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CHAPTER 17

The Role of Self-Efficacy and Related Beliefs in Self-Regulation of Learning and Performance

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One of the most important qualities of successful students is their "sense of agency"—having the means or power to learn in a self-regulated fashion, such as when studying or practicing on their own (Bandura, 2008). As used in this chapter, *self-regulation* is the process whereby students activate and sustain behaviors, cognitions, and affects that are systematically oriented toward the attainment of their goals (Zimmerman, 2000). Social-cognitive researchers have found that students' capabilities to self-regulate depend significantly on their self-efficacy beliefs. *Self-efficacy* refers to personal judgments of one's capabilities to organize and execute courses of action to attain designated goals (Bandura, 1977, 1986), such as completing a science experiment or writing a term paper. The efficacy belief system is not a global trait but a differentiated set of self-beliefs linked to distinct realms of functioning (Bandura, 2006). We contend that self-efficacy beliefs influence and reciprocally are influenced by students' self-regulatory processes, such as goal setting, strategy use, self-monitoring, and self-judgments.

In this chapter, we describe a cyclical phase model of self-regulatory processes and beliefs, the distinctive properties of self-efficacy beliefs, assessment of these beliefs, sources and effects of self-efficacy beliefs, and cyclical relations between self-efficacy and related beliefs and self-regulatory processes. In addition, we discuss the issue of the accuracy or calibration of self-efficacy beliefs and instructional interventions to enhance their accuracy and impact on students' self-regulation of learning.

A CYCLICAL MODEL OF SELF-REGULATION

To enhance their academic performance, many students acquire and apply self-regulatory processes, especially when dealing with challenging tasks, competing attractions, and stressors (Zimmerman & Martinez-Pons, 1986, 1990). Many researchers have sought to explain self-regulation in terms of personal feedback loops that convey information about one's performance or outcomes (Hattie & Timperly, 2007). These loops produce cyclical feedback regarding students' social/environmental outcomes, such as positive or negative comments from teachers or classmates. The loops also can convey feedback regarding a student's behavior, such as time spent in study. Finally, loops can convey feedback concerning covert events, such as changes in self-efficacy beliefs about one's preparation for a test due to studying. A social-cognitive model of self-regulation is used to integrate research on self-efficacy beliefs with research on self-regulatory processes because it encompasses cyclical feedback from covert personal sources, as well as from behavioral and social/environmental sources (Schunk, 2012; Zimmerman, 2000, 2008).

According to this model, feedback loops can be analyzed sequentially. As shown in Figure 17.1, feedback loops involve a cycle of three phases (Zimmerman, 2000). The first phase, *forethought,* occurs before efforts to learn and includes learning processes and motivational beliefs that influence a person's willingness and preparation to learn or perform. The second phase, *performance,* occurs during efforts to learn and includes learning and motivational processes that influence one's concentration and action. The third phase, *self-reflection,* occurs after the performance phase and involves personal reactions to performance phase outcomes. These self-reflections then affect forethought processes and beliefs about subsequent efforts to learn. This completes the self-regulatory cycle.

There are two major categories of forethought phase processes. The category of *task analysis* involves relating a task and its context to goal-setting and strategic planning processes (Winne & Hadwin, 1998). *Goal setting* involves specifying outcomes that one intends to obtain, such as writing an essay in social studies in 3 hours (Locke & Latham, 1990). Goals that are specific, proximal, or challenging are more effective

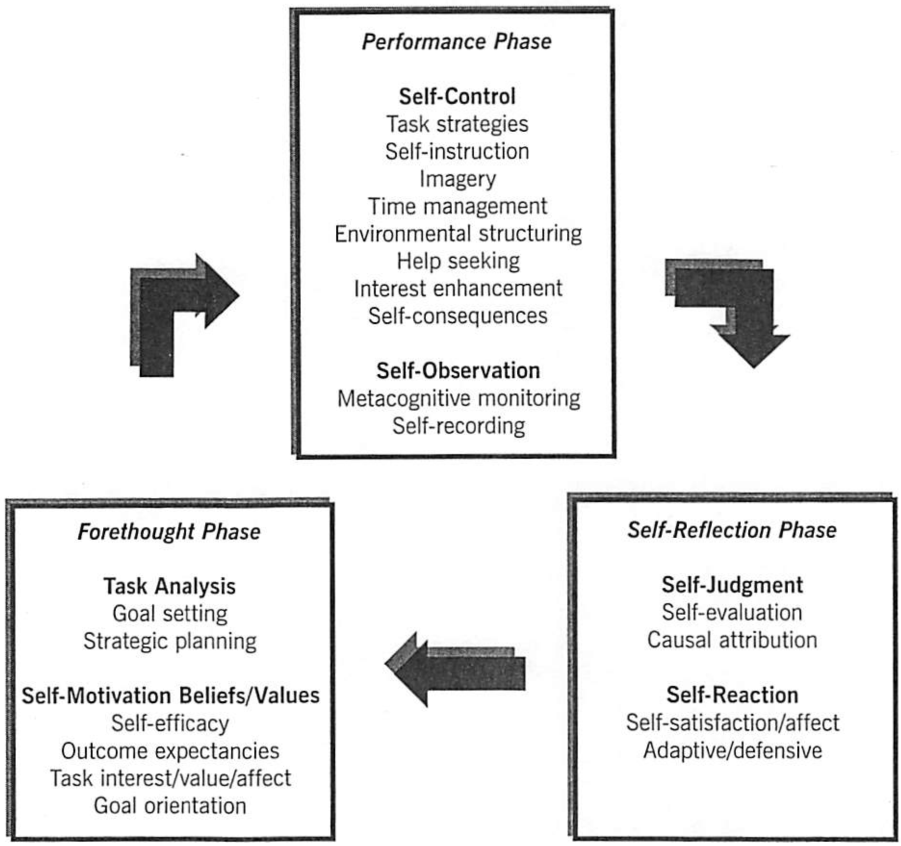

FIGURE 17.1. Relation of self-efficacy beliefs to self-regulatory beliefs and processes.

than goals that are diffused, delayed, or easy (Bandura & Schunk, 1981). There is evidence that goal systems of successful learners are structured hierarchically, with proximal process goals linked to distal outcome goals (Bandura, 1991; Carver & Scheier, 2000).

Strategic planning entails choosing or constructing advantageous learning methods that are appropriate for the task and the environmental setting (Weinstein & Mayer, 1986). Students can study or practice better when their strategic plans are tied to clear goals. For example, imagistic or self-instructional strategies improve recall (Bandura & Jeffery, 1973; Pressley, 1976). However, the effectiveness of self-regulatory strategies can vary during the course of learning. When strategies are applied without planning or adaptation, they can be ineffective, due to unfavorable shifts in personal, behavioral, or environmental conditions (Zimmerman & Kitsantas, 1999). Goal setting and strategic planning often require personal initiative and persistence; as a result, they require high levels of self-motivation (Zimmerman, 1995). A key source of self-motivation is *self-efficacy* beliefs, which are related to performance phase processes such as one's choice of activities, effort, and persistence (Schunk, 1984; Zimmerman & Kitsantas, 1996). A student's self-efficacy perceptions can affect his or her use of learning strategies in diverse areas, such as writing (Schunk & Swartz, 1993) and time management (Britton & Tesser, 1991). We discuss the defining features, theoretical properties, and assessment of self-efficacy beliefs later in this chapter.

Outcome expectancies constitute a second important source of self-motivation. *Outcome expectations* are beliefs about the ultimate consequences of one's performance, such as receiving social recognition or obtaining a desirable position. Students' outcome expectations depend on their knowledge or awareness of potential outcomes, such as salaries, quality of life, and health and retirement benefits. The motivational effect of attractive outcomes has been widely demonstrated, but these expectations also depend on one's sense of efficacy (Schunk & Zimmerman, 2008). For example, a student may want to become a pharmacist. However, if this student lacks a sense of efficacy about passing a course in chemistry, he or she may not be motivated to pursue this career. Thus, both outcome expectations and self-efficacy beliefs play a role in the student's decision.

Task interest, valuing, and affect constitute a third source of forethought phase motivation. These motives refer to a student's liking or disliking a task and its context because of the inherent properties rather than for the instrumental qualities in gaining other outcomes. This class of motives includes measures of intrinsic motivation (Deci & Ryan, 1985), interest value (Wigfield & Eccles, 2002), and interest (Hidi & Renninger, 2006). Research by Ainley, Corrigan, and Richardson (2005) revealed that task interest can influence students' choice of learning strategies, and well as their achievement goals.

Students' *goal orientations,* or reasons for learning, is another source of motivation to self-regulate that pertains to beliefs or feelings about the purpose of learning. Although prominent theorists differ in terms of the names and number of goal orientations that they propose, there is agreement about the purpose of a learning goal orientation and a performance goal orientation. Students who hold a learning goal orientation try to improve their competence via learning, whereas students who adopt a performance goal orientation try to preserve their competence perceptions through favorable comparisons with the performance of others (Dweck & Leggett, 1988). Students' learning goal orientations are formed from the belief that their mental ability can be increased, whereas their performance goal orientations are formed from the belief that mental ability is a fixed entity. Students with a learning goal orientation tend to display higher levels of cognitive strategies than do students with a performance goal orientation (Pintrich & DeGroot, 1990).

The *performance phase* comprises two categories of self-regulatory processes: self-control and self-observation methods (Zimmerman, 2000). Self-control methods include a wide variety of strategies, such as task strategies, self-instruction, imagery, time management, environmental structuring, help-seeking methods, interest enhancements, and setting self-consequences. *Task strategies* are systematic processes for addressing specific components of a task, such as creating steps for editing a term paper in English or for shooting free throws in basketball. *Self-instruction* involves overt or covert self-descriptions of how to undertake a task, such as steps in solving a crossword puzzle, such as "Do the easy words first." However, the effectiveness of one's verbalizations depends on their quality and execution (Zimmerman & Bell, 1982). When these conditions are obtained, verbalizations are likely to enhance students' learning. *Imagery* is a strategy that involves forming mental pictures to facilitate learning and retention, such as converting textual material into diagrams or flow charts. There is extensive evidence that students can recover stored information from nonverbal images (Pressley, 1976). The self-control strategy of *time management* involves setting specific task goals, estimating time requirements, and monitoring progress in attaining those goals. From elementary school (Stoeger & Ziegler, 2011) to college (Schmitz & Wiese, 2006), students have benefited from instruction on time management.

Environmental structuring strategies are used to improve the supportiveness of one's immediate settings. For example, many professional writers carry a notepad with them to capture and develop ideas when they occur spontaneously (Barzun, 1964). The self-control strategy *help seeking* refers to soliciting assistance during learning or performance, such as finding a voice coach to show an aspiring actress how to project her voice. Researchers have shown that, compared with lower achievers, higher-achieving students are less likely to need help but more likely to seek help when it is needed (Karabenick, 2011). Although help seeking may be seen as a form of dependence, it can be viewed as a social form of information seeking if it leads ultimately to greater independence in learning.

Several self-control strategies are designed to improve students' motivation, such as interest enhancement and self-consequences. *Interest enhancement* involves improving the attractiveness of a task, such as by introducing competition into a dull activity (e.g., working out on an exercise bicycle; Wolters, Benzon, & Arroyo-Giner, 2011). The self-control strategy of setting self-consequences is another way for students to motivate themselves. Students can set rewarding or punishing contingencies for themselves, such as delaying phone calls to their friends until their homework is completed. Learners who set consequences for themselves achieve better in school (Zimmerman & Martinez-Pons, 1986).

To be effective, adaptation of self-control strategies needs to be based on learners' task outcomes. Given the importance of this strategic feedback, the accuracy of one's self-observation plays a central role in students' efforts to self-control their performance (Bandura, 1986). Self-regulated learners are distinguished by their reliance on systematic forms of self-observation to guide their efforts to self-control, whereas poorly regulated learners have trouble tracking a particular process, such as discerning a computational error when solving math problems (Zimmerman, Moylan, Hudesman, White, & Flugman, 2011).

One form of self-observation that has been studied is *metacognitive monitoring* (or *self-monitoring*), which refers to informal mental tracking of one's performance processes and outcomes. A second form of self-observation, *self-recording,* refers to creating formal records of learning processes or outcomes, such as a graph of a student's grammatical errors in his or her book reports. Records of one's efforts to learn are advantageous because they increase the reliability, specificity, and time span of self-observations. In addition, self-recording can include information about the setting, such as records of where and with whom one is studying. Experimental evidence shows that self-recording of personal outcomes enhances learning (Zimmerman & Kitsantas, 1997, 1999).

Tracking one's performance can be difficult when the amount of information exceeds one's capacity to process it. When this occurs, a student's tracking becomes disorganized or shallow. However, these limitations can be overcome by selective tracking of key processes, such as one's wrist position when hitting topspin forehand shots in tennis. Self-observation was the first of Bandura's (1986) self-regulatory subfunctions.

Self-reflection, the third phase of self-regulation, involves two self-regulatory subfunctions identified by Bandura (1986): self-judgments and self-reactions. One type of self-judgments, *self-evaluation,* refers to a student's comparisons of his or her performance against a standard. Three evaluative standards have been identified: self-comparisons with prior levels of performance, mastery comparisons with a recognized criterion of performance, and social comparisons with the performance of others (e.g., other students). Learners who are guided by specific forethought phase goals tend to self-evaluate based on attainment of those goals (Zimmerman & Kitsantas, 1997). The type of standard that is operative is determined by the setting, such as teachers' use of a mastery standard of 0–100% when grading students' tests. This standard of comparison is advantageous because it conveys self-improvement rather than social advantage or disadvantage in comparison to other students.

A second type of self-judgment is *causal attributions,* beliefs that focus on the perceived causes of personal outcomes, such as one's ability, effort, and use of strategies (Schunk, 2008; Weiner, 1992). Unfortunately, certain types of attributions for performance outcomes can undermine self-motivation. For example, attributing errors to uncontrollable factors such as insufficient talent or ability can be counterproductive. On the other hand, students who attribute errors to controllable factors, such as choice of a strategy, can maintain motivation during periods of poor performance (Zimmerman & Kitsantas, 1997, 1999).

There are two forms of self-reactions during the self-reflection phase. *Self-satisfaction* refers to cognitive and affective reactions to self-judgments, and it has been studied because students prefer learning activities that previously led to satisfaction and positive affect and tend to avoid those that produce dissatisfaction and negative affect, such as anxiety (Bandura, 1991). By contrast, *adaptive decisions* students' motivation to undertake further cycles of learning, for example, by continuing their use of a strategy or by modifying it. *Defensive decisions* preclude further efforts to learn because they shield a student from experiencing further dissatisfaction and negative affect. Among the forms of defensiveness that have been studied are helplessness, procrastination, task avoidance, cognitive disengagement, and apathy. Both self-satisfaction and adaptive/defensive self-reactions are dependent on self-judgments during the self-reflection phase (Kitsantas & Zimmerman, 2002), for example, when students' favorable self-evaluations of their performance and attributions to controllable causes can produce increased self-satisfaction and sustained efforts to learn adaptively.

Thus, according to a social-cognitive model of self-regulation, the impact of forethought phase processes, such as self-efficacy beliefs, can extend to the performance and self-reflection phase processes and through cyclical feedback to subsequent efforts to learn. We now discuss self-efficacy beliefs.

DISTINCTIVE PROPERTIES OF SELF-EFFICACY BELIEFS

Self-efficacy measures can be distinguished from other self-belief measures on the basis of five criteria (Table 17.1). The first criterion involves the type of self-belief being assessed. Self-efficacy beliefs involve cognitive judgments of personal capability to perform specific tasks or activities, such as "I am confident that I can write essays in English." Self-efficacy measures contrast with other self-belief measures that include affective feelings of self-worth and generalized judgments of personal adequacy and competence (Pajares, 1996). A second criterion is type of self-evaluative standard. Self-efficacy measures are based on a goal-mastery standard, such as "How sure are you that you can convert a temperature reading from Centigrade to Fahrenheit in science?" Other self-belief measures are frequently interpreted on the basis of social/normative standards, such as comparisons of one's competencies to those of others (Pelham, 1995).

The third criterion concerns the temporal focus of self-judgments. Self-efficacy measures involve predicting future generative

TABLE 17.1. Comparison of Self-Efficacy Beliefs and Other Self-Beliefs

	Types of self-belief	
Comparison criteria	Self-efficacy beliefs	Other self-beliefs
Type of self-judgment	Cognitive judgments of capability	Feelings of competence, adequacy, and affect
Type of self-evaluative standard	Confidence in goal mastery	Social/normative comparisons
Temporal focus of self-judgments	Predicted generative capability	Attained competence
Relation to task outcomes	Context-dependent	Domain-dependent
Reactions to experience	Adaptively malleable	Trait-like resistance

performances, such as "I rate my confidence to learn English grammar at 80%" (Bandura, 2006, p. 326). To achieve this predictive function, Bandura (1977) cautioned researchers that self-efficacy measures should be administered prior to the performances of interest. Other self-belief measures focus instead on prior attainment of competence, such as "I am good in mathematics."

The fourth criterion deals with the relation of a self-measure to task performance outcomes. Self-efficacy measures are designed to be adaptive to specific task features and environmental contexts. Because of their emphasis on goal setting, self-efficacy measures can be assessed at varying levels of specificity depending on researchers' predictive or explanatory goals (Bandura, 2006). For example, students' academic goals in mathematics may range in specificity from a problem level to a course level. Although other self-belief measures have been designed to predict one's performance in specific domains such as academic subjects, they have not been designed to be sensitive to contextual issues.

The fifth criterion involves a student's reactions to experience, for example, to instructional training or challenging task conditions. Given that self-efficacy beliefs are designed to be malleable to experience, they contrast with self-measures that attempt to capture trait-like individual differences resistant to change from experience (Bong, 2006). Because of their sensitivity, self-efficacy beliefs can be assessed over time and provide evidence of growth. For example, changes in self-efficacy ratings in a course can be compared with students' subsequent performance in the course. "This modifiability of self-efficacy judgments vividly contrasts with the frustration educators often experience when they strive to augment students' generalized self-perceptions" (Bong, 2006, p. 301). We next consider the issue of how to assess self-efficacy beliefs.

ASSESSING SELF-EFFICACY BELIEFS

Bandura (2006) cautioned that there is not an all-purpose measure of perceived efficacy Instead, self-efficacy scales should be tailored to the particular realm of interest. Like other self-belief measures, self-efficacy typically is assessed using rating scales. Bandura emphasized that self-efficacy is assessed optimally when a percentage response format is employed to reveal the strength of the belief. Self-efficacy beliefs can be measured most accurately when their level, strength, and generality are considered.

The early self-efficacy studies were conducted in clinical settings using self-report instruments to assess self-efficacy. For example, Bandura, Adams, and Beyer (1977) gave adults with snake phobias self-efficacy and behavioral tests whose items consisted of progressively more threatening encounters with a snake (e.g., touch it, allow it to sit in one's lap). For the self-efficacy assessment, participants initially rated the magnitude or level of self-efficacy by designating which tasks they believed they could perform.

They then rated the strength of self-efficacy by judging how sure they were that they could perform the tasks they had judged they could perform. To measure generality of self-efficacy, participants made magnitude/level and strength ratings for the same tasks but with a type of snake different from the type used on the pretest.

This methodology has been labeled "microanalytic": Self-efficacy and skill are assessed at the level of specific tasks (DiBenedetto & Zimmerman, 2013). The microanalysis involves asking participants fine-grained questions within a specific context. In the Bandura and colleagues (1977) study, participants judged whether they could perform specific tasks involving a snake, then were asked to perform those tasks. Although researchers often sum and average ratings and performance outcomes across tasks, participants were not asked for a general rating of how well they felt they could deal with snakes.

A similar methodology was used in the early educational research studies. The first application of self-efficacy theory to an educational learning setting was conducted by Schunk (1981). Children with low long-division skills judged self-efficacy, then completed an achievement test. For the self-efficacy assessment, children were shown pairs of problems; for each pair, the two problems were comparable in form and difficulty. Children judged how certain they were that they could solve problems of that type. Achievement test problems corresponded to those on the self-efficacy test in form and difficulty.

The microanalytic methodology has been used to assess self-efficacy in clinical settings (Schunk & DiBenedetto, 2014) and with athletic tasks such as basketball shooting and dart throwing (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). The first study to use microanalysis to comprehensively assess the processes of the phases of self-regulated learning (discussed later) using an academic task was conducted with high school students studying science and involved comparing low, moderate, and high achievers (DiBenedetto & Zimmerman, 2010). Students were given a passage on tornados to read, study, and be tested on while being asked microanalytic questions. For example, students were asked questions about their self-efficacy for learning (e.g., "How self-confident do you feel in your capability to completely learn and remember all of the material in this passage?") and self-efficacy for performance (e.g., "How self-confident do you feel in your capability to earn 100% on the tornado knowledge test?").

The microanalytic methodology captured the cognitive, affective, and behavioral processes in which students engaged during a real-time learning task. Trend analyses revealed positive linear relations between students' levels of achievement and self-regulation, amount of time spent studying, and science performance. The size of each of these linear effects was large, suggesting that high-achieving students in science use more self-regulated learning processes in each self-regulated learning phase than did students who are average or at-risk. This microanalytic methodology has been shown to have construct and predictive validity when compared to previously established measures (DiBenedetto & Zimmerman, 2013).

Because self-efficacy beliefs are cast in context-specific performance terms, their relation to performance outcomes can be established empirically. For example, a *correlation* between a self-efficacy item regarding solving a mathematical problem and subsequent performance on a conceptually identical problem is an index of validity. Conversely, a *difference* between a self-efficacy rating and subsequent performance is a measure of one's accuracy in self-monitoring. Over- or underpredictions of self-efficacy can be expected to affect learning adversely. This hypothesis has led to the emergence of a body of research called *calibration* (Bol & Hacker, 2001; Hacker & Bol, 2004; Ramdass & Zimmerman, 2008; Zimmerman et al., 2011). Calibration studies are described later in this chapter, along with their pedagogical impact. When self-rating items are cast in goal-related performance terms, such as self-efficacy and self-evaluation items, it is easier to study their linkage to self-regulatory processes such as self-monitoring.

SOURCES AND EFFECTS OF SELF-EFFICACY BELIEFS

Self-efficacy beliefs do not simply originate from nowhere. There are various sources of influence that individuals use to assess their self-efficacy in any particular situation. As originally hypothesized by Bandura (1977), self-efficacy can have diverse effects in achievement contexts. We discuss in this section discusses the sources and effects of self-efficacy beliefs.

Sources of Self-Efficacy Beliefs

Bandura (1997) postulated that learners acquire information to judge self-efficacy from four sources: actual performances, vicarious (e.g., modeled) experiences, forms of social persuasion, and physiological indices. Researchers have substantiated the importance of these four sources (Joët, Usher, & Bressoux, 2011; Usher, 2009).

The most reliable influence on self-efficacy comes from how students interpret their performances because these performances are tangible indicators of their capabilities. Performances interpreted as successful should raise self-efficacy, and those deemed as failures should lower it, although an occasional failure (success) after many successes (failures) may not have much impact on self-efficacy. Successful performances can influence achievement by enhancing motivation and continued learning (Schunk & DiBenedetto, 2014).

Students acquire information about their capabilities vicariously through knowledge of how others perform (Bandura, 1997). Similarity to others is a cue for gauging self-efficacy (Schunk, 2012). Observing similar others succeed can raise observers' self-efficacy and motivate them to try the task when they believe that if others can perform the task, then they can as well. A vicarious increase in self-efficacy, however, can be negated by subsequent performance failure because performances give the clearest information about capabilities.

Students also can develop self-efficacy beliefs as a result of social persuasions they receive from others (Bandura, 1997), for example, when a teacher tells a student, "I know you can do it." Social persuasions must be believable, and persuaders must be credible for persuasions to develop students' beliefs that success is attainable. Positive feedback can raise learners' self-efficacy, but the increase will not persist if they subsequently perform poorly (Schunk, 2012).

Students gain some self-efficacy information from physiological and emotional indicators such as anxiety and stress (Bandura, 1997). Strong emotional reactions to a task provide cues about an anticipated success or failure. When learners experience negative thoughts and fears about their capabilities (e.g., feeling nervous about speaking in front of a large group), those reactions can lower self-efficacy and trigger additional stress and agitation that can produce inadequate performances.

Information gained from these sources does not automatically affect self-efficacy because students interpret the results of events. Attribution theory predicts that people form *attributions* (perceived causes) for outcomes (Graham & Williams, 2009); for example, "They did well on a test because they studied hard." These interpretations are used to make self-efficacy judgments (Pajares, 1996). Thus, students who attribute a low test score to their feeling sick on the day of the test may hold higher self-efficacy for performing well in the course than students who attribute a low test score to their low ability to learn the content.

Effects of Self-Efficacy Beliefs

Self-efficacy can have multiple effects in educational contexts (Bandura, 1986, 1997). Self-efficacy can influence the choices students make (Patall, 2012) and the goals they set (Zimmerman, Schunk, & DiBenedetto, 2015). Self-efficacious learners are likely to set high goals and strategically plan ways to attain them. They also are likely to select tasks and activities in which they feel self-efficacious and to avoid those in which they do not. Unless they believe that their actions will produce the desired consequences, they have little incentive to engage in those actions. Self-efficacy also helps determine how much effort learners expend on an activity, how long they persevere when confronting obstacles, and how resilient they are in the face of difficulties (Joët et al., 2011;

Moos & Azevedo, 2009). In turn, higher self-efficacy affects students' motivation and predicts achievement outcomes (Fast et al., 2010; Zimmerman et al., 2015).

Self-efficacy beliefs can influence students' capability to manage their *emotions* by decreasing their stress, anxiety, and depression (Bandura, 1997). Pajares and Kranzler (1995) found a complex relation between self-efficacy and students' anxiety reactions regarding mathematics. Although the two measures were negatively correlated, only self-efficacy predicted mathematics performance using path analysis. There is also evidence that students' performance in academically threatening situations depends more on self-efficacy beliefs than on anxiety arousal. Siegel, Galassi, and Ware (1985) found that self-efficacy beliefs are more predictive of mathematics performance than is anxiety. The predictive power of self-efficacy beliefs was substantial, accounting for more than 13% of the variance in final mathematics grades. By contrast, anxiety proved to be a weak predictor of achievement. Together these results provide strong evidence of the discriminant and predictive validity of self-efficacy and imply that fostering a positive sense of personal efficacy is desirable.

Despite its importance, self-efficacy is not the only influence on behavior (Bandura, 1997). High self-efficacy will not yield a competent performance when students lack the needed skills to succeed (Schunk, 2012). Students' *values* (perceptions of importance and utility of learning) also can affect behavior (Wigfield, Cambria, & Eccles, 2012). Students who feel self-efficacious for learning mathematics are unlikely to take mathematics courses that they do not value because they believe these courses are not germane to their goal of becoming a writer. *Outcome expectations,* or beliefs about the anticipated outcomes of actions (Bandura, 1997), also are important. Students typically engage in activities that they believe will result in positive outcomes and avoid actions that they believe may lead to negative outcomes. Students who feel highly efficacious about learning the content in a course may not work diligently if they believe that no matter how well they do, they will not receive a high grade. In summary, assuming requisite skills and positive values and outcome expectations, self-efficacy is a key influence on students' motivation, learning, self-regulation, and achievement (Schunk, 2012).

TRAINING SELF-REGULATORY PROCESSES AND SELF-EFFICACY BELIEFS

According to this cyclical perspective on self-regulation, students' self-efficacy beliefs can influence and be influenced by their use of self-regulatory processes during self-directed learning and performance. To verify the role of these processes empirically, Schunk and his colleagues conducted a series of intervention studies that involved prompting or training students to employ self-regulatory processes to enhance their academic learning and performance, and engender positive self-efficacy beliefs regarding future learning.

In an investigation of the effects of *goal setting* during the forethought phase on the acquisition of mathematical division skills, Schunk (1983b) asked students to set either a difficult goal of completing a challenging number of problems or an easier goal of completing fewer problems. To motivate the students to attempt to attain their goals, half of the students in the two goal-difficulty conditions were directly informed that they could work the designated number of problems. The other half of the students were told that similar students had been able to work the designated number of problems. Students who set difficult goals and received direct attainment information showed the highest self-efficacy and achievement. Schunk also found that direct attainment information led to higher perceptions of self-efficacy than socially comparative attainment information. Students who set more ambitious forethought phase goals and were given direct information showed higher levels of self-efficacy and division skill.

In a forethought phase intervention designed to enhance students' *valuing of a reading comprehension strategy,* Schunk and Rice (1987, Experiment 1) taught fourth- and fifth-grade remedial readers a multistep strategy for identifying main ideas in a textual passage. Some of these students were told specifically that this strategy helps children like them answer questions about main ideas. Students in a second group were told that the strategy could be used generally to answer questions about passages they read. Students in a third group were not given strategy-value information. Both the specific- and the general-value information enhanced students' self-efficacy beliefs and reading comprehension better than no-strategy value information. These results suggest that, in addition to strategy training, remedial readers need information that emphasizes the self-regulatory value of a strategy for locating main ideas.

In a second experiment, Schunk and Rice (1987) presented feedback about the effectiveness of the students' strategic performance after learners' attempted to employ the main ideas strategy. This performance phase intervention of strategic value differs from the forethought phase intervention in the first study. In the former methodology, strategy information was given before attempts to learn, whereas in the latter methodology, strategy information was given while performing. However, both self-regulatory interventions proved effective in enhancing students' self-efficacy beliefs, as well as reading comprehension.

In another performance-phase intervention study, Schunk and Rice (1993) taught students to identify main ideas during reading comprehension through *self-instruction*. These researchers investigated self-instruction training and fading with fifth-grade students with low reading skills. The instructor trained them to use a multistep comprehension strategy, teaching some students to fade their overt verbalizations to inner speech as they practiced. In addition to variations in fading, some students received feedback that linked strategy use with improved performance. The results revealed that students who faded their verbalizations and received feedback regarding their strategic success displayed higher levels of self-efficacy. Fading of verbalizations plus feedback led to higher reported strategy use and reading comprehension skill. Self-instruction during one's performance can enhance students' self-efficacy beliefs and comprehension skill.

Another self-regulatory process that has been studied in conjunction with self-efficacy is *self-evaluation*. Unlike self-efficacy, self-evaluations are collected after performance during the self-reflection phase. Reactive students do not self-evaluate their competencies spontaneously, but they can be taught to evaluate their performance more effectively.

For example, in research conducted by Schunk (1996), fourth graders were given instruction and practiced solving mathematical fraction problems. Students were asked to set either a learning goal (e.g., learn to use a strategy to solve problems) or a performance goal (e.g., solve problems). In each goal condition, half of the students evaluated their problem-solving capabilities at the end of each of six daily sessions. Students who set a learning goal, with or without self-evaluating, or who set a performance goal with self-evaluating surpassed classmates who set a performance goal without self-evaluating in skill, self-efficacy, and motivation.

Because self-evaluation was so effective, it obscured the goal-setting results. To surmount this problem, Schunk (1996) conducted a second study, in which self-evaluations were more subtle and less frequent. The students in each goal condition evaluated their progress in skill acquisition. Students who set a learning goal displayed higher motivation and achievement than did students who set a performance goal. These studies show that systematic efforts to self-evaluate can enhance perceptions of self-efficacy and the attainment of mathematical skill.

The effects of goal-setting and self-evaluating were investigated also with college students as they learned computer skills during three study sessions (Schunk & Ertmer, 1999). Students were instructed to set a learning goal and evaluate their learning progress. After the second session, students who set learning goals reported higher self-efficacy, self-judged learning progress, self-regulatory competence, and strategy use than students who set performance goals. Students' self-evaluations enhanced their self-efficacy beliefs. In a second study, self-evaluation was extended to all three sessions. Frequent self-evaluations produced comparable results for both learning and performance goals. Self-evaluating is a powerful self-regulatory process that works in conjunction with goal setting to enhance skill attainment and self-efficacy.

The impact of a self-reflection phase intervention involving ability and effort *attributional feedback* on students' self-efficacy beliefs and achievement was studied by Schunk (1983a). Third-grade children with low subtraction skills were taught subtraction operations and solved problems, after which they were informed either that they were working hard (effort attribution) or that they were good at subtraction (ability attribution). Children receiving ability attributional feedback displayed higher self-efficacy and subtraction skill than children given effort feedback. The latter children showed greater self-efficacy and subtraction attainment than students in a no-feedback control group. It should be noted that the teachers' gave feedback statements contingent on children's successful problem solving. For attributional feedback to be effective it must be credible. Attributing children's erroneous answers to high ability or effort will not enhance students' self-efficacy or achievement.

In research bearing on the self-reflection phase, Schunk (1982) provided effort attributional feedback to elementary school students who lacked subtraction skills. While these students worked on a booklet of subtraction problems, a proctor periodically asked each student what page he or she was working on and provided attributional feedback by commenting that the student had been working hard. Effort attributional feedback for achievement led to faster mastery of subtraction operations, greater subtraction skill, and higher perceptions of self-efficacy. Regression analyses also revealed that students' self-efficacy beliefs and training progress each produced a significant increase in variance in posttest subtraction skill. These results imply that students' self-efficacy was affected by self-reflection phase attributions to effort.

In addition to these limited-phase intervention studies, a growing number of multiphase intervention studies have been conducted on the role of self-efficacy and related beliefs during cyclical efforts to learn. These studies constitute a more complete test of the cyclical model of self-regulation. For example, Zimmerman and Kitsantas (1999) studied writing revision with high school girls. The task required the writer to revise highly redundant passages, and these revisions could be objectively scored for missing information and redundancies. Initially, all participants were taught a three-step revision strategy for identifying key information, eliminating redundant words, and combining the remaining words into sentences. After training was completed, a practice session was held. Participants in the learning-process goal group focused on the strategic steps for revising each writing task, whereas those in the performance-outcome group concentrated on minimizing the number of words in their revised passages. Participants in a shifting goal group initially pursued learning-process goals, then were shifted to performance-outcome goals after automaticity occurred. Half of the members in each goal group self-recorded their learning processes or performance outcomes. Girls in the process group self-recorded missing elements of the writing revision strategy; members of the outcome group self-recorded the number of words in the revision.

The results showed that girls who shifted goals from learning processes to performance outcomes after reaching automaticity surpassed the writing revision skill of girls who adhered to learning process goals. Girls who focused on outcomes displayed lower writing revision skill than girls in the shifting or process goal groups, and self-recording enhanced writing revision skill for all goal-setting groups. In addition to their acquisition of superior writing revision skill, girls who shifted goals displayed advantageous forms of self-motivation, such as greater attributions to strategy use (i.e., controllable causes), enhanced self-satisfaction, more optimistic self-efficacy beliefs, and greater task interest. Forethought phase goal setting and performance phase self-recording significantly enhanced not only writing skill but also self-reflection phase strategy attributions and self-satisfaction reactions. Goal setting influenced two forethought motivational beliefs regarding subsequent cycles of learning: self-efficacy and intrinsic interest. These findings show that self-efficacy plays an important role in predicting participants' cyclical use of important self-regulated learning processes.

In another intervention study of the role of self-efficacy and related beliefs during cyclical efforts to learn, similar self-regulation results were found with an athletic task (Zimmerman & Kitsantas, 1997). In a study of dart throwing, high school girls were taught a multistep strategy involving gripping the dart, taking the proper stance, sighting, throwing, and following through. The target involved seven concentric circles, which were assigned increasing numbers depending on their proximity to the bull's-eye. As in the prior study, the intervention involved goal setting and self-recording. Goal setting involved process goals, outcome goals, or shifting goals. The latter goal-setting group shifted from learning process goals to performance outcome goals after attaining automaticity. Self-recording for the process group involved tracking missing elements of the strategy, whereas self-recording for the outcome group involved tracking the dart-throwing points that were earned.

Participants who shifted goals from learning processes to performance outcomes surpassed the dart-throwing skill of participants who adhered to learning process goals. Participants who focused on outcomes displayed lower dart-throwing skill than the shifting or process goal groups, and self-recording enhanced acquisition for all goal groups. In addition to their acquisition of superior dart-throwing skill, girls who shifted goals displayed greater attributions to controllable causes (i.e., strategy use), enhanced self-satisfaction, more optimistic self-efficacy beliefs, and greater task interest. In short, forethought phase goal-setting and performance phase self-recording significantly affected not only dart-throwing skill but also self-reflection phase attributions and self-satisfaction reactions. Goal setting also influenced two forethought motivational beliefs regarding subsequent cycles of learning: self-efficacy and intrinsic interest. These athletic skill findings replicate those involving an academic skill, and they suggest that self-efficacy plays an important role in predicting participants' cyclical use of important self-regulated learning processes.

This experimental evidence of the differential effectiveness of learning processes and performance outcomes with both academic tasks (Zimmerman & Kitsantas, 1999) and athletic tasks (Zimmerman & Kitsantas, 1997) has led to the question of whether this differential effectiveness is evident with other self-regulation scales as well. More specifically, first, do scales that focus on learning processes form a separate composite from scales that focus on performance issues? Second, does the learning composite predict the students' academic achievement better than a performance composite factor?

In research designed to address these questions (Zimmerman & Kitsantas, 2014), performance scales focused on avoiding coping problems, such as hyperactivity, delay of gratification, and anxiety, whereas learning scales focused on developing sources of agency, such as self-efficacy, strategy use, and goal orientations. The reliability of the learning composite (r = .91) and performance composite (r = .87) were both very high, and the correlation between the composites was moderate in size (r = .54). These results indicate that formation of the two composites was supported empirically and that the composites were distinctive but moderately related. Hierarchical regression analyses revealed that the composite of learning scales was more predictive of the students' grade point average and performance on a statewide achievement test than the composite of performance scales. Thus, the scope of the learning and performance effects in self-regulation research appears to be wide.

IMPROVING SELF-EFFICACY CALIBRATION

Although self-efficacy is widely viewed as a motivator of learning, we have discussed its close linkage to self-regulatory processes such as goal setting, strategic feedback, and attributions. An additional issue to consider is the relation between self-efficacy and metacognitive monitoring. A compelling anecdotal example of this relation is described by Artur Rubinstein, a pianist of renown during the 20th century. He attributed his artistry and self-confidence to his close daily monitoring of his practice. "When I don't practice for a day, I know. When I don't practice for two days, the orchestra knows. When I don't practice for three days, the world knows" (Rubinstein, 2008, para. 1). The consequences of an inaccurate appraisal of his preparation for a concert were a constant concern to Rubinstein.

Metacognitive (i.e., self-) monitoring is a subtle phenomenon. A recently developed measure of this self-regulatory process shows promise. *Calibration* is a measure of the accuracy of metacognitive monitoring in terms of the congruence between one's perceptions of competence about performing a particular task and one's actual performance. Social-cognitive researchers have studied students' calibration by using measures of self-efficacy. These researchers generally have reported positive correlations between the strength of students' self-efficacy beliefs and their motivation and performance (Schunk & Pajares, 2004).

The calibration of self-efficacy perceptions can be measured when task-specific measures of self-efficacy and performance are employed, such as a student's confidence about an answer to a statistics problem. Students often overestimate their efficacy judgments (Klassen, 2002; Pajares & Miller, 1994), but underestimates also occur. The danger of overestimates is that they can lead to insufficient efforts to learn (Ghatala, Levin, Foorman, & Pressley, 1989). When people monitor more accurately, their high-quality covert feedback enables them to learn more effectively (Schunk & Pajares, 2004). DiBenedetto and Bembenutty (2013) found that among college students in biology self-efficacy at the beginning of the semester was higher than at the end, but course grades were better calibrated with end-of-semester self-efficacy, suggesting that students initially may have held unrealistic efficacy beliefs.

It is not unusual to find students who make inaccurate self-evaluations, although students who self-evaluate frequently attain higher academic outcomes than those who self-evaluate infrequently (Chen, 2003; Kitsantas, Reiser, & Doster, 2004; Schunk, 1996). It is notable, however, that low-achieving students are less accurate and more overconfident than high-achieving students who are slightly underconfident (Bol & Hacker, 2001; Kruger & Dunning, 1999). Unfortunately, interventions designed to improve students' self-evaluative accuracy have not always been successful (Bol & Hacker, 2001; Hacker & Bol, 2004). The inability of overconfident students to improve the accuracy of their self-evaluations may be a self-regulation issue. Overconfident students are more prone to select difficult problems to solve and are more likely to fail. This error in forethought can undermine their subsequent self-efficacy to continue learning (Bandura, 1986; Schunk & Pajares, 2004).

Recent research indicates that students ranging from elementary to college levels can learn to monitor their performances more accurately and acquire greater academic skills. In a social-cognitive intervention designed to enhance elementary school students' calibration of their self-efficacy perceptions, Ramdass and Zimmerman (2008) taught a metacognitive self-monitoring strategy to fifth- and sixth-grade students learning mathematical division problems. An instructor showed all students a step-by-step problem solution. Students in the experimental group were given a strategy for self-checking their answers by multiplying the quotient by the divisor, whereas students in the control group were not. Students then practiced using a checklist to guide self-correction.

After correcting for pretest differences in division skill, the self-correction group displayed significantly higher division skill, self-efficacy, and self-evaluation than the control group. In terms of calibration, self-correction students displayed significantly greater accuracy in their self-efficacy and self-evaluation judgments, and significantly less bias (i.e., overestimation) than the control group. As expected, self-efficacy and self-evaluation beliefs correlated positively with students' mathematical performances. Self-efficacy accuracy and self-evaluation accuracy also correlated positively with performance, whereas self-efficacy bias and self-evaluation bias correlated negatively with performance. The negative direction of the bias measures indicates that quality of students' performances decreased as they became more overconfident (Chen, 2003).

These results indicate that teaching strategic planning enhanced not only forethought phase self-efficacy beliefs but also calibration of self-monitoring processes and mathematical performances. An educational

SRL Math Revision Sheet, Quiz #____ Item # ____ Student: ____________________ Date: _______

Instructor: ________________________

Now that you have received your corrected quiz, you have the opportunity to improve your score. Complete all sections thoroughly and thoughtfully. Use a separate revision sheet for each new problem.

PLAN IT [ ] 8pts

1 a. How much time did you spend studying for this topic area? _______
  b. How many practice problems did you do in this topic area ______________________________in preparation for this quiz?
  (circle one) 0 – 5 / 5 – 10 / 10+
  c. What did you do to prepare for this quiz? (use study strategy list to answer this question)

2. After you solved this problem, was your confidence rating too high (i.e. 4 or 5)? yes no

3. Explain what strategies or processes went wrong on the quiz problem.

PRACTICE IT [ ] 8pts

4. Now re-do the original quiz problem and write the strategy you are using on the right.

	Definitely not confident	Not confident	Undecided	Confident	Very confident
5. How confident are you now that you can correctly solve this similar item?	1	2	3	4	5

6. Now use the strategy to solve the alternative problem. [ ] 4pts

7. How confident are you now that you can correctly solve a similar problem on a quiz or test in the future? 1 2 3 4 5

FIGURE 17.2. SRL math revision sheets (i.e., self-reflection form). From Zimmerman, Moylan, Hudesman, White, and Flugman (2011, p. 127). Reprinted with permission from Pabst Publishers.

implication of these findings is that there is a need to monitor the calibration of middle school students because overestimates of personal skill can impair their learning. Fortunately, this study revealed that a self-correction strategy can be learned.

Calibration problems also have emerged with self-efficacy and self-evaluation judgments of older students. DiBenedetto and Zimmerman (2010) examined calibration among high school juniors' judgments of self-efficacy for learning and for performance. For both measures, low achievers overestimated their competence in science. High achievers showed a slight overestimation and average achievers, a moderate amount. Overestimation can occur when learners do not fully understand the task (Schunk & DiBenedetto, 2015), which may explain why the low achievers showed the poorest calibration. There is other evidence that overestimates of competence are less likely to occur when people have more relevant knowledge and expertise (Kruger & Dunning, 1999).

In a study of the effects of self-reflection training (Zimmerman et al., 2011), at-risk technical college students were taught to interpret their academic grades as self-reflective feedback rather than as signs of personal limitation. This is a challenging population of students because a majority of community college students are unprepared to engage in college-level coursework, and the dropout rate is high (Stinebrickner & Stinebrickner, 2012).

These students are often given developmental education courses to remediate their deficient skills, but there is extensive evidence that these courses do not prepare them to succeed in college-level courses (Bailey, 2009). Clearly, the problem is widespread, and alternative forms of instruction are needed. Students in developmental (remedial) mathematics or introductory college-level mathematics courses were randomly assigned to an intervention or a control classroom of their respective courses. In intervention classrooms, teachers used modeling techniques and assessment practices to enhance self-reflection processes. Frequent opportunities were given to students in intervention classrooms to improve their achievement through use of a self-reflective feedback form designed to self-regulate their learning and problem solving.

Self-reflective feedback was given during every second or third class session. A quiz composed of four or five problems provided frequent feedback to students and teachers. The quiz forms required students to make task-specific self-efficacy judgments before solving individual problems and self-evaluative judgments after attempting to solve each problem. After the quizzes were graded by the instructor, students in the intervention group were encouraged to correct their errors by completing the self-reflection forms and receiving quiz grade incentives.

The self-reflection form required students to compare their self-efficacy and self-evaluative judgments with their answers to the quiz item, explain ineffective strategies, create a more effective strategy, and rate their confidence for solving a new problem (see Figure 17.2). When the students' answers to the problem were incorrect and they were unaware of the reason, they were encouraged to seek help from other students or the instructor. At the outset of the course, the instructors demonstrated how the self-reflection forms should be completed, then allowed students to practice. Students were shown the formula for calculating bias in their self-efficacy and self-evaluation ratings of their solutions on the self-reflection forms.

The results revealed that students in self-regulation classes outperformed those in control classes on three periodic tests and a final course examination. Although there was substantial evidence of overconfidence by these at-risk students, students in self-regulation classes were better calibrated in their self-efficacy beliefs and their self-evaluative judgments than students in control classes. Significant relations among self-regulated learning processes were found. Students' self-efficacy and self-evaluation judgments regarding their performance on periodic tests were positively correlated with their achievement on the tests. Students' self-efficacy for the third and final exams, their standards for self-satisfaction, and their self-reported learning strategy use were positively correlated with final exam scores.

Teachers in self-regulated learning classes observed that students varied considerably in their use of the self-reflection form. For students in the developmental (i.e., remedial) course, high self-reflection form users (i.e., high self-reflectors) displayed significantly greater achievement on the second and third periodic tests, as well as on the final exam. High self-reflectors did not surpass low self-reflectors significantly on the first periodic test. For students in the introductory course, the high self-reflectors significantly surpassed low self-reflectors on all three periodic tests and on the final exam. It appears that students with greater background in mathematics were better able to profit from self-regulatory training on the first exam.

Because students in these classes were not admitted to this technical college as regular-status students, they were classified as at risk (or as developmental according to Bailey's [2009] criteria). To gain entrance into credit-bearing courses and make progress toward obtaining a degree, developmental students must pass a collegewide entrance test. It was discovered that 25% more of these students in the self-regulation classes passed the entrance test than students in control classes, a difference that was statistically significant. Thus, as a result of their self-regulatory training, a significantly greater percentage of these students were no longer academically at risk. These findings of success on the entrance test represent successful passage through a major gateway in the academic lives of these at-risk students. New opportunities had become available for them to take advanced courses and pursue majors that involved mathematical competence (Zimmerman et al., 2011). These life-changing results were obtained with a brief self-reflection form that could be introduced readily into the curriculum of regular classes.

FUTURE DIRECTIONS FOR RESEARCH ON SELF-REGULATED LEARNING

The purpose of a cyclical model of self-regulation is to describe the underlying processes and beliefs in order to measure sequential changes before, during, and after repeated efforts to learn. The model seeks not only to explain existing research findings but also to guide the development of new measures. These measures, termed *microanalytic,* are intended to provide a dynamic account of a student's self-regulatory strengths and limitations, and there is evidence that microanalytic measures predict academic outcomes better than a well-validated teacher rating scale of their students' self-regulation in class (DiBenedetto & Zimmerman, 2013). Furthermore, the feedback produced by microanalysis was preferred by teachers more than feedback produced by traditional measures regarding students' appraisals (Cleary & Zimmerman, 2006). The cyclical model was also designed to provide a platform for individualized interventions that can target specific self-regulatory dysfunctions, such as overly optimistic self-efficacy beliefs, weak planning or forethought skills, and ineffective use of strategies. The Self-Regulation Empowerment Program (SREP) is an example of such an intervention grounded in the cyclical model. Broadly speaking, the SREP is an applied, academic intervention program designed to induce change in students' motivation, strategic skills, and metacognitive skills (Cleary & Zimmerman, 2004). It adheres to a semistructured instructional protocol format whereby SREP coaches use various modules and instructional guides but are afforded flexibility to adapt instruction to meet individual student needs.

The SREP has been studied with ethnically diverse and academically at-risk groups of adolescents attending urban middle school or high schools (Cleary & Platten, 2013; Cleary, Platten, & Nelson, 2008; Cleary, Velardi, & Schnaidman, 2016). These initial mixed-method case studies focused on small groups of high school students in the area of biology (Cleary & Platten, 2013; Cleary et al., 2008). Recommended by their teachers for failing or nearly failing biological science test grades and because of motivational or self-regulatory difficulties, students in these two projects received approximately 20 SREP sessions to help them learn to self-regulate their thoughts and actions as they prepared for biology tests. In addition to being exposed to foundational knowledge in self-regulated learning (SRL) processes, students received extensive instruction in SRL strategies, as well as frequent opportunities to practice using these strategies to learn course content or to manage their behaviors. The SREP coaches also guided students through self-reflection activities that enabled them to evaluate and refine use of these strategies to strive for their test grade goal. For example, following each test performance, the SREP coach asked each student, "What is the primary reason you got this score on this test?" and "What do you need to do to improve your next test score?" Asking microanalytic questions cyclically during the intervention provided self-regulation tutors or coaches with information that they could use to guide and modify the intervention. To measure changes in student motivation and self-regulation, pretest–posttest case studies were conducted involving multiple measures, such as self-report scales, teacher rating scales, microanalytic protocols, and field notes observations.

This methodology provided converging evidence regarding appropriateness of inferences regarding cyclical processes and beliefs. In these initial studies, all participants showed gains in their exam scores above the average *z*-score gains for their biology class during the study. One month after the SREP training was completed, seven out of nine participants exceeded the class mean score on the exam, and two of the students earned exam scores of 93 and 95%. In terms of evaluating changes in self-regulatory behaviors and cognitions using reliability change index scores, there was also some evidence for significant growth from pretest to posttest.

More recently, Cleary and colleagues (2016) conducted a field-based experiment to examine the effectiveness of SREP for improving the strategic thinking, motivation, and mathematics achievement of seventh-grade students in a middle school. There were two groups in this study, each with 22 students: SREP and an existing mathematics remediation program provided by the middle school. Although the authors used the SREP modules and procedures emphasized in the prior studies, they placed particular emphasis on engaging students in two types of feedback loops: (1) a weekly feedback loop that centered on students' learning and refining their use of strategies, and (2) a unit test feedback loop that focused more broadly on students' performance on the unit mathematics exams. Using a pretest–posttest control group design, the authors found statistically significant and medium-to-large effects of SREP in terms of the quality of students' attributions, adaptive inferences, and test preparation strategies at posttest. These effects were maintained at 2-month follow-up, except for the test preparation strategies. In terms of *z*-score mathematics achievement, the SREP condition, but not the alternative intervention condition, displayed a significant linear trend from pretest to 8-month follow-up, with *z*-scores improving from a value of –0.53 at pretest to 1.70 at 8-month follow-up. Finally, consistent with both Cleary and Platten (2013) and Cleary and colleagues (2008), the authors found strong evidence supporting the social validity of SREP; that is, both students and SREP coaches reported that the program was highly acceptable and useful in impacting important aspects of students' performance and behavior in school.

These initial efforts to validate the SREP in terms of students' academic achievement are encouraging. The greater challenge, however, is to establish the effectiveness of the intervention in teaching students to think and act in a cyclical self-regulated way as they learn biological science. By examining changes in individual students using single-subject and case study designs, SREP tutors can provide their students with a dynamic understanding of the how and why their self-regulatory processes can enhance their achievement.

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