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Investigating Self-Regulation and Motivation: Historical Background, Methodological Developments, and Future Prospects

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The topic of how students become self-regulated as learners has attracted researchers for decades. Initial attempts to measure self-regulated learning (SRL) using questionnaires and interviews were successful in demonstrating significant predictions of students' academic outcomes. The present article describes the second wave of research, which has involved the development of online measures of self-regulatory processes and motivational feelings or beliefs regarding learning in authentic contexts. These innovative methods include computer traces, think-aloud protocols, diaries of studying, direct observation, and microanalyses. Although still in the formative stage of development, these online measures are providing valuable new information regarding the causal impact of SRL processes as well as raising new questions for future study.

KEYWORDS: self-regulated learning (SRL), motivation and SRL, event measures of SRL, cyclical analyses of SRL

Research on self-regulation of academic learning and performance emerged more than two decades ago to answer the question of how students become masters of their own learning processes. Unlike measures of mental ability or academic performance skill, self-regulated learning (SRL) refers to the self-directive processes and self-beliefs that enable learners to transform their mental abilities, such as verbal aptitude, into an academic performance skill, such as writing. SRL is viewed as *proactive* processes that students use to acquire academic skill, such as setting goals, selecting and deploying strategies, and self-monitoring one's effectiveness, rather than as a reactive event

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that happens to students due to impersonal forces. Although SRL was viewed as especially important during personally directed forms of learning, such as discovery learning, self-selected reading, or seeking information from electronic sources, it was also deemed important in social forms of learning, such as seeking help from peers, parents, and teachers. The core issue is whether a learner displays personal initiative, perseverance, and adaptive skill. These proactive qualities of learners stem from advantageous motivational feelings and beliefs as well as metacognitive strategies (Zimmerman & Schunk, 2007).

Research on SRL has evolved as a result of developments in theoretical paradigms and methodologies (Boekaerts, Pintrich, & Zeidner, 2000; Zimmerman & Schunk, 1989, 2001). During the 1970s and 1980s, researchers such as Ann Brown, Joel Levin, Donald Meichenbaum, Michael Pressley, Dale Schunk, and others focused on the impact of individual self-regulatory processes, such as strategy use, goal setting, imagery, or self-instruction. Typically, a student was trained to use a strategy, such as imagery, during subsequent efforts to learn. These studies showed that these strategies were usually effective in producing superior learning—even with young children. However, these students seldom used the strategies spontaneously in nonexperimental learning contexts, such as when studying at home (Pressley & McCormick, 1995). Clearly, other self-regulatory processes needed to be considered when explaining students' failures to apply these strategies effectively on their own.

An early defining moment in research on self-regulation was a symposium at the American Educational Research Association annual meeting in 1986 that was published in a special issue of *Contemporary Educational Psychology* (Zimmerman, 1986b). It sought to integrate under a single rubric research on such processes as learning strategies, metacognitive monitoring, self-concept perceptions, volitional strategies, and self-control by researchers such as Monique Boekaerts, Lyn Corno, Steve Graham, Karen Harris, Mary McCaslin, Barbara McCombs, Judith Meece, Richard Newman, Scott Paris, Paul Pintrich, Dale Schunk, and others.

An outcome of the 1986 symposium was an inclusive definition of SRL as the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process (Zimmerman, 1986a). This definition focused on students' proactive use of specific processes or responses to improve their academic achievement.

A number of instruments were developed during the 1980s that assessed SRL as a metacognitive, motivational, and behavioral construct. For example, the Learning and Study Strategies Inventory (LASSI; Weinstein, Schulte & Palmer, 1987) is an 80-item self-report inventory of students' strategies for enhancing their study practices. The LASSI involves 10 scales that assess skill, will, and self-regulation strategies—a classification system that corresponds with a metacognitive, motivational, and behavioral definition of self-regulation. Scales classified as skill (or metacognition) include Concentration, Selecting Main Ideas, and Information Processing. Scales classified as will (or motivation) include Motivation, Attitude, and Anxiety. Scales classified as self-regulation

(or behavior) include Time Management, Study Aids, Self-Testing, and Test Strategies. Students respond to items in each subscale using 5-point ratings that range from *not at all typical of me* to *very much typical of me*.

Another questionnaire measure of SRL that was widely used is the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1993). This 81-item questionnaire is composed of two major sections: Learning Strategies and Motivation. The Learning Strategies section is further divided into a Cognitive-Metacognitive section, which includes rehearsal, elaboration, organization, critical thinking, and metacognitive self-regulation, and a Resource Management section, which includes such behaviors as managing time and study environment, effort management, peer learning, and help seeking. The Motivation section involves scales that involve valuing, expectancy, and affect. The Valuing scales include Intrinsic-Extrinsic Goal Orientation and Task Value. The Expectancy scales include Self-Efficacy and Control of Learning, and the Affect section includes Test Anxiety. The Motivation section, the Cognitive-Metacognitive section, and the Resource Management Strategy section correspond to the three elements in the definition of SRL: motivation, metacognition, and behavior. Students respond to questions on these scales using 7-point ratings that range from *not at all true of me* to *very true of me*.

A third instrument that was used to assess SRL as a metacognitive, motivational, and behavioral construct was the Self-Regulated Learning Interview Scale (SRLIS; Zimmerman & Martinez-Pons, 1986, 1988). During this structured interview, students are presented six problem contexts to which they are asked to respond, such as preparing for a test or writing an essay. The answers to these open-ended questions are transcribed and coded into 14 self-regulatory categories that focus on motivation, metacognition, or behavior. Included among the motivation categories are self-evaluation reactions and self-consequences. Included among the metacognitive categories are goal setting and planning, organizing and transforming, seeking information, and rehearsing and memorizing. Included among the behavioral categories are environmental structuring; keeping records and monitoring; reviewing texts, notes, and tests; and seeking assistance from peers, teachers, and parents. Students' answers to each learning context were recorded for their frequency, and students were also asked to rate their consistency in using a particular strategy using a 4-point scale that ranges from *seldom* to *most of the time*.

Each of these three instruments measured processes that can be classified as self-regulatory according to the three defining SRL criteria, but some of the names of these processes varied. For example, both the LASSI and the MSLQ listed anxiety as a component of motivation, whereas the SRLIS interview would have coded anxiety responses as a form of self-evaluation reactions. These variations in names are probably due to differences in the assessment instruments. The LASSI and the MSLQ were both retrospective reports, whereas the SRLIS involves prospective answers to hypothetical learning contexts.

Research using these interview and questionnaire measures of students' self-regulatory strategies revealed them to be significantly correlated with measures of course performance (Pintrich et al., 1993; Zimmerman & Martinez-Pons, 1986). A self-regulation strategy measure also predicted students' academic grades and their teacher's ratings of their proactive efforts to learn in class (Zimmerman & Martinez-Pons, 1988). There was also evidence that self-regulatory strategies mediated the effects of students' verbal ability measures on their outcomes in writing (Zimmerman & Bandura, 1994). Research also showed that students who were high in their overall use of self-regulation strategies sought help more frequently from peers, teachers, and parents and learned more than students who did not seek help (Pintrich et al., 1993; Zimmerman & Martinez-Pons, 1986).

These early studies produced clear evidence that SRL was an important construct that merited further research. Winne and Perry (2000) classified the LASSI, MSLQ, and SRLIS as *aptitude* measures of self-regulation, which they defined as a relatively enduring attribute of a person that predicts future behavior. Items on aptitude scales are designed to aggregate self-regulatory responses over time by using ratings such as "most of the time" or that "is typical of me." An alternate approach assesses SRL as an *event*, which is defined as a temporal entity with a discernable beginning and an end. Although an event spans time, it is demarcated by a prior event and a subsequent event. An example of an event approach to the assessment is a phase model of SRL, which separates students' efforts to self-regulate into phases, such as before, during, and after attempts to learn (Pintrich, 2000; Zimmerman, 2000). Because event measures can assess sequential dependency of responses, they are well suited for making causal inferences about online changes in self-regulation in real time and authentic contexts.

This article will discuss recent efforts to assess students' SRL online, such as computer traces, think-aloud protocols, structured diaries, direct observations, and microanalytic measures. Because of this methodological emphasis, I will focus on a limited number of innovative studies to describe in detail.

These new methods for conducting online research on SRL have given rise to several key questions regarding changes in students' use of self-regulatory processes during the course of learning. A first emergent question concerns how trace measures of SRL compare to self-report measures in assessing changes in self-regulation during learning. A second emergent question deals with whether increases in students' level of SRL in personally managed contexts, such as at home or in the library, are linked to improvements in their overall academic achievement. A third emergent question involves whether teachers can modify their classrooms to foster increases in self-regulated learning among their students. A final emergent question concerns the role of students' motivational feelings and beliefs in initiating and sustaining changes in their self-regulation of learning.

Methodological Innovations and SRL Findings

Trace Logs of SRL Processes in Computer-Assisted Environments

A first emergent question concerns comparison of trace measures of SRL to self-report measures in assessing changes in self-regulation during learning. One of the most technologically advanced efforts to answer this question has been reported by Winne and his colleagues (Winne et al., 2006). They have developed an innovative software program called gStudy that enables learners to make notes, create glossaries, label and index content, construct concept maps, search for information, chat and collaborate, and receive coaching. This software environment serves as a shell that allows students to upload texts and other materials for learning on virtually any topic.

For example, a student could use the note-taking function of the program to extract key information or write a summary of a section of the text. The notes are automatically keyed to the section to which they refer. They can also be cut and pasted to form a personalized account of the material by the learner. Supportive software features of gStudy, such as note taking, can remain in the background or can be opened as a separate window. If a part of the text is unclear, the student can use other features of gStudy to search for relevant information in resident or Web-based sources.

This program also allows learners to seek help from social sources, such as guided chats with a knowledgeable tutor or fellow student. This communicative feature permits learners to collaborate more effectively, such as when two students are jointly writing a report from different locations. It allows them to critique each other's work, share insights, and paste their sections together. Clearly, the gStudy computer environment can provide students with many more ways to self-regulate their learning than provided by traditional instructional software.

In addition to its capability to offer diverse supports to enhance learning, gStudy also provides a log analyzer that unobtrusively records *traces* of students' methods of learning, such as the frequency and pattern of highlighting text, accessing various supports for learning, and obtaining feedback from efforts to learn. Traces are defined as observable indicators about cognition that students create as they engage in a task (Winne & Perry, 2000). Researchers can reconstruct an event description of a student's methods of study from these traces. These logs can be used to link students' methods of study to academic outcomes in real time. This trace information can also be used pedagogically to help struggling learners see which strategies work best for them. Measures of students' self-regulatory processes and their outcomes can be depicted in terms of simple frequencies or in graphic form. The gStudy program also permits learners to keep a personal diary regarding metacognitive judgments, such as not understanding certain material and deciding to return to it later. The capacity of the computer to record all of these events unobtrusively is extraordinary, and it provides researchers with a high level of detail about learners' methods of studying, their self-beliefs

about their competencies, and their progress. This leads us to ask, How effective is the gStudy environment, and how do trace measures of SRL compare with self-report measures?

The accuracy of college students' self-reports of their study methods and achievement gains while using the gStudy software environment was investigated by Winne and Jamieson-Noel (2002). The academic task involved a seven-paragraph description of how lightning develops. After the students studied the text, they were administered a questionnaire about their methods of studying. For example, they were asked how often they used various study methods that the software had recorded as traces of studying. The disparity between students' traces and the self-report measures was quantified in terms of two indices of calibration: bias and accuracy. *Bias* refers to the direction of students' misjudgments of knowing, namely, to over- or underestimates of their knowledge. *Accuracy* refers to the absolute levels of correctness of students' judgments (ignoring the direction of these judgments). These two indices of calibration were applied to students' reports of using self-regulatory processes, such as planning, setting objectives, highlighting, taking notes, creating organizers, and reviewing. The students were also given a posttest on the subject matter and were asked to make estimates of the correctness of their answers to each item on the test. This measure was labeled students' calibration of *achievement judgments*.

Regarding these achievement judgments, the students' index of bias indicated that they were slightly overconfident, but the students' index of accuracy indicated that they were very accurate in an absolute sense. Despite this high overall level of accuracy, there were sizable individual differences between the students, which indicated that certain students were at risk when judging their level of achievement. The students' calibration of the accuracy of their achievement was significantly correlated with their actual posttest total score.

In contrast to the students' success in monitoring their achievement, they experienced great difficulty in tracking their use of self-regulatory strategies. For example, with regard to bias, students reported overestimates of planning by 29% and overestimates of reviewing figures by 26%. Interestingly, the trace logs revealed that contrary to students' reports, few resident strategies in gStudy were used during this study. These strategies included creating analogies, examples, mnemonics, and questions. The accuracy of students' self-regulatory judgments was uncorrelated with their scores on the academic posttest.

Collectively, these results indicate that self-reports are often incongruent with trace measures of self-regulatory processes when studied in a specialized learning environment, such as gStudy. Winne and colleagues (Winne & Perry, 2000) have cautioned that trace measures should be interpreted in conjunction with other measures of SRL. For example, a high frequency of note-taking trace could mean that a student is not selective in recording information, instead being comprehensive. When additional measures, such as interviews, are used in conjunction with trace measures, more valid conclusions can be drawn. The development of high-tech study environments

is yet in its infancy, but its potential for assisting students to use SRL strategies is impressive.

Think-Aloud Protocol Measures of SRL in Hypermedia Environments

A second emergent question concerns whether increases in students' level of SRL in personally managed contexts, such as at home or in the library, are linked to improvements in their overall academic achievement. Azevedo and his colleagues (Azevedo & Cromley, 2004; Azevedo, Cromley, & Siebert, 2004) developed an elaborate think-aloud method for assessing students' self-regulated learning processes as an online event in a hypermedia learning environment (HLE). A think-aloud protocol involves students' reports about their thoughts and cognitive processes while performing a task (Ericsson, 2006).

HLEs have much potential for improving learning, but they require personal initiative and skill, because hyperlinks are nonlinear in format and require students to integrate multiple representations (e.g., text, diagrams, and animations). Azevedo and colleagues have concluded that learning in a hypermedia environment requires self-regulation skills to navigate, organize, and combine information into viable mental models. These skills include goal setting, monitoring, and controlling cognition, motivation, and behavior.

In recent research, Greene and Azevedo (2007) studied learning from a science module on the human circulatory system by middle and high school students. The module was selected from an Encarta DVD on the topic, and it involved nearly 17,000 words, 107 hyperlinks, and 35 illustrations. The instructional session lasted 40 minutes. After receiving instructions regarding the learning task and features of the Encarta program, the students were told to say everything that they were thinking while they were working on the task.

An advantage of the think-aloud methodology is that it is open-ended, and the students' responses are coded into self-regulatory process categories by trained observers at a later point in time. A high degree of reliability was attained in coding nearly 18,000 verbal segments. Clearly, this is a very labor-intensive methodology. The coding system involved 35 SRL categories that were grouped conceptually into five major areas: planning, monitoring, strategy use, task difficulty and demands, and motivation. These major process areas have been widely recognized and included in other research methodologies. The primary dependent measure was the quality of the student's diagram of the human circulatory system.

The results showed that six of the categories of SRL were significant predictors of the quality of the students' mental model. These categories fell in three major process areas. Within the area of strategy use, the following four of the categories attained significance: coordinating informational sources, inferences, knowledge elaboration, and expectation of adequacy of information. Regarding the area of monitoring, the category of feelings of knowing proved to be significant predictors of the students' mental model, but no categories within the areas of planning or motivation were significant predictors.

Within the task difficulty and demands area, the category of control of context unexpectedly correlated negatively with the quality of students' mental models. This category was scored each time a student accessed a hyperlink, and apparently students who accessed it frequently were not integrating the material into their mental model of blood circulation.

Clearly, the think-aloud methodology is an effective way to assess students' self-regulatory processes online, but this research needs to be extended to see if planning and motivation will emerge as significant predictors of students' mental models.

Structured Diary Measures of SRL

The third emergent question concerned whether teachers can structure their classroom instruction to foster increases in SRL among their students. Several recent innovative intervention studies have addressed this question using structured diaries and time-series data. For example, Schmitz and Wiese (2006) studied a sample of civil engineering students at a German university over a 5-week period. The study was designed on the basis of a cyclical model of self-regulated learning involving three sequential phases: preaction, action, and postaction (Zimmerman, 2000).

The intervention was composed of four weekly 2-hour training sessions that focused on key self-regulatory processes, such as goal setting, time management, planning, behavioral self-motivation, cognitive self-motivation, and concentration. The first weekly session trained students to set goals that were concrete, realistic, challenging, and proximal. The second session trained students to avoid procrastination by daily and weekly planning using prestructured time-management forms. The third weekly session taught behavioral self-motivation along with further time-management training. Self-motivation involved setting self-rewards and arranging a supportive environment. The fourth weekly session focused on cognitive self-motivation and concentration. The former measure of SRL involved self-instruction designed to stop negative thoughts and encourage positive ones. Concentration training involved the use of systematic relaxation. The diaries were collected at the end of each week during the study.

The SRL diaries were structured using a series of event questions regarding the students' study session. The questions pertaining to the *before* phase dealt with the learning goal that was set for the day (i.e., goal setting) and their thoughts about how to proceed (i.e., planning). The student's motivation for studying was queried using items such as "I find the topic interesting" (i.e., intrinsic interest), "I want to do well on the next test" (i.e., extrinsic interest), and "I can remain calm when facing learning difficulties because I can rely on my abilities" (i.e., self-efficacy). Questions regarding the *after* phase dealt with the following issues: How much total time was spent in studying, how much time was spent studying effectively, and whether the students reached the individual goal that they had listed before studying. Other questions concerned how much of the material was actually mastered

and whether the students skipped some of the tasks that they wanted to accomplish.

In addition to the online diary of SRL events, the students completed a questionnaire at the outset and the end of the study that involved an aptitude measure of self-regulation. The questionnaire included items that assessed affect and motivation, learning strategies, and volitional strategies. The Affect and Motivation scales assessed positive and negative affect, intrinsic and extrinsic motivation, and self-efficacy. The Learning Strategies scale assessed monitoring, management of internal resources, attention, and time management. The Volitional Strategies scale measured self-motivation, attention, procrastination, and handling distractions. The control group students were pre- and posttested but did not receive SRL training or use the diaries.

The authors conducted three types of analyses. First, pretest and posttest measures were compared for the experimental and control groups. Students who received self-regulatory training displayed significant improvements in the following questionnaire measures: intrinsic studying motivation, self-efficacy, effort, attention, self-motivation, handling distractions, and procrastination. Students in the control group displayed increases in only self-motivation during the study. A second analysis analyzed linear trends in self-regulation that were reported in the diaries during the course of the 5-week intervention. These trend analyses revealed significant increases in the following forms of self-regulation and motivation: self-efficacy, positive affect, personal understanding, and satisfaction. The third method of analysis involved interrupted time-series analyses. These event analyses compared changes from the week before a particular self-regulatory process was taught to 2 weeks after training. According to the diaries of students in the training group, there were significant improvements in time management, planning, and concentration and a significant decrease in procrastination during the week following training to use those specific self-regulatory processes.

The diary proved to be a more sensitive online measure of studying than traditional questionnaire measures. The average amount of studying per day by these engineering students was nearly 4 hours, although they did not study every day. Of particular methodological interest was the comparison of the results of a control-group analysis with those of the time-series analysis. When diary measures were analyzed using time-series methodology, they were shown to be of equal or greater sensitivity to change than pre- and posttest questionnaire measures of SRL by students in the training group. In contrast, control-group students displayed virtually no changes in use of SRL processes from pre-to posttesting. Clearly, a diary time-series methodology has much to offer as an online way to assess training effects in ecologically valid contexts. Although this study did not include measures of academic achievement, it did show that college students who were trained in SRL processes were effective in reaching the study goals that they set for themselves.

Diary measures of SRL have also been used with elementary school children in Germany. A recent study by Stoeger and Ziegler (2007) addressed the emergent question of how teachers can structure their regular classroom

assignments to convey SRL processes. These researchers trained teachers of fourth-grade students to implement SRL processes during mathematical instruction according to a cyclical model (Zimmerman, Bonner, & Kovach, 1996). This instructional model emphasizes such self-regulatory processes as monitoring and self-evaluation, goal setting and strategic planning, strategy implementation and monitoring, and strategic outcome monitoring.

Teachers were randomly assigned to either an experimental or a control group. Nine classroom teachers were trained to convey the underlying cyclical model and to develop homework exercises, quizzes, and a final examination in arithmetic skill. The control group of eight teachers gave the same homework assignments and tests but received no self-regulation training. The students in both experimental conditions kept diary accounts of SRL events, such as when and for how long they studied, what kinds of breaks were taken, what types of distractions were present, whether they studied alone, and where studying takes place. Teachers in the SRL training condition gave students a copy of the cyclical model of self-regulation along with a picture of a "learning expert," who recommended self-regulatory practices that the teacher modeled for them. Students were given daily feedback regarding their homework and quiz scores and were encouraged to set challenging goals and choose an effective strategy for themselves. Students in the experimental group were given points on the basis of their homework answers.

The students also completed an aptitude questionnaire that assessed their interests, attitudes, and self-related cognitions before and after a 5-week training program. All scales were adapted to focus on the domain of mathematics. Self-efficacy beliefs were assessed as well as time management skills. Items measuring feelings of helplessness were included as well as items assessing students' learning goal orientations and their willingness to exert effort. The math achievement test covered the subject matter that had been presented in the classes during the 5-week training period.

The results showed that students in the training group reported significantly greater increases in time management skill and self-reflection on their learning than those in the control group. Students in the self-regulation training condition also displayed increases in several measures of motivation. Their willingness to exert effort, their task interest, their learning-goal orientation, and their perceptions of self-efficacy all increased after training, and their feelings of helplessness declined significantly. Students in the self-regulation training group displayed significantly greater gains in math achievement than students in the control group. Interestingly, all students in the self-regulation training group passed an entrance exam for admittance to a higher level school, which was an increase of 50% compared to past cohort groups of students.

Stoeger and Ziegler (2007) also conducted an event analysis of the growth rate in students' homework scores and quizzes during the course of the study. Hierarchical statistics revealed a linear increase in math skill over the 5-week training period, but this growth curve did slow as the students

approached mastery toward the end of the training period. Students' self-efficacy perceptions prior to training were also significantly related to their growth in math skill. The variables of self-efficacy beliefs, learning-goal orientation, and time-management skills were linked to an increase in math skill.

Thus, the results of this training study showed that multiweek training in time-management skills can be implemented by teachers as part of their classroom math assignments. When compared to control students, SRL trained students displayed significant increases in homework effectiveness, time-management skills, a broad array of self-reflection measures, and math performance skill. The study showed that self-regulation interventions involving diary logs of self-regulatory events can be used effectively with elementary school youngsters, and this classroom training conducted by teachers enhanced not only students' use of SRL processes but also their achievement in mathematics.

Observation and Qualitative Measures of SRL

Another approach to answering the emergent question of whether teachers can adapt their regular classroom activities and assignments to foster increases in their students' SRL was reported by Perry and her colleagues (Perry, Vandekamp, Mercer, & Nordby, 2002). They used a variety of quantitative and qualitative measures, such as observation forms, portfolio assessments, and interviews of teachers and students, to study changes in SRL during classroom learning events.

For example, in a study of writing acquisition by second and third graders, Perry (1998) trained teachers in SRL during weekly classroom visits over a 6-month period. Three of the teachers were designated as high in support for SRL, and two teachers were labeled as low in support for SRL, on the basis of their answers to a questionnaire regarding five criteria. These included giving students choice of writing tasks, permitting them to designate the level of challenge of the writing task, allowing them to self-evaluate, and soliciting support from teachers and peers. Students of the three high-SRL teachers were surveyed using a questionnaire that assessed their perceptions of personal control and teacher support in their classroom. The students were also asked about their beliefs, values, and expectations regarding writing. Finally, the teachers ranked their students in terms of their achievement levels, and five high and five low achievers were selected for further assessment in each teacher's class. These students were observed in classroom contexts and were interviewed subsequently.

The results revealed that students in high-SRL classes were more engaged in their writing than students in low-SRL classes. The former students also monitored and evaluated their writing progress more productively than control students. Finally, students in the high-SRL classrooms sought instrumental support from one another and their teachers more frequently than students in low-SRL classes. Unexpectedly, students in the high- and low-SRL classes did not display significant differences in measures of motivation (i.e., beliefs,

values, and expectations regarding writing), which Perry attributed to the ineffectiveness of these measures. Thus, high-SRL teachers offered their students more opportunities for controlling their learning experiences than low-SRL teachers. Unfortunately, there was no standardized measure of students' writing achievement, and this limitation precluded determination of the effects of students' SRL on their writing competence.

Although the motivation measures that Perry included in her study (beliefs, values, and expectations regarding writing) did not distinguish between high- and low-self-regulated learners, these measures have generally shown relatively strong correlations with students' use of specific self-regulatory processes (Schunk & Zimmerman, 2007). For example, Stoeger and Ziegler (2007) found that students given SRL training displayed a greater increase in effort, task interest, learning-goal orientation, and perceptions of self-efficacy than control-group students. Schmitz and Wiese (2006) also reported significant improvements due to SRL training on a number of measures of motivation, such as intrinsic studying motivation, self-efficacy, effort, attention, self-motivation, handling distractions, and procrastination.

Microanalytic Measures and Cyclical Analyses of SRL

A fourth emergent question concerns the role of students' motivational feelings and beliefs in initiating and sustaining changes in their self-regulation of learning. To investigate this and other issues as an event during online efforts to learn, my colleagues and I developed a microanalytic methodology for assessing SRL in three sequential phases (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002).

In this approach, specific questions are used to measure well-established self-regulatory processes and motivational beliefs or feelings at key points before, during, and after learning. The learner is asked open- or closed-ended questions that produce both qualitative and quantitative data, respectively. The questions are brief and task specific in order to minimize disruptions in learning. For example, self-efficacy can be assessed during a math problem-solving session by showing the learner a scale that ranged from 0 to 100 (with 10 = *not sure*, 40 = *somewhat sure*, 70 = *pretty sure*, and 100 = *very sure*) and asking, "How sure are you that you will be able to solve these math problems?" Notice that this self-efficacy measure pertained directly to the next performance event (i.e., the solution of these problems) rather than to a learner's overall mathematical aptitude. A key feature of these measures is that they can be used during repeated efforts to learn, and changes in a learner's self-efficacy over practice efforts can be plotted to show trends. In addition, the learner's estimates of self-efficacy can be calibrated against his or her actual performance.

This methodology has been used to study the effects of SRL processes and motivational beliefs as an event within and across the three phases of a cyclical model of SRL (Zimmerman, 2000). To date, microanalytic measures have been created to assess all SRL processes and motivational beliefs in the

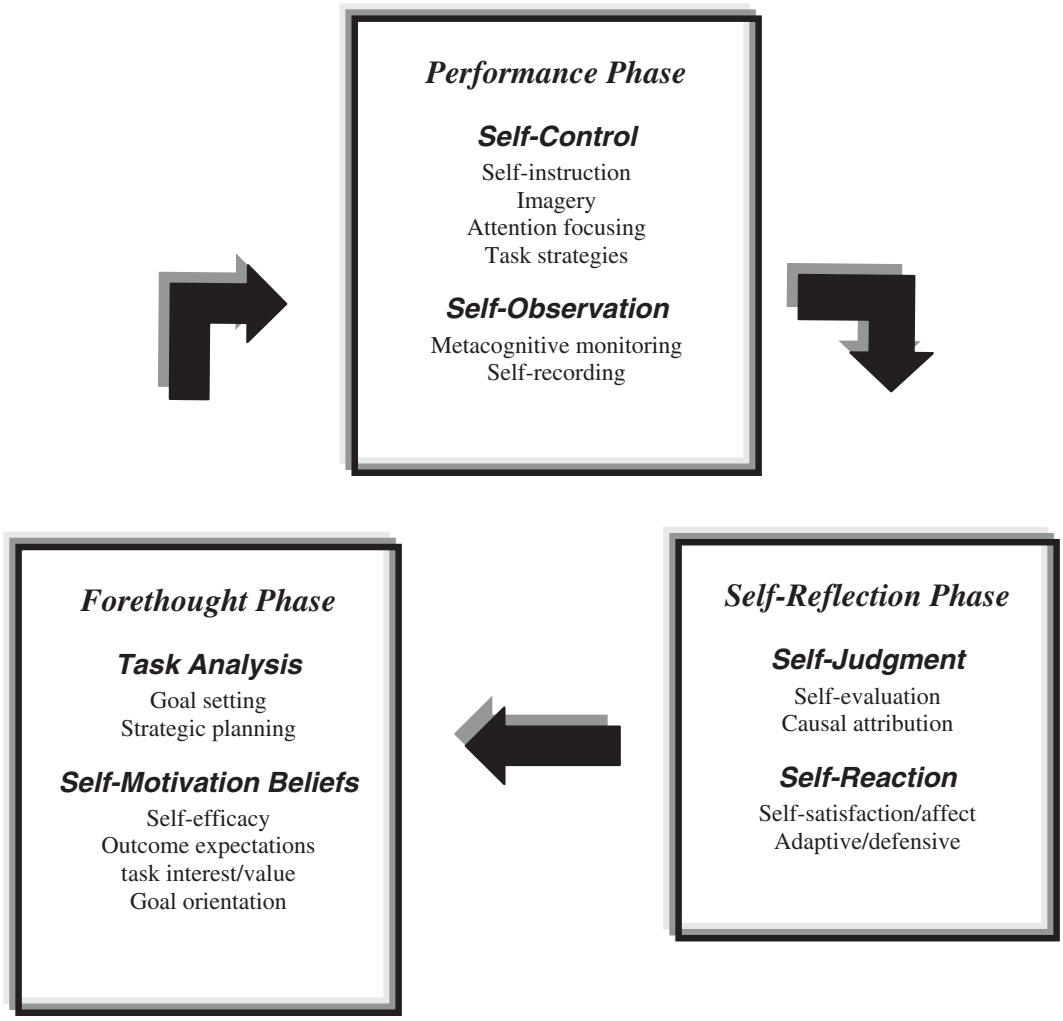

Figure 1. **Phases and subprocesses of self-regulation. From "Motivating Self-Regulated Problem Solvers" by B. J. Zimmerman and M. Campillo, 2003, in J. E. Davidson and R. J. Sternberg (Eds.), *The Nature of Problem Solving*, p. 239. New York: Cambridge University Press. Copyright 2003 by Cambridge University Press. Adapted with permission.**

cyclical model in Figure 1 except for goal orientation, which focuses on the purposes of achievement tasks rather than on a specific event. Despite their brevity, these microanalytic measures have proven to be reliable and predictive of changes in functioning (Kitsantas & Zimmerman, 2002).

The model assumes significant correlations between variables within a particular SRL phase, and it assumes potentially causal influences of SRL processes across phases. The *before*, or forethought, phase involves a number of well-known motives to self-regulate, such as self-efficacy beliefs, outcome expectations, task interest or value, and goal orientation as well as two

key self-regulatory processes: goal setting and strategic planning. There is growing empirical support for this model. For example, research has shown that students' level of self-efficacy about their writing performance was positively correlated with the grade goals they set for themselves as well as with the grades they actually received in a writing course (Zimmerman & Bandura, 1994). In addition, there is evidence that students' performance-phase strategic processes and self-recorded outcomes are linked causally to self-reflection-phase outcome attributions and feelings of satisfaction (Zimmerman & Kitsantas, 1997). Finally, research (Zimmerman & Kitsantas, 1999) has shown that students' self-reflection-phase feelings of satisfaction with their writing performance were predictive of two forethought-phase sources of motivation regarding further efforts to improve their writing skill: self-efficacy and task interest or valuing. Clearly, students' use of high-quality SRL processes can enhance their motivation to continue additional cycles of learning.

To date, microanalyses of SRL processes and sources of motivation have been used most frequently to investigate learning of athletic skills, such as free-throw shooting, volleyball serving, and dart throwing, and these measures of SRL revealed significant differences between experts, nonexperts, and novices (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). When compared to nonexperts and novices, experts made the most extensive use of SRL processes and reported the most positive motivational beliefs and feelings. Although high levels of expertise take years to develop (Ericsson, 2006), there is recent evidence (Cleary, Zimmerman, & Keating, 2006) that novices who are taught multiphase SRL strategies displayed significantly greater athletic skill and improved motivational beliefs during relatively brief practice sessions than novices in an untutored control group.

Implications and Topics for Future SRL Research

The first emergent question concerned how closely trace measures of SRL would compare to self-report measures in assessing changes in self-regulation during learning. Winne and his colleagues (Winne & Jamieson-Noel, 2002) addressed this question using trace logs of SRL from students in a computer-assisted study environment and found low levels of calibration. In contrast, Schmitz and Wiese (2006) found a relatively high degree of correspondence between online diary measures of studying and summary questionnaire items at the end of a 5-week training episode in traditional (i.e., non-computer-assisted) learning environments.

It is interesting to note that Winne and Jamieson-Noel (2002) discovered that students' calibration in reporting self-regulatory processes was significantly lower than their calibration in reporting achievement outcomes. Research in noncomputer contexts (Stone, 2000) has similarly revealed a positive relation between students' use of SRL processes and their calibration of knowledge (i.e., achievement outcomes), although the direction of causation has not been established. Clearly, more research is needed regarding the accuracy of students' reports of using self-regulatory processes. Because calibration is a

key measure of the accuracy of one's self-monitoring, it will continue to be a major topic in future research on SRL.

The second emergent question concerns whether changes in students' level of SRL in personally managed contexts is linked to improvements in their overall academic achievement. Azevedo and his colleagues (Azevedo & Cromley, 2004; Azevedo et al., 2004) addressed this issue by using think-aloud measures of SRL to investigate students' learning in a hypermedia environment. They discovered that 6 of 35 self-regulatory process categories identified in students' think-aloud protocols were predictive of high-quality mental models of a science topic (i.e., blood circulation). These results provide an affirmative answer to the emergent question. However, future researchers need to establish the generality of these findings. The think-aloud methodology should be extended to HLEs on other science topics and other subject matter, such as math or a foreign language. It is possible that different SRL process categories may come into play when a different topic is studied.

The third emergent question involves whether teachers can modify their classrooms to foster increases in self-regulated learning among their students. The study by Stoeger and Zigler (2007) demonstrated that regular classroom teachers could be trained to teach specific SRL skills to fourth-grade children as part of their regular math assignments during a 5-week intervention. These affirmative results implied that similar interventions might be effective in other areas of students' academic functioning, such as note taking, test preparation, reading for comprehension, and writing. The study by Schmitz and Wiese (2006) showed that college students could also profit from training in key SRL skills and diary monitoring skills. The two German studies revealed important advantages for using time-series statistical analyses to assess changes in SRL online during the course of training. This methodology offers researchers not only a sensitive measure of SRL but also a graphic depiction of the shape of the learning curve. However, it should be noted that aptitude measures of SRL were included as well as online event measures in both of the two German studies and, although less sensitive to change, did prove useful in measuring changes in self-regulation.

In contrast to the German researchers' focus on students' SRL in out-of-class contexts, Perry (1998) focused on students' SRL within the context of elementary school classrooms. Her online event measures of students' self-regulatory processes proved useful during classroom observations. Her methodological approach involved triangulating various qualitative measures, such as students' observations, portfolios, interviews, and measures of academic performance. This methodology enabled Perry to identify classroom social and physical environments that curtail students' use of SRL processes and recommend ways for teachers to modify them to increase students' level of self-regulation. The effects of classroom affordances and constraints on changes in students' SRL should be studied further. Perry's qualitative methodology for assessing classroom events is well suited to answer these questions as well as other social context questions, such as how SRL is both an individual and a

social process and what individual and sociocultural factors influence students' development of SRL (Butler, 2002).

The final emergent question concerns the role of students' motivational feelings and beliefs regarding initiating and sustaining changes in their self-regulation of learning. Microanalytic efforts to answer this question have revealed a close relation between key SRL processes and many sources of motivation during three sequential phases of learning. Event measures of self-motivation constructs were developed for administration during the appropriate phase of learning by an interviewer. Among the motivational measures that were developed for administration during the forethought phase of SRL were self-efficacy beliefs, outcome expectancies, and task interest or values. Additional measures of motivation, such as anxiety and perhaps goal orientation, should be developed in future research. Among the motivational measures that were developed for administration during the self-reflection phase were attribution judgments and self-satisfaction reactions. In terms of future research topics, there is a vital need to extend a microanalytic methodology to learning of academic tasks over longer periods of time when students' motivation is expected to wane. There is also a need to extend the use of this methodology to assess the effectiveness of academic interventions designed to motivate recalcitrant students to engage in SRL.

Conclusion

Although aptitude measures of SRL have and will continue to provide useful information regarding students' methods of learning, online event measures of SRL offer detailed information concerning the interrelation of the various processes in real time, such as the impact of goal setting on self-monitoring. This contextually linked information is especially useful when diagnosing and remediating self-regulatory dysfunctions. For example, a student who reports knowing a strategy on an SRL aptitude questionnaire may not know how to adapt it to work in a particular academic context. At its core, SRL involves a dynamic feedback loop (Butler & Winne, 1995; Hattie & Timperley, 2007; Zimmerman, 1989), and online event measures can capture subtle changes in functioning during each learning cycle. To date, there have been few attempts to study SRL over multiple feedback cycles, but such studies are needed in order to track students' adaptations based on personal feedback. This research can uncover the dynamic nature of self-enhancing cycles of learning as well as self-defeating cycles.

Although significant progress has been made in answering the four emergent questions about SRL, further research is needed to extend these findings. The innovative online measures of SRL that were discussed are still in an early stage of development and will need to be modified to assess SRL in different academic content areas. Clearly, these online measures show great promise in providing more complete answers to the ultimate question that launched research on SRL: How do students become masters of their own learning processes?

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