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Feedback and Self-Regulated Learning: A Theoretical Synthesis

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Self-regulated learning (SRL) is a pivot upon which students' achievement turns. We explain how feedback is inherent in and a prime determiner of processes that constitute SRL, and review areas of research that elaborate contemporary models of how feedback functions in learning. Specifically, we begin by synthesizing a model of self-regulation based on contemporary educational and psychological literatures. Then we use that model as a structure for analyzing the cognitive processes involved in self-regulation, and for interpreting and integrating findings from disparate research traditions. We propose an elaborated model of SRL that can embrace these research findings and that spotlights the cognitive operation of monitoring as the hub of self-regulated cognitive engagement. The model is then used to reexamine (a) recent research on how feedback affects cognitive engagement with tasks and (b) the relation among forms of engagement and achievement. We conclude with a proposal that research on feedback and research on self-regulated learning should be tightly coupled, and that the facets of our model should be explicitly addressed in future research in both areas.

Theoreticians seem unanimous—the most effective learners are self-regulating. In academic contexts, self-regulation is a style of engaging with tasks in which students exercise a suite of powerful skills: setting goals for upgrading knowledge; deliberating about strategies to select those that balance progress toward goals against unwanted costs; and, as steps are taken and the task evolves, monitoring the accumulating effects of their engagement. As these events unfold seriatim, obstacles may be encountered. It may become necessary for self-regulating learners to adjust or even abandon initial goals, to manage motivation, and to adapt and occasionally invent tactics for making progress. Self-regulated students are thus aware of qualities of their own knowledge, beliefs, motivation, and cognitive processing—elements that jointly create situated updates of the tasks on which the students work. This awareness provides grounds on which the students judge how well unfolding cognitive engagement matches the standards they set for successful learning (Corno, 1993; Howard-Rose & Winne, 1993; Winne, in

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press; Zimmerman, 1990). In short, self-regulated learning (SRL) is a deliberate, judgmental, adaptive process.

For all self-regulated activities, feedback is an inherent catalyst. As learners monitor their engagement with tasks, internal feedback is generated by the monitoring process. That feedback describes the nature of outcomes and the qualities of the cognitive processing that led to those states. We hypothesize that more effective learners develop idiosyncratic cognitive routines for creating internal feedback while they are engaged with academic tasks. For example, by setting a plan for engaging in a task, a learner generates criteria against which successive states of engagement can be monitored. In some cases, when a discrepancy exists between current and desired performance, self-regulated learners seek feedback from external sources such as peers' contributions in collaborative groups, teachers' remarks on work done in class, and answer sections of textbooks. Research generally confirms that learners are more effective when they attend to externally provided feedback (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991; Kulhavy & Stock, 1989; Meyer, 1986).

Traditionally, studies of feedback in educational settings have focused on information provided to students by an external source, such as a teacher or a computer. Usually, this feedback is not available during learning activities but is given after a task has been completed or a test of achievement has been administered. The purpose of such feedback has almost always been conceptualized as seeking to confirm or change a student's knowledge as represented by answers to test or assignment questions. We believe broader scope, deeper analysis, and a reviewing of the temporal location of feedback's effects are necessary to capture feedback's roles in knowledge construction. To acknowledge feedback's multiple and multifaceted roles in learning, we position feedback within a model of self-regulation that guides cognitive activities during which knowledge is accreted, tuned, and restructured (Rumelhart & Norman, 1978).

A model of how feedback integrates with self-regulated approaches to academic learning begs answers to questions different from "Does feedback improve achievement?" SRL is a process that unfolds step-by-step over time. It is also recursive; that is, internal monitoring of a current state in a task, the trigger for engaging SRL, generates feedback that, in turn, is input contributing to the learner's regulation of subsequent cognitive engagement. Thus, modeling feedback in the context of dynamically self-regulating processing calls for an account that considers simultaneously how cognitive processing unfolds as a function of regulative feedback and how feedback is generated or accessed within cognitive processing.

We suggest that, in general, research investigating feedback and self-regulation has focused on behaviors at too large a grain size—for example, studying whole passages or answering sets of test items after studying is over—and has thereby collected data that fail to reflect the variance in behavior that *is* regulation (Howard-Rose & Winne, 1993; Winne, 1982, in press). This has masked the phenomena that constitute SRL and hidden feedback's roles within the self-regulating processes that such research sought to describe. For example, consider a study by Zellermayer, Salomon, Globerson, and Givon (1991), in which some students wrote essays using a sophisticated computer application called the Writing Partner. The Writing Partner provided metacognitive information appropriate to different phases of writing, such as planning ("Do you want your composition to persuade or to describe?" or "What is the topic of your composition?") and transcribing a first draft ("What else do I know about this?" or "Wouldn't it be better to move this information to the front?"). When the Writing Partner presents these questions or displays a student's answers to such questions later in the writing process, this information simultaneously provides backward-reaching feedback about what a student has done and forward-reaching feedback about the quality of cognition that led to the present state of work (Zellermayer et al., 1991, pp. 378–379). This is the sort of information that models of self-regulation indicate is essential for engaging or modifying self-regulating activities.

Zellermayer et al. (1991) did not examine data that could reflect what a student did at the point when this information was presented. Rather, after an entire essay was written, each student gave an overall appraisal of the extent to which the Writing Partner's information was used to guide work. This was an aggregate rating drawn over multiple self-regulating incidents. The measure of achievement was a holistic evaluation of each student's essay—again, an aggregate rating drawn over multiple revisions a student may have made at various points when the Writing Partner provided information. The data examined in this study represent large-scale activities that do not correspond to individual instances of self-regulation. Hence, these data cannot be used to model the temporal flow of self-regulating activities undertaken by a student as he or she planned, drafted, and revised an essay (Howard-Rose & Winne, 1993; Winne, 1982, 1992). Moreover, when in quantitative analyses of these data scores are summed across students, statistics represent aggregations of an even larger grain size. Though Zellermayer et al.'s study provides solid grounds for inferring that a student probably self-regulated, its data are less useful for modeling how a student regulates engagement during learning (Winne, 1987; Winne, Gupta, & Nesbit, 1994). In general, methodological approaches to studying self-regulation that depend on data and analyses like these provide only indirect illumination of the events that constitute SRL.

We offer a more fine-grained analysis of feedback's roles in dynamic cognitive activities that unfold during SRL. We begin by outlining a model of self-regulation distilled from a spectrum of educational and psychological models (Bandura, 1993; Carver & Scheier, 1990; Corno, 1993; Kuhl & Goschke, 1994; Mithaug, 1993; Paris & Byrnes, 1989; Zimmerman, 1989). We use this synthesis as a structure for analyzing cognitive processes involved in self-regulation, and for interpreting and integrating findings from several disparate research traditions that have investigated feedback and its effects on achievement. More specifically, we review several areas of research not usually cited in educational research on feedback or on SRL: affect and its relation to persistence during self-regulation, the role of self-generated feedback in decision making, the influence of students' belief systems on learning, and the process of conceptual change in the face of misconceptions. We then build on and integrate these lines of research to illuminate the process of self-regulation. Specifically, we examine the functions of knowledge and beliefs in cognitive engagment; the process of selecting goals; processes by which students select, adapt, and generate tactics and strategies during learning; and the pivotal process of monitoring. Regarding monitoring, we give special attention to four main issues: (a) how students monitor, (b) types of internal feedback students generate while monitoring, (c) how well students monitor, and (d) difficulties that can arise during monitoring. In the final section of the review, we reexamine a variety of recent studies on feedback using our enhanced model of SRL to reexplain findings about feedback's effects on learning. We conclude by suggesting directions for future research, arguing that research on feedback and research on SRL should be tightly coupled.

A Model of Self-Regulated Learning

Self-regulation is constituted as a series of volitional episodes (Kuhl & Goschke, 1994) that, in the aggregate, are characterized by a recursive flow of information (Figure 1). As self-regulating learners engage in academic tasks, they draw on knowledge and beliefs to construct an interpretation of a task's properties and requirements. Based on the interpretation they construct, they set goals. Goals are then approached by applying tactics and strategies that generate products, both mental (cognitive and affective/emotional) and behavioral. Monitoring these processes of engagement and the progressively updated products they create generates internal feedback. This information provides grounds for reinterpreting elements of the task and one's engagement with it, thereby directing subsequent engagement. In particular, students may modify their engagement by setting new goals or adjusting extant ones; they may reexamine tactics and strategies and select more productive approaches, adapt available skills, and sometimes even generate new procedures. If external feedback is provided, that additional information may confirm, add to, or conflict with the learner's interpretations of the task and the path of learning. As a result of monitoring task engagement, students may alter knowledge and beliefs, which, in turn, might influence subsequent self-regulation.

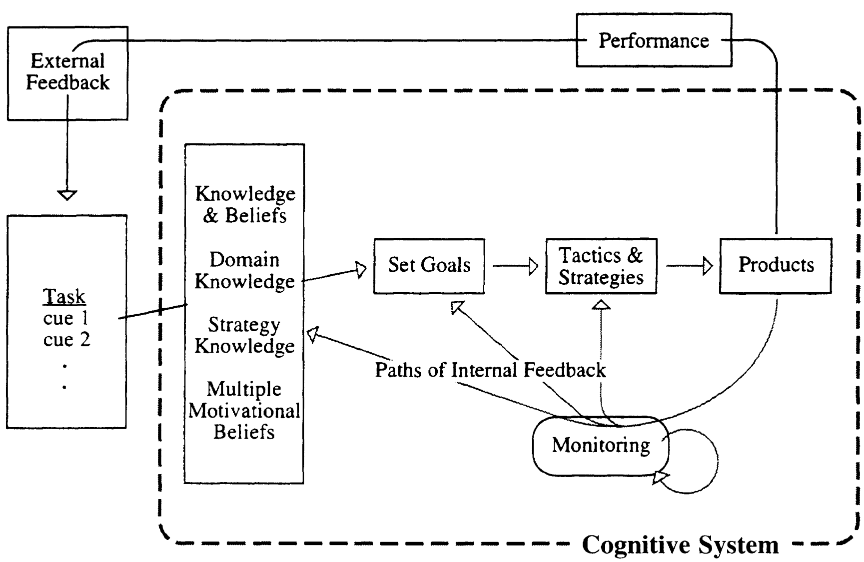

FIGURE 1. *A model of self-regulated learning*

In the next section, we examine four lines of research that elaborate this outline of self-regulated processing. First, we make use of Carver and Scheier's (1990) model of self-regulation to examine more specifically the production and influence of affect during self-regulation and the nature of internal feedback. Second, we draw on Balzer, Doherty, and O'Connor's (1989) review of one strand within the literature on feedback to explicate relationships among task characteristics, task performance, and externally provided feedback. Finally, we describe two lines of research—one by Schommer (1990, 1993; Schommer, Crouse, & Rhodes, 1992) and another reviewed by Chinn and Brewer (1993)—concerning the influence of students' knowledge and beliefs on self-regulation and feedback processing. We then integrate these and other sources to propose a more detailed, elaborated model of SRL and of the role of externally provided feedback in that process.

Four Views on Feedback and Engagement for Learning

Self-Regulation, Affect, and Internal Feedback

Carver and Scheier (1990) provide an appropriately generalizable model (Kuhl & Goschke, 1994, p. 113) that describes people's self-regulated engagement with serial tasks and subtasks. Briefly, Carver and Scheier theorize that if a person encounters an impediment while pursuing a goal, the interruption triggers a reassessment of the situation. Engaging in this reassessment leads learners to estimate how probable it is that they can achieve their goal if they invest further effort, modify their plan, or both. If confidence (self-efficacy; Bandura, 1993) or hopefulness exceeds an idiosyncratic threshold (i.e., if the goal is not abandoned because it is judged beyond reach), then the person attempts to adapt the plan that has been guiding engagement and continues working toward the initial goal. At this point in the stream of cognitive processing, self-regulation has been exercised.

Thus Carver and Scheier (1990) suggest, as do other modelers of SRL (e.g., Bandura, 1993; Kuhl & Goschke, 1994; Mithaug, 1993; Zimmerman, 1989), that students' goals couple with motivational beliefs and affective reactions to shape self-regulation. According to Carver and Scheier, affective reactions arise when the learner monitors the rate of progress toward goals relative to the rate at which he or she expects to progress. When discrepancies between goals and outcomes are reduced at the rate expected—that is, when modified plans are exactly as successful as predicted—affect (one's subjective experience of arousal, either nonspecific or targeted) is neutral because the expected rate of success matches the actual rate. If progress is achieved faster than predicted—for instance, because a change in studying tactics is more effective than predicted—then positive affect is generated about the approach that promoted rapid success. However, if the rate of progress is lower than predicted—for example, if the new studying tactic is successful but only after much time (effort)—then success is accompanied by negative affect. Carver and Scheier's model therefore makes two interesting predictions: (a) making progress exactly in accord with a plan can engender neutral rather than positive affect; and (b) under some conditions, achievement actually begets negative affect. These affective products influence subsequent engagement, with the same task or with similar tasks, by shaping judgments of confidence or hopefulness at points where a learner monitors progress (see also

Eisenberger, 1992; Kuhl & Goschke, 1994).

Carver and Scheier's (1990) model has three important implications. First, when a discrepancy is perceived between a current state and goals, the model suggests that a learner chooses to act based on what he or she predicts will reduce that discrepancy. The learner may change from one plan to another, modify levels or facets of goals previously set, or attempt to invent new means—new tactics and strategies—to increase the rate of progress. Alternatively, the learner may opt to abandon the task and thus set an entirely different goal (e.g., saving face by failing to try; Covington, 1992). Second, continuous progress in academic tasks at a rate less than expected may generate negative affect. This may lead a learner to disengage from tasks when obstacles are encountered, a sign of depressed motivation relative to those tasks. Third, internally generated feedback is inherent in task engagement. Such feedback has a tripartite nature consisting of (a) a judgment of task success in relation to multifaceted goals, (b) a judgment of the relative productivity of various tactics and strategies in relation to expected or desired rates of progress, and (c) affect associated with judgments about productivity.

Task Characteristics, Task Performance, and Externally Provided Feedback

The simplest and most common type of feedback is *outcome feedback*, sometimes labeled *knowledge of results.* It is binary information describing whether or not results are correct (acceptable relative to externally defined criteria) or, if given at steps in the midst of a task, whether or not work is on a path that can lead to achievement. Outcome feedback carries no additional information about the task other than its state of achievement. Hence, outcome feedback provides minimal external guidance for a learner about how to self-regulate. Alternatively, feedback can be elaborated to supply several different types of information in place of or in addition to outcome feedback.

Balzer et al. (1989) recently reviewed one line of studies on elaborated feedback in areas such as teaching, medical diagnosis, labor negotiations, and personnel selection. They examined these areas using Brunswik's (1956) lens model, a metaphor by which information for decision making is gathered and focused to predict achievement. In the lens model, both task characteristics and students' progress on tasks are described in terms of a set of features or a profile of cues. This set or profile can be used to predict final performance; in this sense, it is analogous to a multiple regression model in which predictors are weighted to maximize the predictability of an outcome. For example, in studying a passage for a test, a reader's place in the text might be one cue that predicts achievement. Values for this single cue might be "just started," "in the middle," and "nearly done." Other cues might be the reader's memory about the theme and a judgment about how important a new vocabulary word is for understanding the text. The lens model allows that cues can correlate with one another, thereby introducing redundancy among predictors of achievement. For example, place in the text likely correlates strongly with time spent studying. A less redundant cue might be whether the passage has an advance organizer (introductory information that provides an overview of lesson content; Corkill, 1992). Each cue alone, and the set of cues together, may predict whether a reader will ultimately achieve the goal of comprehending the entire passage.

Each cue's value (presence or absence, frequency, or degree) and its predictive validity for forecasting achievement can be measured from two vantage points. One is that of an observer—a curriculum developer, a teacher, or a researcher. From this vantage point, a cue's value in the task environment is set by the task's design—for example, an advance organizer is either provided or not, a text either has annotated figures and graphs or does not. From the observer's perspective, a cue's validity describes the correlation between the cue's values and measures of students' achievement (e.g., whether presence of an advance organizer is associated with increased reading comprehension). This might be estimated by an effect size from an experiment that contrasts comprehension by students who studied with an advance organizer with comprehension by students who studied without an advance organizer.

The second perspective from which to view cues is that of the learner (Winne, 1982; Winne & Marx, 1977, 1982). If a learner does not register a cue's presence, then the cue has a value of zero for the learner and will not affect the learner's self-regulation. For example, a reader might skip over an advance organizer or treat it as just more text to read. Students' beliefs about cues are conditional knowledge about the utilities (Winne, 1985) of learning approaches in relation to differing task conditions. When a learner perceives links between task conditions (cues) and approaches, and when those perceptions are accurate (in the sense that the cues actually predict performance in the way the learner believes), then the learner is said to be well calibrated (Nelson & Narens, 1990). In tasks where learners self-regulate by recursively adjusting approaches based on perceived task cues, achievement will be a function of the learner's calibration.

Examining the relationship between instructional interventions or treatment conditions and the average achievement of a group of students is commonplace in educational research. This activity can be likened to estimating the predictive validity of task cues generalized over persons, from an observer's perspective. Less common, however, is gathering data on the value of cues at the level of individual students, from the perspective of either an observer (e.g., whether a given individual benefits from the presence of an advanced organizer) or the individual student (e.g., whether the indivdual uses an advance organizer or judges the use of one to be helpful). But if tasks are constructed to collect traces (Winne, 1982, 1985, 1992) of learners' on-line cognitive processing, then students' perceptions of cues and their values can be assessed. Specifically, it is possible to collect traces of learners' (a) perceptions of cues' values, (b) expectations for success on a task (presumably based on the utility of approaches given task cues), and (c) perceptions of actual achievement.

Such an analysis gives rise to several elaborated forms of feedback that may support students' self-regulated engagement in tasks by enhancing the students' calibration (accurate associations between cues and achievement). In Balzer et al.'s (1989) terms, *cognitive feedback*, in contrast to outcome feedback, can provide students with information that links cues and achievement. Three types of cognitive feedback have been defined:

(1) *Task validity feedback* describes an observer's perception of the relation between a task's cues and achievement. An example of task validity feedback based on group data might be a teacher saying, "Notice that the first paragraph of the chapter provides an overview rather than presenting information to learn. In

general, if you had used its information to organize your studying, you would have a better understanding of the material." Task validity relations could reflect principles grounded in experimental research (i.e., relations between treatment levels and achievement) or they might be calculated using data about a specific learner's history, gathered, for example, during tutorials provided in an adaptive learning environment (Winne, 1989, 1992). This feedback brings to the learner's attention the relationship between a cue, such as the presence and use of an advance organizer, and the probability of successful performance (see Elawar & Corno, 1985, and Zellermayer et al., 1991, for examples).

(2) *Cognitive validity feedback* describes a learner's perceptions about the relationship between a cue and achievement. For example, in an adaptive learning environment, a learner who studies text on a computer screen might be prompted after reading each chapter to rate how much he or she used an advance organizer in that chapter. Cognitive validity feedback might suggest to the learner, "You aren't using the advance organizer to guide your studying." This feedback conveys the extent to which the learner perceives cues and judges performance to be influenced by them.

(3) *Functional validity feedback*, in general, describes the relation between the learner's estimates of achievement and his or her actual performance. For example, in an adaptive learning environment, a reader might be asked to rate how well he or she is understanding a chapter's information. Then, after the learner's estimate is compared to a measure of achievement (e.g., the student's answers to adjunct questions asked at the end of a section), functional validity feedback might suggest to the learner, "Based on your answers to questions so far, I estimate you understand about 60% of the concepts, not 80%."

Among other matters addressed in their review, Balzer et al. (1989) collected findings from research about (a) whether the three kinds of validity-related feedback (task, cognitive, and functional) were more effective than outcome feedback, and (b) whether one of those three kinds of validity-related feedback was more effective than others. Across the spectrum of tasks, domains, and ages of participants in the research they reviewed, feedback providing validity-related information was judged more effective than feedback providing only outcome information. And, although the body of research does not lend uniform support, there was modest evidence that task validity feedback was more effective in supporting learning and problem solving than was cognitive validity information alone. In accounting for this latter finding, Balzer et al. (1989) hypothesized that learners are aware of criteria they use in making judgments, so cognitive validity feedback that identifies the cues that learners use (e.g., "You use the advance organizer in this way") may be redundant.

There are two implications of the lens model and its distinctions among kinds of information that elaborated feedback might include. First, outcome feedback, the most common kind of information students receive after engaging in academic tasks, provides the least guidance about how to self-regulate. The benefits of outcome feedback depend heavily on learners' (a) being attentive to multiple cues' values and performance during study, (b) having accurate memories of those features when outcome feedback is provided at the task's conclusion, and (c) being sufficiently strategic to generate effective internal feedback about predictive validities (e.g., "Which factors boost my performance?"). On the other hand, cognitive feedback, as construed in the lens model, may help students identify cues and monitor task engagement. Thus, cognitive feedback probably enhances learners' calibration by helping them recognize important cues (e.g., task features and cognitive activities they engage in while learning) and the relationships of those cues' values to performance. As we noted earlier, this monitoring function is essential in self-regulation.

Beliefs and Understandings May Filter Feedback's Effects

The lens model is one representation of an assumption common to many contemporary theories of learning and instruction: that learners' perceptions of tasks and cues mediate forms of engagement and, in turn, affect performance. Schommer and her colleagues (Schommer, 1990, 1993; Schommer et al., 1992) have explored another representation of this assumption by examining relationships among learners' beliefs about learning, their use of strategies, and their performance. Specifically, Schommer and her colleagues' research has demonstrated that secondary and postsecondary students hold epistemological views about learning. Within these views, three dimensions concern (a) the degree to which effort is necessary to learn, (b) how quickly knowledge is acquired, and (c) the certainty of knowledge that is learned. These three epistemological views correlated with several kinds of outcomes. For example, an epistemological belief that learning should progress "quickly" predicted the use of relatively superficial strategies for studying. A fourth epistemological belief in simple learning—that what is learned should be "unambiguous" and should have "only one answer"—was positively related to overconfidence in learning and negatively related to achievement.

Students' beliefs about learning affect self-regulation by influencing the nature of and interpretation of feedback. For instance, consider the relationship between epistemological beliefs and the production of affect during self-regulation. Carver and Scheier (1990) argued that negative affect arises when students discover that actual rates of progress are lower than expected. Students who believe in quick learning will set stringent criteria for judging progress. They may be more likely to generate negative affect based on internally generated feedback (see also Boekaerts, 1994) and, if that affect is strong enough, change goals so significantly that they withdraw from the task. In Balzer et al.'s (1989) terms, students' epistemological beliefs condition their interpretations of task cues (e.g., the amount of effort exerted as gauged by place in the chapter being studied and time spent) and how those cues predict performance. This is conditional knowledge, in the form of IF-THEN rules, that students use to select tactics or strategies in self-regulating their study. For example, IF a student believes that learning is easy or that effort (a cue) is unimportant in performance, THEN that student may choose not to adapt learning tactics to improve learning outcomes. The result may be lower achievement.

Students' beliefs about learning are one kind of "knowledge" that influences subsequent task engagement. Another line of research into types of knowledge students hold has shown that commitments to mistaken views of school subjects also influence learning. Specifically, students' content area misconceptions impede revisions to and replacements of incorrect knowledge (Chinn & Brewer, 1993; Perkins & Simmons, 1988). Chinn and Brewer recently reviewed research on the nature of and means for changing students' entrenched views and misconceptions about scientific principles. They named four complex factors that influence conceptual change of an entrenched stance: (a) the nature of a student's prior knowledge, (b) characteristics of a new model or theory meant to replace the student's inadequate or misconceived one, (c) aspects of anomalous information presented to the student in order to signal that his or her current conceptual structure is inaccurate, and (d) the depth of processing the student engages in when considering the anomalous data. Chinn and Brewer also identified seven ways that students respond to anomalous information. One is to replace incorrect knowledge with correct information. Six other types of response, however, mitigate positive conceptual change (p. 39): ignoring the feedback, rejecting it, judging the feedback irrelevant, holding the feedback separate from the belief so that the belief is not influenced by the feedback, reinterpreting the feedback so that information it provides conforms to the preexisting belief, and making superficial rather than fundamental changes to the belief. In each of these responses, feedback's influence is conditional on how its information is filtered through a student's existing beliefs.

In the context of SRL, Schommer's (1990) research and Chinn and Brewer's (1993) review signal that considering feedback merely in terms of the information it contains is too simplistic. Rather, learners interpret such information according to reasonably stable and relatively potent systems of beliefs concerning subject areas, learning processes, and the products of learning. These beliefs influence students' perceptions of cues, their generation of internal feedback, and their processing of externally provided feedback. In the last case, beliefs filter and may even distort the message that feedback is intended to carry. Moreover, characteristics of information in elaborated feedback, such as the plausibility of a new explanation for a subject (e.g., history) or for a process like SRL, influence how a learner will use feedback.

Updating Theory About Feedback and SRL

The foregoing characterizations of learning yield a complex view of feedback's roles in learning subject matter and in developing SRL. In general, each line of research suggests that traditional views of feedback be broadened. For example, though most feedback research has focused on externally provided feedback, Carver and Scheier's (1990; also Kuhl & Goschke, 1994) model of self-regulated behavior identified the importance of feedback that learners generate for themselves as they engage in tasks (including information about task success, the productivity of tactics or strategies, and affect). By distinguishing cognitive feedback about cue-performance relations from outcome feedback about performance per se, Balzer et al. (1989) illustrated that externally provided feedback does more than just correct or elaborate a learner's knowledge—for example, it can enhance calibration and therefore a learner's effective engagement in tasks. An added benefit of the lens modeling approach for examining learning is that, if appropriate data can be gathered, important intra- and inter-individual differences in students' self-regulated task engagement and their uses of feedback can be examined. Finally, research by Schommer (e.g., 1990) and Chinn and Brewer (1993) has suggested that feedback's roles in learning are mediated by a learner's beliefs and knowledge. Specifically, students' beliefs about learning-as-process influence monitoring as well as qualities of the feedback that they generate internally. Also, students' domain understandings shape their interpretations of feedback provided by external sources.

Together, these lines of research suggest value in seeking a fuller account of interactions between features of tasks, individual differences, feedback, and judgments made in the course of and about learning. They also suggest that research about feedback's influences on learning should adopt a broader view of how feedback mediates performance through a series of recursively linked, self-regulated cognitive engagements. In the sections that follow, we elaborate our model of self-regulation to illustrate the advantage of considering feedback in the context of SRL (see Figure 1). First, based on our review of several literatures, we develop a more articulated picture of specific processes involved in SRL. We then reexamine research on feedback within the context of our elaborated model of SRL.

Functions of Knowledge and Beliefs in Cognitive Engagement

Schommer (1990, 1993) and Chinn and Brewer (1993) described two lines of evidence linking students' knowledge and beliefs with their self-regulated engagement in tasks. In this section, we elaborate on the roles of knowledge and beliefs in self-regulated cognitive engagement. In addition to students' epistemological beliefs, four types of knowledge have received attention in research on self-regulation: domain knowledge, task knowledge, strategy knowledge, and motivational beliefs (Borkowski & Muthukrishna, 1992; Paris & Byrnes, 1989; Zimmerman, 1990).

The impact of entrenched domain knowledge on self-regulation was evident in the research on conceptual change reviewed by Chinn and Brewer (1993). When domain knowledge was incorrect and entrenched, students were erratic in applying productive learning strategies (Burbules & Linn, 1988). Other reviews showed that as domain-specific knowledge increased in depth and richness, students' acquisition, use, and transfer of cognitive strategies that supported SRL were enhanced (Alexander & Judy, 1988; Salomon & Perkins, 1989).

Through experiences with academic activities, students also develop knowledge about tasks (Doyle, 1983; Marx & Walsh, 1988), and such task knowledge influences self-regulation. In Winne and Marx's (1982) study of thinking during classroom lessons, students' perceptions of tasks mediated goals they selected and approaches—tactics and strategies—they adopted to learn, including opting out of engagement even though the nature and rewards of being actively engaged were understood. Graham, Schwartz, and MacArthur (1993) found that writers with learning disabilities focused on mechanical aspects of composing essays because they perceived spelling and grammar to be prominent features of good writing. Such perceptions might guide students as they select approaches to writing. Similarly, Schommer (1990) demonstrated that undergraduates' epistemological beliefs about tasks influenced their understandings about goals and, as a result, the diversity of ideas reflected in their writing about a controversial topic. Collectively, it has been shown that students' interpretations of tasks influence the goals they establish and the cues they attend to and act on as they engage with those tasks.

As students complete tasks, their knowledge about tactics and strategies is simultaneously constructed and refined along with task knowledge and domain-specific understanding. Three forms of strategy knowledge can be distinguished (see Winne & Butler, 1994): *declarative knowledge* (that describes what a strategy is), *procedural knowledge* (of how to use a strategy), and *conditional knowledge* about a strategy's utility (that is, when and where a strategy can be used to meet particular purposes and how much effort is involved in using it). Pressley (1986) and Borkowski and Muthukrishna (1992) also differentiate between specific and general strategy knowledge. *Specific strategy knowledge* concerns a particular strategy and episodic memories about the situation in which the strategy was first learned (Martin, 1993). *General strategy knowledge* concerns the importance and value of approaching tasks strategically. Students' knowledge about tactics and strategies is pivotal in SRL because it establishes boundaries for the self-regulation that can be exercised (unless significant effort is put towards adapting extant tactics and strategies or generating entirely new ones).

Among the variety of motivational beliefs involved in self-regulation (McGinn, Winne, & Butler, 1993), self-efficacy has been emphasized (Bandura, 1993; Borkowski & Muthukrishna, 1992; Borkowski, Weyhing, & Turner, 1986; Paris & Byrnes, 1989; Zimmerman, 1989). *Self-efficacy* refers to individuals' "beliefs about their capabilities to exercise control over their own level of functioning and over events that affect their lives" (Bandura, 1993, p. 118). In SRL, self-efficacy influences goals a student sets, commitment to those goals, decision making at branch points along a path the learner constructs to reach those goals, and persistence (Bandura, 1993). At those branch points where students encounter obstacles to performance, Carver and Scheier's model (1990) maps in greater detail how achievement expectancies about rates of progress influence affective reactions and task persistence.

Within a given academic task and across the myriad tasks that comprise a school career, students interpret information and construct understandings within each of these main categories of knowledge. A question facing educators and educational researchers alike is, How can feedback support students in developing useful and valued knowledge in each category while simultaneously scaffolding students' self-regulated involvement in tasks?

Selecting Goals

When teachers give students an academic task, such as writing a composition or studying feedback on a recent quiz, it might appear that students have a singular goal: to develop a composition that meets certain standards or to correct wrong answers. This is too simplistic a view of academic tasks (Marx & Walsh, 1988; Winne & Marx, 1982). With the exception of students who reject the teacher's assignment (e.g., a defiant student who refuses to write a composition or a hurried student who sets aside the test paper to complete a late assignment), students always have latitude to select goals, both within the confines of an assigned task and orthogonally to that task. The goals they adopt will drive their cognitive engagement.

Dweck (1986) describes two types of task-related goals that students choose between or balance in some measure: *learning goals* and *performance goals*. Students who adopt learning goals seek expertise in the task's subject matter domain. In contrast, students who adopt performance goals strive to enhance their own and others' perceptions of their competence in the task. The relative emphasis a student assigns to learning goals versus performance goals is related to several prior beliefs, illustrating again the role of knowledge in shaping self-regulation. For example, choosing learning goals is positively correlated with positive beliefs about (a) agency, (b) the need to apply effort in learning, and (c) whether ability is a malleable (incremental) aptitude. In general, students who emphasize learning goals over performance goals study more strategically (Meece, Blumenfeld, & Hoyle, 1988; Pintrich & De Groot, 1990). Strategy knowledge can be inspected by these students because it is a focus of their deliberation about how to engage with a task (Winne, in press). We hypothesize that cognitive feedback that supplies information about important task cues (conditional knowledge; Balzer et al., 1989) should be particularly effective for students who adopt learning goals.

If students misperceive the goal that a teacher intends when assigning a task, they may engage inappropriate tactics for completing the task or they may adopt an inappropriate reference for monitoring qualities of their work (Butler, 1994). In their study of classroom interactions, Winne and Marx (1982) revealed that students held such misperceptions. Inappropriate goal selection may be relatively automatic (McKoon & Ratcliff, 1992), so that work on the task proceeds "off track" until some salient event puts the relevance of the goal into sharper relief, making it a focus for deliberate consideration.

Students can also hold goals that importantly reconfigure what might at first be considered a unitary task. For example, in the case of a student studying feedback on a test, one might imagine that the goal is to be able to answer each item correctly (because, in well-designed tests, different items assess different knowledge). Thus, if a student answered an item incorrectly and anticipated a retest or a future assignment calling on that item's information, logic would suggest that the student should carefully inspect feedback on that item to correct gaps or flaws in knowledge. A study by Schutz (1993) suggests otherwise. Whether or not students requested feedback about particular missed test items depended on the goals they had set for achieving overall test scores, say, 70% versus 100%. In this case, processing feedback about each wrongly answered item had a marginal utility (Winne, 1991) that depended jointly on (a) the student's overall goal and (b) the number of items already correctly answered (i.e., either correct in the first place or already corrected following feedback review). In this instance, feedback's effects were jointly dependent on a student's overall goal and the item-to-item change in aggregate knowledge as the serial list of wrongly answered test items was reviewed.

Carver and Scheier's (1990) model of regulated behavior provides a slightly different perspective about how goals are selected. Carver and Scheier view goals as hierarchically nested, so that attainment of a goal at one level of behavior (e.g., doing well on individual test items) enables goal attainment at the next highest level (e.g., doing well on a whole test). When goals at one level are not reached, actions are engaged at the preceding (lower) level. According to this model, effectively elaborated feedback should provide information at a level lower than the one at which a gap or error appears. For example, to help students achieve a score of 90% correct on a math test, feedback should support cognitive engagement aimed at correcting individual items. In effect, such feedback addresses a subgoal relative to the goal for which performance occasions the feedback.

Learners can also adopt different kinds of goals simultaneously, for example, mastering new material while also learning to monitor learning more accurately, or wanting to appear rebellious to friends while still achieving in school (Covington, 1992). When coexisting goals conflict, students face a problem: reducing discrepancies in one realm necessarily increases discrepancies between performance and goals in another. Individuals who regularly face conflicting goals are less well-adjusted and have more emotional problems (Van Hook & Higgins, 1988). In such a context, feedback that an experimenter (or teacher) provides will have less predictable effects because the student may opt to pursue a goal that differs from the goal the researcher opts to measure.

In complex academic tasks, such as scheduling a weekend's studying sessions or scheduling work project–based learning (Pintrich, Marx, & Boyle, 1993), students face another issue in selecting goals: In what sequence should activities and their respective goals be approached? A review of situations calling for such decision making (Loewenstein & Prelec, 1993) indicates that if people examine each event singularly and judge its value in isolation, they generally prefer to seek the most valued outcome (goal) first, the next most valued second, and so on. However, when people adopt a view of activities as a *sequence*, they prefer to access valued outcomes more evenly over time. The way a task is characterized in instruction or feedback thus may influence how learners set sequential goals and self-reward (Carver & Scheier, 1990).

These lines of research indicate that multiple variables simultaneously affect students' selection of goals and the relations that feedback might have to those selections. Because self-regulated learners judge performance relative to goals, generate internal feedback about amounts and rates of progress towards goals, and adjust further action based on that feedback, the goals students adopt are central in shaping the unfolding process of SRL. If instructional feedback is to contribute jointly to self-regulation and achievement, it must impact this cycle of cognitive activity by addressing the types of goals students adopt and by supporting their processes for prioritizing, selecting, and protecting or revising those goals (Butler, 1994, 1995).

Selecting, Adapting, and Generating Tactics and Strategies

Once learners select goals, they must engage actions to reach them. In very familiar tasks, actions may proceed automatically. If tasks are less familiar or if obstacles arise in the course of working on them, self-regulated learners deliberate about deploying tactics and strategies that can lead to progress toward goals. Some strategies are familiar and well honed, occasions for engaging low-road transfer (automatic transfer across a range of task conditions the learner has already experienced; Salomon & Perkins, 1989). In the face of new tasks or unforeseen difficulties, however, students may need to adapt or even generate strategies, a high-road transfer situation (transfer based on an abstraction of general principles about strategies and applied in a new context; Salomon & Perkins, 1989) that strongly invites self-regulation (Borkowski, 1992).

Tactics and strategies are often categorized according to the cognitive or volitional functions they serve (Weinstein & Mayer, 1986; Zimmerman, 1989). For example, strategies may target specific learning objectives, such as rehearsing information to improve retrievability, elaborating information to enhance its meaningfulness, and organizing information to expose its structure. Corno (1993) adds two types of action control strategies to such lists: motivation control strategies and emotion control strategies. These protect task engagement and guide the student in allocating and managing resources for making progress. Corno explains that

> motivation control strategies enhance or strengthen the motivational basis of intentions—regulating the attributes of goals and tasks, their visualized enactment, and their contingent outcomes. Emotion control strategies are useful in managing emotional states that might disrupt or inhibit action, such as feelings of inadequacy, anxiety, or other emotions tied to past academic experiences. (p. 16)

Emotion control strategies might be required, for example, in cases where self-regulation occasions negative affect because rates of progress are perceived as unsatisfactory (Carver & Scheier, 1990).

Students can encounter four logically distinct kinds of problems in applying tactics and strategies (Winne, 1982). First, they may have difficulty or fail in recognizing conditions (task cues; Balzer et al., 1989) under which strategies might be employed profitably. Second, students may misperceive task goals (and, therefore, task cues) and thus mismatch strategies to a task's actual conditions. Third, students may select appropriate strategies but fail to execute them effectively because they lack proficiency in deploying them or because other aspects of the task interfere. Finally, when none of these three impediments prevents strategy use, students may simply lack motivation to spend the effort required to apply a strategy. Overcoming these four problems attending the use of tactics and strategies therefore requires a multifaceted approach (Butler, 1995) in which feedback will have multiple targets.

Monitoring

Monitoring is pivotal in SRL. It is the cognitive process that assesses states of progress relative to goals and generates feedback that can guide further action. Monitoring is portrayed in Figure 2 as receiving two multivariate profiles as inputs, one describing a goal and the other describing the present state of the task on which the learner is working. These profiles can include information about desired (achieved) outcomes (e.g., learning a specific concept, impressing classmates, getting an A on an exam) or the qualities of cognitive processing engaged (e.g., using a particular strategy, learning quickly, maintaining attention on the task). Based on a comparison of the two multivariate inputs, the process of monitoring creates information in the form of a third multivariate profile. It characterizes differences between the two inputs in two ways (Winne, 1985; Winne & Butler, 1994), describing qualitatively or quantitatively the nature and degree of difference(s) (a) between corresponding items that describe the current state of a task and goal (Variables A, B, C, and D in Figure 2), and (b) between items present in one profile but absent in the other (i.e., the correspondence of items across the pair of input profiles; Variable E in Figure 2).

How do learners use such internally generated feedback? The multivariate profile input to monitoring identifies current task conditions that are cues in the learner's lens model (Balzer et al., 1989). The values the learner assigns to those

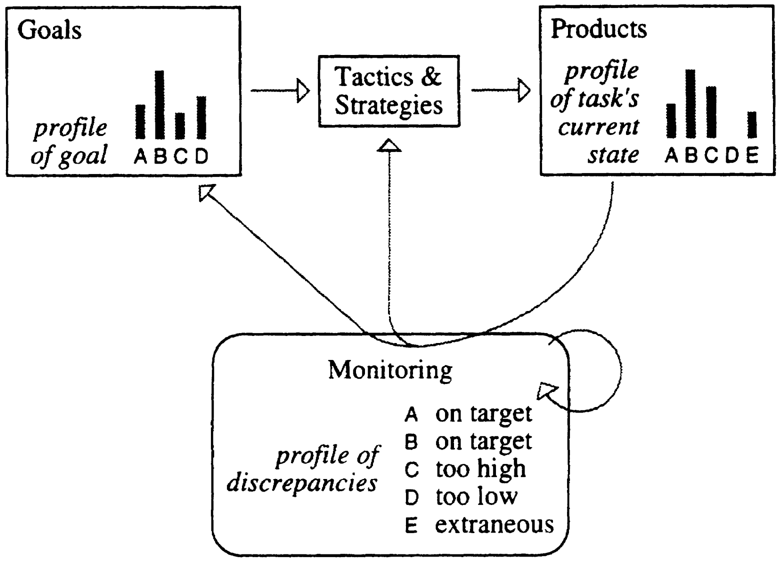

FIGURE 2. *Profiles of a goal, the current state of work on a task, and the discrepancy profile that monitoring creates*

cues are influenced by how information is filtered through his or her beliefs about learning processes and products (Chinn & Brewer, 1993; Paris & Byrnes, 1989; Schommer, 1990). When a perceived cue (e.g., that the paragraph just studied was inadequately understood) is linked to a repair tactic or strategy (e.g., to jump to the chapter summary for a clue about the paragraph's relevance to the chapter as a whole), then the learner is poised to adapt. In this case, the internal feedback that monitoring generates is conditional knowledge that bridges past performance to the next phase of engaging with a task. It is at these bridging points, we suggest, that self-regulation can serve learning and that feedback, especially cognitive feedback (Balzer et al., 1989), should be most useful.

Must monitoring be "conscious"? Most models of SRL characterize self-regulation as a conscious event. That is, information that is cognitively processed during self-regulation is available for inspection in working memory, and the process is reflective and planful (Paris & Byrnes, 1989; Zimmerman, 1989; see also Corno & Kanfer, 1993). For example, Carver and Scheier's (1990) review found a positive relationship between students' levels of self-awareness and self-regulating activities such as seeking information about standards and adjusting behavior. Other models (see Winne, in press), however, allow that monitoring can proceed outside conscious awareness. For instance, McKoon and Ratcliff (1992) describe how readers adjust approaches to a text without explicit awareness of monitoring. Kanfer and Ackerman (1989) show how, after transforming declarative forms of rules to procedures, learners shift cognitive resources from learning activities to SRL without deliberation.

The apparent conflict between views of monitoring as deliberative and views of monitoring as nondeliberative is reconciled by allowing that some monitoring activities are occasions where expertise is exercised. Hallmarks of expertise are the very rapid perception of complex patterns and the use of highly automated procedures that exact minimal attention (see Ericcson & Smith, 1991). Only if expertise failed would monitoring and adaptation require deliberate attention, as shown in studies where subject matter experts address problems outside their domain of expertise (Voss, Blais, Means, Greene, & Ahwesh, 1989). Feedback may elevate such monitoring to a level where it can be inspected in working memory, but that alone may not be enough to enhance achievement (Maki & Serra, 1992).

What kinds of internal feedback do students produce? Internal feedback that students generate by comparing evolving states of a task to goals creates conditional knowledge that is the basis for further action. What topics of information might be recorded in the multivariate profile that comprises this conditional knowledge? In our model of self-regulated engagement (Figure 1), cognitive or behavioral products are created by three sequential cognitive events: (a) perceiving task conditions in terms of extant schemata that weave together knowledge and beliefs, (b) adopting goals, and (c) applying tactics and strategies. We posit that information about each of these cognitive events is, in the sense of a lens model, a cue that relates to cognitive products. The values of these cues comprise the multivariate profile of conditional knowledge. Cognitive feedback about these cues and about their relationships to performance can enhance a learner's calibration (e.g., recognition of the relationships between cues and performance) that guides self-regulation of learning (Balzer et al., 1989).

How well do students monitor? Several lines of research suggest that students typically monitor suboptimally. For example, research on readers' comprehension monitoring has shown that younger students, 5 to 11 years old, and less proficient students have difficulty detecting errors in text (Baker, 1984; Wagoner, 1983). Baker suggests there are developmental differences in students' abilities to use standards to monitor reading comprehension, but even college students do not always monitor effectively (Walczyk & Hall, 1989). Pressley, Ghatala, Woloshyn, and Pirie (1990) found that university students can be overconfident about responses to thematic questions, which indicates poor calibration and lack of awareness of even gross comprehension problems. Similarly, research on the effects of allowing students to control the sequence of lessons or the presentation of feedback during computer-assisted instruction (Steinberg, 1989) has generally found that learners who are granted full control often exit instruction before mastering the material whereas peers provided with feedback about current knowledge states are more likely to persist. This suggests that, when left to regulate learning on their own, students often inadequately monitor the level or completeness of their learning. Finally, the research by Schommer and her colleagues (Schommer, 1990, 1993; Schommer et al., 1992) suggests that if students believe that learning is simple, they are likely to be overconfident in their learning, which reflects deficient monitoring. We argue that feedback could be helpful in guiding students to consider conditions under which they should monitor, especially when students who believe in "simple learning" are left to their own judgments about when studying should cease.

Why do students have difficulty monitoring? In our view, the problems attributed to monitoring are, for the most part, not shortcomings in the primitive cognitive process of monitoring, that is, of comparing multivariate inputs to generate internal feedback (Winne, 1989). Rather, we hypothesize that problems arise because (mis)information is or is not monitored.

From this perspective, four reasons, parallel to those given earlier (Winne, 1982) to account for breakdowns in applying learning tactics and strategies, can account for difficulties in monitoring. First, students' perceptions of tasks and goals determine the task characteristics or cues they take as relevant to effective task engagement (Balzer et al., 1989). Such cues both serve as conditional knowledge, signaling the relevance and utility of alternative tactics and strategies during learning, and act as standards, or criteria, for judging performance during monitoring. Thus, if a student misclassifies a task and/or adopts inappropriate goals, not only is it likely that inappropriate tactics will be adopted, but internal feedback generated during monitoring will neither provide adequate information about task performance nor suggest tactics or strategies which adequately redress difficulties.

Two approaches to supplying missing information about standards against which to measure achievement are illustrated in research on improving comprehension monitoring in reading. In one, students are taught internal criteria against which to judge their performance (e.g., Baker, 1984; Baker & Zimlin, 1989; Bereiter & Bird, 1985). In the second, students are induced to judge their comprehension against external information, such as feedback supplied when they attempt to answer embedded questions (e.g., Walczyk & Hall, 1989). Both approaches have proven helpful when students address near-transfer tasks, presumably because each provides cues that can be used during monitoring to judge performance more accurately in relation to goals.

Second, students may perceive relevant cues but misperceive what those cues predict about performance. In terms of the lens model, the student's understandings about cues lack validity for predicting achievement in the task. Hence, during monitoring, the student will misperceive or mismeasure progress. Consider an example of how such mistaken judgments of performance might arise. When preparing for tests, students must not only judge current comprehension and retention but they must also predict their ability to retrieve the information they have studied after a time delay and under different conditions. Immediately after studying, students are generally overconfident and predict higher scores than they actually achieve (Nelson & Dunlosky, 1991), probably because monitoring is tainted by an availability bias and an anchoring effect (Koehler, 1991; Tversky & Kahneman, 1974). That is, the relative ease and immediacy of retrieval immediately after studying is an invalid cue for predicting later retrievability under different conditions. Theoretically, cognitive feedback supplying students with information about the relationship between cues and performance should have beneficial effects (Balzer et al., 1989).

Third, students may be overwhelmed by cognitive demands during monitoring. This kind of difficulty may arise if either the number of cues to be monitored or the demands of subsequent cognitive processing—tactics and strategies that monitoring identifies as appropriate—overwhelm cognitive resources (Kanfer & Ackerman, 1989; Winne, in press). These problems may be less likely to arise when students' propositional information about tasks is chunked (Marx & Walsh, 1988) or when production systems for tactics and strategies are proceduralized and composed (Anderson, 1983). Instruction and feedback can therefore support monitoring by coordinating the amount of information provided in feedback with qualities of students' knowledge about tasks and strategies.

Finally, if the three preceding difficulties are avoided, learners may lack motivation to effortfully assess or change task approaches. This seems to be the case when students adopt performance goal orientations that undermine self-regulation (e.g., Graham & Golan, 1991; Borkowski & Muthukrishna, 1992). Alternatively, beliefs that learning should be easy (Schommer, 1990; Schommer et al., 1992) may lead students to apply less effort to monitoring. Or, students may lack effective action control strategies to motivate effortful cognition (Corno, 1993). Feedback that supports students' construction of positive motivational beliefs and/or use of action control strategies thus may support engagement in self-regulation.

In this section, we have considered the information on which the complex activity of self-regulation depends and with which self-regulation operates (see also Alexander, Schallert, & Hare, 1991). Feedback generated internally as a result of monitoring can supply information regarding any aspect of self-regulated processing. In the next section, we survey research relating feedback to achievement, reexamining reviews and selected experiments in light of the information and cognitive processing that form the basis for SRL.

Reexamining Research on Feedback

Several reviews of feedback and its effects on achievement have been published recently (e.g., Bangert-Drowns et al., 1991; Kulhavy & Stock, 1989; Kulik & Kulik, 1988; Meyer, 1986; Steinberg, 1989). In the most recent of these, Bangert-Drowns et al. concluded that feedback is effective to the extent that it "empowers active learners with strategically useful information, thus supporting self-regulation" (p. 214). Their five-step model, which makes several points of contact with our model of feedback's role in SRL, operates as follows. First, students enter the task with prior knowledge, goals, and motivational beliefs (Step 1). Then they employ strategies (Step 2) to answer questions (Step 3). Finally, students evaluate their responses in light of feedback information (Step 4), and, as a result, modify knowledge and beliefs (Step 5). We reexamine this landscape of research, adding to these views of how feedback affects achievement hypotheses about how feedback can promote and sustain productive SRL. However, because our model integrates a learner's knowledge and beliefs within SRL (see Figure 1), we also reconsider some aspects of how feedback affects achievement per se.

To begin, we make a case that distinguishing the source of feedback—external or internal—is arbitrary when developing an account about how feedback might facilitate learning. Then, we propose five functions for feedback that are shared between promoting domain knowledge, on the one hand, and cognitive processing that constitutes SRL, on the other. With this background, we reexamine selected experiments investigating feedback's effects on learning. We divide these into two categories: those focused on providing feedback to change learning products (most often, domain-specific understandings), and those focused on changing some aspect of the learning process as a means for shaping knowledge and beliefs. When the studies in each category are examined, it becomes apparent that researchers who make interpretations of feedback's effects are beginning to recognize the mediating role of students' cognitive processing and self-regulation.

Sources of Feedback

In their review of how feedback affects learning in test-like events, Bangert-Drowns et al. (1991) distinguished two sources of feedback: that which students self-generate by monitoring their engagement with learning tasks, and that provided externally. As we have already discussed, the information in self-generated feedback is rich. It concerns current states of knowledge, goals set, the productivity of strategies or tactics employed, the rate of progress towards goals, and affective content in reaction to perceptions about achievements and progress. At each stage or branch point in a task, this configuration of information (cues; Balzer et al., 1989) is contextualized or filtered by the learner's knowledge, and that amalgam of information verifies, updates, or reconstitutes the task's conditions. While self-generated feedback may lack accuracy (e.g., Nelson & Dunlosky, 1991) and explicitness, students nonetheless are continuously judging qualities of their engagements in learning (McKoon & Ratcliff, 1992).

Feedback originating in external sources can be incidental, arising from unplanned interactions with the environment, peers, or adults. Or it can be intentionally provided by teachers, directly or through other media (e.g., written comments, computer displays). Our model (Figure 1) proposes that students filter information provided by external feedback through knowledge and beliefs, applying conditional knowledge to identify cues. Those cues set in motion the process of setting goals, which provide criteria for selecting among tactics and strategies. As these cognitive tactics and strategies generate cognitive products, monitoring is engaged. Thus, like self-generated (internal) feedback, externally provided feedback influences learning through acts of monitoring. At a surface level, external feedback may initiate monitoring that assesses at minimal depth features of newly learned information (e.g., a superficial scan of memory to estimate whether information about a concept or a schema is present). This is the minimal effect of outcome feedback when performance is correct or accurate. More elaborate feedback can enrich the criteria by which cognitive processing and its products are monitored. The results of such monitoring may trigger other forms of cognitive processing, such as assembling schemata, translating among forms of representation (e.g., semantic to figural), or searching memory for further knowledge/beliefs with which to elaborate information (primitive SMART cognitive operations; Winne, 1989).

Functions of Feedback

Instruction aims to help students construct and deepen understandings in domains such as physics, art, and history, as well as the domain of self. Our model indicates that students' prior knowledge and beliefs inherently influence how learning proceeds. Feedback, regardless of its source, is contextualized according to a student's prior knowledge and beliefs before cognitive tactics and strategies are applied. Thus, as prior reviews have concluded, feedback that informs students only about content in a domain is minimally sufficient to affect knowledge construction. At such minimal levels, feedback merely provides informational capital for modifying knowledge or beliefs.

Actively metacognitive students may monitor outcomes for the correspondence (or lack of it) between current understandings and understandings suggested by feedback. In this, students may self-generate feedback about how to approach learning more effectively in the future. However, research clearly indicates that this is uncommon (Corno, 1993; Salomon & Perkins, 1989). To better guide learning in authentic complex tasks, we propose that feedback should provide information about cognitive activities for learning (Winne, 1982, 1985) and about relations between cues and successive states of achievement (Balzer et al., 1989; Winne, in press). At a second level, then, feedback can guide students toward more productive engagement in learning activities. We propose that more productive feedback messages have two facets, providing (a) information about a domain and (b) information for guiding tactics and strategies that process the domain-specific information. We illustrate this proposition through two examples below. In each, we chart factors that might impede students' learning, thereby identifying targets that externally provided feedback might address.

Targeting knowledge and beliefs. In a review of research on teachers' correctives to students' reading miscues and wrong answers to orally posed questions about texts, Meyer (1986) identified four errors reflected in students' incorrect answers: (a) lack-of-information errors, where students' mistakes could be traced to missing knowledge; (b) motor errors, where students knew an answer but were unable to express the information; (c) confusions, where students failed to discriminate correctly between concepts or ideas; and (d) rule application errors, where students incorrectly applied rules in problem-solving situations. Meyer argued that feedback should be tailored to each kind of misunderstanding. Chinn and Brewer's (1993) review of research on conceptual change in science suggests a fifth impediment to achievement: students' entrenched theories or schemes that compete with scientifically accepted theories for explaining the same phenomena (see also Burbules & Linn, 1988).

Relative to these five kinds of comprehension difficulties, we propose five functions that feedback can serve (see also Rumelhart & Norman, 1978). First, when students' conceptual understandings or beliefs are consistent with instructional objectives, feedback can *confirm* that condition. Second, if students lack information (e.g., Meyer's lack-of-information errors), feedback can help students *add* information, thereby elaborating and enriching prior knowledge. Third, where elements of prior knowledge are incorrect or prior beliefs are inappropriate, feedback can provide information to replace or *overwrite* those propositions. Fourth, if students' understandings are basically correct, they still may need to *tune* those understandings, for example, by discriminating between concepts (e.g., Meyer's confusion errors) or by specifying conditions for applying learned rules (e.g., Meyer's rule application errors). Fifth, if students hold false theories that are incompatible with new material to be learned, they may need to completely *restructure* schemata with which information in the domain is represented.

Targeting cognitive processing. Spurring changes in knowledge requires that students themselves engage in learning activities. If students experience difficulties in carrying out forms of cognitive processing, then instructors might consider providing feedback that is targeted at enhancing students' cognitive engagements with tasks. Because tactics and strategies are themselves forms of knowledge, this calls for feedback that assists students in confirming, adding to, overwriting, tuning, or restructuring tactics and strategies. Targeting feedback at the tactics and strategies that drive cognitive processing may offer an additional advantage by facilitating students' subsequent maintenance and transfer of those tactics and strategies (Corno, 1993).

In Table 1, we recap the difficulties learners might experience in implementing cognitive strategies and in monitoring, and suggest aspects of knowledge or processes that feedback might address so as to support learning. Our organization highlights the interdependence between knowledge and cognitive processing—procedural knowledge "in action"—during learning events.

Feedback's Roles in Changing Products of Learning

Traditional feedback studies. By far the most common question investigated in research on feedback is how various operationally definable characteristics of feedback (e.g., timing, amount of information, type of information presented) affect students' domain knowledge. We label these feedback studies *traditional* to acknowledge their prevalence in the literature, because they are the subject of prior reviews (Bangert-Drowns et al., 1991; Kulik & Kulik, 1988; Kulhavy & Stock, 1989), and because they serve as a point of comparison from which new visions of feedback are emerging.

In traditional studies, the feedback message almost always includes information about the correctness of a response (outcome feedback). This may be paired with content-related information (e.g., an explanation about why a response is correct). The target of instruction in these studies is students' domain knowledge. Most studies acknowledge that cognitive processing is cued by feedback and adopt a theoretical view of feedback that suggests that if feedback cues active and elaborate processing of content (deep processing) then achievement will increase. Thus, externally provided feedback is presumed to influence active processing and, thereby, affect cognitive products and observable reflections of those products.

Experiments by Schroth (1992) and Andre and Thieman (1988) are representative of traditional studies surveyed in recent reviews (Bangert-Drowns et al., 1991; Kulik & Kulik, 1988; Kulhavy & Stock, 1989). They address the characteristics of externally provided feedback most often investigated, namely, timing and information load (i.e., amount of information in the feedback message).

Schroth (1992). Schroth examined the effects of varying the timing and content of feedback on the number of trials students required to learn conjunctive concepts in a first study session and again a week later. The concepts' three defining dimensions—letters (X, H, O), colors (blue, red, green), and size (small, medium, large)—were first described to all participants. Then, students were presented instances of a concept and asked to classify each as an example or a nonexample. Feedback varied on two dimensions. The first was timing; students received feedback either 0, 10, 20, or 30 seconds after classifying an instance. The second was completeness; students received feedback after right responses only, after wrong responses only, or after both right and wrong responses.

In this study, immediate feedback helped students learn concepts in fewer trials in the first study session, but students who had received delayed feedback in the first session learned concepts more quickly on the transfer test a week later. More complete feedback led to faster acquisition of concepts during the first study session. On the delayed test, however, when all students received complete feedback, the completeness of feedback received during the first study session had no persistent effects.

TABLE 1
Reasons students might fail to implement cognitive strategies or monitor effectively, and roles feedback could play to redress resulting deficits

Reasons for difficulty in . . .		Feedback's potential roles	
Implementing strategies	Monitoring	Knowledge needing development	Processes needing improvement
Fails to recognize task conditions that should cue strategy use		Add to or tune knowledge about tasks	Analyzing tasks, setting goals
Misperceives task conditions (cues), thereby selecting the wrong strategies	Misperceives task conditions (cues), thereby setting inappropriate criteria for judging performance	Overwrite, tune, or restructure knowledge about tasks; tune knowledge about strategies	Analyzing tasks, setting goals, selecting strategies, monitoring
	Perceives task cues but fails to recognize relationships between cues and performance (e.g., the learner isn't calibrated)	Add to, tune, or restructure knowledge about tasks; add to, tune, or restructure knowledge about strategies	Analyzing tasks, setting goals, monitoring
Experiences problems executing selected strategies	Overly challenged by cognitive demands while monitoring	Tune knowledge about tasks (assembling or chunking); tune and automate knowledge about strategies	Selecting and implementing strategies, monitoring
Skimps on effort to deploy strategies	Lacks motivation to monitor and adjust performance	Add to, overwrite, tune, or restructure knowledge about action control strategies; add to, overwrite, tune, or restructure motivational beliefs; add to, overwrite, tune, or restructure epistemological beliefs	Selecting and implementing action control strategies, monitoring

In their meta-analysis, Kulik and Kulik (1988) explored the relative benefits of immediate versus delayed feedback using the results of studies like Schroth's (1992). To explain heterogeneous findings, Kulik and Kulik examined the types of tasks in which immediate or delayed feedback were presented. They reported that immediate feedback generally enhanced learning in classroom or programmed instruction settings where students studied, had questions posed to them, answered the questions, received feedback on those responses, and finally took a test with new, parallel test items. Delayed feedback was superior in test acquisition tasks, that is, situations in which students studied material, took a test on which items sampled the full set of information studied, received feedback on their answers to test items, and then responded again to the same test items.

In accounting for delayed feedback's superiority in test acquisition tasks, Kulik and Kulik (1988) advanced two hypotheses. In each, feedback functioned to confirm or overwrite associations between question stems and responses. Following Kulhavy (1977), one hypothesis was that in the interval between initial study and feedback, students forgot an initial incorrect response that could interfere with learning a new, correct response. The second hypothesis concerned the benefits of learning that is distributed over massed practice (see Dempster, 1989). Specifically, when feedback is immediate, learning correct responses is massed into one session, whereas when feedback is delayed, learning is distributed over trials.

Contrary to Kulik and Kulik's (1988) synthesis, Schroth (1992) found that immediate feedback was superior only in the first study session but not a week later. In contrast, in the second study session, students who had experienced delayed feedback during the first session learned *new* concepts faster than students who had received immediate feedback a week earlier. In other words, students who experienced immediate feedback showed no transfer whereas students who received delayed feedback seemed to show transfer effects. Because the domain of concepts was meaningless, Schroth conjectured that students in the delayed feedback condition might have used the time before feedback to consider hypotheses and generate principles about learning in concept formation tasks. Schroth's conjecture reassigns the locus of effect for delayed outcome feedback from qualities of domain information stored in memory to tactical approaches the learner takes to learn.

These results allow that differential effects associated with immediate and delayed feedback may reflect a joint function of the learning task and the kinds of cognitive processing cued in the context of that task (McGinn & Winne, 1994). Thus, if transfer of tactics for learning is the objective, delaying feedback to provide students time to reflect on *how* they learn may be more effective. Such reexamination is a hallmark of SRL.

Andre and Thieman (1988). These researchers explored the impact of inserted questions and varying kinds of feedback on students' active processing of text information. In the first of two studies, students read a text and answered questions inserted in the text that required retrieval of factual information, application of concepts, or a mix of both. After study, the students received either no feedback, correct-answer feedback on their answers to inserted questions, or a copy of the passage with instructions to find the correct answers to inserted questions. The posttest measured achievement using questions repeated from the set students already had seen, plus new questions. Andre and Thieman reasoned that (a) new application questions assessed deeper learning, (b) previously unseen factual questions would measure incidental learning of details, and (c) repeated questions of either type would evaluate students' acquisition of the particular information asked about in the questions attempted during study.

Andre and Thieman hypothesized that the students who generated their own feedback, by reviewing the text to determine whether their answers to inserted questions were correct or not, would engage in the most active processing. Therefore, Andre and Thieman reasoned, those students should score better than others on new application questions. This hypothesis was denied. Students who received correct-answer feedback and students who generated their own feedback did not differ on answers to new application questions or new factual questions, nor did they differ from students who received no feedback at all. However, compared to students who received correct-answer feedback or no feedback at all, students who generated their own feedback achieved higher posttest scores on repeated questions. Feedback that cued deeper processing of specific information enhanced learners' memory for that information on repeated questions.

In another meta-analysis, Bangert-Drowns et al. (1991) summarized research on the effects associated with differences in feedback content. Consistent with Balzer et al.'s (1989) finding that cognitive feedback was generally superior to outcome feedback for decision-making tasks, Bangert-Drowns et al. found that feedback including any type of elaborated information was reliably more helpful than feedback that simply informed the learner whether a response was correct or incorrect. Like Kulik and Kulik (1988), Bangert-Drowns et al. encountered heterogeneous findings. They used statistical criteria to isolate, out of seven variables that they had deemed potentially influential, four that most uniquely accounted for the variance in research findings. These four variables were: (a) the amount of information carried in the feedback message (load), (b) whether students had an opportunity to access feedback before searching memory for their own responses (control for presearch availability), (c) whether students were pretested on content, and (d) the format of instruction (programmed instruction, computer-assisted instruction, text comprehension, or classroom testing). Bangert-Drowns et al. concluded that feedback is more effective when there are fewer cues, organizers, and instructional supports available to support study. This seems sensible because if initial learning is less well supported, then depressed or erroneous acquisition allows feedback to have a positive effect. They also concluded that more effective feedback tends to cue "mindful" processing of information in the feedback message and in the material to be learned.

Schroth's (1992) and Andre and Thieman's (1988) findings are consistent with Bangert-Drowns et al.'s (1991) analysis. In Andre and Thieman's study, compared to plain outcome feedback, feedback that cued more active processing had a greater effect, although only in the context of a test-acquisition task. In Schroth's study, when students had time before feedback was presented to think about their learning (analogous to a situation where presearch availability is controlled and feedback is withheld until students have an opportunity to process information), tactics for learning new concepts improved.

Kulhavy and Stock's (1989) model of feedback processing and extensions. Kulhavy and Stock examined the traditional feedback literature, focusing on test-acquisition tasks (where students answer multiple-choice questions, receive feedback, then answer the same questions again). Paralleling the tack taken in reviews by Kulik and Kulik (1988) and Bangert-Drowns et al. (1991), Kulhavy and Stock sought to account for differences in feedback's effects by positing a mediating factor, certitude, defined as a student's metacognitive judgment of confidence in an initial response to a test item. When external feedback is provided about the correctness of an answer, certitude interacts with the feedback message to produce a perception of discrepancy. High certitude in an initial answer followed by correct feedback produces a low or zero value of discrepancy (because students are confident in their answers and feedback confirms that their answers are indeed correct). In contrast, the highest values of discrepancy arise when confidence is high but feedback indicates that answers are incorrect. Low levels of confidence yield intermediate levels of discrepancy. Kulhavy and Stock propose that the greater the discrepancy, the more motivated a student is to reduce tension, and the greater the effort he or she makes to process feedback and correct the error. Thus, Kulhavy and Stock add to the traditional conceptions of feedback an explicit recognition that learners (a) set goals and (b) monitor performance in relation to those goals. The cognitive product of this monitoring, a perception of discrepancy, describes the learner's perception of the relationship between the current state of the task and desired outcomes. This defines cues (Balzer et al., 1989) for further action.

Kulhavy and his colleagues' studies (e.g., Hancock, Stock, & Kulhavy, 1992; Kulhavy & Stock, 1989; Kulhavy, Yekovich, & Dyer, 1979) generally support the model of discrepancy's effects. Higher levels of discrepancy are associated with greater time spent processing feedback messages and with a higher probability of correcting initially erroneous answers on a retest. These results are also consistent with our model of self-regulation: monitoring (perceptions of discrepancy) influences goals students set, which affects subsequent cognitive tactics applied (time spent processing feedback), influencing performance (correcting erroneous responses).

Recently, Kulhavy and Stock's model has been elaborated. Several researchers noted that in studies by Kulhavy and his colleagues, high discrepancy did not always lead to error correction (Hancock, Hubbard, & Thurman, 1992; Peterson & Swindell, 1991). This led Hancock et al. to reexamine data on initially wrong responses where certitude was high (high discrepancy) and to record (a) the time spent processing the feedback message and (b) whether the error was ultimately corrected. They found that although devoting extra time to processing feedback increased the probability that errors were corrected, high discrepancy was an inconsistent predictor of time spent processing feedback. They speculated that learners might not hold the same goal for each test item, thereby mediating the relation between the correctness of a response, the perceived discrepancy (identified by monitoring), and the effort applied (tactics) to processing feedback.

A subsequent study by Schutz (1993) lends support to Hancock et al.'s (1992) hypothesis. After students completed a set of lessons, Schutz asked them to (a) set a goal by indicating the percentage of questions they hoped to answer correctly on a test, (b) rate how committed they were to their goal, and (c) rate how confident they were in their ability to reach their goal. Students then answered comprehension questions, rated the certitude of each response, and received feedback indicating whether the response was correct. Students were also provided an option to view additional feedback information ("Would you like to see more information about the answer to this question?"). If students chose this option, they were provided additional information about the concept tested in that item. For each response, Schutz calculated the degree of predicted discrepancy based on students' certitude relative to the correctness of the response. Consistent with Kulhavy's model, effort devoted to processing feedback, measured by the amount of feedback requested, was proportional to discrepancy. Consistent with Hancock et al.'s (1992) hypothesis, for high-confidence errors, requests for additional feedback information were more likely when students held higher goals for performance (e.g., 100% vs. 70% correct), and were more committed to and confident in their ability to reach their goals.

Hancock et al.'s (1992) and Schutz's (1993) studies make explicit a proposition in Kulhavy and Stock's model, that students' perceptions of discrepancy depend on the goals they hold for learning. In our terms, the goals students adopt (e.g., to score 90% correct on a test) serve as an input to monitoring. When compared to the state of the task (e.g., whether a given item was answered correctly or how many items were answered correctly overall), monitoring produces information (e.g., I didn't answer this question correctly, and I've answered only 75% correctly) that can correspond to conditions (IFS) in rules. These IFS are cues (Balzer et al., 1989) that trigger actions (THENS) in the form of cognitive tactics and strategies (e.g., to study the feedback information). Thus, self-regulating actions about studying specific test items, a hierarchically lower contributor to reaching the overall goal set for a test, are evoked when discrepancy is high and when confidence (self-efficacy) in the ability to reach goals is high (Carver & Scheier, 1990).

What role does internal feedback play in Kulhavy and Stock's model? Kulhavy and Stock (1989) suggest that as students complete tasks, they generate metacognitive judgments of certitude that contrast goals (e.g., to learn a particular concept) with performance (e.g., success in answering a question on that concept correctly; see Figure 2). When students perceive a discrepancy, which goal is compared to which current state of the task? What is monitored? The answer to this question is critical because it determines the output of monitoring, that is, the information that sets conditions for adapting performance.

According to Kulhavy and Stock (1989), the answer is that monitoring focuses on discrepancies of content—discrepancies between content that has been learned and content that was identified as a goal to be learned. But if students vary their cognitive engagement in response to discrepencies between content goals and actual content learned, they should do so whenever they answer incorrectly, regardless of initial response confidence. Therefore, in addition to the discrepency between goals and cognitive products, we propose a second possibility. Specifically, we hypothesize that students monitor their *calibration*, that is, the extent to which monitoring creates accurate judgments of certitude. Kulhavy and Stock's model contains the seed for our prediction given that, by their definition, discrepency arises when judgements of certitude are inaccurate (e.g., high-confidence errors). We suggest that high-confidence errors lead to more intense re-study because it is under these conditions that calibration is worst. In such cases, the feedback students receive is very unexpected, which, according to Carver and Scheier (1990), triggers a self-regulating adjustment to the process responsible for causing that salient event. In this case, that process is monitoring.

This analysis implies that external feedback providing information about students' domain understandings can lead them to generate information about monitoring, specifically, about the cues they use to calibrate learning. In lens modeling terms (Balzer et al., 1989), external feedback attending high-confidence errors will trigger monitoring that generates internal feedback in the form of functional validity information (e.g., the relationship between the learner's estimate of achievement and actual performance). An important corollary of this logic is that learners do not enter tasks as monitoring "blank slates." Self-regulation is inherent when conditions highlight inadequacies of calibration, as in the case of high-confidence errors.

Feedback's Roles in Changing Learning Processes

We have just shown that incidentally provided external feedback may provide information students use to monitor calibration, a meta-monitoring or self-regulating function. It influences how students cognitively engage with a task within which a goal is learning domain information. Other forms of externally provided feedback more directly address students' self-regulation. For example, in contrast to outcome feedback, cognitive feedback (Balzer et al., 1989) provides information (task validity, cognitive validity, functional validity) that supports meta-monitoring. Underlying Meyer's (1986) corrective procedures specific to each of four types of comprehension problems (lack-of-information errors, motor errors, confusions, and rule application errors) is an assumption that feedback guides students' cognitive processing to effect repairs in comprehension. We next explore several lines of research that seek explicitly to influence how students cognitively engage with tasks—that is, how they self-regulate—and thereby affect learning.

Advisement. Steinberg's (1989) review of research on learner control in computer-assisted instruction included studies on learner advisement. *Advisement* is feedback that typically provides information about current comprehension levels and/or prescriptive advice about how to further engage in learning. It is feedback that aims to influence students' construction of knowledge (comprehension), not by providing content information but by influencing how students cognitively engage with tasks. As we noted earlier, Steinberg reported that, in conditions of complete learner control, students often exit instruction prematurely. This implies ineffective monitoring of how much they need to learn and, perhaps, how to go about learning it. In contrast, when students were provided advisement, including diagnostic and/or prescriptive information, persistence at learning tasks increased and performance improved.

An example of this line of research is Johansen and Tennyson's (1983) study of high school students learning to apply rules of punctuation. All students received initial instruction about these rules by means of paper-and-pencil materials with examples. Then, in a computer-assisted context, students practiced the rules under one of three conditions. In the advisement-with-learner-control condition, they solved a first set of problems under computer control. This established baseline performance. These students then received feedback describing their level of performance on each rule, relative to a mastery criterion of 75% correct, and a recommendation about which rule to study further and how much they should study. Thereafter, students selected which rule to practice and received outcome feedback. In a plain learner control condition, students solved the same initial set of problems under program control but did not receive advice. Thereafter, they selected which rule to practice and received outcome feedback. In the third condition, students completed both the initial and practice instructional phases under complete learner control without advice. Students in the advisement-with-learner-control condition learned the rules better and spent more time studying examples than other students. Students in the plain learner control group scored higher on a unit test than did students under complete learner control, who spent the least time studying.

Other studies show similar results when students are in control of their own learning. In general, learning improves when feedback informs students about their monitoring of learning needs (achievement relative to goals in prior phases of engagement) and guides them in how to achieve learning objectives (cognitive engagement by applying tactics and strategies). Because learners intrinsically regulate their study under conditions that grant the learner control over the amount and sequence of instructional tasks, these studies corroborate Balzer et al.'s (1989) findings about the relative effectiveness of functional and task validity feedback.

Strategy training studies. Strategy training research seeks two objectives. The first is enhancing students' cognitive engagement with tasks by developing declarative and procedural knowledge about tactics and strategies for engaging tasks, plus conditional knowledge about when tactics and strategies apply. Applying conditional knowledge is a form of monitoring (Winne, 1985). Monitoring is also applied whenever, as in many studies, students assess whether middle-of-the-task cognitive products achieve subgoals that they set before moving on to the next phase of a task. Achieving this first objective serves the second objective, promoting students' construction of domain knowledge.

Although externally provided feedback is intrinsic to the strategy instruction phases of these studies, few that we reviewed examined the roles of feedback separately at that point, although there were exceptions (discussed shortly). In many studies (e.g., Butler, 1994, 1995; Sawyer, Graham, & Harris, 1992), students were taught to set goals that defined task cues and provided criteria for monitoring engagement (Balzer et al., 1989) before applying an instructed strategy for achieving goals. According to our model, these conditions jointly set the stage for students to generate internal feedback about the predictive value of cues (Balzer et al., 1989) and about progress (Carver & Scheier, 1990).

Feedback in strategy training research. Recently, strategy training studies have complemented the development of cognitive tactics and strategies per se with instruction intended to promote motivational beliefs that value and support learning (Covington, 1992; Zimmerman & Martinez-Pons, 1992). Among these studies, some specifically evaluated the impact of feedback as a component of strategy training. One main line of this research has investigated the effects of providing feedback designed to influence attributions or self-efficacy (Craven, Marsh, & Debus, 1991; Relich, Debus, & Walker, 1986; Schunk, 1982, 1983, 1984; Schunk & Cox, 1986).

In attribution retraining studies, students typically receive feedback containing motivational content describing the roles of effort, ability, or strategy use in successful performance. In Schunk and Cox's (1986) attribution retraining study, for example, all students learned the same strategies for solving subtraction problems requiring regrouping. Nine conditions differed, first, in terms of the amount of overt verbalization required while students were solving practice problems (during all six sessions, during the first three sessions only, or not at all) and, second, in terms of when effort feedback was provided (during the first three sessions only, during the last three sessions only, or not at all). Externally provided effort feedback entailed telling students at regular intervals that they were working hard. Schunk and Cox hypothesized that self-verbalization about using the strategy would help the students regulate task performance and tackle tasks in a more systematic manner, and would thereby enhance performance. Verbalizations should also allow students to perceive greater control over their learning, and thereby raise perceptions of self-efficacy. Finally, the researchers hypothesized that effort feedback would influence students' attributions, their perceptions of self-efficacy, and ultimately their performance by influencing task persistence and the effort expended.

Students who verbalized through all six sessions completed more problems correctly and had higher perceptions of self-efficacy than those who verbalized through only three sessions, who in turn outperformed those who did not verbalize at all. Our interpretation is that the more students verbalized about using the strategies, the more they were cued to monitor cognitive engagement that otherwise might not have been attended to (McKoon & Ratcliff, 1992). That monitoring helped students regulate task performance. Schunk and Cox (1986) also found that students who received effort feedback at any time during training solved more problems correctly and had higher perceptions of self-efficacy.

An important note about Schunk and Cox's (1986) study is that the effort feedback was not contingent on students' actually applying effort to solve problems. As Schunk and Cox recognize, it may be important to tie students' effort more explicitly to strategies and actual achievements. Further, whether effort feedback is or is not advantageous may depend on an individual's level or quality of skill.

A study by Schunk and Swartz (1992) examined the impact on learning of feedback targeted not at performance or motivational beliefs but at the processing students engage to address tasks. In this study, all participants were provided with the same strategy training, and all received similar performance feedback about how well they wrote different types of paragraphs. Within this context, however, three groups of students were provided either performance goals (to learn to write a specific type of paragraph), strategy goals (to learn the steps involved in writing paragraphs of different types), or strategy goals plus progress feedback that reported how well students were learning to use their strategies in writing different kinds of paragraphs. Strategy goals plus progress feedback resulted in the greatest pretest-to-posttest gains in both task performance and perceptions of self-efficacy. The researchers suggested that feedback about the learning process helped students better assess their skills and link the strategy with desired outcomes.

Our interpretation is that the students in Schunk and Cox's (1992) study generated internal feedback by monitoring their rate of progress as well as the predictive value of cues in the task, generating positive affect (Carver & Scheier, 1990) and appreciation of the utility of effortfully applying a strategy (Balzer et al., 1989; Eisenberger, 1992; Schommer, 1990). Thus, not only were domain-specific skills constructed by students as they mastered writing strategies, but useful knowledge about the task and motivational beliefs were also developed.

Summary

The foregoing selection of research strongly suggests that learners' knowledge, beliefs, and thinking jointly mediate the effects of externally provided feedback. This mediation is the funneling through monitoring of information about various topics—task, self, epistemological characteristics of knowledge, goals, and cognitive tactics and strategies—to confirm, overwrite, add to, tune, or restructure extant knowledge and beliefs. That is, it is this mediation that offers an account of how knowledge is constructed in the process of learning. When studies in the vein of traditional feedback research are reexamined within a broadly framed model of self-regulation, findings reveal more about learning and begin to coalesce. Inductively, it follows that future research linked to a newer and more inclusive tradition of self-regulation may bind heretofore separate lines of research and yield more information for advancing both theory and application.

Conclusions

Guiding students' construction of knowledge entails providing them with or arranging for them to have access to information resources upon which processes of construction must draw. We have argued that SRL is inherent in knowledge construction—learning—though it may be carried out suboptimally or may be oriented in a way contrary to objectives set by educators (see also Winne, in press). Monitoring is the hub of self-regulated task engagement and the internal feedback it generates is critical in shaping the evolving pattern of a learner's engagement with a task. Our model of SRL, depicted in Figure 1, explicitly identifies this role for monitoring and feedback. Also, it acknowledges that feedback information blends with other information to affect a learner's knowledge and beliefs about the domain and tasks, learning processes and products, and performance.

In the context of research on learning, it is clear that students sometimes experience difficulties. Framed in terms of self-regulation, difficulties can arise when students examine information about a task's structure, adopt or set their own goals, select and implement the cognitive tactics and strategies that constitute learning, and monitor their performance. Feedback is information with which a learner can confirm, add to, overwrite, tune, or restructure information in memory, whether that information is domain knowledge, metacognitive knowledge, beliefs about self and tasks, or cognitive tactics and strategies (Alexander et al., 1991). Differentiating these functions of feedback using a broadly framed model of self-regulation, such as the one we propose, both illuminates how traditional research on feedback has focused too narrowly on feedback's effects on achievement and allows a synthesis of diverse studies on feedback and instruction. Adopting a more inclusive view of how feedback contributes to self-regulation suggests that research must attend to interacting factors that jointly affect events in patterns of engagement that unfold as successively recursive states.

Finally, the model we propose suggests a schema for planning future research that integrates instruction, self-regulation, feedback, and knowledge construction.

Such research likely should complement studies that describe averaged qualities of achievements characteristic of a group of students with research focused on idiographic, fine-grained analyses of the activities in which single students engage as they learn (e.g., Butler, 1994, 1995) and the patterns of these activities that lead to successively updated, improved performance (see Winne et al., 1994). Such a stereoscopic view may advance our understandings faster than either monocular representation.

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