Focus on Formative Feedback

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Abstract

This paper reviews the corpus of research on feedback, with a particular focus on formative feedback—defined as information communicated to the learner that is intended to modify the learner's thinking or behavior for the purpose of improving learning. According to researchers in the area, formative feedback should be multidimensional, nonevaluative, supportive, timely, specific, credible, infrequent, and genuine (e.g., Brophy, 1981; Schwartz & White, 2000). Formative feedback is usually presented as information to a learner in response to some action on the learner's part. It comes in a variety of types (e.g., verification of response accuracy, explanation of the correct answer, hints, worked examples) and can be administered at various times during the learning process (e.g., immediately following an answer, after some period of time has elapsed). Finally, there are a number of variables that have been shown to interact with formative feedback's success at promoting learning (e.g., individual characteristics of the learner and aspects of the task). All of these issues will be discussed in this paper. This review concludes with a set of guidelines for generating formative feedback.

Key words: Assessment, formative feedback, directive feedback, facilitative feedback, learning, performance, individual differences, goal orientation, motivation, task characteristics

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1. Introduction

It is not the horse that draws the cart, but the oats. –Russian proverb

Feedback used in educational contexts is generally regarded as crucial to improving knowledge and skill acquisition (e.g., Azevedo & Bernard, 1995; Bangert-Drowns, Kulik, Kulik, & Morgan, 1991; Corbett & Anderson, 1989; Epstein et al., 2002; Moreno, 2004; Pridemore & Klein, 1995). In addition to its influence on achievement, feedback is also depicted as a significant factor in motivating learning (e.g., Lepper & Chabay, 1985; Narciss & Huth, 2004). However, for learning, the story on feedback is not quite so rosy or simple.

According to Cohen (1985), feedback "… is one of the more instructionally powerful and least understood features in instructional design" (p. 33). In support of this claim, consider the hundreds of research studies published on the topic of feedback and its relation to learning and performance during the past 50 years (for excellent historical reviews, see Bangert-Drowns et al., 1991; Kluger & DeNisi, 1996; Kulhavy & Stock, 1989; Kulhavy & Wager, 1993; Mory, 2004; and Narciss & Huth, 2004). Within this large body of feedback research, there are many conflicting findings and no consistent pattern of results.

Consider just one facet of feedback: elaboration (i.e., explanatory information within a feedback message). Some studies report that elaborative feedback produces significantly greater learning among students compared with feedback containing less information (e.g., Albertson, 1986; Grant, McAvoy, & Keenan, 1982; Hannafin, 1983; Moreno, 2004; Pridemore & Klein; 1995; Roper, 1977; Shute, 2006). However, other studies show that increasing the amount of feedback information has no effect on learning or performance (e.g., Corbett & Anderson, 1989, 1990; Gilman, 1969; Hodes, 1985; Kulhavy, White, Topp, Chan, & Adams, 1985; Merrill, 1987). The goal of this paper is to try to make sense of the tangled web of formative feedback research and its relationship to learning. I start by defining relevant terms.

1.1 Definition of Formative Feedback

Formative feedback represents information communicated to the learner that is intended to modify the learner's thinking or behavior for the purpose of improving learning. And while the teacher may also receive formative feedback and use it as the basis for altering instruction, I focus on the student (or more generally, the learner) as the primary recipient of formative feedback in this review.

Information within the feedback may address the accuracy of a response to a problem or task and may additionally touch on particular errors and misconceptions (Azevedo & Bernard, 1995; Birenbaum & Tatsuoka, 1987; Cheng, Lin, Chen, & Heh, 2005; Cohen, 1985; Kulhavy, 1977; Sales, 1993; Sleeman, Kelly, Martinak, Ward, & Moore, 1989), the latter representing more specific or elaborated types of feedback. To be effective, formative feedback should permit the comparison of actual performance with some established standard of performance (Johnson & Johnson, 1993). The definition of formative feedback may be further refined as multidimensional, nonevaluative, supportive, learner-controlled, timely, specific, credible, infrequent, contingent, and genuine (e.g., Brophy, 1981; Schwartz & White, 2000).

In technology-assisted instruction, similar to classroom settings, formative feedback comprises information—a message, display, and so on—presented to the learner following the learner's input (or upon request, if applicable), with the purpose of shaping the perception, cognition, or action of the learner (e.g., Moreno, 2004; Schimmel, 1983; Wager & Wager, 1985). The main goal of formative feedback—whether delivered by a teacher or computer, in the classroom or elsewhere—is to enhance learning and/or performance, engendering the formation of accurate, targeted conceptualizations and skills. Such feedback may be used in conjunction with low- or medium-stakes assessments, include diagnostic components, and even be personalized for the learner (Albertson, 1986; Azevedo & Bernard, 1995; Narciss & Huth, 2004; VanLehn, 1982).

The premise underlying most of the research conducted in this area is that good feedback can significantly improve learning processes and outcomes, if delivered correctly. Those last three words—if delivered correctly—comprise the crux of this review. This paper reviews the literature on feedback, with the goal of cataloging and categorizing key facets (i.e., types and timing), in addition to other variables with which they are known to interact (e.g., learner states and traits and task complexity).

1.2 Goals of the Review

The dual aims of this paper are to (a) present findings from an extensive literature review of feedback to gain a better understanding of the features, functions, interactions, and links to learning and (b) apply the findings from the literature review to create a set of guidelines relating to formative feedback. The overarching goal is to identify the particular features of formative

feedback that are the most effective and efficient in promoting learning and determine under what conditions that learning support holds.

This is not an easy task. The vast literature reveals dozens of feedback types that have been subjected to experimental scrutiny—accuracy of the solution, topic contingent, response contingent, attribute isolation, worked examples, hints, and partial solutions. However, different studies report disparate findings regarding the same feedback variable. In addition, formative feedback variables have been shown to interact with other variables, such as student achievement level, task level, and prior knowledge. Again, my goal is to capture and integrate these feedback features so to begin to define prescriptions relating to formative feedback and its appropriate delivery.

1.3 Focus of the Review

This review focuses on task-level feedback as opposed to general summary feedback. Task-level feedback typically provides more specific and timely (often real-time) information to the student about a particular response to a problem or task compared to summary feedback, and it may additionally take into account the student's current understanding and ability level. For instance, a struggling student may require greater support and structure from a formative feedback message than a proficient student. On the other hand, summary information is useful for teachers to modify instruction for the whole class and for students to see how they are generally progressing.

Some of the major questions addressed in this review include: What are the most powerful and efficient types of formative feedback and under what conditions do these different types of feedback help a learner revise a skill or improve understanding? What are the mechanisms by which feedback facilitates the transformation of rudimentary skills into the competence of a more expert state? Answers to these questions can facilitate the design and development of teacher-delivered or automated feedback to support learning.

This paper begins with a summary of the methods used to accomplish the literature review, followed by an extensive review of formative feedback research, which comprises the bulk of the paper. Afterwards, I showcase four important feedback articles, each associated with a theoretically and empirically based model of formative feedback. I conclude with specific recommendations for using formative feedback that are supported by the current literature review and discuss future research in the area.

<h1 align="center">2. Method</h1>

2.1 Procedure

I began my research by working with colleagues to identify seminal articles in the feedback literature (i.e., from sites that provide indices of importance such as CiteSeer) and then collecting the relevant documents. The bibliography compiled from this initial set of research studies spawned a new collection-review cycle, garnering even more articles and continuing iteratively throughout the review process.

The following online databases were employed in our search-collection efforts:

- *ERIC* (Educational Resources Information Center) contains information on educational reports, evaluations, and research, including data from *Resources in Education Index* and *Current Index to Journals in Education*.

- *PsycINFO,* from the American Psychological Association, includes citations and summaries of scholarly journal articles, book chapters, books, and dissertations in psychology and related disciplines.

- *PsycARTICLES* is a source of full-text, peer-reviewed scholarly and scientific articles in psychology. The database covers general psychology and specialized, basic, applied, clinical, and theoretical research. It contains articles from 56 journals (45 published by the American Psychological Association and 11 from allied organizations).

- *Academic Search Premier* offers information in many areas of academic study including computer science, engineering, physics, language and linguistics, and so forth.

- *MasterFILE Premier,* designed specifically for public libraries, covers a broad range of disciplines including general reference, business, education, health, general science, and multicultural issues.

In addition to these databases, other research sources included the online catalogs at the libraries at ETS and the University of Pennsylvania, which were used to access their electronic collections of journals and research studies. Another source was Google Scholar—a Web site providing peer-reviewed papers, theses, books, abstracts, and articles from academic publishers,

professional societies, preprint repositories, universities, and other scholarly organizations, to search for and acquire specific references.

2.2 Inclusion Criteria

The review focused on full-text documents, accessed using various search terms or keywords such as feedback, formative feedback, formative assessment, instruction, learning, computer-assisted/based, tutor, learning, and performance. Searches were not limited to a particular date range, but did include the most recent research in the literature review. In all, approximately 170–180 articles, dissertations, abstracts, books, and conference proceedings were collected. From this larger set, a total of more than100 documents met the study's criteria for inclusion into the literature review. Inclusion criteria consisted of topical relevance, use of experimental design, and/or meta-analytic procedures (albeit, this selection process was more akin to that of community colleges than ivy-league universities). The majority of the documents were journal articles (103), followed by books and book chapters (24), conference proceedings (10), and other (e.g., research reports, 4).

3. Literature Review

As noted at the beginning of this paper, hundreds of articles have been written about feedback and its role in knowledge and skill acquisition. Many of these papers describe the results from experimental tests examining different features of feedback, and several represent important historical reviews (a few going back to the early 1900s, such as Kluger & DeNisi, 1996; Kulhavy & Stock, 1989; and Mory, 2004). Despite the plethora of research on the topic, the specific mechanisms relating feedback to learning are still mostly murky, with very few (if any) general conclusions. Researchers who have tackled the tough task of performing meta-analyses on the feedback data use descriptors such as inconsistent, contradictory, and highly variable to describe the body of feedback findings (Azevedo & Bernard, 1995; Kluger & DeNisi). Ten years later those descriptors still apply.

Feedback has been widely cited as an important facilitator of learning and performance (Bandura, 1991; Bandura & Cervone, 1983; Fedor, 1991; Ilgen, Fisher, & Taylor, 1979), but quite a few studies have reported feedback as having either no effect or debilitating effects on learning (for examples of nonfacilitative effects of feedback on learning, see Bangert-Drowns et al., 1991; Kluger & DeNisi, 1996; and Mory, 2004). In fact, about one third of the total studies

reviewed in two landmark meta-analyses (i.e., Bangert-Drowns et al.; Kluger & DeNisi) demonstrate negative effects of feedback on learning. For instance, feedback that is construed as critical or controlling (Baron, 1993) often thwarts efforts to improve performance (Fedor, Davis, Maslyn, & Mathieson, 2001). Other features of feedback that tend to impede learning include providing grades or overall scores indicating the student's standing relative to peers and coupling such normative feedback with low levels of specificity (i.e., vagueness) (Butler, 1987; Kluger & DeNisi, 1998; McColskey & Leary, 1985; Wiliam, in press; Williams, 1997). In addition, interrupting a student who is actively engaged in problem solving with feedback from an external source has too has been shown to inhibit learning (Corno & Snow, 1986). In line with the definition in this review, feedback that has negative effects on learning is not formative.

3.1 Feedback Purposes

The main aim of formative feedback is to increase student knowledge, skills, and understanding in some content area or general skill (e.g., problem solving), and there are multiple types of feedback that may be employed toward this end (e.g., response specific, goal directed, immediately delivered, and so on). In addition to various formats of feedback, there are also different functions. According to Black and Wiliam (1998), there are two main functions of feedback: directive and facilitative. Directive feedback tells the student what needs to be fixed or revised. Such feedback tends to be more specific than facilitative feedback, which provides comments and suggestions to help guide students in their own revision and conceptualization. The next section describes some of the ways that feedback may exert influences on student learning.

3.2 Cognitive Mechanisms and Formative Feedback

There are several cognitive mechanisms by which formative feedback may be used by a learner. First, it can signal a gap between a current level of performance and some desired level of performance or goal. Resolving this gap can motivate higher levels of effort (Locke & Latham, 1990; Song & Keller, 2001). That is, formative feedback can reduce uncertainty about how well (or poorly) the student is performing on a task (Ashford, 1986; Ashford, Blatt, & VandeWalle, 2003). Uncertainty is an aversive state that motivates strategies aimed at reducing or managing it (Bordia, Hobman, Jones, Gallois, & Callan, 2004). Because uncertainty is often

unpleasant and may distract attention away from task performance (Kanfer & Ackerman, 1989), reducing uncertainty may lead to higher motivation and more efficient task strategies.

Second, formative feedback can effectively reduce the cognitive load of learners, especially novice or struggling students (e.g., Paas, Renkl, & Sweller, 2003; Sweller, Van Merriënboer, & Paas, 1998). These students can become cognitively overwhelmed during learning due to high performance demands, and thus they may benefit from supportive feedback designed to decrease the cognitive load. In fact, Sweller et al. provided support for this claim by showing how the presentation of worked examples reduces the cognitive load for low-ability students faced with a complex problem-solving task. Moreno (2004) provided additional support using explanatory feedback to support novice learners.

Finally, feedback can provide information that may be useful for correcting inappropriate task strategies, procedural errors, or misconceptions (e.g., Ilgen et al., 1979; Mason & Bruning, 2001; Mory, 2004; Narciss & Huth, 2004). The corrective function effects appear to be especially powerful for feedback that is more specific (Baron, 1988; Goldstein, Emanuel, & Howell, 1968), which is described next.

3.3 Feedback Specificity

Feedback specificity is defined as the *level of information* presented in feedback messages (Goodman, Wood, & Hendrickx, 2004). In other words, specific (or elaborated) feedback provides information about particular responses or behaviors beyond just their accuracy and tends to be more directive than facilitative.

A number of researchers have reported that feedback is significantly more effective when it provides details of how to improve the answer, rather than when it just indicates whether the student's work is correct or not (e.g., Bangert-Drowns et al., 1991; Pridemore & Klein, 1995). Feedback lacking in specificity may cause students to view it as useless and/or frustrating (Williams, 1997). It can also lead to uncertainty about how to respond to the feedback (Fedor, 1991) and may require greater information processing activity on the part of the learner to understand the intended message (Bangert-Drowns et al.). Uncertainty and cognitive load can lead to lower levels of learning (Kluger & DeNisi, 1996; Sweller et al., 1998), or even reduced motivation to respond to the feedback (Ashford, 1986; Corno & Snow, 1986).

In an experiment that tested feedback specificity and its relationship to learning, Phye and Sanders (1994) tested two types of feedback (i.e., general advice versus specific feedback, the

latter providing the learner with the correct answer). Students were assigned to one of the two learning conditions, and they received either general advice or specific feedback as part of a verbal analogy problem-solving task. In line with the research cited above, Phye and Sanders found that the more specific feedback was clearly superior to general advice on a retention task. However, they found no significant differences between feedback types on a transfer task. They cautioned against assuming that procedures that enhance performance during acquisition (e.g., providing specific feedback) will necessarily enhance transfer to new tasks.

In summary, providing feedback that is specific and clear for conceptual and procedural learning tasks is a reasonable, general guideline. However, this practice may depend on other variables, such as learner characteristics (e.g., ability level, motivation) and different learning outcomes (e.g., retention vs. transfer tasks). In addition, the specificity dimension of formative feedback itself is not very specific, as described in the literature. More focused feedback features are reviewed in the next section.

3.4 Features of Formative Feedback

In an excellent historical review on feedback, Kulhavy and Stock (1989) reported that effective feedback provides the learner with two types of information: verification and elaboration. Verification is defined as the simple judgment of whether an answer is correct, and elaboration is the informational aspect of the message that provides relevant cues to guide the learner toward a correct answer. Researchers appear to be converging toward the view that effective feedback should include elements of both verification and elaboration (e.g., Bangert-Drowns et al., 1991; Mason & Bruning, 2001). These features are now described in more detail.

Verification. Confirming whether an answer is correct can be accomplished in several different ways. The most common way involves simply stating whether the answer is correct or incorrect. With computers, there are more options—some of which are explicit and some more implicit. Among explicit verifications, highlighting or otherwise marking a response to indicate its correctness (e.g., with a check mark) can convey the information. Implicit verification can occur when, for instance, a student's response yields expected or unexpected results (e.g., within a simulation). This review focuses more on explicit than implicit feedback as the former is more readily subject to experimental controls.

Elaboration. Feedback elaboration has even more variations than verification. For instance, elaboration can (a) address the topic, (b) address the response, (c) discuss the particular

error(s), (d) provide worked examples, or (e) give gentle guidance. The first three types of elaborated feedback are more specific and directive, while the last two types are more general and facilitative.

In general, elaborated feedback usually addresses the correct answer and may additionally explain why the selected response is wrong and indicate what the correct answer should be. There seems to be growing consensus that one type of elaboration, response-specific feedback, appears to enhance student achievement, particularly learning efficiency, more than other types of feedback, such as simple verification or answer until correct (e.g., Corbett & Anderson, 2001; Gilman, 1969; Mory, 2004). However, as will be discussed in Section 3.9 (see "Goal Orientation"), feedback specificity has been shown to affect performance by way of an interaction with learners' goal orientations.

3.5 Feedback Complexity/Length

While more specific feedback may be generally better than less specific feedback (at least under certain conditions), a related dimension to consider in generating feedback is one of length or complexity of the information. For example, if feedback is too long or too complicated, many learners will simply not pay attention to it, rendering it useless. Lengthy feedback can also diffuse or dilute the message. Feedback complexity thus refers to how much and what information should be included in the feedback messages.

Many research articles have addressed the issue of feedback complexity, but only a few have attempted to array the major variables along a dimension of complexity (albeit, see Dempsey, Driscoll, & Swindell, 1993; Mason & Bruning, 2001; and Narciss & Huth, 2004). I have aggregated information from their respective lists into a single compilation (see Table 1), arrayed generally from least to most complex information presented. Terms appearing in the feedback type column are used throughout the remainder of this paper.

If formative feedback is to serve a corrective function, even in its simplest form it should (a) verify whether the student's answer is right or wrong and (b) provide information to the learner about the correct response (either directive or facilitative). Studies that have examined the type and amount of information in feedback, however, have shown inconsistent results (see Kulhavy, 1977, and Mory, 2004, for summaries of the range of results). Some specific findings on the feedback complexity issue are described below.

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Table 1

Feedback Types Arrayed Loosely by Complexity

Feedback type	Description
No feedback	Refers to conditions where the learner is presented a question and is required to respond, but there is no indication as to the correctness of the learner's response.
Verification	Also called *knowledge of results* (KR), or *knowledge of outcome*, it informs the learner about the correctness of her response(s), such as right/wrong or overall percentage correct.
Correct response	Also known as *knowledge of correct response* (KCR), it informs the learner of the correct answer to a specific problem with no additional information.
Try-again	Also known as *repeat-until-correct* feedback, it informs the learner about an incorrect response and allows the learner one or more attempts to answer the question.
Error-flagging	Also known as *location of mistakes* (LM), error-flagging highlights errors in a solution, without giving correct answer.
Elaborated	A general term, it refers to providing an explanation about why a specific response was correct, and it might allow the learner to review part of the instruction. It also might present the correct answer (see below for six types of elaborated feedback).
Attribute isolation	Elaborated feedback that presents information addressing central attributes of the target concept or skill being studied.
Topic-contingent	Elaborated feedback that provides the learner with information relating to the target topic currently being studied. This might entail simply re-teaching material.
Response-contingent	Elaborated feedback that focuses on the learner's specific response. It may describe why the answer is wrong and why the correct answer is correct. This does not use formal error analysis.
Hints/cues/prompts	Elaborated feedback that guides the learner in the right direction (e.g., strategic hint on what to do next or a worked example or demonstration). It avoids explicitly presenting the correct answer.
Bugs/misconceptions	Elaborated feedback that requires error analysis and diagnosis. It provides information about the learner's specific errors or misconceptions (e.g., what is wrong and why).
Informative tutoring	The most elaborated feedback (from Narciss & Huth, 2004), this presents verification feedback, error-flagging, and strategic hints on how to proceed. The correct answer is not usually provided.

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No effect of feedback complexity. Schimmel (1983) performed a meta-analysis on feedback as used in computer-based instruction and programmed instruction. He analyzed the results from 15 experimental studies and found that the amount of information (i.e., feedback complexity) was *not* significantly related to feedback effects. He also found that feedback effects were significantly larger in computer-based than in programmed instruction.

Sleeman et al. (1989) examined conflicting findings in the literature concerning the diagnosis and remediation of students' errors. They noted that few studies have systematically compared the effects of different styles of error-based feedback, and of those that have, the results are inconclusive. For instance, Swan (1983) found that a conflict approach (pointing out errors made by students and demonstrating their consequences, classified in Table 1 as *bugs/misconceptions*) was more effective than re-teaching (classified in Table 1 as *topic-contingent*), but Bunderson and Olsen (1983) found no difference between these two feedback approaches.

To untangle these conflicting findings, Sleeman et al. (1989) conducted three studies that explicitly compared error-specific or model-based remediation (MBR, *bugs/misconceptions*) with simply re-teaching the algebra content (*topic-contingent*). MBR bases feedback on a model of student errors, while re-teaching simply shows students a correct procedure and answer without addressing specific errors. Their results showed that MBR (a more complex approach) and re-teaching (a simpler approach) are both more effective than no tutoring; however, MBR was *not* more effective than re-teaching. The results are discussed in terms of stability of errors and their relevance to educational practice and to intelligent tutoring systems (ITS). Although the studies used human tutors, the results suggest that, for procedural skills in algebra, feedback based on just re-teaching content was as effective as feedback based on more expensive error analyses.

Negative effects of feedback complexity. Kulhavy, White, Topp, Chan, and Adams (1985) similarly examined the feedback complexity issue. They tested a group of college undergraduates who read a 2,400-word passage, responded to 16 multiple-choice questions about it, and received after responding one of four types of feedback that increased in complexity. Feedback complexity was systematically varied. The lowest level was simply verification feedback with the correct response, and the most complex included a combination of verification, the correct answer, and an explanation about why the incorrect answer was wrong

with a pointer to the relevant part of the text passage where the answer could be found. The main finding was that complexity of feedback was *inversely* related to both the ability to correct errors and to learn efficiently (i.e., the ratio of feedback study time to posttest score). Specifically, the authors showed that more complex versions of feedback had a small effect on students' ability to correct their own errors, and the least complex feedback demonstrated greater learner benefits in terms of efficiency and outcome than complex feedback.

In summary, the inconclusive findings on feedback complexity described above suggest that there may be other mediating factors involved in the relationship between formative feedback and learning. For instance, instead of feedback complexity, a more salient facet of feedback may be the nature and quality of the content, such as providing information about learning goals and the attainment of those goals.

3.6 Goal-Directed Feedback and Motivation

Goal-directed feedback provides learners with information about their progress toward a desired goal (or set of goals), rather than providing feedback on discrete responses (i.e., responses to individual tasks). Research has shown that for a learner to remain motivated and engaged depends upon a close match between a learner's goals and expectations that these goals can be met (Fisher & Ford, 1998; Ford, Smith, Weissbein, Gully, & Salas, 1998). If goals are set so high that they are unattainable, the learner will likely experience failure and become discouraged. When goals are set so low that their attainment is certain, success loses its power to promote further effort (Birney, Burdick, & Teevan, 1969).

According to Malone (1981), goals must have certain features to make them challenging for the learner. For example, goals must be personally meaningful and easily generated, and the learner must receive performance feedback about whether or not the goals are being attained. Hoska (1993) classified goals as being of two types: acquisition (i.e., to help the learner acquire something desirable) and avoidance (i.e., to help the learner avoid something undesirable). Moreover, acquisition and avoidance goals can be either external or internal.

Motivation has been shown to be an important mediating factor in learners' performance (Covington & Omelich, 1984), and feedback can be a powerful motivator when delivered in response to goal-driven efforts. Some researchers suggest that the learner's goal orientation

should be considered when designing instruction, particularly when feedback can encourage or discourage a learner's effort (Dempsey et al., 1993). Goal orientation describes the manner in which people are motivated to work toward different kinds of goals. The idea is that individuals hold either a learning or performance orientation toward tasks (e.g., Dweck, 1986). A learning orientation is characterized by a desire to increase one's competence by developing new skills and mastering new situations with the belief that intelligence is malleable. In contrast, performance orientation reflects a desire to demonstrate one's competence to others and to be positively evaluated by others, with the belief that intelligence is innate (Farr, Hofmann, & Ringenbach, 1993).

Research has shown that the two types of goal orientation differentially influence how individuals respond to task difficulty and failure (Dweck & Leggett, 1988). That is, individuals with a learning orientation are characterized by persistence in the face of failure, the use of more complex learning strategies, and the pursuit of challenging material and tasks. Performance orientation is characterized by a tendency to withdraw from tasks (especially in the face of failure), less interest in difficult tasks, and the tendency to seek less challenging material and tasks on which success is likely. Consistent with these labels, research has generally shown that learning orientation is associated with more positive outcomes and performance orientation is related to either equivocal or negative outcomes (e.g., Button, Mathieu, & Zajac, 1996; Fisher & Ford, 1998; VandeWalle, Brown, Cron, & Slocum, 1999).

One way to influence learners' goal orientations (e.g., to shift from a focus on performing to an emphasis on learning) is via formative feedback. Hoska (1993) showed how goal-orientation feedback can modify a learner's view of intelligence, by helping a learner see that (a) ability and skill can be developed through practice, (b) effort is critical to increasing this skill, and (c) mistakes are part of the skill-acquisition process. Feedback can also serve as a cognitive support mechanism, described next.

3.7 Formative Feedback as Scaffolding

Like training wheels, scaffolding enables learners to do more advanced activities and to engage in more advanced thinking and problem solving than they could without such help. Eventually, high level functions are gradually turned over to the students as the teacher (or computer system) removes the scaffolding and fades away from the process (see Collins, Brown, & Newman, 1989; Graesser, McNamara, & VanLehn, 2005). For instance, Graesser, McNamara,

and VanLehn described a theoretically based approach to facilitating explanation-centered learning via scaffolding, including (a) pedagogical agents that scaffold strategies, metacognition, and explanation construction; (b) computer coaches that facilitate answer generation to questions that require explanations by using mixed-initiative dialogue; and (c) modeling and coaching students in constructing self-explanations. Their systems (i.e., Point&Query, AutoTutor, and iSTART) that were built with these components have shown promising results in tests of learning gains and improved learning strategies.

In their book, *How People Learn*, Bransford, Brown, and Cocking (2000) described how psychological theories and insights can be translated into actions and practices. In relation to feedback, they suggested a goal-directed approach to learning using scaffolding (or scaffolded feedback) that (a) motivates the learner's interest related to the task, (b) simplifies the task to make it more manageable and achievable, (c) provides some direction to help the learner focus on achieving the goal, (d) clearly indicates the differences between the learner's work and the standard or desired solution, (e) reduces frustration and risk, and (f) models and clearly defines the expectations (goals) of the activity to be performed.

Conventional wisdom suggests that facilitative feedback (providing guidance and cues, as illustrated in the research cited above) would enhance learning more than directive feedback (providing corrective information), yet this is not necessarily the case. In fact, some research has shown that directive feedback may actually be more helpful than facilitative—particularly for learners who are just learning a topic or content area (e.g., Knoblauch & Brannon, 1981; Moreno, 2004). Because scaffolding relates to the explicit support of learners during the learning process, scaffolded feedback in an educational setting may include models, cues, prompts, hints, partial solutions, as well as direct instruction (Hartman, 2002). Scaffolding is gradually removed as students gain their cognitive footing, thus directive feedback may be most helpful during the early stages of learning. Facilitative feedback may be more helpful later on, and the question is when. According to Vygotsky (1987), external scaffolds can be removed when the learner develops more sophisticated cognitive systems, where the system of knowledge itself becomes part of the scaffold for new learning. The issue of feedback timing is discussed in more detail in the following section.

3.8. Timing

It was my teacher's genius, her quick sympathy, her loving tact which made the first years of my education so beautiful. It was because she seized the right moment to impart knowledge that made it so pleasant and acceptable to me. −Helen Keller

Similar to the aforementioned feedback variables (e.g., complexity and specificity), there are also conflicting results in the literature relating to the timing of feedback and the effects on learning outcome and efficiency. Researchers have been examining the effects of immediate versus delayed feedback on learning for decades (e.g., Clariana, 1999; Jurma & Froelich, 1984; Pound & Bailey, 1975; Prather & Berry, 1973; Reddy, 1969). The timing-of-feedback literature concerns whether feedback should be delivered immediately or delayed. *Immediately* may be defined as right after a student has responded to an item or problem or, in the case of summative feedback, right after the student has completed a quiz or test. *Delayed* is usually defined relative to *immediately*, and such feedback may occur minutes, hours, weeks, or longer after the student completes some task or test.

Regardless of the particular unit of time, the effects of the feedback timing variable are mixed. Again, while there appears to be no consistent main effect of timing, there are interactions involving the timing of feedback and learning. Some researchers have argued for immediate feedback as a way of preventing errors being encoded into memory, while others have argued that delayed feedback reduces proactive interference, thus allowing the initial error to be forgotten and the correct information to be encoded with no interference (for more on this debate, see Kulhavy & Anderson, 1972).

Support for delayed feedback. Researchers who support using delayed feedback generally adhere to what is called the interference-perseveration hypothesis proposed by Kulhavy and Anderson (1972). This asserts that initial errors do not compete with to-be-learned correct responses if corrective information is delayed. This is because errors are likely to be forgotten and thus cannot interfere with retention.

The superiority of delayed feedback, referred to as the delay-retention effect (DRE), was supported in a series of experiments by Anderson and his colleagues (e.g., Kulhavy & Anderson, 1972; Surber & Anderson, 1975) that compared the accuracy of responses on a retention test with the accuracy of responses on an initial test. Although there are many studies in the literature that do not support the delay-retention effect (e.g., Kippel, 1974; Newman, Williams, & Hiller,

1974; Phye & Baller, 1970), delayed feedback has often been shown to be as effective as immediate feedback.

Schroth (1992) presented the results from an experiment that investigated the effects of delayed feedback and type of verbal feedback on transfer, using a concept formation task. The four conditions of delayed feedback were: 0 seconds, 10 seconds, 20 seconds, and 30 seconds. The verbal feedback conditions were (a) correct-incorrect (verification feedback), (b) correct-nothing (i.e., where nothing means that no feedback was presented if the student solved an item incorrectly), and (c) nothing-incorrect (i.e., no feedback was presented if the student answered correctly). All participants were tested seven days following an initial learning trial. The finding relevant to this paper is that although delayed feedback slowed down the rate of initial learning, it facilitated transfer after the delay.

Support for immediate feedback. Supporters of immediate feedback theorize that the earlier corrective information is provided, the more likely it is that efficient retention will result (Phye & Andre, 1989). The superiority of immediate over delayed feedback has been demonstrated for the acquisition of verbal materials, procedural skills, as well as some motor skills (Anderson, Magill, & Sekiya, 2001; Brosvic & Cohen, 1988; Corbett & Anderson, 1989; 2001; Dihoff, Brosvic, Epstein, & Cook, 2003).

Corbett and Anderson (2001) have been using immediate feedback successfully in their programming and mathematics tutors for almost two decades (see Anderson, Corbett, Koedinger, & Pelletier, 1995). For instance, they used their ACT Programming Tutor to examine differential timing effects on students' learning. The study involved four feedback conditions, the first three of which offered the student different levels of control over error feedback and correction: (a) immediate feedback and immediate error correction (i.e., the tutor intervened as soon as students made errors and forced them to correct the error before moving on), (b) immediate error-flagging and student control of error correction, (c) feedback on demand and student control of error correction, and (d) no-tutor condition and no step-by-step, problem-solving support (the control condition). The immediate feedback group with greatest tutor control of problem solving yielded the most efficient learning (i.e., condition *a*). These students completed the tutor problems fastest, and their performance on criterion tests was equivalent to that of the other groups (excluding the control group). Furthermore, questionnaires showed no significant differences in

terms of preference among the tutor conditions. This study demonstrated that immediate error feedback helped with immediate learning.

Azevedo and Bernard (1995) conducted a meta-analysis on the literature concerning the effects of feedback on learning from computer-based instruction (CBI). They noted that despite the widespread acceptance of feedback in computerized instruction, empirical support for particular types of feedback information has been inconsistent and contradictory. Effect size calculations were performed on 22 CBI studies comparing feedback versus no-feedback relating to immediate outcomes. This resulted in a mean weighted effect size of 0.80. The results from 9 studies employing delayed outcome conditions resulted in a mean weighted effect size of just 0.35. This provides support for the strength of feedback in relation to immediate outcome administrations, at least in CBI.

Conjoining feedback timing findings. A preliminary conclusion derived from both the Schroth (1992) and Corbett and Anderson (2001) findings is that delayed feedback may be superior for promoting transfer of learning, especially in relation to concept formation tasks, while immediate feedback may be more efficient, particularly in the short run and for procedural skills (i.e., programming and mathematics). This proposition has some support. For instance, Schmidt, Young, Swinnen, and Shapiro (1989) conducted an experiment that provided verification feedback following a set of trials relating to a relatively simple ballistic-timing task. Feedback timing consisted of one of four lengths: 1 (i.e., verification after every trial), 5 (verification after 5 trials), 10, and 15 trials. During the acquisition phase when feedback was present, all groups showed general improvements in performance across practice, although those in the longer length conditions showed worse performance relative to the shorter length conditions. In a delayed test, Schmidt et al. found an *inverse* relation between the timing variable (1, 5, 10, or 15 trials between feedback) and error rates. That is, longer delays between feedback episodes resulted in relatively poorer performance during acquisition, but better retention compared with shorter delay conditions.

Mathan and Koedinger (2002) reviewed various studies on the timing of feedback and concluded that the effectiveness of feedback depends not on the main effect of timing, but on the nature of the task and the capability of the learner. They called for further exploration on possible interactions involving timing effects and optimal ways to match feedback (type and timing) to learning tasks and students' individual needs and/or characteristics (e.g., Schimmel,

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1988; Smith & Ragan, 1999). One such interaction reported in the literature concerns feedback timing and task difficulty. That is, if the task is difficult, then immediate feedback is beneficial, but if the task is easy, then delayed feedback may be preferable (Clariana, 1999). This is similar to the ideas presented earlier in Section 3.7.

Summary of feedback timing results. Research investigating the relationship of feedback timing and learning/performance reveals inconsistent findings.[1] One way to resolve the inconsistency is by considering that immediate feedback may activate both positive *and* negative learning effects. For instance, the positive effects of immediate feedback can be seen as facilitating the decision or motivation to practice and providing the explicit association of outcomes to causes. On the downside, immediate feedback may lead to reliance on information that is not available during transfer, and it also may promote less careful or mindful behavior. If this supposition is true, then the positive and negative effects of immediate feedback could potentially cancel each other out. Alternatively, either the positive or negative effects may come to the fore, depending on the experimental context. A similar argument could be made for delayed feedback effects on learning. For example, on the positive side, delayed feedback may encourage learners' engagement in active cognitive and metacognitive processing, thus engendering a sense of autonomy (and perhaps improved self-efficacy). But on the negative side, delaying feedback for struggling and less motivated learners may prove to be frustrating and detrimental to their knowledge and skill acquisition.

3.9 Feedback and Other Variables

So far, formative feedback types and timing have been discussed in relation to their effects on learning. This section examines other variables that may interact with feedback features, such as learner-ability level, response certitude, goal orientation, and normative feedback.

Learner level. As alluded to in Section 3.8, some research has suggested that low achieving students may benefit from immediate feedback, while high achieving students may prefer or benefit from delayed feedback (Gaynor, 1981; Roper, 1977). Furthermore, when testing different types of feedback, Clariana (1990) argued that low ability students benefit from *correct-response* feedback more than from *try-again* feedback. Hanna (1976) also examined student performance in relation to different feedback conditions: *verification*, *elaboration*, and *no feedback*. Verification feedback produced the highest scores for high-ability students, while

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elaborated feedback produced the highest scores for low ability students. There were no significant differences between verification and elaborated feedback for middle ability students, but both of these types of feedback were superior to no feedback. These findings support the research and suppositions presented earlier in Section 3.7.

Response certitude. Kulhavy and Stock (1989) examined feedback and response certitude issues from an information processing perspective. That is, they had students provide confidence judgments (response certitude ratings) following each response to various tasks. They hypothesized that when students are certain that their answer is correct, they will spend little time analyzing feedback, and when students are certain that their answer is incorrect, they will spend more time reviewing feedback. The implications of this are straightforward; that is, provide more elaborated feedback for students who are more certain that their answer is wrong, and deliver more constrained feedback for those with high certitude of correct answers. While Kulhavy and Stock's research supported their hypotheses, other studies did not replicate the findings. For instance, Mory (1994) tried to replicate the response-certitude findings and found that while there were differences in the amount of time needed to study the feedback, there was no significant learning effect for feedback tailored to response certitude and correctness.

Goal orientation. Davis, Carson, Ammeter, and Treadway (2005) reported the results of a study testing the relationship between goal orientation and feedback specificity on performance using a management decision-making task. (Feedback specificity was discussed in Section 3.3.) In short, they found that feedback specificity (low, moderate, and high levels) had a significant influence on performance for individuals who were low on learning orientation (i.e., high feedback specificity was better for learners with low learning orientation). They also reported a significant influence of feedback specificity on performance for persons high in performance orientation (i.e., this group also benefited from more specific feedback). The findings support the general positive effects of feedback on performance and further suggest the use of more specific feedback for learners with either high performance or low learning goal orientations.

Normative feedback. According to research cited in Kluger and DeNisi (1996), when feedback is provided to students in a norm-referenced manner that compares the individual's performance to that of others, people who perform poorly tend to attribute their failures to lack of ability, expect to perform poorly in the future, and demonstrate decreased motivation on subsequent tasks (i.e., similar to learners with a performance orientation, as described earlier).

McColskey and Leary (1985) examined the hypothesis that the harmful effects of failure might be lessened when failure is expressed in self-referenced terms (i.e., relative to the learner's known level of ability as assessed by other measures). In their study, learners received feedback indicating that they did well or poorly on an anagram test, and this feedback was described as either norm-referenced (comparing the individual's performance to that of others) or as self-referenced (comparing performance to other measures of the individual's ability). They found that, compared to norm-referenced feedback, self-referenced feedback resulted in higher expectancies regarding future performance and increased attributions to effort (e.g., "I succeeded because I worked really hard"). Attributions to ability (e.g., "I succeeded because I'm smart") were not affected. The main implication is that low achieving students should not receive normative feedback but instead, self-referenced feedback—focusing their attention on their own particular progress.

This review has presented research findings covering the gamut of formative feedback variables. As with earlier reviews, this one has unearthed mixed findings regarding learning effects—whether examining feedback specificity, timing of feedback, and so on. The next section presents four influential feedback research papers that have attempted to integrate disparate findings into preliminary theories (or models) via large literature reviews and/or meta-analyses. The papers summarized in this section include Kluger and DeNisi (1996), Bangert-Drowns et al. (1991), Narciss and Huth (2004), and Mason and Bruning (2001).

4. Toward a Framework of Formative Feedback

To understand the world, one must not be worrying about one's self. −Einstein

4.1 Kluger and DeNisi (1996)

Ten years ago, Kluger and DeNisi (1996) examined and reported on the effects of feedback interventions (FIs) on performance from multiple perspectives and spanning decades of research—back to Thorndike's classic research in the early 1900s. Kluger and DeNisi conducted an extensive review of the literature, performed a meta-analysis on reported experimental findings, and constructed a preliminary theory based on a number of variables, or moderators. Their preliminary FI theory (FIT) offers a broad approach to investigating FI effects, including such feedback moderators as praise, written or verbal feedback, task novelty and complexity,

time constraints, and types of tasks such as physical, memory, knowledge, and vigilance tasks. The basic premise underlying FIT is that FIs change the locus of a learner's attention among three levels of control: (a) task-learning, (b) task-motivation, and (c) meta-task processes (see Figure 1).
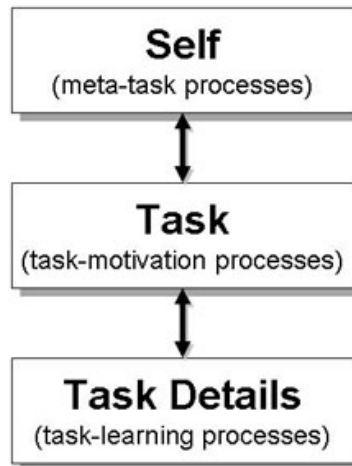

Figure 1. **Abstract hierarchy of processing.**

The general pattern of results from their large meta-analysis of FI studies was consistent with the argument that all else being equal, FI cues affect performance by changing the locus of attention. The lower in the hierarchy the FI-induced locus of attention is, the stronger the benefit of an FI for performance. In other words, formative feedback that focuses the learner on aspects of the task (i.e., the lower part of Figure 1) promotes learning and achievement compared to FIs that draw attention to the self (i.e., the upper box in Figure 1), which can impede learning. This phenomenon was described earlier.

FIT consists of five basic arguments: (a) behavior is regulated by comparisons of feedback to goals or standards, (b) goals or standards are organized hierarchically, (c) attention is limited and therefore only feedback-standard gaps (i.e., discrepancies between actual and desired performance) that receive attention actively participate in behavior regulation, (d) attention is normally directed to a moderate level of the hierarchy, and (e) FIs change the locus of attention and therefore affect behavior. These arguments are interdependent, and each consecutive argument is built on the preceding argument.

Specific results from Kluger and DeNisi's (1996) meta-analysis showed that four moderators (feedback variables) demonstrated significant relationships with d (effect size) at the $p < 0.01$ level: (a) discouraging feedback interventions (FIs) reduce FI effects, (b) velocity FIs (i.e., self-referenced feedback that addresses a change from the learner's prior performance), (c) correct response FIs increase effects, and (d) FI effects on performance of physical tasks are lower than FI effects on cognitive tasks.

Six more moderators became significant after excluding biased studies from the meta-analysis. Of those six, three of them were shown to reduce FI effects: (a) praise, (b) FIs that threaten self-esteem, and (c) orally delivered FIs (from the instructor). Feedback interventions that provide frequent messages enhance FI effects, and FI effects are stronger for memory tasks and weaker for more procedural tasks. Finally, other variables showing significance at $p < 0.05$ level include the following: computerized FIs, which yield stronger effects than noncomputerized FIs; FIs in the context of complex tasks, which yield weaker effects than for simpler tasks; and FIs with a goal-setting intervention, which are more effective than in the absence of goal setting. Figure 2 summarizes the main findings. This figure represents my interpretation (and categorization) of data presented in Kluger and DeNisi (1996).

One important finding from these results concerns the attenuating effect of praise on learning and performance, although this has been described elsewhere in the literature in terms of a model of self-attention (Baumeister, Hutton, & Cairns, 1990), attributions of effort (Butler, 1987), and control theory (Waldersee & Luthans, 1994). Also, Balcazar, Hopkins, & Suarez (1985) reported that praise was not as widely effective a reinforcer as previously believed.

Perhaps the most surprising finding that emerged from the Kluger and DeNisi (1996) meta-analysis is that in over one third of the 607 cases (effect sizes), FIs reduced performance. Furthermore, most of the observed variability cannot be explained by sampling or other errors.

In conclusion, and as the authors observe in a later paper on the topic (Kluger & DeNisi, 1998), FIs may be viewed as double-edged swords. Care should be taken to know which interventions increase performance and under which particular conditions.
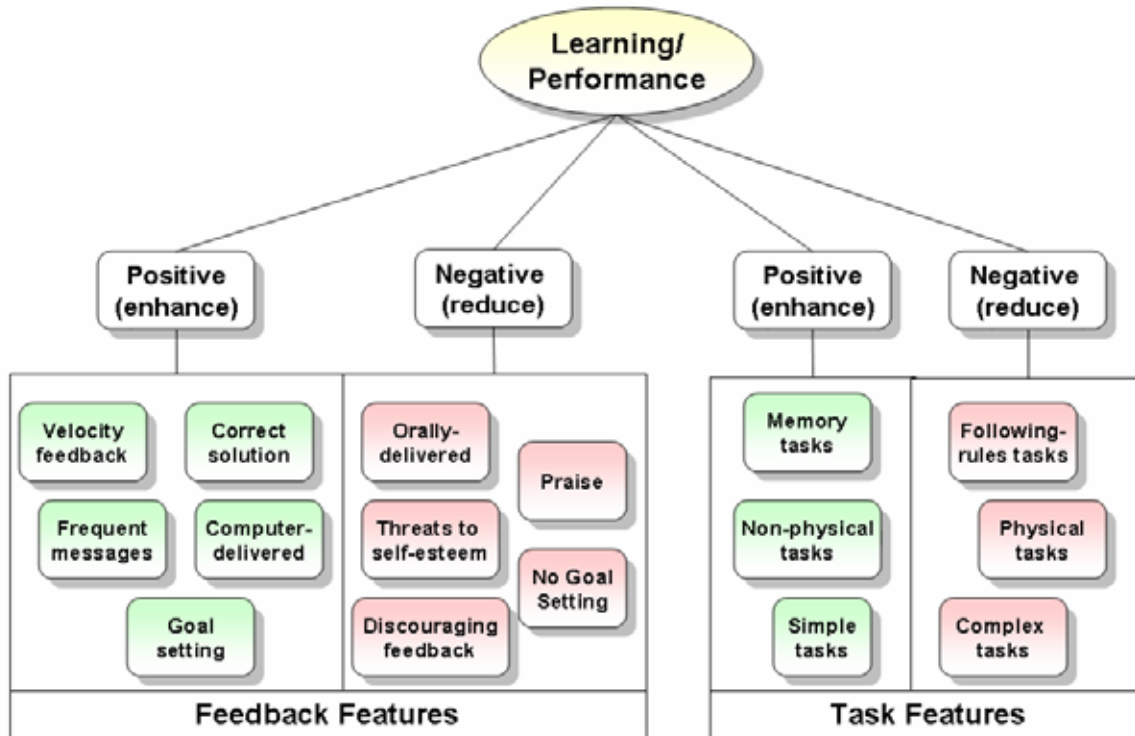
Figure 2. **FI moderators and their relationships to learning/performance.**

4.2 Bangert-Drowns, Kulik, Kulik, and Morgan (1991)

Bangert-Drowns et al. (1991) examined 40 research studies on feedback using meta-analysis techniques. They examined such variables as type of feedback, timing of feedback, and error rates in terms of their respective effect sizes. This widely cited article describes both behavioral and cognitive operations that occur in learning. The basic idea is that in order to direct behavior, a learner needs to be able to monitor physical changes brought about by the behavior. That is, learners change cognitive operations and thus activity by adapting to new information and matching the results of activities to their expectations about performance. Bangert-Drowns et al. emphasized that, "any theory that depicts learning as a process of mutual influence between learners and their environments must involve feedback implicitly or explicitly because, without feedback, mutual influence is by definition impossible. Hence, the feedback construct appears often as an essential element of theories of learning and instruction" (p. 214). To make this point more concrete, imagine trying to learn something new in the absence of any feedback (explicit or implicit).

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Most of the variables they analyzed comprised text-based feedback, which they organized into a five-stage model. This model describes the state of learners as they move through a feedback cycle and emphasizes the construct of mindfulness (Salomon & Globerson, 1987). Mindfulness is "a reflective process in which the learner explores situational cues and underlying meanings relevant to the task involved" (Dempsey et al., 1993, p. 38).

The five stages are depicted in Figure 3 and are similar to other learning cycles (e.g., Kolb, 1984, and Gibbs, 1988), particularly in relation to the importance of reflection.
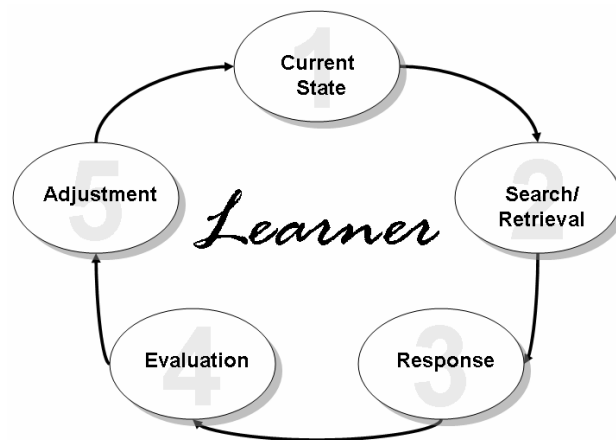
Figure 3. **Five-stage model of the learner during a feedback cycle.**

As described by Bangert-Drowns et al. (1991, p. 217), the five states of the learner receiving feedback include:

1. The initial or *current state* of the learner. This is characterized by the degree of interest, goal orientation, degree of self-efficacy, and prior relevant knowledge.

2. *Search and retrieval strategies.* These cognitive mechanisms are activated by a question. Information stored in the context of elaborations would be easier to locate in memory due to more pathways providing access to the information.

3. The learner makes a *response* to the question. In addition, the learner feels some degree of certainty about the response and thus has some expectation about what the feedback will indicate.

4. The learner *evaluates* the response in light of information from the feedback. The nature of the evaluation depends on the learner's expectations about feedback. For

instance, if the learner was sure of the response and the feedback confirmed its correctness, the retrieval pathway may be strengthened or unaltered. If the learner was sure of the response and feedback indicated its incorrectness, the learner may seek to understand the incongruity. Uncertainty about a response with feedback confirmation or disconfirmation is less likely to stimulate deep reflection unless the learner was interested in acquiring the instructional content.

5. *Adjustments* are made to relevant knowledge, self-efficacy, interests, and goals as a result of the response evaluation. These adjusted states, with subsequent experiences, determine the next current state.

Overall, the meta-analysis by Bangert-Drowns et al. (1991) found generally weak effects of feedback on achievement. More specifically (but not surprisingly), the authors found that verification feedback (correct/incorrect) resulted in lower effect sizes compared to correct response feedback (i.e., providing the correct answer). Also, using a pretest within a study significantly lowered effect sizes, as did uncontrolled presearch availability of answers (i.e., ability to locate an answer prior to responding to a question). These last two findings may be because pretests and presearch availability may be seen as advance organizers, which may support short-term retention, but undermine overall feedback effects in studies that employ them.

The main conclusion from the meta-analysis by Bangert-Drowns et al. (1991) and subsequent five-cycle model is that feedback can promote learning if it is received mindfully. Conversely, feedback can inhibit learning if it encourages mindlessness, as when the answers are made available before learners begin their memory search, or if the feedback message does not match students' cognitive needs (e.g., too easy, too complex, too vague).

4.3 Narciss and Huth (2004)

Narciss and Huth (2004) outlined a conceptual framework for the design of formative feedback. This framework is based on the body of research relating to elaborated feedback types. Cognitive task and error analyses served as the basis for the design of the framework. The impact of the feedback on learning and motivation was ultimately examined in two computer-based learning experiments. The results of these studies showed that systematically designed formative feedback has positive effects on achievement and motivation.

In general, they assert that designing and developing effective formative feedback needs to take into consideration instructional context, as well as characteristics of the learner, to provide effective feedback for complex learning tasks. The conceptual framework for the design of formative feedback is depicted in Figure 4, based on information presented in Narciss and Huth (2004).
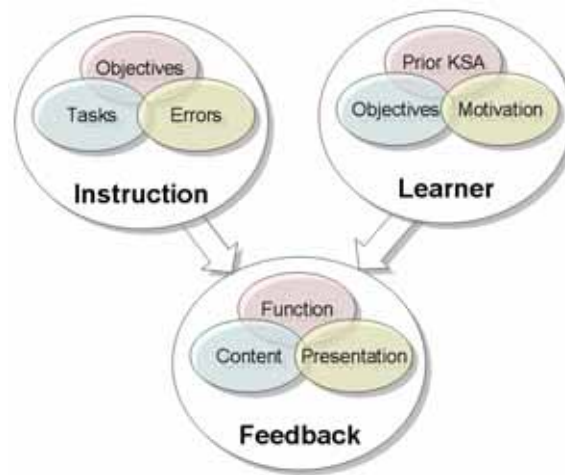
Figure 4. **Factors interacting with feedback to influence learning.**

Each of the three factors is examined in more detail below.

- *Feedback.* The feedback factor consists of three main elements: (a) the *content* of the feedback (i.e., evaluative aspects, such as verification, as well as informative aspects, such as hints, cues, analogies, explanations, and worked out examples); (b) the *function* of the feedback (i.e., cognitive, metacognitive, and motivational); and (c) the *presentation* of the feedback components (i.e., timing, schedule, and perhaps adaptivity considerations).

- *Instruction.* The instructional factor or context also consists of three main elements: (a) the particular instructional *objectives* (e.g., learning goals or standards relating to some curriculum), (b) the learning *tasks* (e.g., knowledge items, cognitive operations, and metacognitive skills), and (c) *errors* and obstacles (e.g., typical errors, incorrect strategies, and sources of errors).

- *Learner.* Information concerning the learner that is relevant to feedback design includes: (a) learning *objectives* and goals; (b) prior *knowledge, skills,* and *abilities*

(e.g., domain-dependent, such as content knowledge, and domain-independent, such as metacognitive skills); and (c) academic *motivation* (e.g., one's need for academic achievement, academic self-efficacy, and meta-motivational skills).

The authors contend that adapting the content, function, and presentation format of the feedback message should be driven by considerations of the instructional goals and learner characteristics to maximize the informative value of the feedback. Specific steps for generating effective formative feedback include selecting and specifying learning objectives (concrete learning outcomes), identifying learning tasks, matching to learning outcomes, and after conducting cognitive task and error analyses, specifying information (i.e., formative feedback) that addresses specific, systematic errors or obstacles.

4.4 Mason and Bruning (2001)

Mason and Bruning (2001) reviewed the literature on feedback that is delivered via computer-based instructional systems and presented a theoretical framework intended to help designers, developers, and instructors build their own computer-based instructional tools. Mason and Bruning's theoretical framework, depicted in Figure 5, is based on research that has examined types of feedback and levels of elaboration in relation to student achievement level, task complexity, timing of feedback, and prior knowledge. The general recommendation they have drawn from the framework is that immediate feedback for students with low achievement levels in the context of either simple (lower level) or complex (higher level) tasks is superior to delayed feedback, while delayed feedback is suggested for students with high achievement levels, especially for complex tasks.

The following research supports their framework. First, significant learning gains often show up in response to various types of elaboration feedback (e.g., Clariana, 1990; Pridemore & Klein, 1991, 1995; Morrison, Ross, Gopalakrishnan, & Casey, 1995; Roper, 1977; Waldrop, Justen, & Adams, 1986). Second, research conducted in classroom settings seems to suggest that response-contingent feedback enhances student achievement more than other types of feedback (e.g., Whyte, Karolick, Neilsen, Elder, & Hawley, 1995). Third, they report that the level of feedback complexity (see Section 3.5) has been shown to both influence and not influence learning, and this lack of effect may be due to interactions involving other variables, such as the nature of the topic (e.g., memorizing vs. troubleshooting) and the type of skill measured (e.g.,

Hodes, 1985; Park & Gittelman, 1992). In cases where the level of feedback complexity has been shown to affect learning, more elaborative information tends to produce increased understanding (Gilman, 1969; Pridemore & Klein, 1991; Roper 1997; Waldrop et al.; Whyte et al.). For instance, while verification feedback did not improve learning, correct response, response-contingent, and a combination of the other levels of feedback have been shown to significantly improve student learning (e.g., Gilman, 1969). This may be due to the extra information available in elaboration feedback, which allows students to correct their own errors or misconceptions. Information on the correctness of an answer (i.e., verification feedback) does not have much utility for learning.
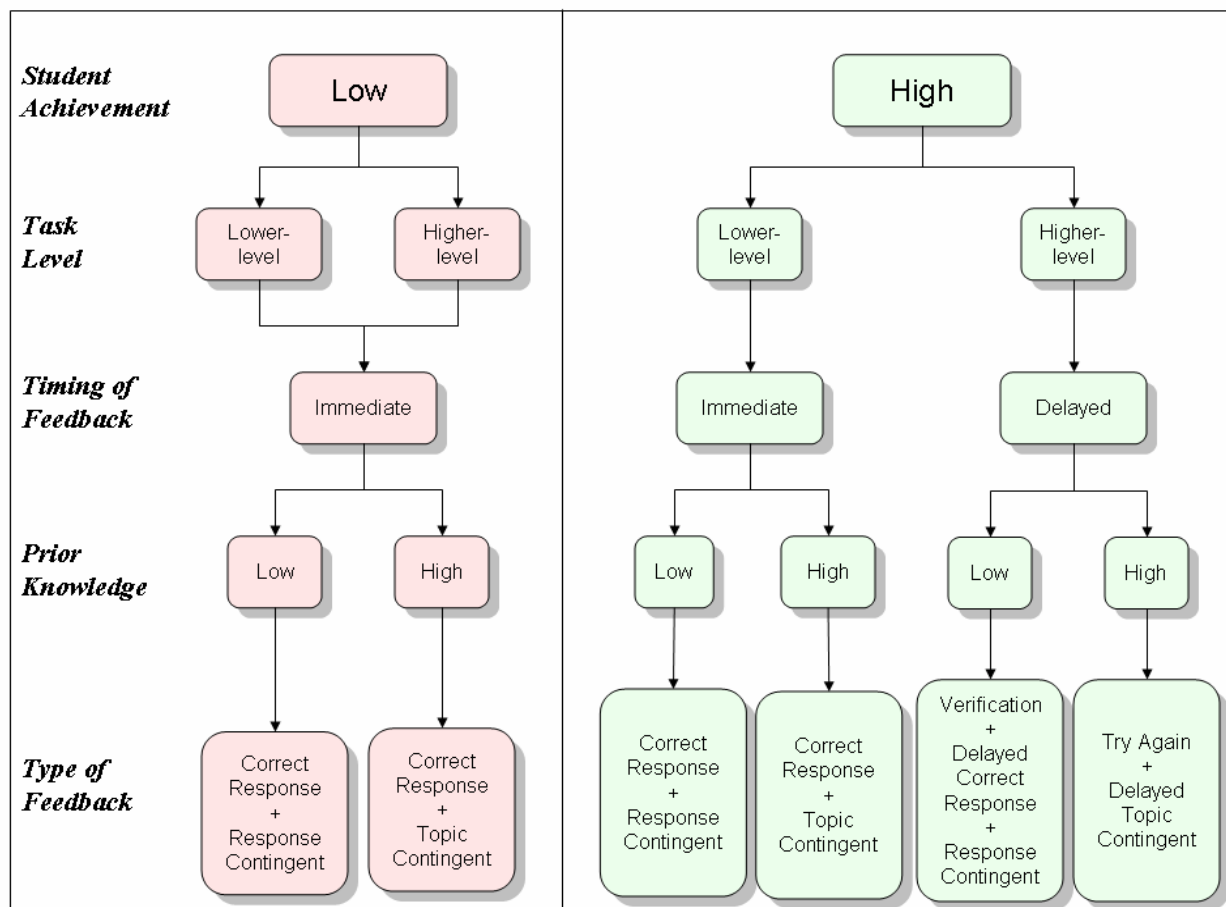

Figure 5. **Feedback variables for decision making in computer-based instruction.**

Note. Adapted from "Providing Feedback in Computer-Based Instruction: What the Research Tells Us" by B. J. Mason and R. Bruning, 2001, Center for Instructional Innovation, University of Nebraska-Lincoln. Copyright 2001 by B. J. Mason and R. Bruning. Reprinted with permission.

5. Summary and Discussion

I'm trying to free your mind, Neo. But I can only show you the door. You're the one who must walk through it. —The Matrix (1999)

Morgan (2006) likened formative feedback to a good murder in that effective and useful feedback depends on three things: (a) *motive* (the student needs it), (b) *opportunity* (the student receives it in time to use it), and (c) *means* (the student is able and willing to use the feedback). However, even with motive, opportunity, and means, there is still large variability of feedback effects on performance and learning, including negative findings that have historically been ignored in the literature (see Kluger & DeNisi, 1996).

Despite this variability, several meta-analyses found that feedback generally improves learning, ranging from about .40 of a standard deviation (Guzzo, Jette, & Katzell, 1985) to .80 and higher (Azevedo & Bernard, 1995; Kluger & DeNisi, 1996), compared to control conditions. But major gaps remain in the feedback literature, particularly in relation to interactions among task characteristics, instructional contexts, and student characteristics that potentially mediate feedback effects. So while there is no simple answer to what feedback works, some preliminary guidelines can be formulated based on the findings reported in this review.

5.1 Recommendations and Guidelines for Formative Feedback

Tables 2–5 present suggestions or prescriptions based on the current review of the formative feedback literature. These are intended to provide a point of departure for more comprehensive and systematic prescriptions in the future. Equivocal findings are not presented, and the references are not exhaustive, but representative. The tables differ in terms of formative feedback guidelines for: (a) things to do, in Table 2, (b) things to avoid, in Table 3, (c) timing issues, in Table 4, and (d) learner characteristics, in Table 5.

Table 2

Formative Feedback Guidelines to Enhance Learning (Things to Do)

	Prescription	Description and references
1	Focus feedback on the task, not the learner.	Feedback to the learner should address specific features of the learner's work in relation to the task, with suggestions on how to improve (e.g., Butler, 1987; Corbett & Anderson, 2001; Kluger & DeNisi, 1996; Narciss & Huth, 2004).
2	Provide elaborated feedback to enhance learning.	Feedback should describe the what, how, and/or why of a given problem. This type of cognitive feedback is typically more effective than verification of results (e.g., Bangert-Drowns et al., 1991; Gilman, 1969; Mason & Bruning, 2001; Narciss & Huth, 2004; Shute, 2006).
3	Present elaborated feedback in manageable units.	Provide elaborated feedback in small enough pieces so that it is not overwhelming and/or discarded (Bransford et al., 2000; Sweller et al., 1998). Presenting too much information may not only result in a superficial learning, but also invoke cognitive overload (e.g., Mayer & Moreno, 2002; Phye & Bender, 1989). A stepwise presentation of feedback offers the possibility to control for mistakes and gives learners sufficient information to correct errors on their own.
4	Be specific and clear with feedback messages.	If feedback is not specific or clear, it can impede learning and can frustrate learners (e.g., Moreno, 2004; Williams, 1997). If possible, try to link feedback clearly and specifically to goals and performance (Hoska, 1993; Song & Keller, 2001).
5	Keep feedback as simple as possible but no simpler (based on learner needs and instructional constraints).	Simple feedback is generally based on one cue (e.g., verification or hint) and complex feedback on multiple cues (e.g., verification, correct response, error analysis). Keep feedback as simple and focused as possible. Generate only enough information to help students and not more. Kulhavy et al. (1985) found that feedback that was too complex did not promote learning compared to simpler feedback.
6	Reduce uncertainty between performance and goals.	Formative feedback should clarify goals and seek to reduce or remove uncertainty in relation to how well learners are performing on a task and what needs to be accomplished to attain the goal(s) (e.g., Ashford, Blatt, & VandeWalle, 2003; Bangert-Drowns et al., 1991).
7	Give unbiased, objective feedback, written or via computer.	Feedback from a trustworthy source will be considered more seriously than other feedback, which may be disregarded. This may explain why computer-based feedback is often better than human-delivered in some experiments in that perceived biases are eliminated (see Kluger & DeNisi, 1996).
8	Promote a learning goal orientation via feedback.	Formative feedback can be used to alter goal orientation—from a focus on performance to a focus on learning (Hoska, 1993). This can be facilitated by crafting feedback emphasizing that effort yields increased learning and performance and that mistakes are an important part of the learning process (Dweck, 1986).
9	Provide feedback after learners have attempted a solution.	Do not let learners see answers before trying to solve a problem on their own (i.e., presearch availability). Several studies that have controlled presearch availability show a benefit of feedback, while studies without such control show inconsistent results (Bangert-Drowns et al., 1991).

Table 3

Formative Feedback Guidelines to Enhance Learning (Things to Avoid)

	Prescription	Description and references
10	Do not give normative comparisons.	Feedback should avoid comparisons with other students—directly or indirectly (e.g., grading on the curve). In general, do not draw attention to self during the course of learning (Kluger & DeNisi, 1996; Wiliam, in press).
11	Be cautious about providing overall grades.	Feedback should note areas of strength and provide information on how to improve, as warranted and without overall grading. Wiliam (in press) summarized the following findings: (a) students receiving just grades showed no learning gains, (b) those getting just comments showed large gains, and (c) those with grades and comments showed no gains (likely due to focusing on the grade and ignoring comments). Effective feedback relates to the content of the comments (Butler, 1987; McColskey & Leary, 1985).
12	Do not present feedback that discourages the learner or threatens the learner's self-esteem.	This prescription is based not only on common sense, but also research reported in Kluger and DeNisi (1996), which reports feedback interventions that undermine learning as it draws focus to the self and away from the task at hand. In addition, do not provide feedback that is either too controlling or critical of the learner (Baron, 1993; Fedor, Davis, Maslyn, & Mathieson, 2001).
13	Use praise sparingly, if at all.	Kluger & DeNisi (1996), Butler (1987), and others have noted that use of praise as feedback directs the learner's attention to self, which distracts from the task and consequently from learning.
14	Try to avoid delivering feedback orally.	This also was addressed in Kluger & DeNisi (1996). When feedback is delivered in a more neutral manner (e.g., written or computer-delivered), it is construed as less biased.
15	Do not interrupt the learner with feedback if the learner is actively engaged.	Interrupting a student who is immersed in a task—trying to solve a problem or task—can be disruptive to the student and impede learning (Corno & Snow, 1986).
16	Avoid using progressive hints that always terminate with the correct answer.	While hints can be facilitative, they can also be abused. If they are employed to scaffold learners, make provisions to prevent their abuse (e.g., Aleven & Koedinger, 2000; Shute, Woltz, & Regian, 1989). Consider using prompts and cues (i.e., more specific kinds of hints).
17	Do not limit the mode of feedback presentation to text.	Exploit the potential of multimedia to avoid cognitive overload due to modality effects (e.g., Mayer & Moreno, 2002). Do not default to presenting feedback messages as text. Instead, consider alternative modes of presentation (e.g., acoustic, visual).
18	Minimize use of extensive error analyses and diagnosis.	The cost of conducting extensive error analyses and cognitive diagnosis may not provide sufficient benefit to learning (Sleeman et al., 1989; VanLehn et al., 2005). Furthermore, error analyses are rarely complete and not always accurate, thus only are helpful in a subset of circumstances.

Table 4

Formative Feedback Guidelines in Relation to Timing Issues

	Prescription	Description and references
19	Design timing of feedback to align with desired outcome.	Feedback can be delivered (or obtained) either immediately after some activity or delayed. Immediate feedback can help fix errors in real-time, producing greater immediate gains and more efficient learning, (Corbett & Anderson, 2001; Mason & Bruning, 2001), but delayed feedback has been associated with better transfer of learning (e.g., Schroth, 1992).
20	For difficult tasks, use immediate feedback.	When a student is learning a difficult new task (where difficult is relative to the learner's capabilities), it is better to use immediate feedback, at least initially (Clariana, 1990). This provides a helpful safety net so the learner does not get bogged down and/or frustrated (Knoblauch & Brannon, 1981).
21	For relatively simple tasks, use delayed feedback.	When a student is learning a relatively simple task (again, relative to capabilities), it is better to delay feedback to prevent feelings of feedback intrusion and possibly annoyance (Clariana, 1990; Corno & Snow, 1986).
22	For retention of procedural or conceptual knowledge, use immediate feedback.	In general, there is wide support for use of immediate feedback to promote learning and performance on verbal, procedural, and even tasks requiring motor skills (Anderson et al., 2001; Azevedo & Bernard, 1995; Corbett & Anderson, 1989, 2001; Dihoff et al., 2003; Phye & Andre, 1989).
23	To promote transfer of learning, consider using delayed feedback.	According to some researchers (e.g., Kulhavy et al., 1985; Schroth, 1992), delayed may be better than immediate feedback for transfer task performance, although initial learning time may be depressed. This needs more research.

Table 5

Formative Feedback Guidelines in Relation to Learner Characteristics

	Prescription	Description and references
24	For high-achieving learners, consider using delayed feedback.	Similar to the Clariana (1990) findings cited in Table 4, high-achieving students may construe a moderate or difficult task as relatively easy and hence benefit by delayed feedback (see also Gaynor, 1981; Roper, 1977).
25	For low-achieving learners, use immediate feedback.	The argument for low-achieving students is similar to the one above, only these students need the support of immediate feedback in learning new tasks they may find difficult (see Gaynor, 1981; Mason & Bruning, 2001; Roper, 1977).
26	For low-achieving learners, use directive (or corrective) feedback.	Novices, or struggling students, need support and explicit guidance during the learning process (Knoblauch & Brannon, 1981; Moreno, 2004), thus hints may not be as helpful as more explicit, directive feedback.
27	For high-achieving learners, use facilitative feedback.	Similar to the above, high-achieving students or more motivated ones benefit from feedback that challenges them, such as hints, cues, and prompts (Vygotsky, 1987).
28	For low-achieving learners, use scaffolding.	Provide early support and structure for low-achieving students (or those with low self-efficacy) to improve learning and performance (e.g., Collins et al., 1989; Graesser, McNamara, & VanLehn, 2005).
29	For high-achieving learners, verification feedback may be sufficient.	Hanna (1976) presented findings that suggest that high-achieving students learn more efficiently if permitted to proceed at their own pace. Verification feedback provides the level of information most helpful in this endeavor.
30	For low-achieving learners, use correct response and some kind of elaboration feedback.	Using the same rationale as with supplying scaffolding to low-achieving students, the prescription here is to ensure low-achieving students receive a concrete, directive form of feedback support (e.g., Clariana, 1990; Hanna, 1976).
31	For learners with low learning orientation (or high performance orientation), give specific feedback.	As described in the study by Davis et al., (2005), if students are oriented more toward performance (trying to please others) and less toward learning (trying to achieve an academic goal), provide feedback that is specific and goal directed. Also, keep the learner's eye on the learning goal (Hoska, 1993).

5.2 Future Research

One reason why studies examining formative feedback effects are so inconsistent may be due to individual differences among motivational prerequisites (e.g., intrinsic motivation, beliefs, need for academic achievement, academic self-efficacy, and metacognitive skills). In fact, Vygotsky (1987) noted that the study of psychology had been damaged by the separation of the intellectual from the motivational and emotional (or affective) aspects of thinking. Crafting and delivering formative feedback may help bridge these aspects of thinking and enhance learning. This seems to be supported by a growing number of researchers (e.g., Goleman, 1995; Mayer & Salovey, 1993, 1997; Picard et al., 2004) who have argued that emotional upsets can interfere with mental activities (e.g., anxious, angry, or depressed students do not learn). Thus one intriguing area of future research is to systematically examine the relationship(s) between affective components in feedback and outcome performance. And while there have been inroads in the area, according to Picard et al., extending cognitive theory to explain and exploit the role of affect in learning is still in its infancy.

Schwartz and White (2000), suggested, in general, a multidimensional view of feedback is needed, where situational and individual characteristics of the instructional context and learner are considered, along with the nature and quality of a feedback message. Narciss and Huth (2004) noted, and I strongly agree, that function, content, and mode of feedback presentation are important facets and should be considered separately, as well as interactively, with learner characteristics and instructional variables. Cognitive task and error analyses may be used to match formative feedback components to (a) learning objectives, (b) skills needed for the mastery of the task, and to (c) typical errors or incorrect strategies. However, such expensive analyses and methods may not, in fact, be necessary to promote learning. (e.g., see Section 3.5 on the Sleeman et al., 1989, findings).

In line with the question concerning the added value of employing error analyses and more diagnostic types of formative feedback, controlled evaluations are needed to systematically test the effects of feedback conditions (as listed in Table 1) on learning, combined with a cost-benefit analysis. Some obvious costs include development time for specifying the feedback types and time for the student to read the feedback. Benefits relate to improvements in learning outcome and efficiency, as well as possibly affective variables. Information about the learner

would be collected to examine possible interactions. The hypotheses are that (a) more complex formative feedback types (e.g., involving extensive and expensive error analyses) do not yield proportionately greater learning gains, and (b) feedback can be made more effective if it can adapt to the particular needs of learners—cognitive and noncognitive characteristics—as well as to different types of knowledge and skills. The general question is: What level of feedback complexity yields the most bang for the buck?

Table 5 provides guidelines for linking a few learner characteristics to different feedback types. Future research may examine (a) additional learner characteristics, as well as (b) links between different types of knowledge and feedback types. For instance, feedback to support fact learning (declarative knowledge) could reiterate definitions or provide the learner with a handy mnemonic technique; feedback to support conceptual knowledge could provide examples, counter-examples, and big pictures; and feedback to improve procedural knowledge could involve demonstrations, solution paths (complete or partial), and so forth. Ultimately, information about the learner, combined with information about desired outcomes, may inform the development of adaptive formative feedback. Various feedback types could be generated and incorporated into a program (or generated on the fly based on formative feedback models) and then accessed and delivered according to the characteristics of the learner in conjunction with the nature of the task and instructional goals.

In closing, the goal of this review was to summarize research findings relating to formative feedback to serve as the foundation for a variety of future educational products and services. As evidenced throughout, there is no best type of formative feedback for all learners and learning outcomes. However, formative feedback has been shown, in numerous studies, to improve students' learning and enhance teachers' teaching to the extent that the learners are receptive and the feedback is on target (valid), objective, focused, and clear.

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Notes

[1]An interesting observation is that many field studies demonstrate the value of immediate feedback (see Kulik & Kulik, 1988), while many laboratory studies show positive effects of delayed feedback (see Schmidt & Bjork, 1992; Schmidt et al., 1989).