**Handbook of Metacognition in Education**

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# 16 Self-Regulation

## Where Metacognition and Motivation Intersect

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"Education is not the filling of a pail but the lighting of a fire"

(W. O. Yeats)

One of the most challenging issues that confronts educational researchers is explaining how students learn in self-regulated contexts, such as when studying or practicing on their own. Acquisition of skills in these demanding contexts requires more than passive compliance with prior directions; it also involves personal initiative, resourcefulness, and persistence—the motivational fire to which Yeats refers. There is evidence that proactive students often seek to create their own enriched environments for learning (Scarr & McCartney, 1983). However, learning in self-regulated contexts can be challenging for students due to (a) competing activities, such as watching television or conversing with friends, (b) insufficient knowledge about how to proceed, (c) difficulty in judging the quality of one's learning, and (d) insufficient incentives. These attention, retention, self-awareness, and motivation issues have been studied as important attributes of self-regulated learners. Self-regulated learning refers to self-generated thoughts, feelings, and actions for attaining one's learning goals.

Research on self-regulated learning initially focused most heavily on students' use of key metacognitive processes, such as strategy use and self-monitoring (Borkowski, 1985; Brown, Bransford, Ferrara, & Campione, 1983). Metacognition refers to knowledge, awareness, and regulation of one's thinking. There is a growing literature indicating that a student's use of these metacognitive processes to learn is not merely a question of competence but is also a question of motivation to explain his or her willingness, effort, and persistence. There is considerable evidence that the effects of strategy training are not well "maintained" over time or "transferred" to non-experimental contexts (Pressley & McCormick, 1995, p. 33). These shortcomings have been attributed to deficiencies in both metacognition and motivation. Regarding metacognitive deficiencies, students may not be aware that a strategy could be used in a new situation. Regarding motivational deficiencies, students may fail to use a known strategy because they did not enjoy carrying it out or did not feel its outcomes were worth the effort (Rabinowitz, Freeman, & Cohen, 1992). These two beliefs—intrinsic value and outcome expectations—are two widely studied sources of motivation to learn on one's own. There is now an extensive effort to include motivational constructs along with metacognitive processes in models of self-regulated learning (Schunk & Zimmerman, 2007).

In this chapter, we use a social cognitive model of self-regulated learning to explain the intersection of students' metacognitive processes and motivational beliefs. Then, we describe how these processes and beliefs can be assessed as they occur during learning using a microanalytic methodology. Third, the usefulness of the three-phase model for training reactive learners to become more proactive is discussed. Fourth, we consider the relation between metacognitive calibration and two key motivational measures: self-efficacy and self-evaluation. Fifth, we describe the results of a recent study that was designed to improve at-risk students' calibration and academic achievement. Finally, we describe the results of two recent meta-analyses of self-regulatory training interventions, with particular attention to the interactive role of metacognitive processes and motivational beliefs.

## A Cyclical Phase Model of Self-Regulatory Feedback

A defining feature of self-regulation theories is a personal feedback loop. This loop refers to information regarding one's performance or outcomes that is used to make subsequent adaptations (Hattie & Timperley, 2007). This feedback may be social, such as guidance or praise from a teacher, peer, or a parent. It may also be environmental, such as from a task or the immediate context, or this feedback may be personal, such as awareness of covert mental outcomes, physiological outcomes, or behavioral outcomes. Building on earlier findings, social cognitive researchers' understanding of the nature and cyclical functioning of personal feedback loops has become more detailed and complete over time.

According to a social cognitive model of self-regulation, students' feedback loops involve three cyclical phases (see Figure 16.1). The forethought phase refers to learning

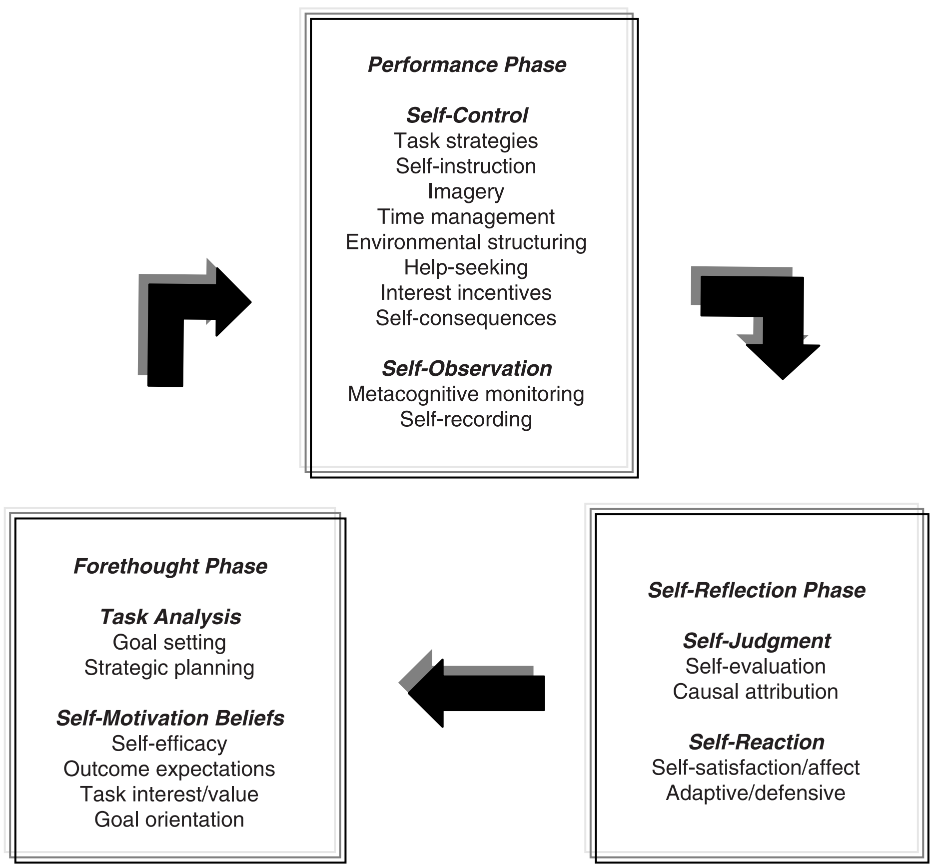


*Figure 16.1* A cyclical phase model of self-regulation that integrates metacognitive processes and key measures of motivation.

processes and sources of motivation that precede efforts to learn and influence students' preparation and willingness to self-regulate their learning. The performance phase involves processes that occur during learning and affect concentration and performance, and the self-reflection phase involves processes that follow learning efforts but influence a learner's reactions to that experience. These self-reflections, in turn, influence forethought regarding subsequent learning efforts, which completes the self-regulatory cycle. It should be noted that the length of a student's self-regulatory cycles will vary based on the frequency and timing of feedback, which in turn depends on outside sources, such as receiving a quiz grade, as well as personal sources, such as keeping a diary.

### *Forethought Phase*

This self-regulatory phase is composed of two major categories: task analysis processes and sources of self-motivation. Task analysis involves decomposing a learning task and its context into constituent elements, and constructing a personal strategy from prior knowledge of these elements (Winne & Hadwin, 1998), such as breaking a math problem down into sequential steps. Task analysis involves two key parts: setting goals and strategic planning. Goal setting refers to specifying the outcomes that one expects to attain, such as solving a page of decimal problems during a one-hour study session (Locke & Latham, 2002). Strategic planning refers to choosing or constructing advantageous learning methods that are appropriate for the task and environmental setting. When students link their strategic plans for learning to short and long-term goals in a sequential or hierarchical system, they can practice effectively by themselves over long periods of time.

Because forethought is anticipatory, it depends on a number of key sources of self-motivation, such as self-efficacy perceptions, outcome expectations, intrinsic interest, and a learning goal orientation. Each of these key sources of motivation has been linked to goal setting and strategic planning. For example self-efficacy, which is defined as beliefs about one's capabilities to learn or perform at designated levels, has been shown to predict students' goals and strategic choices (Zimmerman, Bandura, & Martinez-Pons, 1992). Self-efficacy beliefs can affect performance phase processes directly, such as one's choice of activities, effort, and persistence. A student's self-efficacy perceptions can affect his or her use of learning strategies in diverse areas, such as writing (Schunk & Swartz, 1993), time management (Britton & Tessor, 1991), resistance to adverse peer pressures (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996), and self-monitoring (Bouffard-Bouchard, Parent, & Larivee, 1991).

A second important source of self-motivation, outcome expectancies, refers to beliefs about the ultimate ends of one's performance, such as receiving social recognition or obtaining a desirable employment position. Students' outcome expectations depend on their knowledge or awareness of various outcomes, such as potential salaries, quality of life, and social benefits of a profession. Although the positive effect of attractive outcomes is well established, these expectations also depend on self-efficacy beliefs. For example, a student may believe that it is beneficial to have business accounting skills. However, lacking a sense of efficacy to learn these skills, he or she would not be motivated to enroll in a college accounting course. Thus, students' motivation to self-regulate their learning may be influenced by multiple motives, such as self-efficacy and outcome expectations.

A third source of students' forethought phase motivation is their task interest or valuing. This motive refers to one's liking or disliking a task because of its inherent properties rather than for its instrumental qualities in gaining other outcomes. Deci and Ryan (1985) refer to this motive as intrinsic motivation whereas Wigfield and Eccles (2002) refer to a comparable motive as interest value. Hidi and Renninger (2006) describe a similar motive as interest, which they view as a cognitive and affective predisposition to re-engage with the content of a particular class of objects, activities, or ideas. Research also shows that task interest or valuing can influence students' choice of learning strategies and well as their achievement goals (Ainley, Corrigan, & Richardson, 2005). Undoubtedly, students' task analytic processes are associated with task value/interest sources of motivation.

A fourth source of motivation to self-regulate is students' goal orientation, which involves their beliefs or feelings about the purpose of learning. Although research on students' goal orientations has led to variations in the names and number of goal orientations by prominent theorists, there is a consensus regarding the purpose of a learning goal orientation and a performance goal orientation. Students who adhere to a learning goal orientation seek to improve their competence via learning, whereas students who adhere to a performance goal orientation seek to protect their competence perceptions via favorable comparisons with the performance of others. According to Dweck and Leggett (1988), students' learning goal orientation stems from a belief that their mental ability can be modified incrementally, whereas a performance goal orientation stems from a belief that their mental ability is a fixed entity.

Students' goal orientation is an important predictor of forethought phase strategic planning. For example, in one study, college students with a strong learning goal orientation chose and implemented advantageous "deep" learning strategies more frequently than students with a weak learning goal orientation (Grant & Dweck, 2003). Strong learning goal students also displayed superior self-reflection processes to students with a strong performance goal orientation. These students recovered more quickly from poor performance on the first exam in the course and displayed higher performance by the end of that course. Research also shows that mastery goals are significantly correlated with measures of intrinsic motivation (Harackiewicz, Barron, & Elliot, 1998).

It should be noted that the motivational construct of goal orientations differs from metacognitive goal setting in the following way: Goal setting commits a student to a specific academic outcome at a particular point in time, such as completing an essay in two days, whereas goal orientation does not target a specific outcome in time. In terms of its role in self-regulation, goal setting produces an explicit feedback loop that requires self-evaluation on a specific time. By contrast, a goal orientation is an open-ended commitment to engage in learning or performance activities.

### *Performance Phase*

This second phase of self-regulation involves two major categories: self-control and self-observation methods. Students' use of self-control methods involves a variety of task-specific as well as general strategies. Task strategies refer to developing a systematic process for addressing specific components of a task, such as creating steps for multiplying fractions in math or for putting in golf. Included among general self-control strategies are the following: self-instruction, imagery, time management, environmental structuring, help-seeking methods, interest incentives, and self-consequences. Self-instruction refers to overt or covert descriptions of how to proceed as one executes a task, such as self-questioning as one reads textual material. Although the effectiveness of one's verbalizations depends on their quality and execution, research has shown that verbalizations can improve students' learning (Schunk, 1982).

Imagery is a self-control strategy that involves forming mental pictures to assist learning and retention, such as converting textual information into visual tree diagrams, flow charts, and concept webs. These graphical representations enable students to retrieve stored information in non-verbal images. The self-control method of time management refers to strategies for accomplishing learning tasks on schedule, such as setting specific task goals, estimating time requirements for those tasks, and monitoring progress in attaining those goals. There is evidence that students as young as elementary school age (Stoeger & Ziegler, 2008) and as mature as college age (Schmitz & Wiese, 2006) can profit from training in time management strategies.

Environmental structuring is a self-control method for increasing the effectiveness of one's immediate environments, such as using a computer to write an essay because the word processing program provides feedback regarding spelling and grammar. Help-seeking is a method of self-control that involves soliciting assistance when learning or performing, such as seeking out a tennis coach to assist one to master the service motion. To the casual observer, help-seeking appears to be the antithesis of self-control because assistance is sought from others. However, research has shown that poor achievers are very reluctant to seek advice from others, perhaps because they are unsure of what to ask for, when to ask for it, and who to approach (Karabenick, 1998; Newman, 2007). From this perspective, help-seeking can be viewed as a social form of information seeking.

Some methods of self-control are designed to enhance motivation rather than metacognitive processes (Wolters, 2003). For example, the strategy of interest enhancement seeks to render mundane tasks more attractive by increasing game-like qualities, such as competing with a classmate in recalling foreign language words. Another motivational strategy is self-consequences, which involves setting rewarding or punishing contingencies for oneself, such as putting off the task of answering email messages until after completing a homework reading assignment in chemistry (Zimmerman & Martinez-Pons, 1986). Although this list of self-control methods is illustrative rather than exhaustive, it conveys the range of self-regulatory strategies that have been used to enhance students' learning and performance of academic and non-academic skills.

Whether specific or general, all of these strategies need to be adapted based on learners' outcomes, and this is why self-observation plays such a central role in students' efforts to self-control their performance. There are two key forms of self-observation: metacognitive monitoring and self-recording. Metacognitive monitoring or self-monitoring refers to informal mental tracking of one's performance processes and outcomes, such as one's learning processes and their effectiveness in producing learning. By contrast, self-recording refers to creating formal records of learning processes or outcomes, such as a graph of a student's spelling errors in his or her written assignments. Creating a record of one's efforts to learn is advantageous for learners because it increases the reliability, specificity, and time span of self-observations. Self-recording can also include information regarding the conditions that surround a personal event, such as when time management records include descriptions of distracting phone calls from a friend.

Tracking one's performance is difficult when the amount of information involved in complex academic performance exceeds a person's mental capacity. An overload can produce disorganized or cursory metacognitive monitoring but can be avoided if students learn to selectively track key processes, such as the quality of their notes in a history class. Self-monitoring can be improved by recording because these records decrease students' reliance on recall and enable them to discern and interpret subtle changes in performance over time (Zimmerman & Kitsantas, 1999).

### *Self-Reflection Phase*

This phase is composed of two categories of response: self-judgments and self-reactions. A key form of self-judgment is self-evaluation, which refers to comparisons of one's performance with a standard. Bandura (1986) has identified three major types of evaluative standards: prior levels of performance, mastery of all components of a skill, and social comparisons with the performance of others, such as siblings, peers, and classmates. According to this analysis, learners often have some discretion to select standards to evaluate their performance, such as when a failing student sets a "C" as a personal grade goal. Setting a higher but unrealistic goal (e.g., an "A") will ultimately undermine that student's motivation to continue striving if the feedback is negative. Students' goal setting during the forethought phase will influence the standard that they use to self-evaluate during the self-reflection phase. It is important to note that a student's choice of a particular standard can greatly affect their perceived outcomes and subsequent motivation. For example, a student's use of prior performance levels as a standard of comparison has the advantage of committing him or her to self-improvement rather than to surpassing the performance of other students who may have started with an advantageous level of skill.

A second form of self-judgment that plays an important role in understanding cycles of self-regulation are causal attributions. These attributions are defined as beliefs about the causal implications of personal outcomes, such as one's fixed ability, effort, and use of strategies. A number of researchers (Schunk, 2007; Weiner, 1992) have expressed concern that certain types of attributions for performance can easily undermine self-motivation. For example, attributing errors to uncontrollable factors, such as a lack of talent or ability, prompts learners to react negatively to setbacks and discourages efforts to improve. However, attributing errors to controllable factors, such as use of a particular strategy, can sustain motivation during periods of subpar performance (e.g., Zimmerman & Kitsantas, 1997, 1999). The three-phase social cognitive model of self-regulation places causal attributions and evaluations together as self-judgments because of their conceptual interdependence. For example, if a student evaluates his or her academic performance as successful, then almost any causal attributions for success will increase motivation for subsequent efforts to learn. By contrast, if a student evaluates his or her performance as unsuccessful, then attributions to uncontrollable causes, such as fixed ability, will diminish his or her motivation. Thus, the motivational impact of an attribution depends directly on a student's evaluative judgments.

A second key category of the self-reflection phase is composed of two forms of self-reaction: self-satisfaction and adaptive/defensive decisions. Self-satisfaction is defined as cognitive and affective reactions to one's self-judgments. Self-satisfaction has been widely studied because students prefer learning activities that previously led to satisfaction and positive affect, and they tend to avoid those that produce dissatisfaction and negative affect, such as anxiety (Bandura, 1991). Adaptive decisions refer to students' willingness to engage in further cycles of learning by continuing their use of a strategy or by modifying it. By contrast, defensive decisions avoid further efforts to learn in order to shield a student from future dissatisfaction and aversive affect. Helplessness, procrastination, task avoidance, cognitive disengagement, and apathy are all forms of defensiveness. It is important to note that both forms of students' self-reactions are dependent on self-judgments during the self-reflection phase. For example, favorable self-evaluations of one's performance and attributions to controllable causes will in turn lead to increased self-satisfaction and continued efforts to learn adaptively.

These self-reactions affect forethought phase processes in a cyclical fashion during further efforts to acquire proficiency. For example, positive self-satisfaction reactions are expected to enhance positive motivational beliefs about further efforts to learn, such as a more positive perception of self-efficacy about eventually mastering the academic skill, a stronger learning goal orientation (Dweck & Leggett, 1988), and greater intrinsic interest in the task (Zimmerman & Kitsantas, 1997). Because of their cyclical interdependence, self-regulatory processes can become self-sustaining in that processes and beliefs in each phase create inertia that can facilitate or undermine efforts to learn during subsequent phases. For example, adaptive or defensive decisions can affect students' goals and strategic planning during subsequent cycles of learning. Thus, these altered self-motivation beliefs, goals, and planning form the basis for further self-regulatory efforts.

One of the purposes of the three-phase model of self-regulation was to identify specific metacognitive processes and motivational sources and to explain their cyclical interrelation during ongoing efforts to learn in real contexts. An unexpected by-product of efforts to test this model is the realization that the most prominent sources of motivation involve personal beliefs and feelings that precede, accompany, or follow efforts to learn. For example, self-efficacy refers to a student's a priori confidence about acquiring a skill, whereas task valuing/interest concerns a student's liking of the learning task. A learning goal orientation addresses the purpose of learning, and attributions refer to post hoc judgments of the causes of a student's learning. Self-satisfaction and adaptation deal with students' self-reactions to their ongoing attempts to learn. The point is that any complete accounting of a student's efforts to self-regulate should include not only metacognitive processes but also his or her motivational beliefs and feelings about learning at various points during cyclical feedback loops. Thus, these motivational beliefs are both a cause and an effect of a student's efforts to learn metacognitively.

## Microanalytic Measures and Cyclical Analyses to Assess SRL

Zimmerman and his colleagues developed a methodology for assessing most metacognitive and motivational processes of SRL during ongoing efforts to learn. This microanalytic approach involves assessing an individual student's responses to questions at key points before, during, and after learning. Students' answers to these open- or closed-ended questions yield both qualitative and quantitative data respectively. The questions are brief and task-specific in order to minimize disruptions in learning, and they are contextually-specific, which can increase their validity. For example, there is research indicating that microanalytic measures of self-regulation are highly predictive of performance differences between expert, non-expert, and novice athletes (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). Novices in these studies displayed deficiencies in not only the quantity and quality of self-regulatory processes but also their motivational beliefs. This microanalytic methodology is classified as an *event* measure of SRL, which is defined as a temporal entity that has a beginning and an end (Zimmerman, 2008). Because a self-regulation event, such as using a strategy, occurs in sequence to events that precede and follow it, these measures are sensitive to change and can capture correlational as well as causal relations between metacognitive processes and motivational feelings and beliefs.

For example, microanalytic measures have revealed evidence of high positive correlations among within-phase measures of motivation, such as between attributions to strategy use and self-satisfaction reactions in research on writing revision. In a study of these issues, Zimmerman and Kitsantas (1999) reported evidence of sequential causality in students' forethought phase strategic planning, performance phase learning, and self-reflection phase attributions and feelings of satisfaction with their writing. Finally, it was found that self-reflection phase measures of motivation were predictive of forethought phase motivational beliefs, such as self-efficacy and task interest regarding additional cycles of learning. Clearly, students' use of high quality SRL processes can lead to enhanced motivation to continue additional cycles of learning.

Microanalytic measures of SRL processes and sources motivation have also been used to investigate students' learning of athletic skills, such as free throw shooting, volleyball serving, and dart throwing. These measures of metacognition and motivation revealed significant differences among experts, non-experts, and novices (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). When experts were compared to non-experts and novices, they reported the greatest use of metacognitive processes and the most positive motivational beliefs. In the study of volleyball serving, microanalytic measures of self-regulation during a practice phase were combined and used to predict accuracy in serving during a post-test (Kitsantas & Zimmerman, 2002). The combined measures predicted over 90% of the variance in post-test skill. Clearly, microanalytic measures of self-regulatory processes and motivational beliefs during students' efforts to learn have disclosed some impressive findings! Although high levels of expertise take years to develop (Ericsson, 2006), there is recent evidence (Cleary, Zimmerman, & Keating, 2006) that novices who were taught multi-phase SRL strategies for basketball free throw shooting displayed significantly greater athletic skill and improved motivational beliefs during relatively brief practice sessions than novices in an untutored control group.

## Becoming a Proactive Self-Regulator

Microanalytic research of Zimmerman and colleagues has revealed that even novices attempt to self-regulate their learning in some way, so it can be asked: How should researchers describe self-enhancing and self-defeating cycles of learning according to a three-phase model of self-regulated learning? We define students who focus on and engage in productive forethought before they attempt to learn as proactive self-regulators. Alternatively, we define students who rely primarily on self-reflections based on performance phase outcomes as reactive self-regulators. Unfortunately, the latter students handicap themselves because of their failure to analyze the task, to set specific goals, and plan an effective strategy before attempting to learn (Bandura & Schunk, 1981). By contrast, proactive self-regulators set specific learning goals that are linked closely to strategic planning. There is growing evidence that learners who focus initially on learning processes learn much more effectively than learners who focus initially on learning outcomes (Schunk & Schwartz, 1993; Zimmerman & Kitsantas, 1996).

In addition to this empirical evidence demonstrating the advantage of process goals versus outcome goals, there is extensive anecdotal evidence that learners who set process goals learn more effectively. For example, Paul Annacone (2008), a veteran tennis coach who worked with a highly ranked British tennis player, Tim Henman, described not only the metacognitive advantages of setting process goals but also the motivational benefits, such as attributions to strategy use and self-satisfaction.

> Think about tactics, not results. As I found out early on with Tim, the score can get in the way of your tennis. Tim and I used to talk a lot about being process-oriented rather than results-oriented. If you go into a match ready to fight and win points, you might forget to think about what it is you should do to win those points. Tim really latched onto thinking more about tactics than score. He learned to put patterns together in his mind of how he wanted to play points, rather than focusing on whether he won them or not. Perhaps the biggest benefit to learning to think like Tim: When you've committed to a strategy and tried your best to execute it, you'll have no regrets.
>
> (Annacone, 2008)

Does Annacone's advice mean that setting outcome goals are inherently counterproductive when students seek to learn on their own? An answer to this question requires a detailed analysis of metacognitive as well as motivational processes. We have already discussed research showing that outcome goals that are specific, proximal, and challenging are more effective than outcome goals that are unfocused, distal, and easy (Bandura & Schunk, 1981; Locke & Latham, 2002). Clearly, both high-quality outcome goals and process goals are advantageous, but how should they be structured to optimize learning?

Zimmerman and Kitsantas (1997) hypothesized that with complex tasks, process goals are advantageous during initial learning because of their close linkage to strategic planning and implementation. In terms of their impact on forethought, process goals are designed to incorporate strategic planning—combining two key task analysis processes. With studying and/or practice, students will eventually use the strategy automatically. Automization occurs when a strategy can be executed without close metacognitive monitoring. At the point of automization, students can benefit from outcome feedback because it helps them to adapt their performance based on their own personal capabilities, such as when a basketball free throw shooter adjusts their throwing strategy based on their height. However, even experts will encounter subsequent difficulties after a strategy becomes automatic, and this will require them to shift their monitoring back from outcomes to processes. This is one of the reasons that professional tennis players hire coaches, such as Paul Annacone.

To validate this metacognitive account and establish its motivational power, Zimmerman and Kitsantas (1997, 1999) conducted two experimental studies of process and outcome goals, one with an athletic task and another with an academic task, namely writing. In a study of writing revision with adolescent girls, all participants were initially taught a three-step revision strategy through observation and emulation of a model. Following training, a practice session was conducted. Girls in the process goal group focused on strategic steps for revising each writing task. By contrast, girls in the outcome goal focused on decreasing the number of words in their revised passages. The presence of unnecessary words reduced post-test writing revision scores. Girls in a shifting goal group started with process goals and changed to outcome goals after automatization occurred. Half of the girls in each goal group were ask to self-record their processes or outcomes, and this was expected to enhance both types of performance phase learning.

It was found that girls who shifted goals from processes to outcomes after having achieved automatization surpassed the writing revision skill of girls who adhered exclusively to process or outcome goals. Girls who focused on outcomes exclusively displayed the least writing skill, and self-recording enhanced writing acquisition for all goal setting groups. In addition to their acquisition of superior writing skill, girls who shifted their goals displayed advantageous forms of self-motivation, such as greater attribution to controllable causes (i.e., strategy use), enhanced self-satisfaction, more optimistic self-efficacy beliefs, and greater task interest. The motivational advantages of shifting one's goals metacognitively at the point of automatization were replicated in research on acquisition of an athletic skill (Zimmerman & Kitsantas, 1997).

## Self-Efficacy and Self-Evaluative Calibration

The close linkage between metacognitive processes and sources of motivation is especially evident in recent research on self-efficacy calibration. As was discussed earlier, there is extensive research documenting significant positive correlations between the *strength* of students' self-efficacy beliefs and their academic achievement (Pajares, 1996; Zimmerman, 1995). According to a strength hypothesis, students' reports of higher self-efficacy should lead to higher motivation and achievement. For example, Schunk (1984) found that students' self-efficacy beliefs predicted their persistence during learning as well as their success in acquiring math skills.

However, there is recent research that focuses on another dimension of self-efficacy—the *calibration* of students' self-efficacy beliefs. Calibration is a measure of metacognitive monitoring based on the disparity between one's sense of efficacy about performing a particular task and one's actual performance. This calibration issue has arisen in cases where test item-specific measures of self-efficacy have been employed, such as a student's answer to a math problem. There is evidence that students often overestimate their efficacy judgments—and in some cases quite substantially (Klassen, 2002; Pajares & Miller, 1994). Underestimates of self-efficacy are much less frequent, but their effects on students' motivation can be particularly disabling because they can undermine students' effort, persistence, and choice of challenging academic tasks (Bandura, 1986; 1997). Ideally, students' self-efficacy judgments should not greatly exceed their actual capability because over-optimism can lead to insufficient efforts to learn (Ghatala, Levin, & Pressley, 1989). Well-calibrated people are accurate in judging their capability to perform a task learn more effectively (Schunk & Pajares, 2004).

Although research on self-efficacy calibration is quite recent, there is an older literature on self-evaluation calibration, which involves students' judgments of knowing *after* completing a test item. Research on self-evaluation has also reported extensive evidence that students' accuracy in judging the correctness of their answers is only slightly above chance. However, better accuracy is related to better performance (Chen, 2003). Researchers have found that low-achieving students are less accurate and have a greater tendency toward overconfidence than high-achieving students who tend to be slightly underconfident (Bol & Hacker, 2001). Intervention studies designed to improve students' metacognitive accuracy have been largely unsuccessful, implying that these self-evaluative judgments may be resistant to change (Bol & Hacker, 2001; Hacker & Bol, 2004).

Among possible reasons for the resistance of overconfident students to change, motivational concerns figure prominently. It has been speculated that low-achieving students may resist calibration training because of a self-serving attributional style. That is, optimistic misjudgments of learning are blamed on others whereas accurate self-evaluative judgments are attributed to themselves (Hacker & Bol, 2004). However, inaccurate perceptions of one's capability can have negative consequences. Students who grossly overestimate their capabilities may attempt to solve difficult problems and will experience failure, which can decrease their motivation for engaging in further learning (Bandura, 1986; Schunk & Pajares, 2004). Pajares (1996) has discouraged interventions designed to lower students' self-efficacy judgments, but he has advocated improving the accuracy of their efficacy judgments by helping them metacognitively to comprehend what they know and do not know. Stone (2000) and Zimmerman (1990) hypothesized that self-regulated learners are well calibrated. Students who engage in high-quality task analysis, choose an effective strategy, and implement it as a process goal are unlikely to greatly overestimate their self-efficacy.

## An Intervention Study to Improve Students' Calibration and Self-Reflection

Zimmerman and his colleagues (Zimmerman, Moylan, Hudesman, White, & Flugman, 2008) sought to compare the effects of self-reflection training on students' metacognitive calibration judgments and motivational beliefs in an intervention study with at-risk technical college students who are studying math. This recent study was designed to help these struggling learners interpret their academic grades as sources of self-reflective feedback rather than as indices of personal limitation. College students in developmental (remedial) math or introductory college-level math courses were randomly assigned to either an experimental or a control classroom of their respective courses. In self-reflection classrooms, teachers used modeling techniques and assessment practices designed to enhance self-reflection processes, while students were given frequent, ongoing opportunities to improve their math achievement using a self-reflective feedback form to self-regulate their math learning and problem solving.

Self-reflective feedback was provided every two to three class sessions. Students in the intervention classrooms were administered a 15–20 minute quiz involving four to five math problems as a vehicle for frequent feedback to students and teachers. Quizzes required students to make task-specific self-efficacy judgments before solving individual problems and self-evaluative judgments after attempting to solve each math problem. After receiving graded quizzes from the instructor, students in the intervention group had the opportunity to correct quiz errors by completing self-reflection forms and to receive grade point incentives.

The self-reflection form was designed to guide students' self-reflection processes regarding erroneous answers to items on a mathematics quiz and cyclical self-regulatory efforts to solve transfer problems. For example, the self-reflection form required students to compare their self-efficacy and self-evaluative judgments with their outcome on the quiz item, explain their ineffectual strategies, develop a new more effective strategy, and indicate their confidence for solving a new problem. If the student failed to solve the problem, they were encouraged to seek assistance from an instructor, a tutor, or a peer. To help students understand and complete the self-reflection forms, instructors initially modeled the completion of the forms, and they supported their students with in-class group and individual practice. The rubric for scoring the quality of the students' answers on the self-reflection forms was given to the students by the instructors.

As expected, Zimmerman and his colleagues found substantial evidence of overconfidence by these at-risk technical college students, despite low levels of math achievement. The attrition and failure rate in math classes at this public technological college has been very high. The process of helping students self-reflect on their errors in mathematical learning and problem solving was designed to shift perceptions of assessment feedback from being an end-point to instead being viewed as a source for enhanced self-regulation.

The results revealed that students receiving self-reflection training outperformed control group students on instructor-developed tests and were better calibrated in their task-specific self-efficacy beliefs before solving problems and in their self-evaluative judgments after solving problems. Students in the conventional instruction classes tended to overestimate their perceived competence in mathematics. As predicted from a social cognitive model of self-regulated learning, evidence was found of significant relations among self-regulated learning processes. Specifically, students' self-efficacy and self-evaluation judgments regarding performance on periodic tests were positively correlated with their math test achievement. Additionally, students' self-efficacy for final exam achievement, their standards for self-satisfaction, and their self-reported learning strategy use were each positively correlated with final exam achievement. Furthermore, among students receiving self-regulated learning training, higher amounts of error correction were predictive of math achievement and metacognitive calibration.

These findings suggest that a self-regulated learning intervention designed to improve students' self-reflection did improve the accuracy of students' self-monitoring of their mathematical problem-solving performance. This, in turn, had positive effects on their achievement in entrance-level courses in college mathematics. Receiving an academic grade is an important transactional event between a teacher and a student. From a student's standpoint, feedback from traditional forms of math assessment is usually problematic regarding self-regulation and is often perceived as punishing. An instructional and assessment approach that emphasizes interpreting errors from a self-regulatory perspective is more likely to empower students to respond adaptively to academic feedback. Although this intervention demonstrated the effectiveness of closely linked metacognitive and motivational components, it did not address the issue of their separate and combined effectiveness in comparison to other studies. We turn to this issue next.

## Evaluating the Academic Effectiveness of Metacognitive and Motivational Training

In a recent meta-analysis, Dignath, Buettner, and Langfeldt (2008) reviewed 48 studies derived from 30 articles on the effectiveness of self-regulatory training with primary school students. The conceptual framework for selecting studies involved motivational as well as cognitive and metacognitive processes. To be included in the meta-analysis, the intervention had to be conducted in a classroom setting by either teachers or researchers. Interventions that lacked the following characteristics were excluded: those that did not include strategy instruction, lasted fewer than two days, lacked a control group, or had fewer than 10 participants. Studies that were situated in computer contexts were also excluded. To insure comparable student comparisons across the studies, authors excluded gifted and learning disabled students. Finally, the review did not include studies published before 1992 because that was the date of the last extensive review of research on self-regulated learning strategies (Hattie, 1992).*

The selected studies were classified based on a variety of issues. These included the types of strategies that were taught, such as cognitive, metacognitive, and motivational. Cognitive strategies referred to direct regulation of learned information, such as a math calculation strategy. Metacognitve strategies referred to second-order cognitions designed to control, monitor, and evaluate learning and cognitive activities. Motivational strategies included self-efficacy, attributional orientation, action control methods, and feedback. The studies were also classified based on the theoretical model that guided the study, including metacognitive, motivational, and social cognitive/constructivist as well as combinations of these theories.

The results revealed that most of these self-regulation intervention studies produced not only gains in students' academic performance but also improvements in their strategic behavior and motivation. The mean effect size of self-regulated learning training was 0.61 for overall academic performance, 0.73 for enhanced strategy use, and 0.76 for improved motivation. It should be noted that for these tests, Cohen (1988) classifies effect sizes of 0.80 and above as large, effect sizes between 0.50 and 0.79 as medium, and effect sizes between 0.49 and below as small.

Regarding the effects related to the theoretical background for the study on students' overall academic performance, interventions based on social-cognitive/constructivist theories had a large effect size (0.95), whereas interventions based on motivation theories exerted the smallest effect size (0.33). Interventions based on metacognitive theories were medium in their effect size (0.58). Interestingly, intervention studies that combined social-cognitive/constructivist and metacognitive theories displayed the largest effect (1.44).

The data were also analyzed for the effects of the type of strategies that were implemented to enhance overall academic performance. Note that the theoretical framework behind interventions did not necessarily correspond with the strategies emphasized in

* In this study, Dignath and Buettner (in press) used regression analyses to assess the relation between moderator variables and effect sizes and did not report the effect sizes for these variables. For this reason, we described these findings without reporting the size of the specific effects.

training. It was found that interventions that relied on cognitive strategies produced only low effects. Although the effect of adopting a purely motivational model of self-regulated learning on overall academic performance was small, interventions that emphasized motivational strategies (1.36) or a combination of metacognitive and motivational strategies (1.23) exerted large effects on students' overall academic attainments.

Regarding the metacognitive reflection strategies that were used to enhance students' overall academic performance, the highest effect sizes were found with interventions that provided students with knowledge about strategies (0.91) and demonstrated the benefits of applying the trained strategies or triggered metacognitive reasoning (0.78).

The data were also analyzed according to the effects of different types of motivational strategy on students' overall academic performance. The largest effect size was produced by a feedback strategy (1.41). In addition to its impact on academic learning, the feedback strategy had a very large impact on the students' motivation (1.40). By contrast, causal attribution strategies (0.64) and an action control strategies (0.48) produced medium-sized effects. Clearly the most effective training methods provided students with feedback about their strategic learning. These results provide support for the use of self-reflection forms like those used by Zimmerman and his colleagues (2008) in their intervention study.

Concerning the role of context factors in these self-regulated learning interventions, there is evidence that the school subject matter is important. The size of self-regulatory training effect on students' math outcomes was large (1.00), but the effect on their reading and writing was small (0.44). Another contextual factor involves the impact of the length of interventions on students' academic learning, but the meta-analysis revealed no evidence that the duration of the interventions is predictive of academic outcomes. A third contextual factor involves the person who implements a self-regulatory intervention. The effect size for researcher-directed interventions was large (0.87) whereas the effect size for teacher-directed interventions was small (0.46). In our experience, teachers adhere less closely to intervention guidelines than researchers. A fourth context factor involves the methods used to assess students' use of self-regulatory processes. The largest effect size was found for questionnaire measures (0.86). Medium effect sizes were found regarding the use of task tests, simulation tasks, think-aloud records, and observation measures. The lowest effect sizes were produced by multiple-choice tests. The latter tests do not require recall and are a less demanding measure of self-regulated learning interventions (Ghatala, Levin, & Pressley, 1989). A fifth contextual factor involves the role of students' age in their response to self-regulation training. The results showed no age differences in the effectiveness of self-regulated learning instruction. This indicates that even children in the primary grades (1–3) can acquire self-regulatory competence through systematic training.

In a subsequent meta-analysis of self-regulation training studies, Dignath and Buettner (2008) expanded their database on primary school students to include 35 studies of secondary students that contained 94 effect sizes (357 total for both school levels). This comparative investigation revealed the effect of self-regulation training on secondary students' overall academic performance to be 0.54. This training effect was smaller than that of primary students (0.61). Regarding students' learning of specific academic subjects, the authors found interesting differences based on students' level of schooling. For secondary students, the effect of self-regulation training on reading/writing performance was large (0.92) but on math performance was small (0.23). For primary students, the pattern was reversed: The effect of training on reading/writing performance was small (0.44) but on math performance was large (0.96).

In terms of the effects of self-regulation training on students' use of strategies, the effect size was medium for primary students (0.72) but large for secondary students (0.88). It appears that the effects of strategy training increased from primary to secondary school levels. The effect of self-regulation training on students' motivation was medium in size for primary students (0.75) but small in size for secondary students (0.17). However, there were only six intervention studies of secondary students that included motivation measures, and the authors cautioned readers against drawing conclusions from these limited data. Regarding the effectiveness of self-regulation instructors, both primary and secondary students profited more when training was conducted by researchers rather than regular teachers.

In terms of the effect of the theoretical background of self-regulation training, secondary students responded differently to primary students. For secondary students, the effect of metacognitive interventions on overall academic performance was greater than other interventions whereas for primary school students, the effect for social-cognitive/constructivist interventions was greater. The effect of motivational interventions was smaller than the preceding interventions for both primary and secondary students.

Concerning the impact of different forms of self-regulation training on academic performance, the effects of metacognitive and motivational strategies were each larger than other strategies for primary students whereas the effects for metacognitive reflection or motivational strategies were each larger for secondary students. Clearly, motivational strategies play an important role in the academic success of both primary and secondary students.

## Conclusions

This chapter addressed the role of motivation in students' efforts to self-regulate more effectively. Historically, interventions involving metacognitive measures of learning fared poorly in inducing strategy maintenance and transfer. A case was made that proactive self-regulation depends on the presence of important sources of motivation. We described how a number of highly regarded measures of motivation could be linked conceptually to key metacognitive processes within a social cognitive model of self-regulated learning. Empirical support for this three-phase cyclical model was discussed, especially from research involving event measures of self-regulation during learning episodes.

The intersection of metacognitive and motivational measures has led to the consideration of a number of emergent issues—both methodological and conceptual. One issue concerned the predictive power of microanalytic assessment of self-regulation during the course of functioning. High levels of correlation were reported in research on academic as well as athletic functioning. A second issue was how proactive learners can be developed. The three-phase model was used to explain links between students' process and outcome goal setting (forethought phase), strategy automatization (performance control phase), and motivational reactions to these goal outcomes (self-reflection phase).

A third issue involved research on students' calibration bias regarding two key self-beliefs: self-efficacy and self-evaluation. Calibration is a measure of metacognitive monitoring that is derived from these two widely used measures of motivation, and there is evidence that measures of calibration bias are associated with poorer learning outcomes. A fourth issue concerned whether students' calibration as well as their academic outcomes could be improved through self-reflection training. A recent investigation was successful in enhancing the calibration and achievement of students who were at high academic risk.

A final issue involved the relative effects of metacognitive and motivational components of self-regulated learning. This issue was investigated in meta-analyses of self-regulated learning with primary and secondary school students. Interventions based on social-cognitive/constructivist theoretical backgrounds had a substantial effect on primary students' academic performance whereas interventions based on metacognitive theoretical backgrounds had a substantial effect on secondary students' academic performance. Interventions based on motivational theoretical backgrounds were less effective for both primary and secondary students. However, the inclusion of motivational strategies in self-regulated learning interventions enhanced the overall academic performance of both primary and secondary students. Clearly, exploring the intersection of metacognition and motivation has opened new windows to our understanding of how students self-regulate and self-sustain their learning.

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