scale	Self-regulated learning	31	.90	.92	.88

N: number of items; followup: follow-up measurement after 12 months.

contents. Additionally, they received supporting documents which explained the theoretical background of the units. Every unit followed the same procedure: each began with a short repetition of the preceding unit. Then, the teachers demonstrated a new problem with which the character had been confronted (e.g., how to deal with distractions that restrict one from learning). Following this, the students had to think about this problem and find strategies to solve the problem. Alternatively, they learned the strategies which the character used in order to solve the problem by itself. In addition, the students had to transfer these strategies to their own learning behavior. The units finished with a task that had to be done for homework.

The teachers were asked to work on these learning materials together with their students during their regular mathematics lessons. In order to support the implementation of the contents, the teachers received instructions with recommendations for proceeding. It was the teachers' task to transfer these interdisciplinary strategies to the mathematical contents of their lessons. For example, the second unit focused on goal setting. The students learned how to set goals and were prompted to set their personal goals for their mathematics learning for the following week. Therefore, it can be said that the teachers were actively and personally involved in the implementation of the training.

The learning materials were made available to the teachers a week before the official start of the training. As the students had to work on one unit per week, there was enough time for the teachers to familiarize themselves with the learning materials. Further support was available in the form of a mentor, available at a teacher's discretion [58].

3.4. Instruments

3.4.1. Self-Regulated Learning Questionnaire. Within the framework of the study, a questionnaire was used to measure fourth grade students' self-regulated learning. A first version of this questionnaire was tested and revised in a pilot survey with a parallel student target group ($N = 58$). The students filled out the questionnaire a week before and after the intervention, as well as after a period of twelve months (follow-up measurement). The responses were coded on a scale with scores ranging from 1 to 4 (1: *I disagree*, 2: *I somewhat disagree*, 3: *I somewhat agree*, and 4: *I agree*). Some of the items have been taken from established instruments [43, 59–61], and, if necessary, selected scales were newly developed (for details, see Table 2). Reliabilities (Cronbach's alpha) were assessed for all scales (Table 3).

The questionnaire was applied during regular classes and instructed by qualified experimenters in a standardized

Table 4: Split-half reliabilities of diary scales, evaluated with the odd-even method.

Scale	$r_{\text{odd-even}}$
Forethought phase	
Goal setting	.92
Strategic planning	.69
Intrinsic value	.95
Self-efficacy	.96
Volitional control phase	
Attention focusing	.90
Self-recording	.93
Self-reflection phase	
Self-evaluation	.95
Causal attribution	.83

All items: $P < .001$; $N = 63$.

way. On the one hand, the questionnaire was designed to represent the several contents of the units; on the other, the instrument was developed with respect to the phases and processes of Zimmerman's self-regulation model [8], such as goal setting, strategic planning, intrinsic value, attention focusing, self-recording, self-evaluation, and causal attribution. These processes were chosen to represent the scales of the overall scale self-regulated learning. Following the model, the forethought phase was composed of the scales goal setting, strategic planning, and intrinsic value, with 13 items altogether. Regarding the performance or volitional control phase, two scales with nine items in total were composed which covered themes of attention focusing and self-recording. The self-reflection phase referred to the scales self-evaluation and causal attribution, which were measured by nine items. Altogether, the questionnaire consisted of 31 items. In Table 3, the reliabilities of the questionnaire are depicted for the measurements (pretest/posttest/follow-up measurement). The reliabilities of the posttest were regarded as criterion. Since Cronbach's alpha ranged between 0.61 and 0.85, the reliability of the instrument can be rated as satisfactory ($\alpha > .60$). As the study was designed for regular mathematics lessons, the scales were related to mathematics; for example, "Before I start with a mathematics task, I plan how to begin."

3.4.2. Learning Diary. In order to measure self-regulated learning on the state level, the students of the experimental group were also asked to fill out paper-and-pencil diaries for a period of six weeks. The items of the diary had to be filled out before and after performing homework tasks and were related to items of other instruments, which were already developed in this context (see [43, 54]). As with the questionnaire, they corresponded to the phases of self-regulated learning and were presented in a closed format, coded on a four-point Likert-type scale, with scores ranging from 1 to 4 (1: *I disagree*, 2: *I somewhat disagree*, 3: *I somewhat agree*, and 4: *I agree*). Altogether, the students had to estimate 19 items which asked for their daily learning behavior at home. Therefore, the items were worded concerning the current learning behavior for that day. Before doing their homework, the students had to answer eight items with regard to the processes of the forethought phase (e.g., goal setting: "I know exactly what I want to learn today" or intrinsic value: "Today, I have a mind to learn"). After having finished their homework, they were asked to answer eleven items related to processes of the volitional control phase and the self-reflection phase (e.g., attention focusing: "Today I've learned very concentratedly" or self-recording: "Today while learning, I thought about my learning process").

A split-half reliability was calculated (odd-even coefficient) by dividing the days for each person into two groups, one with even numbers and one with odd numbers. The mean values of each person were correlated for the variables. Table 4 shows the detailed results for each self-regulatory variable, which was measured by the diary. All variables correlated highly significantly ($P < .001$).

3.4.3. Mathematics Test. Additionally, the students had to work on a standardized mathematics test [62] consisting of eight tasks altogether, which dealt with arithmetic, calculations concerning practical problems, and geometry. As the students were asked to work on it before and after the intervention, two versions were administered which were similar regarding item difficulty (approximately $P_i = .67$) and item-scale correlation (approximately $r_{i(t-i)} = 0.33$). The students were able to reach a maximum number of ten points.

3.4.4. Teacher's Register. As the training was carried out by teachers, it was interesting to measure teachers' evaluation of the learning materials including the instructions. The teachers' assessments of the learning materials were used as an indicator for the implementation of the materials. Therefore, a kind of teacher's register was handed out to teachers in order to evaluate each unit regarding design, applicability, and comprehensibility. With respect to a teacher's daily work routine, the evaluation system followed the German system of notation (1: *very good,* 2: *good,* 3: *satisfactory,* 4: *adequate,* 5: *poor,* and 6: *insufficient*). Additionally, the teachers were asked to estimate the motivation of their students while working on the learning materials (1: *not motivated*, 2: *less motivated*, 3: *motivated*, and 4: *very motivated*). A further function of this register was to give teachers an opportunity for feedback and suggestions for useful variations of the learning materials.

4. Results

Following the succession of the hypotheses, the results of the longitudinal data are reported firstly followed by the tests of time series hypotheses.

4.1. Results of the Longitudinal Analyses

4.1.1. Pre/Postanalysis of the Self-Regulation Questionnaire. The research questions postulated that training on self-regulated learning leads to an improvement of self-regulated learning variables. We expected no changes for the untrained

Table 5: Descriptive data of the self-regulated learning variables and results for the interaction time × training.

DV time ∗ training	Group	M (SD) Pretest	Posttest	df	F	η^2
Overall scale						
Self-regulated learning	CG	3.16 (.40)	3.02 (.58)	1, 133	6.58*	.05
	EG	3.12 (.42)	3.16 (.50)			
Scales						
Goal setting	CG	3.42 (.45)	3.42 (.48)	1, 133	3.99*	.03
	EG	3.29 (.55)	3.46 (.52)			
Strategic planning[a]	CG	3.38 (.55)	3.16 (.71)	1, 133	5.74*	.04
	EG	3.12 (.62)	3.28 (.59)			
Intrinsic value	CG	3.17 (.64)	2.96 (.71)	1, 133	6.68*	.05
	EG	3.35 (.66)	3.37 (.64)			
Attention focusing	CG	3.24 (.50)	3.13 (.56)	1, 133	.95	.01
	EG	3.26 (.60)	3.25 (.65)			
Self-recording[a]	CG	3.33 (.59)	3.08 (.78)	1, 133	4.51*	.03
	EG	3.12 (.64)	3.20 (.66)			
Self-evaluation	CG	2.88 (.68)	2.86 (.79)	1, 133	.03	.00
	EG	2.94 (.61)	2.90 (.85)			
Causal attribution	CG	3.08 (.67)	3.00 (.64)	1, 133	1.19	.01
	EG	3.06 (.61)	3.12 (.61)			

CG: control group (N = 72); EG: experimental group (N = 63).
[a]Because of pretest differences, MANCOVA with pretest values as covariate was conducted.
*$P < .05$.

group (control group). The differences between the experimental group and control group were calculated by means of analyses of variance, with time as a repeated measurement factor. As it was not possible to randomly assign the students to the conditions, the pretest differences were controlled first. Regarding self-regulated learning variables, significant pretest differences between the groups were found for the scales strategic planning, $t(133) = 2.57$, $P = .01$, $d = .43$, and self-recording, $t(133) = 2.09$, $P = .04$, $d = .34$. As can be seen, the students of the experimental group reported higher pretest values than the students of the control group did (see Table 5). Because of these pretest differences, analyses of covariance with the pretest value as covariate were conducted to control these differences. Table 5 gives an overview of the results of interaction time × training, as well as means and standard deviations for the overall scale and the scales. The results indicate a significant interaction effect for the overall scale self-regulated learning, $F(1, 133) = 6.58$, $P = .01$, $\eta^2 = .05$, as well as for the scales goal setting, $F(1, 133) = 3.99$, $P = .04$, $\eta^2 = .03$, and intrinsic value, $F(1, 133) = 6.68$, $P = .01$, $\eta^2 = .05$. There were no significant interaction effects for the scales attention focusing, self-evaluation, and causal attribution. Regarding strategic planning and self-recording, the results of the analysis of covariance showed significant effects for both scales (strategic planning: $F(1, 133) = 5.74$, $P = .02$, $\eta^2 = .04$; self-recording: $F(1, 133) = 4.51$, $P = .04$, $\eta^2 = .03$).

Regarding the overall scale self-regulated learning, there was a small nonsignificant increase among the students of the experimental group, whereas a significant decline was found for the students of the control group, $t(71) = 3.36$, $P = .001$, $d = 0.41$. With respect to the self-regulated learning variables, this significant decline for the students of the control group was also detected for the scales strategic planning, $t(71) = 2.73$, $P = .01$, $d = 0.32$, intrinsic value, $t(71) = 4.06$, $P = .00$, $d = 0.49$, and self-recording, $t(71) = 2.82$, $P = .01$, $d = 0.33$. For the students of the experimental group, there was a significant increase concerning the scale goal setting, $t(61) = -2.28$, $P = .03$, $d = 0.28$. Figure 2 presents the results for the students' self-regulated learning and mathematical achievement separately for experimental and control group.

4.1.2. Pre/Postanalysis of the Mathematics Test. Regarding the mathematical competencies of the students, the experimental group as well as the control group should improve their mathematics achievement because both groups were continuously taught in mathematics. However, the experimental group should benefit from training on self-regulated learning strategies in terms of a greater increase in their mathematics achievement. The results of the t-test showed that the mathematical competencies of both groups were improved after the training period (see Figure 2). Regarding the effect size, the experimental group showed a stronger increase, $t(62) = -5.29$, $P = .00$, $d = .68$, than the control group, $t(71) = -2.61$, $P = .01$, $d = .31$.

In addition, it was examined if a training effect could be found. As there were significant pretest differences between the groups of the overall measure (sum over all tasks of the test), an analysis of variance was conducted with pretest values as covariate. The results showed no significant training effect.

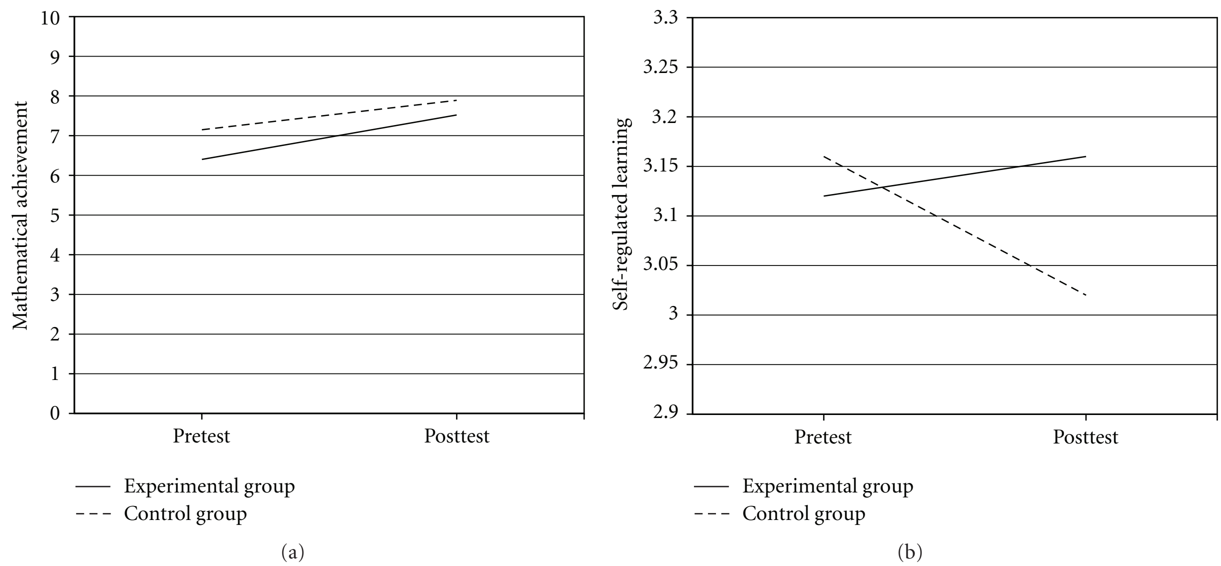

Figure 2: Interaction time × group for the overall scale self-regulated learning as well as for mathematical achievement. Mathematical achievement measures could take values from 0 to 10; self-regulated learning was rated on a four-point scale.

4.1.3. Follow-Up Measurement. The students of the experimental group received the same questionnaire again in order to measure the stability of the training's effect after a period of twelve months. The data of the variables should be stable, which means that no significant additional effects were expected and that the values should not decrease significantly. Therefore, the assumption that there were no changes regarding goal setting, strategic planning, intrinsic value, self-recording, self-evaluation, attention focusing, causal attribution, and the overall scale self-regulated learning was tested and the alpha-level was increased to 20% [63]. In general, results show that the variables did not change significantly between the posttest and the follow-up measurement. Table 6 shows the detailed results for the scales as well as for the overall scale self-regulated learning.

4.2. Results of the Training Evaluation Based on Process Data. In order to describe the training evaluation based on process data of the experimental group, interrupted time series were conducted for the trained self-regulated learning variables related to the units of the learning materials and trend analyses were conducted for the untrained variables self-efficacy, self-recording, and self-evaluation. As 70% of the diaries were filled out with more than 22 data points (>73%), data for the variables of the learning diary were aggregated from 44 students and included into analyses. Therefore, the mean of the variable computed across all participants could be generated for each day. In order to examine the training effects for the components related to the units based on the learning diary data, a multiple baseline design was used and interrupted time series analyses were conducted. Step functions were expected to show an immediate impact and to continue over the long term. In order to analyze ARMA processes, the residuals were used [64]. With the residual data, autocorrelations and partial autocorrelations were conducted to identify ARMA processes.

In Table 7, the results for the trained variables of each unit are depicted. The first column represents the subscales of the diary. The b_0 score shows the intercepts for the variable as an indicator for the basic level, whereas b_1 is the indicator for the change level. Using the t-score, the means before (baseline) and after the training can be analyzed to expose changes. The ARMA model describes how the level of the variable, measured at a previous point in time, influences the same variable at a following point in time. The number of terms in autoregressive (AR) terms of the model reports the dependency among successive observations. Thereby, each term has an associated correlation coefficient that describes the magnitude of this dependency. With regard to the moving average (MA) terms, the model represents the persistence of a random shock from one observation to the next. After the model estimation, (partial) autocorrelations were computed in order to test white noise residuals (with Ljung-Box-Q test).

The results showed that after the first training unit, students reported having been able to improve their goal setting strategies ($t = 4.64$, $P = .00$). The second unit caused no enhancement with respect to the variable strategic planning. After the third unit, the variable intrinsic value improved significantly ($t = 2.65$, $P = .01$). In contrast, with respect to the variables attention focusing and causal attribution, there were no effects of the fourth and fifth units. However, the variable causal attribution showed AR (1) process. For the other variables, there were no dependencies among successive observations (white noise).

Additionally, trend analyses were conducted for the variables that were not explicitly trained but should have been influenced by the intervention. Because of the reactivity effect (see [65–67]), positive linear trends were expected for the nontrained variables self-efficacy, self-recording, and self-evaluation, as well as for the overall scale self-regulated learning. Regarding the variables self-efficacy and

Table 6: Results of the t-tests for follow-up measurements of the experimental group.

Scale	M (SD) Posttest	Followup	df	t^{a}	P	d
Goal setting	3.47 (.51)	3.44 (.53)	57	.49	.62	.15
Strategic planning	3.29 (.58)	3.16 (.60)	57	1.41	.16	.18
Intrinsic value	3.39 (.62)	3.46 (.55)	57	−.84	.40	.11
Attention focusing	3.27 (.62)	3.15 (.53)	57	1.69	.10	.21
Self-recording[b]	3.21 (.67)	3.06 (.73)	57	1.63	.11	.22
Self-evaluation	2.93 (.83)	2.83 (.76)	57	.92	.36	.12
Causal attribution	3.11 (.61)	3.04 (.61)	57	.65	.52	.09
Overall scale						
Self-regulated learning	3.16 (.46)	3.08 (.40)	57	1.49	.14	.19

$N = 58$ (three students were absent on the day of the follow-up measurement); d: effect size.
[a] −indicates an increase, +indicates a decrease.

Table 7: Results of the interruption time series analysis to examine the effects of the intervention.

	b_0	b_1	t	ARMA models	ARMA parameter	t
Kickoff: baseline						
1st unit: goal setting	2.91	.66	4.64**	W.N.		
2nd unit: strategic planning	3.39	.18	.98	W.N.		
3rd unit: intrinsic value	3.12	.45	2.65*	W.N.		
4th unit: attention focusing	3.48	.11	.58	W.N.		
5th unit: causal attribution	3.61	−.24	−1.31	AR (1,0)	.68	4.86**

b_0: basic value, b_1: change; W.N.: white noise.
$^{*}P < .05$, $^{**}P < .01$.

self-evaluation, there were no significant changes, whereas significant linear trends were found with respect to self-recording ($P = .04$; $b_0 = 3.07$; $b_1 = .01$; RSQ = .14) and self-regulated learning ($P = .03$; $b_0 = 3.31$; $b_1 = .01$; RSQ = .16). Thereby, the time trend over a period of 30 days could explain 14% of the variance of self-recording and 16% of the variance of self-regulated learning. Figure 3 shows the results for the linear trend of the overall scale self-regulated learning.

4.3. Teachers' Evaluation of the Learning Materials. The teachers' assessment of the learning materials regarding their design, application, and comprehensibility ranged between 1.60 and 1.67 (design: $M = 1.60$, SD = .72; applicability: $M = 1.73$, SD = .95; comprehensibility: $M = 1.67$, SD = .61). The students' motivation while working on the learning materials was estimated with a mean value of 3.30 (SD = .62). Based on these results, the implementation of the learning materials should be carried out successfully.

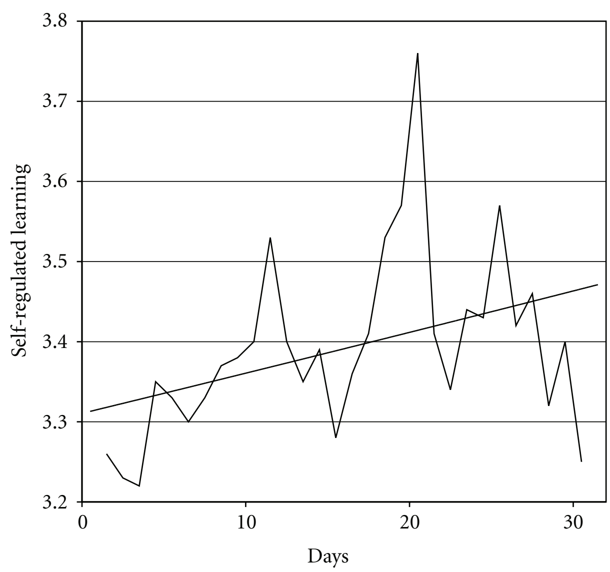

Figure 3: Trajectory and linear trend for self-regulated learning measured on a four-point scale.

5. Discussion

The aim of the intervention was the enhancement of fourth grade students' self-regulated learning by working on interdisciplinary teaching materials, which were related to particular strategies of Zimmerman's self-regulation model [8]. By means of analyses of variance with time as repeated measurement factor, significant interaction effects were found for the overall scale self-regulated learning, as well as for the scales goal setting, intrinsic value, strategic planning, and self-recording.

Regarding the results within the groups, it could be pointed out that the overall scale self-regulated learning did not change in the expected direction. Instead of a significant increase for the experimental group, there was a significant decrease for the control group, whereas for the experimental group the overall scale remained stable. Regarding the experimental group, this result for the overall scale was supported by the results of the scales strategic planning, intrinsic value, attention focusing, self-recording, self-evaluation, and causal attribution. Except for the scale goal setting, a significant increase was found as expected. For the control group, the results of the scales strategic planning, intrinsic value, and self-recording showed a significant decline as did the overall scale self-regulated learning. Twelve months after training, the students of the experimental group filled out the same questionnaire again, in order to measure stability of intervention effects. There should be no significant change of the data according to an increase or decline. The results show that all scales were stable after a period of twelve months.

Besides the improvement in students' self-regulated learning, we also expected an effect with respect to students' mathematical achievement. As the learning materials were related to mathematical contents and implemented during regular mathematics lessons, we dealt with the question of whether there was a supportive effect of self-regulated learning on students' mathematics achievement [5]. Regarding the effects between the groups, no significant interaction effect was found. The results showed an enhancement for the experimental group as well as for the control group. As both groups have been taught mathematics, this increase was not unexpected. Regarding the effects within the groups, we expected a greater increase in mathematics achievement for the experimental group than for the control group. With respect to the effect sizes, the students of the experimental group showed better improvement in their mathematics achievement than the control group did. These results were in line with Perels et al. [49]. In their study, they also found an improvement for both groups, but a greater increase for the students belonging to the experimental group.

On the level of process data, interrupted time series analyses indicated an increase in value of some of the trained variables in the expected direction after the training. In detail, this was the case for the variable goal setting after the second unit, as well as for the variable intrinsic value after the fourth unit. Regarding strategic planning, attention focusing, and causal attribution no significant changes were found. Additionally, linear trends were performed for the nontrained variables self-efficacy, self-recording, and self-evaluation, as well as for the overall scale self-regulated learning. Although these variables were not part of the training, the students had to answer items corresponding to them by filling out the diary each day. Therefore, we expected an influence in terms of the reactivity effect [27, 65]. Regarding the scale self-recording and the overall scale self-regulated learning, significant linear trends were found as expected whereas there were no trends for the variables self-efficacy and self-evaluation. The absent linear trends for these variables are in contrast to the results of other studies (see, e.g., [43, 67]). Therefore, the postulated reactivity effect [65] has to be considered critically because evidence for it was limited. In this study, the learning diary primarily seemed to serve as an evaluation instrument and not as a part of the intervention.

In summary, the results lead to the assumption that the learning materials seemed to be beneficial with regard to fourth grade students' self-regulated learning and mathematics achievement. However, the results of the pretest and posttest measurements for self-regulated learning have to be discussed critically. Regarding the experimental group, there was only a small, nonsignificant increase found for the overall scale and the scales strategic planning, intrinsic value, attention focusing, self-recording, self-evaluation, and causal attribution. Additionally, no interaction effects were found for the variables attention focusing, self-evaluation, and causal attribution. As the variables self-recording and self-evaluation were not involved as part of the training, this result was not unexpected. Obviously, it was not possible to improve these variables by training other specific processes of self-regulated learning. With respect to the other variables, the lack of effects was not expected. It can be discussed as to whether there was enough time to practice and transfer the strategies of these units, which were very complex. The students worked on the teaching materials for the duration of one lesson per week and had to deal with one task per training session. It would probably have been useful if the students had worked on more than one task during each training session to make sure that they transferred the learned strategies to their everyday work. Furthermore, it may be possible that the imparted strategies initially interfere with already existing strategies [68]. As the study was realized at grade four, the students may already have developed their own strategies to regulate their learning behavior. Greater effects might be expected when there is a continuous and fairly long-term instruction of self-regulated learning in regular classes [69].

Moreover, there are limiting factors and unanswered questions regarding this study: for the assessment of self-regulated learning, only self-report methods (questionnaire and learning diary) were used. These self-report methods only measured students' evaluation of their use of strategies, but not their actual use [70]. In future research, multimethod approaches should be used. In this study, the students were also videotaped during regular mathematics lessons (before and after the intervention phase). For further analysis, the observation data has to be analyzed and referred to the results of the self-report data. Consequently, it will be possible to analyze if students actually used the self-regulated learning strategies supported by the learning materials. In this context, also other on-line methods like thinking-aloud protocols might be of interest (see [71]).

Additionally, there is another question concerning the measurement of self-regulated learning. By using learning diaries, we were able to assess and analyze students' self-regulated learning on a daily basis. Following Schmitz and Wiese [9], we used this data as process data to conduct time series analysis. This approach has to be regarded critically because learning diaries represent self-report measurements. It has to be questioned to which extent this data could be concerned as process data.

Another limitation concerns the state aspect of Zimmerman's model [8]. He postulated that self-regulation is an adaptable and cumulative process. According to these assumptions, his self-regulation model tends to focus on state aspects of self-regulation. However, in the study we used self-report data, which rather concerns trait aspects of self-regulation. Thus, there is a discrepancy between the theoretical framework of the study and the chosen assessment methods. However, other authors, such as Schmidt [54] or Hong and O'Neil [72], regard self-regulation at both the state and trait levels. They hypothesize that academic self-regulation consists of transitory (meta)cognitive states and relatively stable (meta)cognitive traits. For example, students with high self-regulatory traits tend to use their metacognitive skills more effectively than students with low trait self-regulation [73]. Hong [74] compared state and trait self-regulation models and came to the conclusion that every self-regulation state refers to a general trait component (see also [75]). Furthermore, she reported high correlations between state and trait constructs (see also [76]). Therefore, analyzing self-regulatory traits by using questionnaire data makes assumptions about self-regulatory states, as postulated in Zimmerman's self-regulation model [8].

Furthermore, the implementation of the developed learning materials has to be discussed because the contents of the units were imparted by the teachers themselves. From the teachers' point of view, the learning materials and the instructions were evaluated as very good to good with respect to design, applicability, and comprehensibility. Furthermore, the teachers estimated the motivation of their students while working on the learning materials to be very positive. These estimations indicate that the developed teaching materials could be successfully implemented in the regular classroom situation. In fact, an innovation such as these learning materials can be evaluated as being successfully introduced as soon as the teachers have adopted it [77]. Adoption in this context means that the teachers are able and willing to implement an innovation into their lessons. Moreover, they have to feel confident in their ability to adapt it to the needs and abilities of their students. Following Bitan-Friedlander et al. [78], teachers' adoption of an innovation in the educational field depends on "agreeing with the theoretical content and with the pedagogical value of the innovation" [78, page 617]. The extent to which an innovation might be adopted by a teacher can be defined in terms of the teacher's personal concerns. In the present study, the teachers expressed being excited about the learning materials. However, there were no other clues as to what extent the teachers were involved and motivated to work with the learning materials. For further studies, this might be an interesting and helpful approach.

Another limitation refers to the question of how the students were assigned to the experimental and the control group. As the learning materials needed to be implemented by teachers into students' regular learning environment, it was not possible to realize a randomized assignment of the students to experimental and control group. Therefore, students' pretest values of self-regulated learning and mathematical achievement were controlled.

Finally, the significant interaction effect for the overall scale self-regulated learning and the scales goal setting, intrinsic value, strategic planning, and self-recording mainly occurred due to the significant decline of the control group. This decline was not expected and cannot be explained in the framework of this study. For further intervention research, it might be worthwhile to assess more information concerning the control group.

In this context, it also might be of interest to design an intervention which involves more or even all of the postulated strategies of Zimmerman's self-regulation model [8]. In our study, there had to be a focus on the selected strategies for two reasons. Firstly, the (meta)cognitive abilities of the target group had to be considered (see [40]). Secondly, the duration of the intervention was determined because the learning materials were implemented into regular mathematics lessons. This implied that the more time was spent on the learning materials, the less time could be spent on the regular mathematics contents. Therefore, and for developmental psychological reasons, the intervention was reduced to six units. However, the study involved both (meta)cognitive and motivational aspects of self-regulated learning corresponding to the three learning phases of Zimmerman's model [8]. This represents an advantage of the study in contrast to other trainings which focused either on (meta)cognitive or motivational components (for an overview, see [79]).

In summary, present findings show that it is possible to maintain a rather high level of self-regulated learning by using self-regulated learning materials which were implemented by teachers. To our opinion it is worth emphasizing that the embedding of specific self-regulated learning strategies into regular mathematics lessons was not at the cost of students' mathematical achievement, but supported it. Thus, it might be assumed that if an improvement of students' self-regulated learning occurs, this improvement might be related to improvements in mathematical achievement. Further studies should investigate if and under what conditions this assumption holds true. Therefore, the learning materials should be optimized and the evaluation instruments adapted to other subjects.

The present study implies practical consequences of creating powerful learning environments for supporting self-regulated learning. As the results show, it is possible to embed self-regulated learning strategies in regular lessons by using interdisciplinary learning materials. As self-regulated learning represents an important factor for academic and lifelong learning [80], teaching these strategies should be integrated into regular elementary school lessons in order to improve the development of advantageous learning behavior as early as possible.

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Research Article

The Use of Solved Example Problems for Fostering Strategies of Self-Regulated Learning in Journal Writing

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Writing learning journals is a powerful tool to integrate self-regulated learning in classrooms. However, to exploit the full potential of journal writing, instructional support is needed that addresses the students' deficits in the use of self-regulated learning strategies. A promising means to foster learning strategies in learning journals is the provision of solved example problems along with prompts. In a quasiexperimental field study, we provided fifth-grade students ($N = 48$) with solved example problems along with prompts either right from the beginning of writing their journals or after they had already written two learning journal entries. We found that the provision of solved example problems along with prompts right from the beginning of the journal writing process fostered the quality of both cognitive and metacognitive strategies and conceptual knowledge in the initial phase. The delayed provision of solved example problems after an initial phase of journal writing yielded a detrimental effect on the quality of cognitive strategies and a beneficial effect on the quality of metacognitive strategies. In sum, our results suggest that the provision of solved example problems along with prompts right from the beginning of journal writing can effectively support fifth-grade students in overcoming deficits in the use of self-regulated learning strategies.

1. Introduction

Self-regulated learning is the ability to actively and constructively engage in a process of meaning generation in order to attain learning goals (see [1]). For instance, fifth-grade students who have just received an introductory lesson on fractional arithmetic might strive to self-regulate their understanding of the new topic by reflecting on the lesson contents at home. A key issue for effective self-regulated learning is the students' ability to apply learning strategies (e.g., [2, 3]). Specifically, according to current theoretical process models of self-regulated learning, the application of both cognitive and metacognitive learning strategies is at the heart of the *action*- or *performance-phase* in the course of self-regulated learning (e.g., [4, 5]; see also [6]). Cognitive learning strategies embrace both organisation and elaboration strategies [7]. Thus, students who strive to self-regulate their understanding of a new topic after they have left the classroom should, for instance, (a) organise the new learning contents in a meaningful way by identifying main ideas (e.g., "Today we learned the concept of fractions. A fraction describes how many equal parts an area is divided into."), and (b) elaborate on new contents by generating their own examples (e.g., "An example for the concept of fractions is when I divide my birthday cake into 12 equal pieces. In this case, each piece is 1/12 of my birthday cake."). Furthermore, the learners should engage in metacognitive learning strategies and thus try to (c) monitor their own understanding to identify comprehension problems (e.g., "I did not understand how fractions (e.g., 1/4 litre of milk) can be converted to "normal" numbers.") and, in case that they identified comprehension problems, to plan remedial activities in order to overcome the specific problems.

However, empirical findings show that the students' learning behaviour rarely conforms to this normative ideal of self-regulated learning. For instance, Rachal et al. [8] showed that many college students hardly ever apply effective cognitive and metacognitive strategies. Given that the use of self-regulated learning strategies is strongly linked to age (e.g., [9]), fifth-grade students can be expected to show even larger deficits in applying effective strategies of self-regulated learning.

A viable means to foster strategies of self-regulated learning is writing learning journals. This activity, as conceptualised in this paper, requires students to write down their reflections on the learning contents from a previous lesson (see [10]). Specifically, journal writing can be conceived as a means to foster cognitive and metacognitive learning strategies as defined by Weinstein and Mayer [11]. When it comes to cognitive strategies, students should try to identify and structure the main contents from a previous lesson (i.e., organisation) in their learning journals. The learners therefore focus on the central contents to be learned and construct *internal* links that relate relevant aspects of a new topic to each other. Furthermore, the students should elaborate on new learning contents by generating their own examples for abstract principles and concepts or by generating possible applications of new principles in everyday life. These elaboration strategies serve the construction of *external* links that help learners to integrate new contents into their prior knowledge (see [11]). In the selecting-organising-integrating theory of active learning (e.g., [12]), organisation and elaboration (i.e., cognitive learning strategies) are essential for meaningful learning because they help learners to both build coherent mental representations of new contents and to deeply integrate these representations with their prior knowledge. Correspondingly, empirical findings in the field of journal writing show that cognitive learning strategies are crucial for beneficial effects on learning outcomes [13].

Besides fostering cognitive learning strategies, writing learning journals is further intended to elicit metacognitive learning strategies. Metacognition refers to learners' knowledge about their own cognitive processes and their ability to control and manage those processes (see [11]). In the course of journal writing, learners should engage in the metacognitive strategy of comprehension monitoring. Comprehension monitoring can help learners to detect gaps in their understanding and thus to avoid illusions of understanding (e.g., [14]). If learners detected comprehension difficulties, they can then plan courses of action intended to remedy them. Hence, the identification of specific comprehension problems should ideally be the onset for developing further cognitive learning strategies that are in service of overcoming the specific problems (see e.g., [15]). In sum, in the course of writing learning journals, students should apply cognitive and metacognitive learning strategies that are crucial for effective self-regulated learning. However, even though writing learning journals may serve as a medium for applying cognitive and metacognitive strategies of self-regulated learning, empirical studies show that simply requiring learners to write learning journals is not sufficient enough to foster the respective strategies. Specifically, empirical studies show that neither advanced high-school students [16] nor university students [13, 17] sufficiently engage in cognitive and metacognitive strategy use in their learning journals if there is no instructional support.

Against the background of research on strategy development, it can be assumed that learners' deficits in applying cognitive and metacognitive strategies in learning journals might be due to different reasons. More specifically, Flavell et al. [18] identified two different reasons for deficiencies in the use of learning strategies, namely, *production deficiencies* and *mediation deficiencies*. A production deficiency implies that learners already have the necessary cognitive skills to effectively use a strategy, but do not do so spontaneously. A mediation deficiency means that learners do not use learning strategies because they lack the necessary cognitive requirements to apply them (see also [19]). A third possible deficiency which has been identified in the development of learning strategies is the *utilisation deficiency* [20]. In contrast to production and mediation deficiencies, utilisation deficiencies do not imply that learners do not use learning strategies [20]. Rather, a utilisation deficiency is diagnosed when learners do not benefit from strategies in the initial stage of usage. One explanation for deficient utilisation is that the application of an unfamiliar learning strategy might require learners to invest large parts of their available cognitive capacity, leaving few capacities for content learning. Depending on the type of deficiency that causes the learners' strategy deficits, different instructional means of fostering learning strategies in writing learning journals should be considered (see [16]).

Prompts have been widely used as an instructional means to overcome production deficiencies in learning journals. Prompts are basically questions or hints that are designed to induce productive learning processes in order to overcome shallow processing on part of the learners (see e.g., [21, 22]). In the course of writing learning journals, prompts can be conceived as learning strategy activators [23]. Hence, prompts are designed to *activate* learning strategies but do not provide instructional guidance on how to apply the respective strategies to a high standard. For instance, prompts designed to induce cognitive learning strategies include questions such as, "In your opinion, what are the main points?" (i.e., organisation prompt, see [13]) or "Which examples can you think of that illustrate the learning contents?" (i.e., elaboration prompt; see [13]). In experiments with university students, prompts to induce cognitive and metacognitive strategies were found to foster both high-quality strategies of self-regulated learning and learning outcomes (e.g., [13, 15, 24]). However, studies with high school students revealed less promising results. Specifically, a study with advanced high school students (mean age = 17.62 years) suggests that providing learning strategy prompts is not sufficient enough to foster the use of high-quality cognitive and metacognitive strategies in the learning journals of these learners [16]. Thus, the effectiveness of prompts designed to induce cognitive and metacognitive learning strategies seems to vary between learners of different ages. Hübner et al. [16] concluded that high school students aged around 17 years, in contrast to university students, do not yet have sufficiently developed skills to apply cognitive and metacognitive strategies. More specifically, they proposed that the lack of strategy application of high school students in prompted journal writing is mainly due to mediation deficiencies. Consequently, they argued that providing sole prompts in the course of journal writing is not sufficient for these learners. Rather, these learners would need further instructional guidance in addition to prompts which fosters the cognitive skills to apply the respective strategies in the first place.

An effective means of supporting learners in initial stages of cognitive skills acquisition is by providing worked-out examples [25, 26]. Typically, worked-out examples include the formulation of a problem, the steps taken to work out that problem, and ultimately the final solution. For the purpose of fostering the acquisition of cognitive skills used to solve algorithmic problems (e.g., problems in mathematics or physics), learning by worked-out examples has been shown to foster the acquisition of cognitive skills more effectively than learning by solving problems (e.g., [7]). Although research in the field of worked-out examples has mainly focused on algorithmic problems, there is growing evidence that example-based learning can foster the acquisition of the cognitive skills needed to solve nonalgorithmic problems as well (e.g., [16, 27, 28]). In contrast to *classical* worked examples, however, examples for nonalgorithmic problems often do not include worked-out solution steps because there are no algorithmic solutions. For example, there is no algorithm for the problem of generating a high quality response to the prompt "Which examples can you think of that illustrate the learning contents?" (i.e., for the application of a high-quality elaboration strategy). Therefore, this type of examples has been referred to as *solved example problems* (see [29]). In the course of fostering the cognitive skills needed to apply high-quality cognitive and metacognitive strategies of self-regulated learning in learning journals, a well-written learning journal example could serve as such a solved example problem.

Initial evidence for the use of learning journal examples to foster the cognitive skills to apply cognitive and metacognitive strategies was presented by Hübner et al. [16]. In a laboratory study, they provided high school students (mean age = 17.62 years) with a presentation that introduced learners to prompts in the first step and provided learners with a written learning journal example as second one. In addition, active processing of the learning journal example was elicited by requiring learners to assign passages of the learning journal to the corresponding cognitive and metacognitive prompts. They found that a solved example problem of a learning journal fostered both cognitive and metacognitive strategies in subsequent learning journals. However, in a field study with ninth-grade high school students (mean age = 14.74 years), a closely related procedure of providing both prompts and a solved example problem in an introductory presentation did not yield high-quality cognitive and metacognitive learning strategies [30]. The authors argued that providing a learning journal example in an introductory presentation might not be sufficient enough to support younger students to apply strategies of self-regulated learning in a high-quality way. Learning by worked-out examples usually implies that the worked-out examples are available until learners have gained understanding of the cognitive skill to be learned (e.g., [26, 31]). Against this background, in the present study we were interested in whether providing younger high school students (e.g., fifth-grade students aged around 11 years) with solved example problems throughout an initial phase of journal writing (e.g., their first two learning journal entries) would foster the quality of both cognitive and metacognitive learning strategies. Moreover, we addressed the open question of whether providing solved example problems throughout an initial phase of journal writing would also foster learning outcomes. Hübner et al. [16] found that although providing a learning journal example in an introductory presentation fostered the application of cognitive and metacognitive strategies in a subsequent learning journal entry, the learners did not benefit from these strategies in their initial entry. They explained this finding in terms of a utilisation deficiency (see [20]). More specifically, they argued that learners might have focused mainly on the application of cognitive and metacognitive strategies in their initial entry and thus were hardly able to devote capacity to content learning. However, as the learning journal example was withdrawn after an introductory presentation in this study, the devotion of rather large parts of the available cognitive capacity to strategy application might have partly been due to the lack of external guidance during journal writing phase. According to the *direct initial instruction principle* [32], in order to reduce cognitive load, a high level of external guidance which shows the learners exactly how to manage a task should be available throughout initial stages of learning. Therefore, it can be expected that holding solved example problems available throughout an initial phase of journal writing would yield different results. Specifically, given that the solved example problems serve as beneficial external guidance in the course of journal writing and thus decrease the cognitive capacity which has to be devoted to strategy application, it can be expected that learners have sufficient cognitive capacity left to benefit from the applied strategies.

Besides these open questions with respect to the effects of solved example problems of a learning journal in an initial phase of journal writing, it is uncertain as to whether the solved example problems could be withdrawn in a second phase of journal writing (e.g., after the first two learning journal entries) without negative effect on the quality of the students' learning strategies. In this respect, the descriptive measures reported in the study by Hübner et al. [16] suggest that—although not explicitly analysed by the authors—the learning strategy measures decreased from an initial learning journal entry to a second entry. However, this effect might also have been due in part to the short-term intervention in this study. Thus, in the present study we addressed the question as to whether the quality of learning strategies would also decrease if learners could draw on the solved example problems throughout writing their first two learning journal entries. As learners have more time to internalise the external guidance provided by the solved example problems in this case, the quality of their learning strategies might remain stable after the solved example problems have been withdrawn.

Another open issue addressed by the present study regarding the use of solved example problems of learning journals is whether it is important to provide them right from the beginning of journal writing (i.e., in an initial phase) or whether delaying the provision of solved example problems yields comparable effects. For instance, for the purpose of motivating learners by experiencing the thrill of independent success (see [33]), teachers could withhold external guidance by solved example problems in an initial phase to provide students with the opportunity to find solutions to the prompts on their own. However, providing young high school students who do not yet have the cognitive skills needed to apply cognitive and metacognitive strategies of self-regulated learning with sole prompts in an initial phase of journal writing basically resembles requiring learners to solve problems in the initial phase of cognitive skills acquisition. In this case, the students have to draw on their rather low level of internal guidance when they respond to the prompts (i.e., when they solve the problems) probably resulting in the use of learning strategies of low quality (e.g., [16, 34]). However, given that these learners do not completely fail to respond to the prompts, learners might nevertheless acquire strategies to respond to the prompts in the initial phase. Hence, it is reasonable that these learners can already draw on higher internal guidance when they receive solved example problems in a second phase of journal writing than learners who receive solved example problems right from the beginning. In this case, it can be expected that providing solved example problems designed to support learners in the initial stage of the acquisition of the skills needed to apply cognitive and metacognitive learning strategies forces learners to engage in reconciliation processes between their internal guidance (e.g., their strategy to respond to the cognitive prompts) and the external guidance provided by the solved example problems. Cognitive load theory [7, 35] provides a powerful and elaborate explanation for the consequences of such reconciliation processes. More specifically, in cognitive load theory, such reconciliation processes between internal and external guidance are referred to as sources of additional cognitive load in working memory [36, 37]. Hence, given that the capacity of working memory is limited [38], requiring learners to engage in reconciliation processes decreases the learners' resources available for the execution of beneficial learning activities (see [36]). Thus, the delayed provision of solved example problems after students have responded to the prompts on their own in an initial phase of journal writing might result in less cognitive capacity available to apply the prompted strategies to a high standard. As a consequence, these learners might not—at least in the short-term—benefit from the delayed provision of solved example problems with respect to learning strategies and learning outcomes.

2. Overview of the Study and Research Questions

The provision of solved example problems in an introductory presentation is a promising instructional support feature in addition to prompts designed to foster cognitive and metacognitive strategies of self-regulated learning in advanced high school students' learning journals [16]. However, providing a solved example problem in an introductory presentation did not yield high-quality learning strategies in younger high school students' learning journals (see [30]). As younger high school students might need more time to acquire the cognitive skills to apply cognitive and metacognitive strategies, these learners might benefit from solved example problems which are available throughout an initial phase of journal writing. However, the effects of providing solved example problems throughout an initial phase of journal writing have hardly been explored. Furthermore, it is an open question as to whether the effects of solved example problems depend on the insertion point. Specifically, to avoid load-consuming reconciliation processes between the external guidance by solved example problems and learner-generated strategies to respond to the prompts, it might be crucial that learners can draw on solved example problems right from the beginning of journal writing. Against this background, we present a quasiexperimental field study which is concerned with the effects of the immediate or delayed provision of solved example problems in addition to prompts to foster both strategies of self-regulated learning in learning journals and learning outcomes. Specifically, we addressed the following research questions

(1) Does the provision of solved example problems in addition to prompts in an initial phase of journal writing foster the quality of both cognitive and metacognitive strategies of self-regulated learning?

(2) Does the provision of solved example problems in addition to prompts in an initial phase of journal writing foster learning outcomes?

(3) Does withdrawing the solved example problems in a second phase of journal writing influence the quality of both cognitive and metacognitive strategies of self-regulated learning?

(4) Does the delayed provision of solved example problems in a second phase influence the quality of both cognitive and metacognitive strategies of self-regulated learning?

(5) Do learners who receive solved example problems in an initial phase of journal writing differ from learners who receive solved example problems in a second phase of journal writing with respect to learning outcomes at the end of the second phase?

3. Method

3.1. Sample and Design. Fifth-grade students ($N = 57$) from two German high school classrooms wrote learning journals in mathematics over the course of four lessons. Nine of the students missed at least one lesson during the study. Therefore, complete data were available for $N = 48$ students (31 females, 17 males). Their average age was 11.21 years ($SD = 0.46$). The average mathematics grade did not differ between the two classrooms (classroom A: 2.00, $SD = 0.65$;

Table 1: Prompts used in this study (translated from German).

Cognitive Prompts
Organisation
(1) "Describe and explain the main contents of the last mathematics lesson. For this purpose, you can also compose a chart that highlights the main contents."
Elaboration
(2a) "Can you create links between the contents of the last mathematics lesson and your knowledge from everyday experience?"
(2b) "How could you apply what you have learned in your spare time? Create an example." (the learners could choose to which prompt they wanted to respond to)
(3) "Create your own task with a solution that reflects the contents of the last mathematics lesson. Describe your task in a way so that a classmate could work on it. The task should be difficult. However, you should be able to solve the task."
Metacognitive prompt
Monitoring
(4) "Which part of the last mathematics lesson have you not understood yet?"

classroom B: 1.79, SD = 0.65; $t(46) = 1.09$, $P = .279$; the best grade in German schools is 1, the worst is 6). The two classrooms received parallel lessons during the study. That is, during the four lessons of the study, the two classrooms were taught the same subject matter (i.e., fractional arithmetic) in the same sequence by the same teacher.

Our field study had a quasiexperimental switching treatments design with two conditions: (a) prompts and (b) prompts plus solved example problems. Thus, our study had two phases. At the end of the first phase, the treatments were switched between the classrooms. A coin toss decided that classroom A received prompts in the first phase and prompts plus solved example problems in the second phase. Correspondingly, classroom B received prompts plus solved example problems in the first phase and sole prompts in the second phase. The students received the same prompts in both phases of the study. All students wrote two learning journal entries in each phase.

3.2. Materials. A major challenge in constructing the materials was to adequately take into account the learning prerequisites of fifth-grade high school students. In addition, as the regular teacher of the two classes had to deliver all materials, it was important to ensure a high level of teacher commitment to the materials. Therefore, we developed all materials in close cooperation with the regular mathematics teacher of the two classes.

3.2.1. Phase 1: Instructions for Writing Learning Journals. In accordance with the principles of effective strategy instruction [39], all students were shown a slide presentation in an introductory lesson which informed them about the use of writing learning journals and how it can be done. More specifically, based on a successful informed training procedure developed by Hübner et al. [16], the students were provided with background information on the utility and functional value of the cognitive and metacognitive strategies to be elicited by the prompts. For example, the functional value of linking new contents to prior knowledge (i.e., elaboration) and of identifying problems in one's own understanding (i.e., negative monitoring) was presented. Furthermore, all students were shown four prompts that they should respond to in each of their learning journal entries (see Table 1). Three of the prompts were intended to elicit cognitive learning strategies. For example, to enhance organisation the learners were provided with the prompt "Describe and explain the main contents of the last mathematics lesson." (see Figure 1). A prompt to elicit elaboration was "How could you apply what you have learned this lesson in your spare time? Create an example." The metacognitive prompt was designed to enhance negative monitoring. These prompts roughly corresponded to prompts that had been used in studies with high school students to elicit learning strategies (see [16, 30]). The learners were required to respond to each prompt in each learning journal entry. To ensure that the prompts were available during writing the learning journals, we integrated the prompts into the learners' learning journals. More specifically, the learners were provided with folders that included pre-printed pages. On each page, one prompt was used as a heading. Thus, each learning journal entry was pre-structured by four preprinted pages. Each folder consisted of eight preprinted pages (i.e., two learning journal entries) and a covering page.

Solved Example Problems. Students in the group that received prompts together with solved example problems were shown an extended version of the slide presentation in the introductory lesson. In this extended version, the presentation of each prompt was followed by a solved example problem (see Figure 2). Each solved example problem consisted of a high-quality response to the respective prompt. As it is important in learning from solved example problems that learners understand the exemplifying domain (i.e., the domain that is used to exemplify how to use the features of a good elaboration strategy, see [28]), the high-quality responses to the prompts were based on contents that the students had learned in a previous lesson (i.e., divisors, see Figure 2). The students were told that the solved example problems were taken from learning journals of fifth-grade students who are used to writing learning journals and that

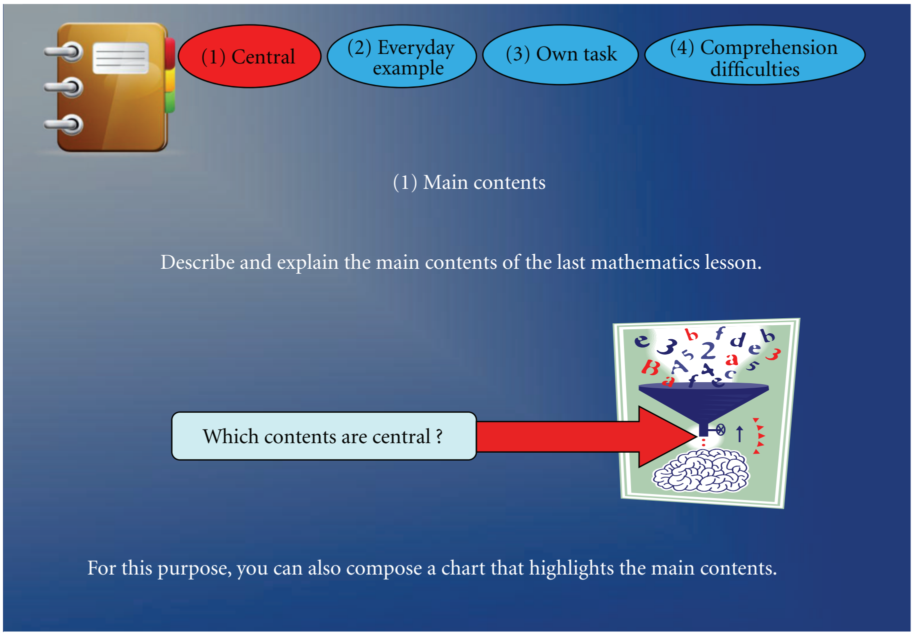


Figure 1: Screenshot of the introductory presentation: Introduction of the organisation prompt (translated from German).

the solved example problems represented good responses to the prompts. Furthermore, they were told that the solved example problems were intended to support them in responding to the prompts in their learning journals. To ensure that the solved example problems were available during writing the learning journal entries, we integrated them into the learners' learning journals. Specifically, the students were provided with the same folders as the learners without solved example problems, with the exception that the solved example problems were printed on the backs of the preprinted pages, beginning with the covering page. Hence, when learners turned the covering page, the solved example problem that corresponded to the first prompt was shown on the left side and an empty page that was headed by the first prompt was shown on the right side (see Figure 3). Thus, each learning journal entry was prestructured by four double pages.

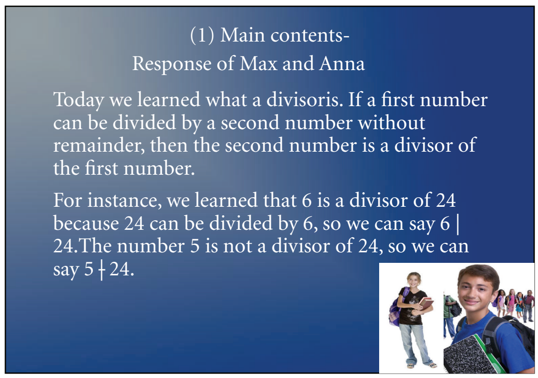
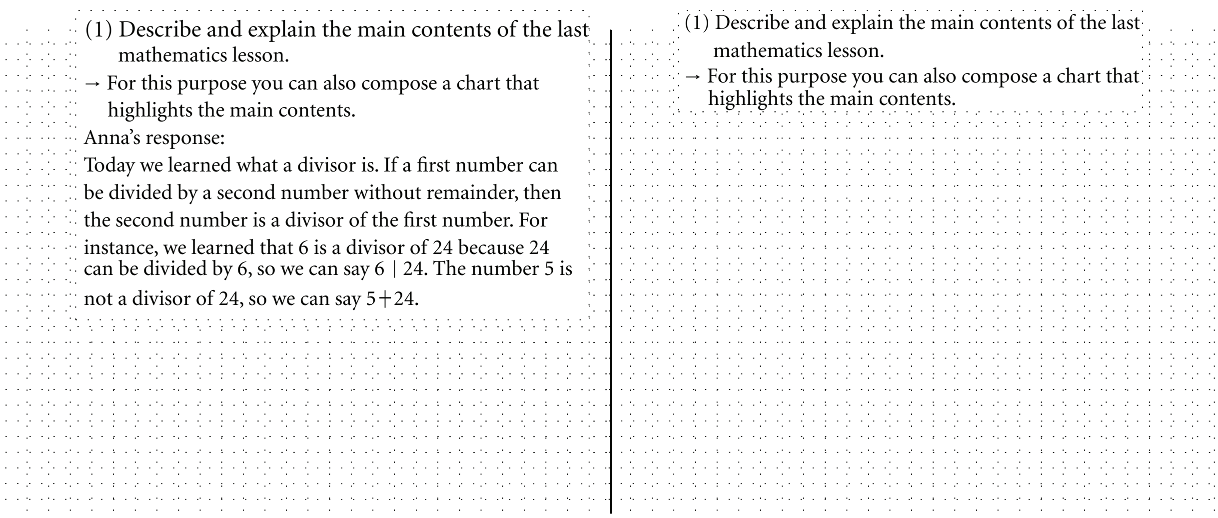


Figure 2: Screenshot of the introductory presentation: solved example problem for the organisation prompt (translated from German).

3.2.2. Phase 2: Instructions for Writing Learning Journals. The instructions that were provided in the second phase of the study (i.e., after the treatments were switched) hardly differed from the instructions that were used in the first phase. Learners from whom the solved example problems were withdrawn in the second phase were shown the same slide presentation that was shown to learners who solely received prompts in the first phase with one exception. On the first slide, the students were informed that the solved example problems were intended to support them in their initial learning journal entries. Furthermore, the students were told that—now that they had already written two learning journal entries—this support would be withdrawn and that they should try to respond to the prompts on their own. Correspondingly, students who received prompts together with solved example problems in the second phase were shown the same slide presentation that was shown to the students who received solved example problems in the first phase with one exception. On the first slide, the students were informed that they—now that they had written two learning journal entries—would receive additional support in form of solved example problems for the purpose of further improving their journal writing. Furthermore, the students were told that this would not imply that their initial learning journal entries were insufficient. The two types of folders remained the same in both phases of the study. However, the type of folders was switched between the two groups at the beginning of the second phase. All learners received new learning journal folders for their learning journal entries in the second phase.


(1) Describe and explain the main contents of the last mathematics lesson.
→ For this purpose you can also compose a chart that highlights the main contents.
Anna's response:
Today we learned what a divisor is. If a first number can be divided by a second number without remainder, then the second number is a divisor of the first number. For instance, we learned that 6 is a divisor of 24 because 24 can be divided by 6, so we can say $6 \mid 24$. The number 5 is not a divisor of 24, so we can say $5 \nmid 24$.

(1) Describe and explain the main contents of the last mathematics lesson.
→ For this purpose you can also compose a chart that highlights the main contents.

Figure 3: Preprinted learning journal pages with integrated prompt (right side) and solved example problem (left side; translated from German).

3.3. Instruments and Measures

3.3.1. Pretest: Assessment of Prior Knowledge. A pretest assessed the students' prior knowledge with respect to the topic fractional arithmetic. Specifically, the pretest consisted of five items that assessed basic knowledge of fractional arithmetic (e.g., "Henry buys five bags of potatoes. Each bag contains three-fifths kilogram. How many kilograms of potatoes has Henry bought? Illustrate your calculation."). Based on a scoring protocol, the learners' answers were scored using a 4-point rating scale ranging from 1 (*low level of understanding*) to 4 (*high level of understanding*). Two independent raters scored the written answers of 20 participants. Interrater reliability as determined by the intraclass coefficient was very good ($ICC_{2,1} = .91$). As interrater reliability was very good, just one rater scored the rest of the written answers.

3.3.2. Analysis of the Learning Journals. To assess the quality of the cognitive and metacognitive learning strategies in the learning journals, the written responses to the four prompts were analysed. For each prompt, we applied 4-point rating scales ranging from 1 (*very low quality*) to 4 (*very high quality*) to assess the quality of the respective prompted learning strategy. The rating scales were developed on the basis of the rating scales of Berthold et al. [13] and Glogger et al. ([30]; see also [34]). The responses to the organisation prompt were rated very high if the main contents of the last lesson were highlighted in a clear and structured way (e.g., "Today we learned the concept of fractions. A fraction describes how many equal parts an area is divided into. It is not limited to areas—weights or more general any quantities can be used for fractions."). The responses were rated very low if merely marginal information was presented. The responses to the elaboration prompts were rated high if the learners generated specific and detailed applications of the new contents (i.e., responses to the first elaboration prompt) and if the self-generated examples were described in whole sentences and contained a complete solution (i.e., responses to the second elaboration prompt). Short and unspecific applications (e.g., "I could use it in a furniture shop.") or short self-generated examples with a high similarity to textbook contents (e.g., "1/5 m = 20 cm") were rated as low quality elaborations. The responses to the monitoring prompt were rated high if they consisted of concrete monitoring episodes (e.g., "I did not understand how fractions (e.g., 1/4 litre of milk) can be converted to "normal" numbers."). By contrast, monitoring episodes with low concreteness (e.g., "I did not understand this topic.") were rated as low quality monitoring.

Two independent raters scored the quality of the cognitive and metacognitive learning strategies in the four learning journal entries of 20 students. The interrater reliability was very good ($ICC_{2,1} = .94$ for cognitive strategies and $ICC_{2,1} = .93$ for metacognitive strategies). As interrater reliability was very good, just one rater analysed the rest of the learning journals. For the later analyses, the scores with respect to the organisation and elaboration strategies were averaged to a total score of cognitive learning strategies. Moreover, the ratings of the learning journal entries that were written in the same phase were averaged to separate scores for the cognitive and the metacognitive strategies in the first and the second phases.

3.3.3. Posttest: Assessment of Learning Outcomes. At the end of the first phase, a posttest was used to assess the learning outcomes. The posttest was an extended version of the pretest and consisted of seven items that assessed basic knowledge of fractional arithmetic. Four items assessed procedural knowledge (e.g., "One kilogram peanuts costs €3. How much do four-fifths of a kilogram cost?"). The other three items assessed conceptual knowledge in the domain of fractional arithmetic. Conceptual knowledge refers to knowledge about facts, concepts, and principles that apply within a domain [40]. For instance, the students were required to explain

Table 2: Means and standard deviations (in parentheses) of the pretest, quality of learning strategies, and posttest scores in the two phases of the study.

	Classroom B		Classroom A	
	First phase: Prompts + solved example problems	Second phase: Prompts	First phase: Prompts	Second phase: Prompts + solved example problems
Prior knowledge				
Pretest	2.63 (0.59)		2.88 (0.55)	
Quality of learning strategies				
Cognitive strategies	3.12 (0.55)	2.57 (0.49)	2.76 (0.61)	2.52 (0.50)
Metacognitive strategies	2.06 (0.98)	1.85 (0.66)	1.35 (0.47)	1.60 (0.70)
Learning outcomes				
Procedural knowledge	2.76 (0.67)	2.88 (0.62)	2.92 (0.54)	3.15 (0.62)
Conceptual knowledge	2.98 (0.60)	3.02 (0.42)	2.87 (0.53)	2.77 (0.50)

the basic principles of fractional arithmetic or what the number 2/3 means. At the end of the second phase, learners received a second posttest. This posttest consisted of the same items as the first posttest with the exception that all cover stories and numbers were varied (e.g., "One kilogram strawberries costs €4. How much do five-eights of a kilogram cost?"). Based on a scoring protocol, the learners' answers were scored using a 4-point rating scale ranging from 1 (*low level of understanding*) to 4 (*high level of understanding*). Two independent raters scored the written answers of 20 participants. Interrater reliability as determined by the intraclass coefficient was very good ($ICC_{2,1} = .98$ for the first posttest and $ICC_{2,1} = .95$ for the second posttest). For the later analyses, the scores of each posttest were averaged to separate scores for the procedural knowledge and the conceptual knowledge in the first and the second phase.

3.4. Procedure. Both strategy instruction and the data collection took place in the students' familiar classroom environment and were conducted by the regular mathematics teacher of the two classrooms during regular mathematics lessons. Thus, the data of classroom A and classroom B were collected separately. To ensure that both the introductory presentations and the materials were properly delivered, the teacher was trained by one of the researchers two days before the presentations and materials were needed. In addition, to address potential open questions or uncertainties, there was a daily exchange between the teacher and one researcher throughout the entire study.

In a first lesson, all students took the pretest. In the next lesson, all students filled in a questionnaire on demographic data. Then the teacher delivered the respective version of the introductory presentation. After the presentation, the students were provided with their learning journal folders. In the next two lessons, the teacher gave parallel lessons on fractional arithmetic in both classrooms. Journal writing was assigned as homework for each lesson. In the following lesson, all students worked on the first posttest. Furthermore, the teacher collected all learning journal folders. Thereby, the first phase of the study ended.

In the next lesson, the second phase of the study began. In this lesson, the teacher delivered the respective versions of the slightly modified introductory presentation to the students. After the presentation, all students were handed new learning journal folders. In the next two lessons, the teacher gave parallel lessons on fractional arithmetic in both classrooms. Journal writing was assigned as homework for both lessons. In the following lesson, all students worked on the second posttest. Furthermore, the teacher collected all learning journal folders, thereby ending the second phase of the study. In the following lesson, all students were informed about the purpose of the study. Moreover, they received—without any prior notice—a personalised participation certificate and a lanyard keychain for their participation.

4. Results

Table 2 presents the means and standard deviations for the two quasiexperimental groups on prior knowledge, learning strategy measures (quality of cognitive and metacognitive strategies), and learning outcomes in the two phases of the study. An alpha-level of .05 was used for all statistical analyses. As effect size measure, we used d qualifying values of approximately 0.20 as small effects, values of approximately 0.50 as medium effects, and values of approximately 0.80 or bigger as large effects (cf. [41]).

With respect to prior knowledge, a t-test revealed no significant difference, $t(46) = 1.50$, $P = .138$. Hence, there was no a priori difference between the two quasiexperimental groups with respect to this important learning prerequisite. Nevertheless, we included prior knowledge as a covariate in subsequent analyses with respect to learning outcomes in order to reduce error variance.

4.1. Effects in the Initial Phase of Journal Writing

4.1.1. Effects on Learning Strategies. With respect to research question 1, we were interested whether the provision of solved example problems in addition to prompts in the initial phase of journal writing would foster the quality of both cognitive and metacognitive strategies of self-regulated learning. Regarding the quality of cognitive strategies, a t-test yielded a significant and medium difference in favour of the solved-example-problems group, $t(46) = 2.13$, $P = .019$, $d = 0.63$ (one-sided t-test). The learners who received prompts together with solved example problems in the initial phase applied cognitive strategies of higher quality in their learning journals than learners who solely received prompts. Regarding the quality of metacognitive strategies, a t-test revealed a significant and strong effect in favour of the solved-example-problems group, $t(33.30) = 3.18$, $P = .001$, $d = 0.94$ (t-test for unequal variances; one-sided). Thus, the provision of solved example problems in addition to prompts in the initial phase of journal writing also fostered the quality of metacognitive learning strategies.

4.1.2. Effects on Learning Outcomes. Regarding research question 2, we were interested whether the provision of solved example problems in addition to prompts in the initial phase of journal writing would foster learning outcomes. With respect to procedural knowledge, a t-test did not yield a significant effect in favour of the solved-example-problems group, $t(45) = 0.63$, $P = .265$ (one-sided t-test). Hence, learners who received prompts together with solved example problems in the first phase did not outperform learners who merely received prompts with respect to the acquisition of procedural knowledge. However, with respect to conceptual knowledge, a t-test yielded a significant and medium effect in favour of the solved-example-problems group, $t(45) = 1.70$, $P = .048$, $d = 0.51$ (one-sided t-test). Thus, learners who received prompts together with solved example problems acquired more conceptual knowledge in the initial phase than learners who solely received prompts.

4.2. Effects in the Second Phase of Journal Writing

4.2.1. Effects on Learning Strategies. With respect to research question 3, we were interested whether withdrawing the solved example problems in the second phase of journal writing would influence the quality of the cognitive and metacognitive strategies in the learning journals. For the quality of cognitive strategies, a t-test revealed a significant and strong decrease in the second phase of journal writing, $t(23) = 4.73$, $P < .001$, $d = 1.08$ (dependent t-test). Thus, learners from whom the solved example problems in the second phase of instruction were withdrawn showed a strong decrease in the quality of cognitive strategies in their learning journals in the second phase. Regarding the quality of metacognitive strategies, a t-test yielded no significant effect, $t(23) = 1.13$, $P = .266$ (dependent t-test). Withdrawing the solved example problems did not influence the quality of metacognitive strategies in the learning journals that were written in the second phase.

With respect to research question 4, we analysed whether the delayed provision of solved example problems as additional guidance to prompts would influence the quality of cognitive and metacognitive strategies in the learning journals. For the quality of cognitive strategies, we found a significant and small decrease from the first to the second phase of journal writing, $t(23) = 2.64$, $P = .015$, $d = 0.44$ (dependent t-test). Hence, the delayed provision of solved example problems as additional guidance to prompts in the second phase yielded cognitive strategies of lower quality as compared to providing sole prompts in the first phase. For the quality of metacognitive strategies, however, a t-test revealed a significant and small increase in the second phase of journal writing, $t(23) = 2.22$, $P = .037$, $d = 0.42$ (dependent t-test). Hence, the delayed provision of solved example problems as additional guidance to the prompts in the second phase fostered the quality of metacognitive strategies in the learning journals that were written in the second phase.

4.2.2. Effects on Learning Outcomes. With respect to research question 5, we were interested whether learners from whom the solved example problems were withdrawn and learners who received solved example problems delayed would differ with respect to learning outcomes at the end of the second phase. With respect to procedural knowledge, a t-test did not yield a significant effect, $t(45) = 0.75$, $P = .457$. Thus, the two quasiexperimental groups did not differ with respect to procedural knowledge at the end of the second phase. Regarding conceptual knowledge, however, we found a different pattern of results. A t-test revealed a significant and medium effect in favour of the group that had the solved example problems withdrawn in the second phase, $t(45) = 2.31$, $P = .012$, $d = 0.69$. Hence, the group that received the solved example problems in the second phase did not catch up with the group that received solved example problems in the initial phase with respect to conceptual knowledge at the end of the second phase. In order to explore whether the pattern of results regarding the conceptual knowledge scores had changed from the end of the initial phase to the end of the second phase, we furthermore contrasted the conceptual knowledge scores after the initial phase and the second phase within the two conditions. Neither in the group that had the solved example problems withdrawn in the second phase of journal writing nor in the group that received delayed solved example problems, we found significant differences between the conceptual knowledge scores after the initial phase and after the second phase, $t(22) = 1.54$, $P = .138$, and $t(22) = 1.74$, $P = .095$, respectively. Thus, the pattern of results had hardly changed from the end of the initial phase to the end of the second phase.

5. Discussion

In summary, our study made two contributions to the problem of fostering cognitive and metacognitive strategies of self-regulated learning in learning journals of high school students by providing solved example problems along with prompts. (a) Providing fifth-grade students with solved example problems along with prompts fostered both cognitive and metacognitive strategies of self-regulated learning and the acquisition of conceptual knowledge in the initial phase of journal writing. (b) The delayed provision of solved example problems along with prompts in the second phase of journal writing fostered metacognitive strategies but was detrimental with respect to the quality of cognitive learning strategies and did not foster learning outcomes.

The result that providing fifth-grade students with solved example problems in addition to prompts fostered the quality of both cognitive and metacognitive learning strategies in the initial phase of journal writing complements previous findings regarding the use of providing learning journal examples along with prompts to enhance strategies of self-regulated learning in learning journals of high school students (see [16, 30]) in two ways. On the one hand, our study shows that the combination of both prompts and solved example problems can—in principle—not only foster learning strategies of advanced high school students (i.e., eleventh-grade students; see [16]) but can also foster learning strategies of younger high schoolers, such as fifth-grade students. This suggests that both younger and advanced high school students do not only have production deficiencies that can be overcome by sole prompts but also have mediation deficiencies. That is, the students lack the cognitive skills necessary to apply cognitive and metacognitive strategies of self-regulated learning to a high standard. Hence, to foster the respective strategies in high school students' learning journals, instructional support should address both production and mediation deficiencies in the initial phase of journal writing. In this respect, our results suggest that the combination of prompts and solved example problems is a powerful instructional approach to overcome these deficiencies in the initial phases of strategy application. On the other hand, against the background of Glogger et al.'s [30] finding that providing ninth-grade students with a learning journal example in an introductory presentation did not yield high-quality strategies of self-regulated learning our results suggest that keeping the solved example problems available throughout the initial phase of journal writing was crucial for the beneficial effects in our study. Specifically, by integrating the solved example problems into the learners' learning journal folders, we provided learners with the opportunity to draw on the external guidance provided by the solved example problems during their first responses to the prompts (i.e., during the entire initial phase). Therefore, learners were provided with more instructional guidance than by providing a learning journal example in an introductory presentation. Research on learning from *traditional* worked-out examples shows that worked-out examples should be available until learners have gained understanding of the to-be-learned skill (e.g., [25]). Keeping in line with this, our result that the learners who received solved example problems in the initial phase of journal writing achieved—at least with respect to the quality of cognitive learning strategies—high scores in the initial phase (see Table 2) suggests that providing learners with solved example problems throughout the initial phase of journal writing has an added value as compared to providing learners with a learning journal example in an introductory presentation.

Besides these promising effects of providing solved example problems with respect to fostering the quality of cognitive and metacognitive strategies of self-regulated learning in learning journals, our study furthermore shows that providing learners with solved examples problems along with prompts also fostered learning outcomes in the initial phase. Specifically, we found that learners in the solved-example-group outperformed their counterparts in the group with sole prompts with respect to the acquisition of conceptual knowledge in the initial phase. This result stands in contrast to the previous finding that high school students did not benefit from their strategies with respect to learning outcomes in an initial phase of journal writing due to utilisation deficiencies (see [16]). One explanation for this contradistinction is that in our study the students could draw on the solved example problems throughout the entire initial phase whereas the solved example problem was withdrawn after an initial presentation in the study by Hübner et al. [16]. Hence, in the present study, the solved example problems might have provided learners with more instructional guidance during the application of learning strategies in their learning journals. As a consequence, the learners in our study might have been required to invest relatively less cognitive capacity in the application of the cognitive and metacognitive strategies, leaving more capacity for content learning (see [32]). From this view, the finding that providing learners with prompts and solved example problems in the initial phase of journal writing did not foster procedural knowledge seems surprising at first glance. An explanation for the beneficial effect of the provision of solved example problems along with prompts on conceptual knowledge and the neutral effect on procedural knowledge might be that especially the cognitive prompts (see Table 1) elicited learning strategies that were focused on conceptual aspects of fractional arithmetic. For instance, in response to the organisation prompt, learners predominantly highlighted new concepts or principles and hardly procedural aspects, such as the execution of an algorithm. Furthermore, in response to the elaboration prompts, learners mainly generated examples that showed how they could use a new principle in everyday life (e.g., that they could calculate how many birthday cakes they would get if each of their ten guests brought three-fourths of a birthday cake) without elaborating on the different calculation steps. Consequently, as the learners who received solved example problems in the initial phase applied these strategies to a higher standard, they acquired more conceptual knowledge in the initial phase than learners who solely received prompts. However, as learners hardly focused on procedural aspects of fractional arithmetic in their prompts responses, learners in the solved-example-group did not outperform their counterparts in the group that solely received prompts with respect to the acquisition of procedural knowledge even though they applied cognitive and metacognitive strategies to a higher standard. Note that—to our knowledge—none of previous studies in the field of fostering cognitive and metacognitive strategies of self-regulated learning in learning journals (e.g., [10, 13, 24, 42]) reported separate scores for conceptual knowledge and procedural knowledge. Therefore, it is an open question as to whether the cognitive and metacognitive prompts generally tend to focus learners on conceptual aspects of the learning contents or whether the results are specific for this study.

One important restriction of our findings with respect to the initial phase of journal writing is that we did not employ a condition in which a class did not receive any instructional support in the initial phase. Hence, we do not know whether the instructional means had an added value as compared to no instructional support regarding the quality of cognitive and metacognitive learning strategies. However, in the light of previous findings which show that even university students struggle with the application of high quality learning strategies in their learning journals when no instructional support is provided (e.g., [13, 17]), it is reasonable to assume that at least the combination of prompts and solved example problems fostered the quality of strategies of self-regulated learning as compared to no instructional support in the initial phase. Another restriction of our findings regarding the initial phase follows from the fact that there was no condition which solely received solved example problems in the initial phase of journal writing. Consequently, we do not know whether the combination of prompts and solved example problems in the initial phase of journal writing has an added value as compared to sole solved example problems. However, as the solved example problems included the prompts (see Section 3), it would have hardly been possible to isolate the effects of prompts and solved example problems in the present study. Nevertheless, it remains an open question as to whether the provision of solved example problems and thus integrated prompts would have fostered the quality of cognitive and metacognitive learning strategies in the students' learning journals to a similar extent as the combination of separate prompts and solved example problems.

In contrast to our promising results regarding the provision of solved example problems along with prompts in an initial phase of journal writing on both strategies of self-regulated learning and the acquisition of conceptual knowledge, we found that withdrawing the solved example problems after the first two learning journal entries yielded a substantial decrease in the quality of cognitive learning strategies. Moreover, in line with the finding that high quality cognitive learning strategies are especially crucial for high learning outcomes [13], we found that learners from whom the solved example problems were withdrawn did not further improve with respect to conceptual knowledge from the end of the initial phase to the end of the second phase of journal writing. Regarding the quality of metacognitive strategies, we did not find a significant decrease in the second phase of journal writing. However, the students did not show the use of high-quality metacognitive strategies in either the initial phase in which the students could draw on the solved example problems or the second phase. The rather low quality cognitive and metacognitive strategies found in the second phase suggest that the students did not internalise the external guidance provided by the solved example problems to a sufficient degree in the initial phase of journal writing and thus did not adequately acquire the skill to consistently apply the cognitive and metacognitive learning strategies to a high level of quality. One reason for this inadequate internalisation might be that we did not require learners to self-explain the solved example problems. Specifically, a central guideline for fostering learning from worked-out examples is that self-explanation activities on part of the learners should be elicited because the students' self-explanations are crucial for the intended knowledge-building activities in example-based learning (see e.g., [14, 26, 43]). Thus, prompting the learners to actively process the solved example problems in the initial phase of journal writing might have yielded better results in the second phase. However, requiring learners to self-explain the solved example problems might have also overwhelmed the fifth-grade students. For instance, it has been shown that requiring learners to engage in self-explanation activities imposes additional cognitive load on the learners (e.g., [44, 45]). Hence, eliciting self-explanations might have also yielded a cognitive overload on part of the fifth-grade students resulting in detrimental effects.

Besides this open question with respect to a potential added value of fostering self-explanation activities in the initial phase, it is also an open issue how an adaptive fading of the solved example problems in writing learning journals could be integrated in the instructional setup used in our study. Recent research in the field of learning from worked-out examples suggests that instructional guidance should be faded in a manner adaptive to the learners' individual understanding of the cognitive skill to be learned (e.g., [31, 46]). Regarding the setup used in the present study, this would mean that the external guidance by the solved example problems should be faded to the extent that the learners acquire the skills to apply the cognitive and metacognitive strategies to a high standard. More specifically, such an adapted fading procedure could be established by using journal writing as a means to assess the students' learning strategies in a first step (see [47]) and by adding or withdrawing solved example problems of learning journals in a second step. Furthermore, in addition to the external guidance by the solved example problems, teachers could provide the students with individual feedback that would help them to further improve the quality of their learning strategies and thus to take the next step in self-regulated learning (see [34]). However, up to now the question is open as to whether an adaptive fading of solved example problems and the provision of feedback would yield high-quality strategies of self-regulated learning in the long-term.

Our second contribution to the problem of fostering cognitive and metacognitive strategies of self-regulated learning in learning journals of high school students by providing solved example problems along with prompts refers to the effects of the delayed provision of solved example problems. We found that the delayed provision of solved example problems in the second phase of journal writing was detrimental with respect to the quality of cognitive learning strategies. One explanation for this finding could be that the instructional guidance provided by the solved example problems did not adequately relate to the knowledge base of these learners. More specifically, as students who solely received prompts in the initial phase, nevertheless found ways to respond to the cognitive prompts and thus applied cognitive strategies of considerable quality (see Table 2), it can be expected that providing solved example problems in the second phase required learners to engage in reconciliation processes between their internal guidance that they had developed in the initial phase (i.e., their strategy to respond to the cognitive prompts) and the external guidance provided by the solved example problems. Hence, in terms of cognitive load theory [7, 35], the delayed provision of solved example problems might have increased cognitive load and thus decreased the cognitive capacity available to apply cognitive strategies to a high standard. The students, therefore, were hindered by the delayed provision of solved example problems with respect to the application of cognitive strategies of self-regulated learning. In addition, the requirement to reconcile internal and external guidance might have drawn on the students' motivational resources for responding to the cognitive prompts (see [48]). Our result that the students who were provided with delayed solved example problems did not catch up with learners who received the solved example problems in the initial phase with respect to the acquisition of conceptual knowledge even though these learners did not further improve from the end of the initial phase to the end of the second phase could also be a consequence of the reconciliation processes between internal and external guidance. More specifically, given that high quality cognitive learning strategies are especially crucial for high learning outcomes [13], the absent catch-up effect could be due to the relatively low quality of cognitive learning strategies in the second phase. The finding that the delayed provision of solved example problems nevertheless fostered the quality of metacognitive learning strategies supports our interpretation from the perspective of cognitive load theory. The learners who received solved example problems at a later time showed the use of very low quality metacognitive strategies in the initial phase of journal writing (see Table 2). Hence, it is reasonable that the learners acquired hardly any strategies to respond to the metacognitive prompt in the initial phase. Consequently, the external guidance provided by the solved example problems might have hardly interfered with the students' internal guidance and thus served as beneficial scaffolding to increase the quality of the metacognitive strategies in the learning journals. Besides that, it has to be acknowledged that, in sum, all learners showed the use of rather low quality metacognitive strategies in both phases of the study. A reasonable explanation for this could be that even the combination of solved example problems and prompts did not provide sufficient instructional guidance with regard to the application of high-quality metacognitive strategies. This finding is in line with previous studies which indicate that it may be generally more difficult for learners to apply metacognitive strategies to a high standard than to apply high-quality cognitive strategies (e.g., [24, 34]). The application of metacognitive strategies is possibly a learning activity that students tend to minimise naturally because they do not find it very rewarding to question their own understanding [24]. In the present study, this might have been even aggravated by the fact that the learners were merely prompted to monitor their understanding but were not prompted to plan and apply remedial activities in order to overcome potential comprehension difficulties. Hence, as the learners were not prompted to use the detected comprehension difficulties as the onset for the planning and the application of remedial activities, they might have perceived questioning their understanding as a waste of time and effort in the present study. Thus, in line with the finding that prompting metacognitive strategies in learning journals is particularly beneficial when they result in remedial activities [15], it can be expected that prompting both monitoring and planning of remedial strategies would have yielded better results.

Note that one important restriction of our findings with respect to the delayed provision of solved example problems is that we do not know whether the detrimental effect on the quality of cognitive learning strategies applies only in the short-term or in the long-term as well. For instance, it is reasonable that the reconciliation processes between internal and external guidance diminish over time because the learners get used to drawing on the external guidance provided by the solved example problems. Thus, the delayed provision of solved example problems might have delayed effects on the quality of cognitive strategies of self-regulated learning. Furthermore, we do not know whether learners perceived responding to the prompts on their own as being motivating in the initial phase of journal writing and whether the delayed provision of solved example problems affected the learners' motivation in the second phase of journal writing. Therefore, further research is needed that addresses both the short- and the long-term effects of the delayed provision of solved example problems to foster cognitive and metacognitive strategies in learning journals and which explicitly assesses cognitive load and the learners' motivation during journal writing.

In addition, it is an open question as to whether the learners who received sole prompts in the initial phase would have been better off without the solved example problems in the second phase. The design of the present study required that learners in both conditions received parallel lessons throughout the study. One disadvantage of this field study design was that there was only a restricted number of fifth-grade classes available who could run parallel during our study. Therefore, it was not possible to employ conditions which received either type of instructional support (i.e., prompts or prompts and solved example problems) in both phases. As a result, our study does not allow for between-subjects comparisons regarding the effects of the instructional means in the second phase of journal writing (e.g., whether sole prompts or prompts plus solved example problems yield better effects in a second phase when learners received sole prompts in the initial phase). In future studies it would be interesting to compare all four sequences of either prompts or the combination of prompts and solved example problems with respect to their potential to foster cognitive and metacognitive strategies of self-regulated learning in learning journals.

Besides the aforementioned restrictions and the several open questions for further research, our findings imply the following conclusions with respect to integrating self-regulated learning at school. First, when teachers intend to engage fifth-grade students in writing learning journals as follow-up course work as a means to integrate self-regulated learning in their classrooms, the teachers should not only provide cognitive and metacognitive prompts but also solve example problems right from the beginning. Evidently, providing both prompts and solved example problems of a learning journal in an initial phase of journal writing can effectively foster the quality of both cognitive and metacognitive strategies of self-regulated learning as well as the acquisition of conceptual knowledge. In the light of the finding that students tend to benefit more if researchers conduct the strategy instruction instead of their regular teachers [49], the results of the present study suggest that prompts and solved example problems can form a powerful combination in service of supporting fifth-grade students in both applying and benefiting from cognitive and metacognitive strategies of self-regulated learning in learning journals. For the concrete integration of these instructional means in classrooms, the learning journal folders with integrated prompts and solved example problems that were used in the present study can be seen as a promising starting point. Moreover, our results suggest that the teachers should not withdraw the solved example problems before the learners have successfully internalised the external guidance provided by the solved example problems. From this view, both prompts that require learners to actively explain the solved example problems to themselves and a formative assessment of the students' expertise on learning strategies might serve as promising add-ons to the instructional setup used in the present study.

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Research Article

What Teachers Think about Self-Regulated Learning: Investigating Teacher Beliefs and Teacher Behavior of Enhancing Students' Self-Regulation

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In order to foster self-regulated learning (SRL), teachers should provide students with learning strategies, as well as with constructivist learning environments that allow them to self-regulate their learning. These two components complement each other. When investigating teachers' promotion of SRL, not only teacher behavior, but also teachers' beliefs as well as their knowledge about SRL are relevant aspects to consider. Therefore, this study seeks to examine teachers' knowledge and beliefs on promoting SRL, as well as their predictive value on teachers' promotion of SRL in the classroom. Forty-seven primary school teachers completed questionnaires on knowledge and beliefs towards both components of the promotion of SRL: strategy instruction and a constructivist learning environment. In addition, teachers had to answer open-ended questions on their understanding of SRL, as well as their implementation of SRL in their classroom. The results show that teachers are more positive towards constructivist than towards SRL (teacher beliefs), and most teachers mentioned characteristics of constructivist learning environments, while only few teachers addressed strategy instruction when being asked about their understanding of SRL (teacher knowledge). Moreover, teacher beliefs are the only predictor for teacher behavior. The results indicate how teacher education could support teachers to learn how to promote SRL effectively.

1. Introduction

Research on the promotion of self-regulated learning (SRL) has revealed that students can learn how to self-regulate their learning, but investigation of training them to do so has pointed out teachers producing weaker effects of training than researchers do (see, e.g., [1] for primary school and [2] for secondary school). Observational studies of teachers fostering students' SRL have shown that teachers give students the freedom of self-regulation, but do not prepare them to handle the new responsibilities (see, e.g., [3]). Although most teachers tend to use learner-activating teaching methods, in most cases they neglect teaching their students *how* to learn (see, e.g., [4]). However, providing students solely with autonomy but not with means to execute strategies has not been found to be beneficial for students (see for an overview [5]). Both the instruction of metacognitive strategies—strategies on how to learn—as well as learning environments that require and enable self-regulation have been found to predict students' self-regulation [6].

According to Perry et al. [7], most teachers agree with the concept to support their students to become self-regulated learners; yet many of the teachers that they investigated reported to feel unsure about how to do that. Knowledge of whether teachers do not *know* how to enhance their students' self-regulation or whether (for unknown reasons) they refuse to, could indicate where teacher training would have to start and which points would have to be addressed. Kramarski and Michalsky [8] found that teachers' ability for SRL was associated with their pedagogical knowledge as well as with their beliefs on student-centered learning. Looking backwards, it would even enhance our understanding of the delineated problem by comparing the beliefs of teachers who are fostering SRL in their classroom to those who are not. As Tillema [9] found, teacher beliefs are filtering the learning process in a way that learning is supported only when training content and teacher beliefs correspond. Thus, both—teachers' prior knowledge as well as their beliefs—seem to have an impact on teacher learning and might also influence teacher behavior.

The goal of the present study was to investigate the relationship between teachers' knowledge and beliefs on fostering self-regulation of learning among their students and their teaching behavior, while taking into regard strategy instruction. Equally important was the consideration in how far students were provided with a learning environment conducive to self-regulation. Since research on SRL is increasingly taking students into account as early as at primary school age [1], we focused on investigating primary school teachers' promotion of SRL.

1.1. Fostering Self-Regulated Learning. When searching the literature on SRL, it becomes obvious that a wide range of definitions exists varying among their focus on different aspects of the concept. The probably most-quoted definition of SRL [10], grounded on social-cognitive theory, stems from Schunk and Zimmerman [11]: SRL means the learners' "…self-generated thoughts, feelings, and actions which are systematically oriented toward attainment of their goals."

As the literature shows, teachers can support students to acquire self-regulation strategies [2, 12], using different elements of instruction that are not necessarily mutually excluding: on the one hand, teachers can model strategy use, or explicitly instruct strategies [6, 13–15]; on the other hand, teachers can structure the learning situation in a way that students have the opportunity to discover strategic procedures themselves. S. G. Paris and A. H. Paris [14] refer to two well-established theories to provide examples for both direct as well as indirect ways to support SRL. To illustrate explicit strategy instruction, they draw on Brown et al. [16] who distinguish three levels of strategy instruction. On the lowest level of training, the so-called blind training, students are induced to use a strategy without providing them with any information about this strategy in order to foster a concurrent understanding about the significance of this activity. They are not explicitly told why to use a certain strategy, and in which situations this activity is appropriate. The students are induced to perform a certain activity without being explicitly informed that this activity is a learning strategy. Although this can enhance children's use of this activity, it is prone to fail in its adaption as a general tool by the student. The intermediate level includes the informed training. Students are both induced to apply a certain strategy but are also provided with some information about the significance of this strategy. This type of training should lead to an improved performance as well as keeping the activity up when a similar problem reoccurs. The self-control training, the highest level of instruction, combines the informed training with an explicit instruction of how to apply, monitor, check, and evaluate that strategy. This type of training facilitates the transfer of strategy application to appropriate settings in the most sustainable way [16]. This aspect plays an important role when looking at the promotion of SRL.

Another example for direct, although less explicit ways of supporting SRL can be derived from Collins et al. [17] model of *Cognitive Apprenticeship*, which assumes successful teaching to be based on several components of the learning environment: the content taught, the instructional methods, the sequencing of learning activities, and the sociology of learning [17]. This way of apprenticeship almost approaches or can overlap with explicit strategy instruction. In addition to this, teachers can design the learning environment in a way that it fosters students' self-regulation.

Self-regulation is a complex concept, including various features of the learner and his or her environment that have an impact on the learning process [18]. Therefore, the promotion of SRL is supposed to take place on two different levels: in addition to systematic strategy instruction, students need opportunities for exercising self-regulation. Therefore, features of the learning environment that foster the application of self-regulation strategies should also be acknowledged. Theorists on self-regulation describe SRL as an "inherently constructive and self-directed process" (e.g., [19]). In the same scope, Pressley et al. [15] describe successful strategy instruction in constructivist terms. The environment has to have features that allow active construction of knowledge, in order to be conducive to SRL.

When investigating teachers' beliefs on promoting SRL, both approaches thus have to be taken into account: teachers' beliefs on the instruction of self-regulation strategies, as well as their beliefs on the design of the learning environment. The same applies to teachers' knowledge on the promotion of SRL. In the following chapter, we will take a closer look at theories on teacher beliefs and teacher knowledge and will transfer these theories to teacher beliefs and knowledge about the promotion of SRL.

1.2. Teacher Beliefs

1.2.1. A Distinction between Teacher Beliefs and Teacher Knowledge. According to Pajares [20], when talking about teachers' attitudes towards education, one refers to teachers' edu-cational beliefs as only a subpart of teachers' general beliefs system. Beliefs encompass both attitudes and subjective norms, which makes it difficult to disentangle teachers' indi-vidual preferences from their opinion on how things have to be. Knowledge is based on objective facts, while beliefs are affective and involve a certain kind of judgment or eva-luation. Therefore, teachers can gain new knowledge, but are still influenced by their beliefs when deciding whether they accept it as true or not [21]. Although when examining teacher knowledge the focus is more on cognition, while beliefs include more emotional aspects, both concepts are intertwined and hard to fully separate during assessment [22].

Teacher knowledge can be classified into three categories: pedagogical knowledge, content knowledge, and pedagogical content knowledge [23]. Pedagogical knowledge implies teachers' knowledge about how to teach, while content knowledge refers to the subject matter that teachers have to teach. Pedagogical content knowledge—as opposed to general pedagogical knowledge—relates to teaching strategies on how teachers transfer a specific subject matter to their students, including knowledge on representing the subject matter to make it understandable for students, as well as knowing about students' conceptions and misconceptions. Teacher knowledge and beliefs on fostering self-regulated learning when looking at teacher beliefs on pedagogical practice, most studies distinguish between two dichotomous concepts: constructivist versus empiricist (also traditional) views on learning [24]. However, the question is whether both sides really have to be opposed to each other. When drawing on the theories on supporting students' self-regulation reported earlier in this paper, both conceptions can be beneficial (see [6]), probably in different moments a direct strategy instruction would probably go along with moments of more traditional teaching, while the creation of a constructivist learning environment would of course fit to the constructivist views on learning. Nevertheless, both are necessary and one cannot work without the other. Several studies researching teacher beliefs have already questioned a strict dichotomous distinction between both conceptions [24, 25]. Defining teacher beliefs on SRL reveals a complex construct involving several aspects of teacher beliefs. On the one hand, this includes how teachers think about learning in general: is learning regarded as a process of transmission of knowledge or is learning the process of constructing knowledge? General beliefs on pedagogical practice can cover this aspect. On the other hand, beliefs on fostering SRL also include beliefs on how to instruct and how to foster strategy use, which goes beyond general pedagogical beliefs, for example, in terms of beliefs on how many strategies to instruct at a time, or how to integrate the instruction of a certain strategy into the content of a lesson, as well as measures taken to support transfer of strategy use to other contexts.

The same applies to teacher knowledge. Do teachers know about the importance of providing students with strategies before or in addition to giving them autonomy while learning? How much do teachers know about one or both aspects of fostering SRL? Askell-Williams et al. [26] rank teachers' knowledge about scaffolding SRL among content knowledge and among pedagogical content knowledge about cognitive and metacognitive learning strategies. They report that beginning teachers lack a strong knowledge on how to learn [26].

1.2.2. Teacher Beliefs, Teacher Knowledge, and Teaching Behavior. In his review on beliefs, Pajares [20] sums up that beliefs strongly influence one's behavior. Belief structures more emotional and unstructured than knowledge, take over in complex or new situations, when appropriate reasoning is not working. Most reviewers on teacher beliefs and teacher knowledge conclude that teacher beliefs are stronger predictors for teacher behavior than teacher knowledge is [20, 27]. Similar knowledge of teachers can thus lead to different teaching behavior. One explanation is that learned knowledge is often not used in practical situations. Many studies have delivered empirical support for the association between teacher beliefs and teacher behavior (e.g., [28–30]). Hashweh [29], for example, found that teachers with constructivist beliefs opposed to traditional beliefs of teaching turned out to be more likely to help students to elaborate on their ideas and conceptions, which could indicate teachers supporting students in using cognitive strategies. However, other studies could not find evidence for such an association and the majority of studies have not been able to prove causality (e.g., [31]; see for a review [24]).

Beliefs are relatively resistant to change. Only when they prove unsatisfactory, which they only do when being challenged, individuals are motivated to replace their beliefs. The older beliefs are, the stronger they are and the more difficult they are to replace, even when they are based on incomplete or incorrect knowledge, and even when people are confronted with new (and correct) information. The perseverance of beliefs is not only due to their emotional quality, but also due to encoding biases that support confirmation of existing beliefs when integrating new information into the beliefs system. In the same way, perception is affected by beliefs, which in turn evokes behavior that is consistent with these beliefs—a self-fulfilling prophecy is at hand.

1.3. The Current Study. This study seeks to examine primary school teachers' knowledge on enhancing SRL, as well as their beliefs on the promotion of students' self-regulation. In addition, associations between teacher knowledge, teacher beliefs, and teacher behavior will be investigated. With regard to the presented models of fostering self-regulation, teachers' beliefs on the promotion of SRL were assessed including both beliefs on strategy instruction as well as beliefs on constructivist learning environments. We therefore used several scales as well as open-ended questions.

(1) Drawing on the results of observation studies investigating teachers' instruction to SRL (e.g., [3, 6]), we also wanted to explore whether teachers report more positive views on constructivist learning environments or on the instruction of learning strategies (teacher beliefs) and whether teachers assign more importance to creating constructivist learning environments or to the instruction of learning strategies when thinking about fostering SRL (teacher knowledge).

(2) Moreover, we wanted to investigate whether teachers' implementation of SRL in their classroom is positively related with their beliefs as well as with their knowledge about the promotion of SRL. Furthermore, we would like to know whether teachers who perceive both the instruction of learning strategies and the design of the learning environment as important components of fostering SRL demonstrate the promotion of SRL.

2. Method

2.1. Sample. The questionnaire was sent to a randomized sample of 300 primary schools within the Netherlands.

Forty-seven Dutch teachers who taught grade 7 or 8 (This corresponds to grade 5 and 6 in the US system.) filled in the questionnaire. Thirty-two teachers were female, fifteen teachers were male, which overrepresents the percentage of male teachers, as only 14.5% of Dutch primary school teachers are men. Teachers' age ranged from 24 to 63 years, covering all possible age groups of primary school teachers, with an average age of 40 years. Teachers' work experience ranged from 0.5 to 40 years with an average of 15 years work experience as primary school teacher. The sample might represent a group of teachers who seem to be interested in the topic of SRL, although we do not know whether all the teachers in the sample were highly motivated for SRL in general.

2.2. Instruments

2.2.1. Teacher Beliefs. In accordance with the model on fostering SRL presented earlier in this paper, the assessment of teachers' beliefs on the promotion of SRL includes both the instruction of self-regulation strategies (direct way of enhancing SRL), as well as the design of a SRL-conducive learning environment (indirect way of enhancing SRL). We therefore assessed teachers' attitude towards constructivist learning environments with the subscale Constructive-Oriented Beliefs about Learning and Instruction of the Beliefs about Primary Education Scale by Hermans et al. [32] that includes eight items. The constructive-oriented beliefs scale of the BPES was used to operationalize the indirect way of supporting SRL by creating a constructivist learning environment. Since we were not interested in traditional versus constructivist teacher orientation in general but only with the special focus of fostering SRL, the traditional-oriented beliefs scale of the BPES was not applied. For the constructivist learning environment (which is a rather general way of (also) fostering SRL (among others)), the items did not need to be adapted to the special context (since SRL is constructivist by nature); however, explicit strategy instruction is much more specific than what the traditional-oriented beliefs scale would assess, since in this case we wanted to assess teachers' orientation with regard to strategy instruction and not any instruction in general.

Moreover, we assessed teachers' preference for constructivist learning environments with three of the four verbal and graphic metaphors of the Teaching and Learning Perceptions Questionnaire by Kramarski and Michalsky [8]. The original Teaching and Learning Perceptions Questionnaire consisted of four metaphors (indirect way of enhancing SRL) that teachers had to rate. In this way, four perceptions of teaching and learning were assessed along a continuum from teacher-centered to student-centered: transmitting information ("The learner is like an empty vessel to be filled"), modeling by the teacher ("The learner is like a tourist on a guided tour"), and self-construction of knowledge ("The learner is like an independent mountain climber"). As we wanted to force teachers to make a choice for the metaphor that reflects best their perception on teaching and learning, we decided to use only the three of the metaphors that are most selective and to let teachers choose the metaphor that fitted best to them. With the scale of Hermans et al., we assessed in how far teachers favor a constructivist learning environment (so indirect way of fostering SRL). We also wanted to pinpoint whether teachers would prefer a totally indirect way of promoting SRL by teaching in a way that fits to the metaphor for self-construction of knowledge ("The learner is like an independent mountain climber"), or whether they prefer the direct way that fits to the metaphor for transmitting information ("The learner is like an empty vessel to be filled"), or whether they prefer the combination of both which fits to the metaphor for modeling by the teacher ("The learner is like a tourist on a guided tour").

Items to assess teacher beliefs on the instruction of SRL were adapted from the Self-Regulated Learning Teacher Belief Scale by Lombaerts et al. [33] covering 15 items (direct way of enhancing SRL). Examples of items can be found in Table 1.

All scales produced acceptable reliabilities: Cronbach's α was .67 for the subscale of the Beliefs about Primary Education Scale, and .75 for the Self-Regulated Learning Teacher Belief Scale. Therefore, the scales could be included into the analyses. Coding of the questions with open answer format was accomplished by two coders. Interrater reliabilities were found to range above 80%.

2.2.2. Teacher Knowledge. Teachers' knowledge on the promotion of SRL was assessed partly in a quantitative and partly in a qualitative way. Eight items were generated to measure teachers' knowledge on effective strategy instruction (direct way of enhancing SRL) that were based on the model of effective strategy instruction by Pressley et al. [15], for example, "When instructing strategies, it is important to explain explicitly how to use a strategy and to mode strategy use." The reliability for the items on effective strategy instruction was $\alpha = .77$.

In addition to teachers' knowledge about strategy instruction, we wanted to capture whether teachers consider teaching self-regulation strategies at all. Therefore, teacher knowledge was also assessed in a qualitative way in order not to influence teachers with the direction of their response, no answer categories were provided but open-ended questions were asked like in an interview. First, teachers were asked to specify the best way to enhance students' learning behavior using the open question developed by Lonka et al. [35]: "What is the best way to enhance the learning behavior of students, to teach them learning to learn? Why?" "Learning to learn" was used as term as it also involves the concept of SRL (e.g., [36, 37]) but is more familiar to practitioners than the term "self-regulated learning". Second, to capture teachers' knowledge (conceptions and misconceptions) about SRL, teachers were questioned on how they define the concept "self-regulated learning". Teachers responded in writing, and all responses were transcribed and coded for data analysis using a coding scheme that had been developed to observe teachers' promotion of SRL in the classroom [6]. Both open-ended questions were analyzed by means of a coding scheme that built on the model of fostering SRL

Table 1: Examples of items.

Scale	Example item	Measured construct	Way of promoting SRL
Teacher beliefs			
Beliefs about Primary Education Scale: Hermans et al. [32]	I find it important to use time to have students working together (in groups)	Teacher beliefs on constructivist learning	Indirect
Teaching and Learning Perceptions Questionnaire: Kramarski and Michalsky [8]	The learner is like an empty vessel that needs to be filled	Teacher beliefs on student-centered learning	Indirect
SRLTB Self-Regulated Learning Teacher Belief scale: Lombaerts et al. [34]	The instruction of learning strategies leads to students being better in evaluating their learning	Teacher beliefs on self-regulated learning	Direct and indirect
Teacher knowledge			
Based on Pressley et al. [15]	When instructing strategies, it is important to explain explicitly how to use a strategy and to mode strategy use	Teacher knowledge on strategy instruction	Direct
Lonka et al. [35]	What is the best way to enhance the learning behavior of students, to teach them learning to learn? Why?	Teacher knowledge on learning to learn	Direct and indirect
	How would you define “self-regulated learning”?	Teacher knowledge on self-regulated learning	Direct and indirect

by both—direct strategy instruction and designing a constructivist learning environment. The direct instruction of learning strategies included all aspects of teacher behavior that serves to address the use of strategies, for example, teachers explaining the use of a certain strategy, reflecting with the students on their strategy use, discussing advantages and disadvantages of strategies, and modeling the use of a strategy by showing the students how to use it with or without thinking aloud. Both were coded-explicit discussion of strategy use, but also more implicit instruction of strategy use. Collins et al. [17] differentiate between four different aspects of apprenticeship that can serve to instruct strategies. Although these are rather indirect ways of instruction, they take place in a direct interaction between teacher and student(s): modelling, scaffolding, fading, and coaching. In *modelling*, the student watches the teacher at using a certain strategy. The student learns to use the strategy by observing the teacher using the strategy in terms of modelling. *Scaffolding* means the support that the teacher gives to the student in carrying out a task. This can imply that the teacher is doing parts of the task that the student cannot yet manage, but can also imply that the teacher just gives occasional hints to the student on what to do next. In *fading*, the teacher slowly removes his or her support and gives more and more responsibility to the student. *Coaching* comprises the whole process of apprenticeship instruction, including the choosing of tasks, providing students with hints, scaffolding, giving feedback, and structuring the procedures of the learning process. This way of apprenticeship almost approaches or can overlap with explicit strategy instruction. With regard to the design of a learning environment that allows students to self-regulate their learning, we coded teacher responses according to four common principles of constructivist learning, which are the basis of powerful learning environments [38], that were considered as being strongly related to the promotion of SRL: activating prior knowledge (relating new knowledge to already existing knowledge), cooperative learning (social interaction), learning in context, as well as self-regulated learning. Knowledge acquisition is defined as a process of knowledge construction, assuming that the learner builds his or her knowledge by relating new knowledge to already existing knowledge[39]. Second, different constructivist viewpoints also share the idea of the impact of *social interaction* during knowledge construction (e.g., [40]). As the level of communication among students is similar, but differs from the level of communication of the teacher, social interaction among the students should foster discussions on the subject matter that is related to deeper understanding [41]. Third, constructivist learning as learning in context should resemble real-life situations by challenging students with authentic and meaningful problem structures in terms of complex problems with interacting elements and allowing multiple solutions in order to facilitate transfer of knowledge (e.g., [42]). Fourth, constructivist learning implies students' self-direction of their learning, based on the idea that it is insufficient to regulate one's cognitive activity when participating in active knowledge construction; but also metacognitive, affective, and behavioural aspects need to be regulated [11]. Students can benefit from learning environments that allow them to take over responsibility for their own learning [43]. In relation to that, constructivists agree on the importance of *motivation to learn*, affecting *if*, *when* and *how* students learn [44]. We coded whether teachers mentioned none, one or both of these two aspects. An example for a teacher response that was coded as strategy instruction was "Teaching your students to look at their work critically and to provide them with opportunities to check whether they did it the right way". Constructivist learning environment was coded for this exemplary teacher response: "Students can decide themselves in which order they want to work on their tasks and how much time they need for every task."

2.2.3. Teacher Behavior. Teachers had to explain what they do in order to enhance their students' self-regulation of learning in their classrooms. For the same reasons as mentioned for teacher knowledge, an open-ended question was asked to not direct teachers' answers. Again, this open-ended question was coded according to the model of fostering SRL directly through the instruction of learning strategies, as well as indirectly by creating a constructivist learning environment. A teacher response that was coded for strategy instruction was, for example, "I start every lesson by telling my students what the goal of the lesson will be." The example response "My students search for information themselves by asking each other questions in their group and try to solve problems together" was coded as promotion of a constructivist learning environment.

3. Results

3.1. Research Question 1: Teacher Beliefs and Teacher Knowledge on the Promotion of Self-Regulated Learning. With regard to our first research question, we wanted to know whether teachers assign more importance to the design of constructivist learning environments than to strategy instruction when asked about their beliefs and their knowledge on SRL.

3.1.1. Teacher Beliefs. Teachers' beliefs on SRL in primary school turned out to be relatively positive (M = 3.65, SD = .41 on a five-point rating scale). Teachers' beliefs on constructivist learning were found to be very positive as well (M = 4.04, SD = .36 on a five-point rating scale). However, most of the forty-five teachers who had answered the item on the metaphors representing views on teaching and learning were favoring the metaphor for "modeling by the teacher" (N = 29) over "transferring information" (N = 8) or˜"self-construction of knowledge" (N = 8); so not the most student-centered one but a moderate "average". Spearman correlations with the scale of these three metaphors and the scale of teacher beliefs on constructivist learning revealed that both measures were highly correlated (Rho = .42**, P < .004). The more teachers agreed with constructivist views on teaching and learning, the more student-centered was the metaphor they chose for. A univariate analysis of variance was conducted to check for differences between the teachers who are favoring the three different metaphors. It turned out that teacher beliefs differ significantly between the three groups of teachers for both beliefs on SRL (F (2, 42) = 7.54, P < .01) as well as on constructivist learning (F (2, 42) = 4.88, P < .05). Post hoc analyses using the Scheffé post hoc criterion for significance indicated that the scale mean for teacher beliefs on SRL is significantly lower for teachers who chose the metaphors representing transmitting information (M = 3.58, SD = .35) and modeling by the teacher (M = 3.54, SD = .36) than for teachers who chose the metaphor representing self-construction of knowledge (M = 4.09, SD = .38), P < .05. Concerning teacher beliefs on constructivist learning, the Scheffé test revealed significantly a higher-scale mean for teachers who had chosen for the metaphor "self-construction of knowledge" (M = 4.33, SD = .25) than for the metaphor "transmitting information" (M = 3.54, SD = .36), P < .05. As a paired samples t-test revealed, teachers scored significantly higher on constructivist learning than on SRL (t (46) = 7.38, P < .01).

3.1.2. Teacher Knowledge. Pertaining to the instruction of strategies, teachers were very much in line with the characteristics of good strategy instruction proposed by Pressley and colleagues [15] which were assessed by means of the according items (M = 4.21, SD = .39 on a five-point rating scale). Concerning the questions on teachers' knowledge on the promotion of SRL that required open answers, responses were coded according to the options (a) direct strategy instruction, (b) indirectly fostering students' self-regulation through constructivist learning environments, or (c) direct and indirect strategy instruction. To the question "How would you define self-regulated learning", the responses of the forty teachers who had answered this question were coded into two categories: characteristics of learning that focused on student autonomy versus focus on learning strategy instruction. None of the forty teachers who had replied to the open-ended questions, had referred to both aspects, 31 teachers had described aspects of student autonomy (e.g., "students can choose themselves when they work on a task", or "students can learn according to their own speed and rhythm"), while nine teachers had emphasized aspects of strategy instruction (e.g., "students learn to know their strong points and how to use them", or "find strategies to improve learning"). With regard to the question "What is the best way to enhance the learning behavior of students, to teach them learning to learn? Why?", only two teachers did not give any answer. Again, the majority of 32 teachers stressed aspects of constructivist learning environments (e.g., cooperative learning, situated learning, student autonomy), but thirteen teachers responded with characteristics of strategy instruction (e.g., learning to plan one's learning process, reflecting together on how to learn, etc.) as well as constructivist learning environments. No teacher focused on the instruction of strategies only.

3.1.3. Teacher Behavior. When asked whether and how teachers incorporate aspects to foster SRL into their teaching, only seven teachers responded not to do so at all. Twenty-six of the thirty-eight teachers, who had answered that they promoted SRL, mentioned only characteristics to foster student autonomy (e.g., discovery learning, cooperative learning, student autonomy, etc.), while five teachers also reported to instruct learning strategies as well (e.g., "I'm teaching my students how to plan their learning"). Descriptives can be found in Table 2.

3.2. Research Question 2: Predicting Teacher Behavior with Teacher Beliefs and Teacher Knowledge. Ordered logistic regressions were computed to analyze the predictive impact of teacher beliefs concerning constructivist learning environments, teacher beliefs concerning SRL, as well as teachers' knowledge concerning fostering SRL on their self-reported promotion of SRL in their classrooms. We chose ordered logistic regressions [45] since our dependent variable was coded according to three answering categories that reproduce ordered levels (no promotion of self-regulated learning/providing students with a constructivist learning environment only/additionally instructing learning strategies). According to our second research question, we wanted to investigate the predictive value of teacher beliefs and teacher knowledge to teacher behavior. As Table 3 shows, the analyses revealed that when controlling for all teacher beliefs and teacher knowledge variables only teachers' beliefs on SRL predicted teacher behavior ($B = 2.52$, $P < .05$). Teacher beliefs on constructivist learning and their perception of student versus teacher-centered teaching and learning did not predict teacher behavior significantly, neither did teachers' knowledge.

4. Discussion

4.1. Summary. In this study we investigated teacher beliefs and teacher knowledge on how to foster SRL and tested whether they predict teachers' promotion of SRL in their classrooms. As the results to the first research question show, teachers are more positive towards constructivist than towards SRL. This is in line with observation research on teachers' promotion of SRL, revealing teachers to mainly provide students with autonomy, but not to teach them learning strategies that help to deal with this autonomy (e.g., [3, 6]).

When being asked how they would define self-regulated learning in order to assess teacher knowledge, most teachers mentioned characteristics of constructivist learning environments, while only few teachers addressed strategy instruction. No teacher reported to integrate both aspects of fostering SRL. Upon the second question to assess teacher knowledge (What is the best way to enhance the learning behavior of students, to teach them learning to learn?), again most teachers named characteristics of constructivist learning environments. However, thirteen teacher answers included both aspects the learning environment as well as strategy instruction. No teacher mentioned strategy instruction only. The results indicate that primary school teachers have already incorporated the idea of designing constructivist learning environments to foster students' self-regulation into their teaching conceptions. This result is in line with the result that arises from the analyses of teacher beliefs. Most teachers have a positive attitude towards constructivist as well as (slightly less positive) towards SRL at primary school, and most teachers associate SRL with student autonomy through constructivist learning environments. These results are not surprising, considering the results of classroom observation studies on the promotion of SRL that have produced a similar picture. Teachers do create learning environments that allow students to self-regulate; however, they do not provide students with the necessary learning strategies [3, 6]. Yet, teachers differentiate between SRL and learning to learn, assigning more importance of the learning environment to the term "self-regulated learning", but integrating the aspect of strategy instruction into their definition when being asked for "learning to learn". Teachers refer more to the part of explicit strategy instruction when they think of "learning to learn", and they refer more to the indirect way of fostering SRL when they think of the term "self-regulated learning". Both concepts—self-regulated learning and learning to learn—seem to be rather independent concepts for most of the teachers. This is in line with a result that Waeytens et al. [46] found when interviewing teachers about their definition of "learning to learn". The concept is rather vague and unclear for many teachers.

When looking at teacher beliefs and teacher knowledge, it becomes clear that teachers have positive beliefs towards SRL, but they do not dispose of a broad knowledge on how to foster it. Most teachers do not cover both aspects of fostering their students' self-regulation. The same result occurs when looking at teachers' behavior. With regard to our first research question, we can conclude that both can be confirmed: The results of teacher beliefs and knowledge reflect earlier results on teacher behavior observed in their classrooms. However, the majority of teachers chose a metaphor representing the modeling of the teacher to reflect their perception of teaching and learning and not the most student-centered metaphor representing self-construction of knowledge. Thus, these teachers *do* acknowledge their task of modeling which plays an important role in strategy instruction (see [17]).

Concerning the predictive value of teacher beliefs, it turned out that only teacher beliefs on SRL predicted teachers fostering SRL in their classrooms, but not their beliefs on constructivist learning environments. Those teachers, who do integrate both aspects of the promotion of SRL into

Table 2: Descriptives.

Scale	Reliability	Mean (SD)	Min	Max
Hermans et al. [32]. Beliefs about Primary Education Scale	$\alpha = .67$	4.04 (.36)	3.30	4.70
Lombaerts et al. [34]. SRLTB Self-Regulated Learning Teacher Belief Scale	$\alpha = .75$	3.65 (.41)	2.75	4.88
Teacher Knowledge about Strategy Instruction: based on Pressley et al. [15]	$\alpha = .77$	4.21 (.39)	3.38	5.00

Table 3: Multiple-ordered logistic regression to predict teacher behavior.

Teacher behavior	B	SE	P	e^b
Teacher knowledge-1	−.73	.85	.39	.48
Teacher knowledge-2	1.30	.91	.16	3.66
Teacher beliefs on SRL	2.52	1.15	.03	12.45
Teacher beliefs on constructivism	−.94	1.38	.50	.39
Teacher beliefs on student versus teacher centeredness	.13	.66	.85	1.13

their teaching, have particularly positive views on the concept. With regard to teacher knowledge, we found that teachers who covered both aspects in their answers also more frequently reported to integrate both aspects into their teaching. However, as the regressions showed, only teachers' beliefs on SRL predicted teacher behavior when including all variables into the analyses. This finding is consistent with Lombaerts et al. [34] who also found only teachers' beliefs on SRL to predict teachers' recognition of self-regulation practices.

An interesting point that requires further investigation is the inconsistency between teacher beliefs and teacher practice. Although teachers consider SRL as important, most of them do not integrate strategy instruction into their teaching. As teachers' beliefs seem so positive, there might be misconceptions among teachers about providing students with the tools to manage autonomy effectively. A limited or improper theoretical understanding of teachers could lead to frustration among students as well as among teachers about SRL (see [47]).

4.2. Limitations. The presented study is subject to some limitations. The small sample size does not allow generalization to primary school teachers at large. Teachers who were willing to participate were probably already motivated and interested in the topic. Thus, the general picture on teachers' beliefs on self-regulated and constructivist learning might be less positive and less promising. However, the results on teachers' knowledge—assuming that the teachers of this sample were more motivated and interested than the average teacher—allow the assumption that the knowledge of primary school teachers in general might be even more limited with regard to direct and indirect promotion of SRL. A second limitation is the assessment of teachers' beliefs, knowledge, and behavior by means of self-report. Teachers might want to produce a more positive picture so that their self-report could be subject to social desirability. Classroom observations could serve to get a more representative picture of teachers' behavior with regard to fostering students' self-regulation. Finally, a general difficulty in assessing teacher beliefs and knowledge is that both are hard to assess separately from each other, since the two constructs are hard to disentangle also from a theoretical perspective. Moreover, we have tried to cope with the risk of teachers answering in a socially desirable way by asking them open questions to assess their knowledge on fostering SRL. This goes along with the general disadvantage of open questions, that they cannot provide ratings.

4.3. Implications. The results of this study can give an indication to the causes why teachers do not instruct SRL more often, and where researchers and teacher educators would have to start in order to enable teachers to promote SRL effectively. When looking at teachers' conceptions of the enhancement of self-regulation among their students, it becomes clear that the area of direct strategy instruction has somehow got lost in teachers' minds (or has never existed) next to the constructivist idea of leaving students the autonomy to regulate their learning on their own. The results illustrate the need for informing teachers through teacher training. Concerning primary school teachers, the problem lies not in teachers' attitude but rather a lack of knowledge on how to support students' self-regulation effectively. However, teacher beliefs play the crucial role when predicting teachers' promotion of SRL in their classrooms. Helping teachers to develop an effective way of integrating SRL into their teaching would have to start by creating awareness of both ways to foster self-regulation. Moreover, the study has shown that teachers already dispose of positive attitudes towards the idea of providing students with autonomy. The question is whether the positive picture that has appeared in this study really constitutes the base that teacher educators would have to start from, or whether it reflects teachers' ideas on how they *should* think. When trying to change teachers' beliefs on enhancing SRL, there might be more variables affecting teacher behavior than just their conceptions on promoting it. One could think, for example, of teachers' self-efficacy. Teachers might appreciate the idea of SRL, but if they do not feel capable of managing more student autonomy, they won't integrate it into their teaching, no matter their positive beliefs. As Kramarski and Revach [47] concluded, based on the teacher training that they had conducted to help teachers' integrating SRL in their classrooms, teachers' self-efficacy might be related to teachers' professional development and might cause teachers not implementing what they have learned during training. Future research should account for teachers' perceived behavioral control when further investigating the association between teacher beliefs and teacher behavior with regard to fostering self-regulation.

Furthermore, with regard to teacher training, one should keep in mind that teacher beliefs also influence the perception of new information [9, 20]. Therefore, it is crucial to be aware of teachers' conceptions and misconceptions and to take them into account when developing trainings. Moreover, training should take place as early as possible for two reasons. First, preservice teachers in the beginning of their career start using traditional teaching methods that they know from their own schooling experience (see [24]). Second, teachers at some point develop their own (potentially incorrect) beliefs on the promotion of self-regulation based on their teaching experience. These beliefs then start influencing their perceptions of new information. It is important to change teacher beliefs before this happens.

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Review Article

Self-Regulated Learning in the Classroom: A Literature Review on the Teacher's Role

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Empirical research has supported the long held assumption that individual differences exist in how students learn. Recent methodological advancements have allowed educational research to examine not only *what* students learn, but also *how* they learn. Research has found that active involvement in learning, including setting meaningful goals, selecting appropriate and task-specific strategies, monitoring motivational levels, and adapting based on feedback are all positively related to learning outcomes. How can teachers support students' development and use of these learning processes? The goal of this paper is to examine research that has used the Self-Regulated Learning (SRL) theory to consider this broad question. Methodological advancements recently used in this field of research, various SRL theoretical frameworks guiding this research, and studies that empirically examined self-regulation with both preservice and inservice teachers are discussed. The paper concludes with the theoretical, methodological, and practical implications of the reviewed studies.

1. Introduction

Empirical research has supported the long held assumption that individual differences exist in how students learn. Recent methodological advancements have allowed educational research to examine not only *what* students learn, but also *how* they learn. Moos and Azevedo, for example, have used a think-aloud protocol to capture the dynamic nature of how individual students use strategies, monitor emerging understanding, and make plans during learning. The think-aloud has provided rich data, as evidenced by the following excerpt from one of their studies [1]. This study provided process data on how students learn about a conceptually complex science topic. The regular font indicates the student's thoughts as she thinks aloud, whereas the italicized font indicates reading from the material during the learning task.

I am going to start with the circulatory system just because I am already there…and I'm just reading the introduction…circulatory system…also known as the cardiovascular system and it deals with the heart…it transports oxygen and nutrients and it takes away waste…um, it does stuff with blood and I'm kind of remembering some of this from bio in high school, but not a lot of it.

> *Reads: The heart and the blood and the blood vessels are the three structural elements and the heart is the engine of the circulatory system, it is divided into four chambers.*

I knew this one, two right and two left…the atrium, the ventricle and the left atrium, and the left ventricle…okay start the introduction [of the heart], just kind of scout it out real quick…and there's a section called function of the heart…and it looks like it will give me what I need to know…um…introduction, oh that's just basic stuff that we've been doing…

> *Reads: Structure of the heart has four chambers…*

We did that…

> *Reads: The atria are also known as auricles. They collect blood that pours in from veins…*

So, it looks like the first step is atria in the system and then the veins.

Though this segment is a small snapshot of the student's learning process for this particular task (see [2] for the complete data), it is clear that she was actively engaged in the learning process. She monitored the relationship between the content and her prior domain knowledge (i.e., "I am kind of remembering some of this from bio in high school"), while also using appropriate strategies. Even within this short learning segment, the student engaged in these monitoring processes and used strategies at multiple points (i.e., "We did that..." and "So, it looks like the first step is atria..."). This student's active engagement was not observed with all the participants in this study, as demonstrated by the following excerpt from another participant who was asked to learn the same material in an identical context as the above student.

I am going to the introduction...

> *Reads: Circulatory system, or cardiovascular system, in humans, the combined function of the heart, blood, and blood vessels to transport oxygen and nutrients to organs and tissues throughout the body and carry away waste products...*

I'm going to take notes...transport oxygen...nutrients...to organs and tissues and carry away waste products.

> *Reads: Among its vital functions, the circulatory system increases the flow of blood to meet increased energy demands during exercise and regulates body temperature. In addition, when foreign substances or organisms invade the body, the circulatory system swiftly conveys disease-fighting elements of the immune system, such as white blood cells and antibodies to regions under attack...*

I'm writing down the structural elements...

> *Reads: The heart is the engine of the circulatory system. It is divided into four chambers: The right atrium, the right ventricle, the left atrium, and the left ventricle. The walls of the chambers are made of a special muscle called myocardium, which contract continuously and rhythmically to pump blood.*

...okay, the heart...engine...the chambers...right and left atrium...right and left ventricle. Okay...special muscle...myocardium...mmmm...

> *Reads: The human heart has four chambers, the upper two chambers...the right side of the heart is responsible for pumping oxygen-poor blood to the lungs...This oxygen-poor blood feeds into two large veins, the superior vena cava and inferior vena cava. The right atrium conducts blood to the right ventricle, and the right ventricle pumps blood into the pulmonary artery. The pulmonary artery carries the blood to the lungs, where it picks up a fresh supply of oxygen and eliminates carbon dioxide.*

This student exhibited a different learning process, with limited monitoring activities and use of a small subset of strategies. Such differences in how students learn explain variability in what they learn.

These two examples are consistent with the long held theoretical assumption that students actively construct knowledge in an idiosyncratic process (i.e., Constructivism; [3]). Ideally, students actively engage in the learning process, such as setting meaningful goals, selecting appropriate and task-specific strategies, monitoring motivational levels, and adapting based on feedback are all positively related to learning outcomes [1, 2, 4–12]. However, empirical research has provided process data that reveal the substantial individual differences with which students engage in the learning process. Certainly, individual cognitive characteristics (e.g., prior domain knowledge), motivational levels (e.g., self-efficacy), and developmental constraints affect how students learn. Aside from personal variables, the context can assume a particularly powerful role in how students approach the learning process and further develop their learning skills. Imagine, for example, a teacher who holds a personal belief that authority figures have knowledge that is inaccessible to novices. This teacher may resort to more didactic classroom practices, such as a reliance on lecturing/direct instruction, and thus may limit opportunities for students to engage and further develop learning skills. A fundamental question arises as to how teachers can best support students' development and use of learning processes. The goal of this paper is to examine research that has considered this broad question. The first step in examining this question is to articulate a theoretical framework that is robust enough to explain the complexities of learning. As such, the next section will first provide an overview of the Self-Regulated Learning (SRL) theory. Following this overview, SRL in the context of the classroom will be briefly examined and the role of the teacher in self-regulation will be introduced. Finally, a detailed rationale for this paper is provided at the conclusion of this section.

2. Overview of SRL Theories

In order to examine how teachers can best support their students' SRL, it is necessary to first understand *how* students can self-regulate their learning. Though the field of SRL has led to the development of distinct theoretical approaches that focus on a variety of constructs [13, 14], there are four common assumptions regarding how students can self-regulate their learning [15]. First, it is assumed that students can potentially monitor and regulate their cognition, behavior, and motivation, processes that are dependent on a number of factors including individual differences and developmental constraints. A second assumption suggests that students actively construct their own, idiosyncratic goals and meaning derived from both the learning context and their prior knowledge. Thus, students engage in a constructive process of learning. Not surprisingly, then, it is also assumed that all student behavior is goal-directed and the process of self-regulation includes modifying behavior to achieve goals. Lastly, it is assumed that self-regulatory behavior mediates the relationship between a student's performance, contextual factors, and individual characteristics.

While these assumptions provide the foundation for most SRL theories (see [14] for an overview), specific approaches have been predominant in research examining how students self-regulate their learning within the context of the classroom. Zimmerman's [16] SRL theory is one of the most common theories in this line of research. In this model, self-regulation is composed of three phases: *forethought*, *performance control*, and *self-reflection*. In the first phase, the student "sets the stage" for the upcoming learning task. Self-regulated students develop realistic expectations, create goals with specific outcomes, and identify plans to maximize success in the particular learning task. It is in this phase that self-regulated students may ask themselves such questions as "Where is the best place for me to complete the work?", "What conditions will create challenges for me?", and "How will I start?" Performance control, the second phase of SRL in this theoretical approach, constitutes processes that are involved during learning. This phase includes specific strategies such as self-talk and self-monitoring that are used to maximize success on a learning task. Questions that self-regulated students may ask themselves in the second phase are "Am I following my plan correctly?", "Am I being distracted?", and "What strategies can I use to help me keep working?" Lastly, self-regulated students reflect at the conclusion of the learning activity, the third phase of SRL. This self-evaluation compares the performance outcome to goal(s). Self-regulated students in the phase will ask themselves such questions as "Did I meet all of the goals?", "Which conditions helped me be successful and what conditions distracted them?", and "Which strategies were effective given the context and learning activity?"

Pintrich [15] offers a slightly different perspective on how students can self-regulate their learning, with a comprehensive framework of four phases and four areas. The four phases include *planning*, *monitoring*, *control*, and *reflection*. These phases are intended to reflect common assumptions shared by many SRL models [17]. In phase one, the student plans, sets goals, and activates knowledge about the context, text, and self. Phase two is defined when the student exhibits metacognitive awareness and monitoring of cognition. In phase three, the student selects cognitive strategies and regulates different aspects of the context, task, and self. Lastly, in phase four, the student makes cognitive judgments and reflections on the context, task, and self. Within these individual phases, Pintrich [15] also proposes four different areas in which self-regulation can occur. Based on different psychological functioning (see [18]), the first three areas for regulation are *cognition*, *motivation/affect*, and *behavior*. The last area reflects contextual features, such as task characteristics, which can impede or facilitate an attempt to self-regulate their learning. As commonly suggested by most SRL theories, Pintrich's [15] model assumes that these phases are not hierarchical because they can occur concurrently and dynamically.

Winne and colleagues (i.e., [19–22]) offer another perspective that is guided by the Information Processing Theory (IPT). This model includes four phases of SRL: (1) *understanding the task*, (2) *goal-setting and planning how to reach the goal(s)*, (3) *enacting strategies*, and (4) *metacognitively adapting to studying*. In the first phase, the student constructs a perception of the task from information in the learning context (Task Conditions) as well as information from prior experience and knowledge (Cognitive Conditions). The student develops goals and plans in the second phase, followed by selection and use of tactics and/or strategies in the third phase. Phase four includes monitoring activities and making cognitive evaluations about discrepancies between goal(s) and current domain knowledge. This model assumes that SRL has a recursive nature due to a feedback loop, during which discrepancies revealed by monitoring activities will lead self-regulated students to adapt their planning and/or strategies.

3. SRL in the Classroom

All three of these theoretical frameworks explicitly account for the role of context in students' SRL. The social cognitive approach to SRL (Zimmerman, 1994 [17]), for example, assumes that environmental factors have a bidirectional interaction with students' personal and behavioral characteristics. Interaction with the context results in cyclical development and adaptation of students' SRL. For example, teachers could foster their students' *self-reflection* by prompting them with questions such as "Did you meet all of the goals of the learning task?" and "Which strategies were effective for this particular learning task?" This prompting by the teacher may, in turn, foster the students' engagement in *forethought* as they "set the stage" for the subsequent, upcoming learning task.

Though the IPT approach [20, 21] offers distinct assumptions, it also provides an explanation of how context affects SRL. According to this theory, students develop perceptions of the learning task partly based on information provided in the context. This theory assumes a cyclical nature to SRL; information processed in one phase can become an input to subsequent information processing. Teachers' support of metacognitive monitoring, for example, can assist students in this critical component of SRL. These theoretical assumptions regarding the importance of the context and documented empirical relationships between SRL and learning outcomes have led to recommendations that classroom instruction should extend beyond factual knowledge. It has been argued that competencies with the process of learning, such as students' ability to self-regulate their learning, should be a central, explicit aim within education [23]. Thus, teachers' ability to support students' development of self-regulation should be carefully considered if students' SRL is an educational goal [24].

Research has also suggested that teachers should focus on their own self-regulated learning skills because it allows them to more deeply reflect on their own teaching practices, which can lead to increased student performance (Let and Lin 2003; Xiaodong et al., 2005). Others have argued that teachers need to be self-regulated learners themselves due to ever-changing curricular revisions, which require innovation and adaptability [25]. Teachers who engage in self-regulation are better able to meet these demands because they can balance a variety of professional demands, engage in reflective thinking, and embrace adaptation. Furthermore, a growing body of research has found a significant relationship between teachers' personal beliefs and their instructional pedagogy [26–28] (Shraw and Olafso, 2002). Teachers who are incapable of self-regulating their own learning and/or do not hold personal beliefs that students can engage in SRL are less likely to support the development of these capabilities in the classroom [29–31].

4. Rationale of Literature Review

Given the importance of SRL in the context of classrooms, it is not surprising that a rich body of empirical research has emerged examining how teachers support their students' self-regulation, as evidenced by literature reviews on classroom applications of SRL. For example, Paris and Paris [32] provide an incredibly informative literature review that categorizes relevant research into two groups, both of which focused on promoting SRL in students. One group of studies assumed a developmental view of SRL and sought to examine how students self-regulate learning to meet personal goals. A second group of studies examined the role of a transmission model in the acquisition of SRL. These studies considered the effect of explicit instruction in the use of self-regulated learning strategies. Such reviews have greatly advanced the field by providing clear and explicit guidelines for promoting SRL in the classroom. It was our aim to provide a literature review that offers a slightly different perspective from existing reviews by considering the methodological advancements recently used in this field of research (i.e., process data), discussing various theoretical frameworks guiding this research, and summarizing studies that empirically examined SRL with both pre-service and in-service teachers. This literature review aims to systematically consider each of these areas through the following research questions:

(1) What implications do the literature provide for supporting SRL in teacher education programs?

(2) What implications do the literature provide for supporting SRL with different kinds of teachers?

(3) How is SRL measured in research that examines self-regulation in the classroom?

5. Method

5.1. Criteria of Selection. The empirical studies selected for this Literature Review examined the teacher's role in relation to SRL. After the initial selection of articles, inclusion criteria were used to identify which studies would be examined for this Literature Review. These criteria centered on three main areas: (1) Theoretical Framework; (2) Focus on Teachers; and (3) Methodology.

First, studies were chosen that were explicitly guided by a SRL theory and used this theoretical framework as a lens to interpret the results. Studies were excluded from this review if they examined a specific process of SRL, such as strategy use, but did not explicitly reference a SRL theory. Secondly, studies had to include either pre-service or in-service teachers in the sample. Because our research questions consider the teacher's role in SRL, it was necessary for included studies to measure and assess teachers in some way. Third, the methodology of each study was evaluated in order to determine the soundness of its statistical analyses. In addition, the sample of the study needed to be appropriately described. Lastly, studies that focused on development of SRL measures were excluded due to the scope of this Literature Review.

5.2. Search Procedures. Based on a suggested framework for developing literature reviews (see [33]), the literature search was comprised of two stages: (1) Identify all relevant articles in an initial search; (2) Select articles to review based on inclusion criteria. First, a search for articles from the PsycInfo database was performed. During this initial literature search, a variety of keywords ("self-regulated learning"; "self-regulat*"; "SRL"; "teacher"; "student teacher"; "pre-service teacher") from the articles' abstracts were used to identify the most relevant articles.

The first stage of the search produced 186 articles on SRL and teachers. In the second stage of the search, dissertation, chapters, literature reviews, and technical reports were removed from the pool of potential articles. In the third stage of the search, the inclusion criteria were applied to the remaining articles. The articles that were explicitly guided by a SRL theory, had a focus on in-service and/or pre-service teachers, and used a sound methodological approach were included. This final stage of the search, which concluded in June of 2011, resulted in 38 articles to be included in this Literature Review. Articles published after June of 2011 were not included in this Literature Review.

We examined these remaining articles for natural groupings and created three research questions that captured what we believe to be important components of the topic. The articles in these three main research questions were further divided into subsections illustrating specific trends within each question (see Figure 1 for the research questions and subsections). The organization of the articles for the first research question was not explicitly guided by predetermined categories, but rather was done post-hoc to determine the most natural groupings. This bottom-up approach was deemed to be most appropriate given there were no inherent assumed categories for this question, particularly when compared to the second and third research question. Many of the articles could have been placed in multiple categories so we assigned them according to the best fit (see Table 1 for complete list of articles, by research question). We chose thirteen of these articles to address the first research question, which considered the implications for teacher education programs. Nineteen studies examined the implications for in-service teachers supporting SRL with different kinds of teachers, our second research question. The final six articles formed a group relating to the third research question that considered how SRL is measured in the studies.

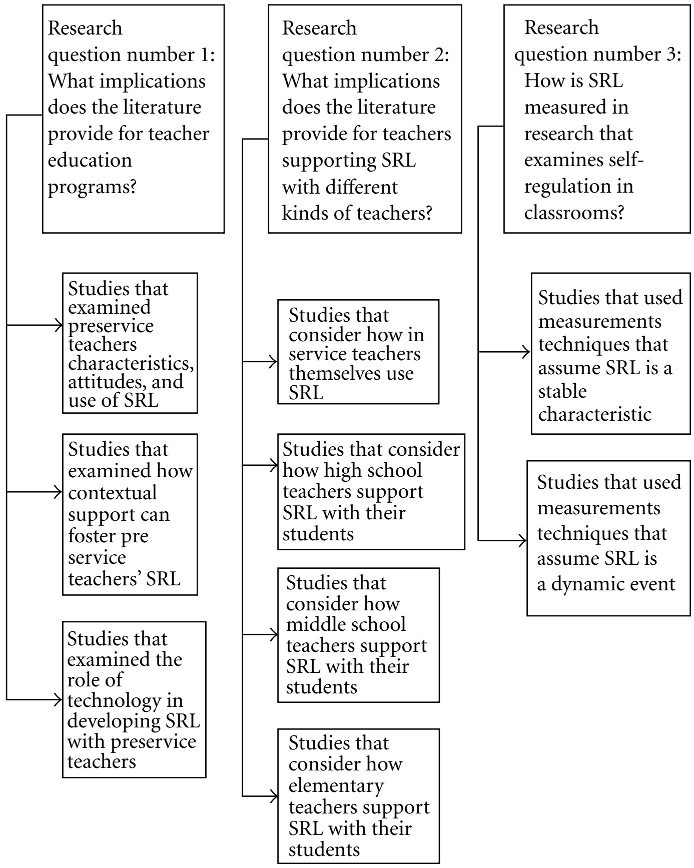

Figure 1: List of research questions and subsections.

6. Results

6.1. What Implications Does the Literature Provide for Teacher Education Programs? This section synthesizes studies that empirically examined self-regulation within populations of preservice teachers. Not surprisingly, a group of these reviewed studies considered the relationship between preservice teachers' characteristics and attitudes with SRL. For example, Bråten and Strømsø [34] examined the role of personal theories of intelligence and epistemological beliefs in "motivational and strategic components" of SRL with 108 student teachers and 178 business administration college students. Multiple regressions revealed a significant effect of personal beliefs on SRL. Specifically, beliefs about knowledge construction were a strong predictor of SRL for the student teachers. Other studies reveal that preservice teachers' personal beliefs regarding SRL may be conceptually different than their teacher educators. Kremer-Hayan and Tillema [35] interviewed 32 Israeli and 58 Dutch teacher educator, and student teachers in order to investigate potential differences in how these two groups view the meaning and implementation of SRL in the classroom. Somewhat surprisingly, the teacher educators were found to have a *less* positive attitude towards SRL and *lower* expectations about their competencies related to self-regulation. Other research has focused on the relationship between preservice teachers' motivation and use of learning strategies during education courses. Atputhasamy and Aun [36] found a positive relationship between those who used deeper level processing strategies such as metacognition and elaboration and learning goal orientation. Student teachers who reported an achievement goal orientation, on the other hand, used fewer self-regulatory processes, including organization and critical thinking.

The relationship between preservice teachers' personal beliefs and SRL raise the question of whether there is a developmental trajectory with their self-regulation competencies during teacher education programs. Some research has shown that appropriate contextual support can enhance SRL development. Hutchinson and Thauberger [37] present compelling evidence that student teachers can, in fact, be mentored to more effectively foster elementary children's use of SRL. Detailed analyses of transcripts revealed that a variety of scaffolding techniques during discussions support student teachers' development of SRL practices within elementary classrooms. Perry et al. [38] provide additional information on how student teachers can be mentored to design instructional contexts that support SRL. These two studies provide promising data that student teachers are capable of designing such tasks. These findings are contrary to the notion that several years of experience are required before teachers can begin to consider students' needs and

Table 1: Complete list of reviewed studies by research question.

Research question 1: what implications does the literature provide for teacher education programs? ($n = 13$)
Studies that examined preservice teachers' characteristics, attitudes, and use of SRL
(i) Bråten and Strømsø [34]
(ii) Kremer-Hayon and Tillema [35]
(iii) Atputhasamy and Aun [36]
Studies that examined how contextual support can foster preservice teachers' SRL
(i) Hutchinson and Thauberger [37]
(ii) Perry et al. [38]
(iii) Perry et al. [40]
(iv) Kramarski and Michalsky [29]
(v) Kramarski and Michalsky [41]
(vi) Michalsky and Kramarski [43]
(vii) Kramarski [44]
(viii) Kramarski and Revach [45]
Studies that examined the role of technology in developing SRL with preservice teachers
(i) Delfino et al. [25]
(ii) Dettori et al. [46]
Research question 2: what implications does the literature provide for teachers supporting SRL with different kinds of teachers? ($n = 19$)
Studies that consider how inservice teachers themselves use SRL
(i) Kreber et al. [47]
(ii) Hoekstra et al. [51]
(iii) Tillema and Kremer-Hayon [48]
(iv) Van Eekelen et al. [49]
(vi) Gordon et al. [50]
Studies that consider how high school teachers support SRL with their students
(i) Oolbekkink-Marchand et al. [52]
(ii) Kistner et al. [53]
(iii) Veenman et al. [54]
(iv) Postholm [55]
Studies that consider how middle school teachers support SRL with their students
(i) Pauli et al. [56]
(ii) Cooper et al. [57]
Studies that consider how upper elementary teachers support SRL with their students
(i) Ee et al. [58]
(ii) Housand and Reis [59]
(iii) Meyer et al. [60]
(iv) Cartier et al. [61]
(v) Hilden [62]
Studies that consider how younger elementary teachers support SRL with their students
(i) Perry [63]
(ii) Perry and VandeKamp [64]
(iii) Perels et al. [65]
Research question 3: how is SRL measured in research that examines self-regulation in the classrooms? ($n = 6$)
Studies that used measurements techniques that assume SRL is a stable characteristic
(i) Kramarski and Michalsky [29, 41, 66]
(ii) Lombaerts et al. [67]
(iii) Hwang and Vrongistinos [68]
Studies that used measurements techniques that assume SRL is a dynamic event
(i) Davis and Neitzel [69]
(ii) Perry et al [30]
(iii) van Eekelen et al. [49]

abilities when planning and implementing instruction [39]. Direct scaffolding and explicit instruction, both in education courses and during student teaching, can assist preservice teachers' implementation of classroom tasks that offer autonomy, control challenge, and non threatening self and peer evaluations, all of which are hallmarks of classrooms that support SRL [38]. Perry et al. [40] also examined whether master teachers can mentor student teachers to develop and implement classroom practices that foster SRL in an elementary school setting. Data indicate mentoring is effective and that master teacher practices accounted for 20% of the variance observed in the student teachers' SRL practice.

Other research has turned to technology as a means to support preservice teachers' SRL development. Kramarski's robust and innovative line of research has evidenced the potential of emerging technology in preparing teachers, particularly for supporting self-regulation in the classroom. Kramarski and Michalsky [29], for example, investigated how the development of three dimensions (SRL in pedagogical context, pedagogical knowledge, and perceptions of teaching and learning) was affected by various contextual supports, namely, e-learning with and without SRL support and face-to-face learning with and without SRL support. In this study, preservice teachers randomly assigned to the e-learning condition were asked to solve pedagogical tasks (i.e., compare different types of cooperative learning) with a nonlinear technology environment. Preservice teachers assigned to the face-to-face condition, on the other hand, were asked to solve the same pedagogical tasks with material provided by the teacher (i.e., a more "traditional" classroom setting). Results indicated a significant effect of SRL support; those who received it in both the face-to-face and e-learning conditions outperformed those who did not receive it. However, those preservice teachers who received this support in the context of technology (e-learning) demonstrated highest SRL ability, pedagogical knowledge, and student-centered learning perceptions. Kramarski and Michalsky [29] argue that the nature of emerging technology, such as the e-learning environment used in this study, encourages the use of exploration, elaboration, and activation of prior knowledge because of its inherent nonlinear design. Therefore, explicit support of SRL in these environments promotes more active engagement of learning material. Kramarski and Michalsky [41] found similar results in another study that examined the effects of two hypermedia environments and SRL support with 95 preservice teachers. This study focused on a specific component of SRL, metacognition. Originally conceptualized as "thinking about thinking" (see Miller et al. 1970, p. 613), metacognition has more recently been conceptualized to include both the conscious awareness and regulation of one's own learning. Metacognition is a construct that focuses on processes related to the abstraction of existing or new cognitive structures [42]. A number of SRL theories highlight the importance of metacognition in self-regulation (e.g., [21]), noting its role in effective task execution. Metacognitive processes affect the use of cognitive activities, which support the acquisition and retention of knowledge (Ku and Ho, 2010). Kramarski and Michalsky [41] found that exposing preservice teachers to metacognitive support in hypermedia environments enhances their own metacognition. Participants who received metacognitive support during the experimental learning session demonstrated a significantly better ability to regulate and reflect on their own learning processes. Based on these findings, Kramarski and Michalsky [41] suggest that preservice teachers with more developed metacognition ability will be better prepared to support this aspect of SRL with their own students [43]. Other studies have shown that metacognitive scaffolding can effectively foster preservice teachers' ability to use SRL processes such as self-monitoring and evaluation strategies [44, 45].

Karmarski and colleagues' work has typically used technology as the context for SRL support. Given the emerging nature of technology in preservice teacher education, this context is important to consider. Online classrooms, distance education, and hybrid classroom settings are becoming more commonplace. Some argue that these environments can optimize the SRL development of preservice teachers. Delfino et al. [25], for example, used an interaction analysis to examine how collaborative activities in an online classroom can develop preservice teachers' ability to support students' SRL. Participants repeatedly demonstrated SRL, including self-reflection, self-awareness, and setting immediate goals. Dettori et al. [46] also examined the impact of online learning environment on preservice teachers' development of SRL. Their study identifies specific aspects of the environment that can foster self-regulation, including social competencies, motivational aspects and metacognitive and cognitive skills.

6.2. What Implications Do the Literature Provide for Supporting SRL with Different Kinds of Teachers Groups? A small subset of the reviewed studies for this research question focused on how inservice teachers themselves use SRL to learn new information and engage in professional development. Kreber et al. [47] used semistructured interviews to examine how 31 university science teachers engage in SRL when developing their expertise about teaching. Guided by both Zimmerman's SRL model [16] and Kreber and Cranton's Scholarship of Teaching model, the researchers came to the conclusion that individual differences in how university teachers engage in SRL are a product of educational development experiences. Workshops on teaching, active solicitation of student feedback, and adaptation of teaching practices positively affect SRL of university teachers. Tillema and Kremer-Hayon [48] found that in addition to previous experiences, personal beliefs of university teachers also affect the extent to which they engage in SRL. Data gathered from 12 Israeli and 17 Dutch teacher educators surprisingly suggest a divergence between teachers' pedagogy and the extent to which the teachers were engaging in SRL themselves. van Eekelen et al. [49] found similar results with fifteen experienced college teachers from The Netherlands. Using semi-structured interviews and a digital diary study, they found limited examples of teachers engaging in self-regulation with their learning. This somewhat surprising lack of SRL within this particular group of in-service teachers raises pedagogical issues and questions for teacher education programs, particularly if it is assumed that teachers' own self-regulatory behavior affects the classroom environment [50]. Research has suggested that changes in experienced teacher's self-regulatory behavior are related to their experimentation with new teaching methods and active reflection on the effectiveness of a variety of teaching methods [51].

From a developmental perspective, Oolbekkink et al. [52] considered the differences and similarities between 36 university and secondary teachers' perspectives on SRL. The researchers aimed to use teachers' perspective on SRL as an explanatory lens for why some students face a problematic transition from secondary to higher education. Not surprisingly, a qualitative analysis of the interview protocols in the study revealed that while university teachers focus on the variety of content, secondary teachers tend to consider the variety within students, particularly with how they engage in self-regulation. Kistner et al. [53] provide perspectives on how high school teachers support SRL with a study that included 20 German mathematics teachers and their 538 secondary students. A coding system was used to assess the teachers' explicit and implicit instruction of various SRL strategies, including motivation (resource management), metacognition (planning), and cognition (organization). Students' performance, which was measured before and after the learning lesson, was positively related to cognitive strategies. However, these researchers also note that while explicit instruction of cognitive strategies was positively related to student performance (more so than implicit instruction), the occurrence of this embedded instruction was rare. Veenman et al. [54] provide a potential explanation for the rarity of explicit SRL instruction in high school classrooms. This study included a SRL training program for 25 Dutch secondary school teachers, with a quasiexperimental, treatment-control group. Classroom observations and ratings from both teachers and students led to the conclusion that the SRL training program had little effect on classroom practices. It was concluded that training secondary teachers to explicitly embed the instruction of SRL strategies is time consuming and effects may not been seen immediately. Actively embedding SRL instruction is important, though, even for the older development group of high school students. Research has demonstrated that students of this age benefit from explicit instruction and teachers' willingness to adapt classroom practices to meet their developmental level with respect to SRL [55].

Substantially fewer studies have considered the role of the middle school teacher in supporting SRL. Pauli et al. [56] explored the extent to which 8th grade math teachers implement various features of SRL to promote problem solving and mathematical modeling. Measurement techniques included videotapes of lessons, student and teacher questionnaires, and math achievement tests. Teachers reported how frequently they provided opportunities for SRL and independent problem solving. Results indicate that teachers' personal beliefs influenced the extent to which they fostered independent problem solving. Furthermore, opportunities for SRL were positively related to students' learning experience. However, research has demonstrated that these opportunities need to be explicit to the students, as evidenced by Cooper et al. [57] study. This study examined how 7th grade high school English teachers can foster SRL. The researchers collaborated with the participating teachers, meeting once a week over a three-month period to discuss how to design higher-order reasoning questions in a myriad of class assignments. Interviews revealed that conscious and explicit embedded instruction of SRL resulted in students' increased understanding of self-regulation, particularly with goal setting.

Research has supported the assumption that SRL can be fostered with even younger students in upper elementary grades. Ee et al. [58] study examined the relationship between teachers' goal orientations and instructional practices with their Primary 6 students' SRL. The sample included 566 high achieving Primary 6 students and 32 teachers across 34 Singapore schools. Surprisingly, this study found a negative relationship between teachers' explicit SRL instruction (primarily cognitive strategies) and students' ego goal orientation. One explanation is that participants were all high-achieving and thus may have reached a certain level of automaticity with the use of cognitive strategies. As a consequence, explicit instruction of a skill that was already possessed may have had negative motivational effects on the students. This somewhat surprising finding concerning explicit SRL instruction with middle school students contradicts other findings with upper elementary students. For example, Hilden and Pressley [62] found evidence that a year-long professional development program in which 5th grade teachers were trained how to explicitly teach SRL resulted in the improvement of both their reading comprehension instruction and their students' self-regulated use of comprehensive strategies.

These two findings suggest that the effectiveness of explicit SRL instruction may be mediated by personal characteristics. Housand and Reis [59] present an argument that gifted and high achieving students as early as fifth grade may have already obtained the capacity to engage in a variety of SRL processes. Their findings suggest some upper elementary students demonstrate the ability to engage in self-regulation even in classrooms that are characterized as low self-regulation. Though fewer in numbers, these studies indicate that while the environment certainly can affect the development of SRL, there are personal characteristics that play a role. However, it is commonly assumed that in addition to personal characteristics the context of the environment and instructional opportunities need to be clearly considered, if SRL is an educational goal [61]. Some research has pointed to technology as an instructional opportunity to foster self-regulation for upper elementary students. Meyer et al. [60], for example, examined the impact of an electronic portfolio, ePEARL, on the literacy and SRL of 296 4th–6th graders across three Canadian provinces. The 14 teachers who participated in this study reported that the use of this electronic portfolio had a positive impact on their SRL teaching strategies and that the students' increased literacy was a result of the planning and reflecting required by this learning tool.

Given the developmental trajectory of students' SRL, it has been questioned whether younger elementary students can engage in SRL. Perry and colleagues have added significant work in this area. Their rich line of research has provided compelling evidence that the youngest elementary-aged students are capable of self-regulating their learning. Perry's earlier work [63] challenged the notion that young children lack the capacity to engage in SRL and adapt their motivational orientations. Contextual factors of the environment can provide the necessary support for students as young as 2nd and 3rd grade to develop the ability to self-regulate their learning. Classroom observations led Perry and VandeKamp [64] to the conclusion that nonthreatening evaluation practices, involvement in complex reading and writing activities, the provision of autonomy related to what the students read and write about, and the ability to modify learning tasks to control challenge are all contextual features of classrooms that promote SRL in younger elementary-aged children. Others have shared Perry's findings, such as Perels et al. [65]. This study examined the effect of SRL training on 35 German kindergarten teachers. Results from teacher self-report questionnaires and student interviews suggest that training effectively improves teachers' ability to foster SRL with students as young as preschool.

In sum, these lines of research suggest that teachers of different age groups distinctly support SRL in their classrooms. Generally speaking, research has found limited examples of learning opportunities that support SRL in university and college classrooms [49]. Findings suggest that these teachers tend to focus on the content of their class. On the other hand, secondary (high school) teachers tend to consider the variety within students, particularly with how they engage in self-regulation [52]. However, research suggests that while high school teachers may offer more opportunities for students to engage in SRL, these experiences may be implicit in the teacher's pedagogical approach [53]. Explicit instruction of SRL is not readily apparent in high school teachers' instruction, findings that have also been replicated within middle school classrooms. Though middle school students benefit from explicit SRL instruction, teachers of this developmental group do not routinely integrate this component into lesson plans [57]. Quite surprisingly, while empirical documentation of explicit teacher support with middle and high school students' SRL has not been substantially documented, research at the elementary level suggests that these teachers do, and should, support SRL. Nonthreatening evaluation practices, involvement in complex reading and writing activities, the provision of autonomy related to what the students read and write about, and the ability to modify learning tasks to control challenge are all pedagogical practices observed of elementary school teachers that promote SRL [64].

One common thread among the empirical findings from different groups of teachers is the existence of individual differences in how they support SRL. While the findings suggest some differences between groups of teachers, there are also distinctions within these groups of teachers. The findings suggest that personal beliefs explain these individual differences, an assumption that is supported by previous work. Sugrue [70] argued that teacher's beliefs are the latent foundation for their behaviors and instructional decisions, a notion that has been supported by various lines of research (see [71–75]). For example, teachers who hold personal beliefs that authority figures have knowledge that is otherwise inaccessible may resort to classroom practices that do not explicitly support SRL, such as lecture/direct instruction. Furthermore, previous research suggests that teachers' beliefs concerning student capacities affect implementation and planning of instruction [76]. For example, teachers are more likely to integrate student-centered activities in their instruction planning if they believe their students have the capacity to be active participants in their own learning. Taken together, future research would be well served to consider the interaction between the personal beliefs of inservice and preservice teachers and their instructional support of SRL.

6.3. How Is Self-Regulation Measured in Research That Examines How SRL Is Supported in the Classroom? The empirical research reviewed for the first two research questions illustrates how teachers support SRL in the classroom. Clearly self-regulation affects learning, and thus the teachers' role in supporting SRL is an important topic to empirically explore. Critical examinations of the teacher's role, though, are incomplete without consideration of the methodology behind the research. Researchers have used a variety of measures to examine SRL in the classroom, each of which reflects a distinct perspective of the underlying properties of self-regulation. Thus, a review of how teachers support SRL needs to also examine the underlying methodology. Winne (1997) and Winne and Perry [22] proposed that SRL could be viewed as having one of two properties, *aptitude* or *event*. An aptitude is a relatively enduring trait of an individual, which can be used to predict future behavior [13]. Based on this assumption, self-perceptions are considered valid measures of SRL. These perceptions often are derived from self-report questionnaires [22]. Relatively easy to administer and score, self-report questionnaires are an efficient tool in measuring students' self-perception of how they regulate their learning. On the other hand, viewing self-regulation as an event suggests that SRL unfolds within particular contexts and self-regulatory processes are dynamic unfolding events [13]. Several different protocols have been used to measure SRL as an event, including error detection tasks, observations, concurrent and retrospective think-alouds, and diaries.

A majority of the reviewed studies assumed SRL is a stable characteristic (i.e., an aptitude), as evidenced by their use of self-report questionnaires. The *Motivated Strategies for Learning Questionnaire* (MSLQ) has received considerable attention within this body of research. This self-report questionnaire includes declarations and conditional relations and was developed to assess "college students' motivational orientations and their use of different learning strategies for a college course" ([77]; page 3). Kramarski and Michalsky [66] used the MSLQ to investigate the effect of metacognitive prompts in a web-based learning environment for 144 first-year preservice teachers. Results from this self-report questionnaire found that supporting the participants' through the evaluation phase [16] was the most effective approach for fostering their perceived SRL in both learning and teaching contexts. Research has also used the MSLQ to examine the effect of diaries on preservice teachers development of SRL. Arsal [78] presented data that suggests preservice teachers' metacognition and time management can be improved by asking them to self-report their engagement in SRL use with a daily diary. Others have used revised versions of the MSLQ, such as Hwang and Vrongistinos [68]. The College Students' Self-Regulated Learning Questionnaire (CSSRQ) is a revised version of the MSLQ and consists of 93 items related to seeking help, time management, regulatory process, metacognition, critical thinking, organization, elaboration, rehearsal, self-efficacy, causal attributions, task value, extrinsic motivation, and intrinsic motivation. All items are answered on a Likert scale ranging from 1 (*not at all true*) to 6 (*very true*). This study found that the academic performance of inservice teachers is positively related to self-reported use of SRL processes. High-achieving inservice teachers were more likely to engage in elaboration, metacognition, and other self-regulatory processes. Lombaerts et al. [67] used a different self-report questionnaire, the *Self-Regulated Learning Inventory for Teachers* (SRLIT) to assess elementary teachers' perceptions of SRL practices (Lombaerts, Engels, and Athanasou, 2007). The SRLIT consists of three subscales that represent Zimmerman's SRL model [16]: forethought, performance control, and self-reflection. The questionnaire contains 23 items answered on a six-point Likert scale ranging from 0 (*never*) to 5 (*always*). Results indicated that while demographic and background variables did not affect teachers' SRL recognitions, teacher-level variables had a positive impact. Beliefs concerning the influence of SRL in elementary school settings and school context satisfaction both positively are related to the teachers' self-reported SRL recognition.

Other lines of research have taken a different methodological approach by assuming SRL is a dynamic event that should be captured in real time. For example, Perry et al. [30] used observations of mentor and student teachers, videotapes of professional seminars, and samples of student teachers' reflections on lesson plans to capture how beginning teachers support SRL. Perry and colleagues [30, 79] have argued that process data, such as observations and other running records, address many of the challenges of measuring SRL in a valid manner. Observations and running records allow for the measurement of self-regulation in real time and enable the researcher to accurately identify behavior and classroom contexts that effectively support SRL. These measurements do not rely on the teacher or students' ability to predict how they will support SRL or use self-regulatory processes in the classroom, making these measurements ostensibly more accurate. Davis and Neitzel [69] have also used observational data to examine upper-elementary and middle school teachers' conceptions of their classroom practices. This methodological approach revealed that the teachers generally did not create an environment that optimally supported the development of their students' SRL, despite the teachers' deep understanding of classroom assessment.

7. Discussion

7.1. Overview. Theoretical assumptions that individual differences exist in student learning have been supported by empirical research. Paper, such as the one provided by Paris and Paris [32], offer a synthesis of this research and provide critical implications for how teachers can support their students' learning. Our goal in writing this paper was to extend the current research by summarizing studies that empirically examined SRL with preservice and/or inservice teachers. The following research questions guided the scope of this paper: (1) *What implications do the literature provide for supporting SRL in teacher education programs?* (2) *What implications do the literature provide for supporting SRL with different kinds of teachers?* (3) *How is SRL measured in research that examines self-regulation in the classroom?* The studies that were reviewed for these three questions provide theoretical, methodological, and practical implications for research that focuses on how teachers can support SRL.

7.2. Theoretical Implications. While a variety of SRL theories have guided research in this area, Zimmerman's [16] theory has been the most frequently cited in the reviewed studies. For example, Perels et al. [65] used this theory to guide their research on the effect of training 35 German kindergarten teachers on developing their own self-regulation skills and SRL within their students. Results are similar to that of Perry's research. Findings suggest that students as young as kindergarten have the capacity to self-regulate and training can effectively support teachers' ability to create classroom environments that foster SRL. Others have used Zimmerman's theory to examine the SRL of experienced teachers, including Hoekstra et al.'s [51]. This study examined changes in SRL of 32 teachers in informal learning environments. The findings suggest individual differences regarding how teachers change their SRL orientation. The extent to which teachers reflected on the effectiveness of their lessons seemed to positively correlate with conceptions of SRL. Zimmerman's [16] perspective of SRL has understandably been the predominant theory in this line of research. It offers a robust, explanatory lens that articulates the bidirectional interaction with students' personal and behavioral characteristics and their environment, as evidenced by both Perels et al. [65] and Hoekstra's [51] studies.

Other SRL theories have received less empirical attention in this line of research but are worth considering. Winne's model (i.e., [21, 22]), for example, provides unique assumptions that should be more closely examined with research considering the broad question of how teachers can support their students' SRL. This particular model of SRL stresses the role of metacognitive monitoring in the process of self-regulation. When students engage in metacognitive monitoring, they identify potential discrepancies between any teacher and/or student set goals and their current profile on a task [19, 20]. As such, metacognitive monitoring provides internally generated feedback, which assists students in adapting their SRL. Furthermore, metacognition allows students to regulate and govern task execution and is a critical process in the acquisition and retention of knowledge

(Ku and Ho, 2010). As Michalsky and Kramarski [43] have argued, teachers with more developed metacognitive ability themselves will be better equipped to support this critical aspect of SRL. While Kramarski's body of research has provided robust findings on types of metacognitive scaffolds that can foster preservice teachers' ability to use processes such as self-monitoring, there remains a paucity of research that is guided by Winne's model of SRL (i.e., [21, 22]).

7.3. Methodological Implications. In addition to theoretical considerations, the reviewed studies also provide methodological implications. A vast majority utilized self-report questionnaires to measure SRL, most notably the MSLQ [77]. This methodological approach assumes that self-regulatory processes are stable. Furthermore, self-report measures assume that both students and teachers can accurately report how they engage in the learning and teaching process. However, Perry et al. [79] suggest that self-regulatory processes should be examined in *real* time because SRL is an ongoing process that unfolds within particular contexts. As such, recent research has advocated that SRL should be considered an event and that self-regulation data should be collected during learning [22, 63, 80–82]. A smaller body of the reviewed studies utilized this type of process data. For example, Perry and colleagues' have successfully employed observations to measure both teachers and students' SRL, even with students as young as 2nd grade [63]. Other forms of process data may provide additional measures to successfully capture SRL in the classrooms.

The think-aloud, which has recently emerged as a useful protocol to measure SRL with emerging technologies (e.g., [4, 8, 11, 12, 83, 84]), offers an additional approach to capturing SRL in the classroom. This protocol is an online trace methodology that captures SRL *during* learning [80]. The think aloud has an extensive history in cognitive psychology and cognitive science (see [85–87]), where both concurrent and retrospective think-aloud protocols are used as data sources for cognitive processes [88]. While the think-aloud protocol has been most popular in reading comprehension [89, 90], it has been shown as an excellent tool to gather verbal accounts of SRL and to map out self-regulatory processes during learning (e.g., [13, 84]). Concurrent think-aloud protocols may be most appropriate with empirical research examining how preservice teachers use SRL. A concurrent think-aloud protocol asks participants to verbalize their thoughts, but not describe or explain what they are doing, while performing a task [86]. Based on the assumption that thought processes are a sequence of states and that information in a state is relatively stable [85] (Ericsson and Simon, 1993), verbalizing thoughts during learning will not disrupt the learning process. Empirical evidence has supported this assumption and suggested that an appropriately designed experimental session with a concurrent think-aloud protocol will not significantly affect cognitive and metacognitive processes during learning (i.e., [91–93]). An alternative approach is a retrospective think-aloud protocol, which involves participants verbalizing their thoughts following the completion of the task. For example, a teacher's lesson would be video and audio recorded without any disruption from the researcher(s) (other than the recording). Following the completion of the lesson, the teacher would watch the video and verbalize thoughts as they relate to how he or she supported SRL in the classroom. The teacher's firsthand account of how she or he supports SRL in the classroom diminishes potential validity issues associated with self-report questionnaires.

7.4. Practical Implications. Students' ability to actively engage with the learning material, such as setting appropriate goals, accurately monitoring their emerging understanding, and adapting the use of strategies, are critical competencies that should be a central, explicit aim within education [23]. Despite the importance of these self-regulatory processes, several of the reviewed studies suggest that explicit instruction of SRL is often rare. Veenman et al. [54], for example, found that the occurrence of embedded instruction of cognitive strategies was rare in high school classrooms. Why might teachers rarely integrate explicit SRL instruction into their lesson plans when it is shown to be effective? The reviewed studies indicate that this answer is not related to the effectiveness of training, professional development, and/or scaffolding. Empirical research has demonstrated that professional development programs are effective in improving teachers' ability to explicitly teach SRL within their classroom (e.g., [62]). Furthermore, Perry and colleagues provide robust evidence that student teachers can improve their ability to create classroom tasks that offer autonomy, and nonthreatening self and peer evaluations, as well as control challenge with the assistance of direct scaffolding from expert teachers. If, then, professional development and scaffolding can support inservice and preservice teachers' ability to create classrooms that support SRL, what accounts for an apparent rarity in this type of instruction [49, 54]?

Research suggests that changes in experienced teacher's support of SRL in the classroom are related to their willingness to experiment with new teaching methods and active reflection on the effectiveness of various teaching methods [51]. Furthermore, empirical findings indicate that instructional practices are significantly associated with personal beliefs (e.g., [74]). Sugrue [70], for example, found that teachers' beliefs are the latent foundation for their behaviors and instructional decisions, a notion that has been supported by various lines of research (see [71, 72, 75]). Bruning et al. [76] further suggests that teachers' behavior is directly aligned with their beliefs concerning specific components of the classroom, including beliefs about *course content* and *teaching*. Teachers' treatment of *course content* is, in part, dependent on their views about the nature of knowledge. Collectively, these beliefs represent personal epistemology, a field of study that has enjoyed a long history (Perry, 1970). Originally describing the understanding of knowledge as a progression from dualistic to relativist thinking, the field of epistemology has evolved and models have emerged suggesting that epistemology is composed of distinct dimensions (e.g., [27, 94–99]). Teachers' beliefs regarding *teaching*, on the other hand, relate to the implementation and planning of instruction [76], which is affected by a teacher's personal epistemology. Take, for example, a hypothetical teacher who has a more naïve personal epistemology and thus believes that knowledge is certain and absolute. This particular teacher would be more likely to resort to didactic instruction, which is not a characteristic of classrooms that support SRL. While this hypothetical teacher may have the capacity to learn how to support SRL in the classroom through a training program, personal beliefs mediate the teacher's willingness to do so. Thus, it would stand to reason that any SRL professional development for inservice teachers and direct SRL instruction to preservice teachers should be accompanied by consideration of their personal epistemologies. The formulation of personal beliefs in teacher education programs can create the foundation that guides teachers' behavior in the classroom.

In addition to considering personal beliefs of teachers, successful implementation of learning tasks that support SRL requires careful consideration of students' needs and abilities. A number of the reviewed studies support the notion that explicit SRL instruction has positive effects in the classroom. Kistner et al. [53] found that high school math teachers' explicit instruction of SRL was positively related to their students' performance, findings that were echoed in middle school students (e.g., [57]) as well as elementary students (e.g., [62, 63]). However, the reviewed studies also provide empirical evidence that explicit SRL instruction may not always benefit students. Ee et al. (2010) found a negative relationship with this type of instructional practice and the motivation of high-achieving students. The researchers suggest that the students in this study were all high achieving and had reached automaticity with cognitive strategies. Thus, the execution and retrieval of cognitive strategies for these students did not require the use of any of the working memory resources [100]. Automaticity bypasses the limited space associated with working memory and allows cognitive resources to be used in other capacities. In other words, students who already have the capacity to use cognitive strategies may have adverse reactions to explicit instruction with these SRL processes. As with any other classroom practice, optimal SRL instruction requires the consideration of students' individual differences with their self-regulation ability.

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