To Foster Development of Cognitive Strategies,
Use Embedded Scaffolding Techniques.

IF the required **outcomes** are the development of organization, elaboration, and comprehension-monitoring strategies,

AND IF **conditions** are that learners are engaged in activities with limited teacher interaction,

THEN use the **method** of offering pre-constructed templates for data collection and organization, and the **method** of building metacognitive prompts into the instruction.

Principle 1: To foster development of organization and elaboration strategies for learners engaged in directed research activities in settings with limited teacher interaction, offer pre-constructed templates for data collection and organization.

Principle 2: To foster development of comprehension-monitoring strategies for learners in settings with limited teacher interaction, build metacognitive prompts into instruction.

Keywords

Cognitive strategies
Scaffolding
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Organization
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Introduction

Cognitive strategies are techniques that learners use to monitor and control their own cognitive processes. These strategies are seldom taught directly and tend to develop naturally in only "good" students (Smith & Ragan, 1993). Fortunately, recent research suggests that cognitive strategies can be systematically developed (Davis, 1996; Grabinger, 1996; Jacobson, 1998; Perkins & Grotzer, 1997). The implication of these findings cannot be denied, "If schools are going to help all students become expert learners, the metacognitive capabilities of learners must be acknowledged, cultivated, and exploited. . . . A major function of all schooling must be to help create learners who know how to learn" (Ertmer & Newby, 1996, p. 22).

Methods for cognitive strategy instruction have been well documented in the literature (Jacobson, 1998; Mangieri & Block, 1994; Pressley, Woloshyn & Associates, 1995; Shin, 1998; Smith & Ragan, 1993). The vast majority of recommended methods require that learners have direct, highly individualized contact with the instructor. Most suggested methods recommend that the instructor model the use of the strategy and then facilitate repeated guided practice sessions, providing substantial evaluative feedback to learners at every stage. This places a heavy burden on the instructor:

- Because instruction is given until students can execute the strategy proficiently, there is a great deal of responsibility on the teacher to monitor student progress, diagnose student difficulties, and adjust instruction accordingly. A lot of teacher and student effort is required for students to construct knowledge of strategies. (Pressley, Woloshyn & Associates, 1995, p. 11)

Unfortunately, this ideal model of high instructor/student contact is probably unrealistic in many public school settings and certainly improbable in most distance-learning situations. So, given the high student/teacher ratio in public schools and the trend toward alternative technological methods of lesson delivery (CD-ROM, Internet, etc.), can cognitive strategies realistically be developed? This paper asserts that the answer is yes, by embedding cognitive support tools into instruction. Two principles that can be used to guide the design of cognitive strategy instruction for students in settings with limited teacher interaction are proposed. These principles are by no means intended to encompass all aspects of embedded cognitive strategy design. They have been proposed to spur discussion of the topic and generate interest in further research.

The Psychology of Scaffolding

The concept of instructional scaffolding is rooted in the work of Soviet psychologist Lev Semenovich Vygotsky (1896-1934) who argued that higher mental functions, such as thinking and memory, have their origins in social interactions, rather than physiological or cognitive developments within the individual (Rogoff & Wertsch, 1984). Vygotsky was especially interested in the phase of cognitive development in which a child has only partially mastered a task but can successfully execute it with supervision and guidance. To describe this phase, he coined the term "zone of proximal development" which he defined as follows:

- . . . the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (Vygotsky, as cited in Duffy & Cunningham, 1996, p. 183)

The notion of "instructional scaffolding" is one example of a practical application of Vygotskyís theory. Rogoff & Wertsch define scaffolding as, ". . . a process wherein an adult provides support to a child learning to master a problem" (p. 4). This traditional definition is very much in keeping with Vygotskyís emphasis on the social nature of cognition. Not surprisingly, the vast majority of research on cognitive strategies instruction has focused on using traditional scaffolding to transfer strategic thinking from an expert to a novice through modeling, guided practice, and feedback.

Not all researchers, however, maintain that social interaction is a necessary component of scaffolding. Duffy and Cunningham (1996) define scaffolding as any type of support for learning. This includes not only the support of other individuals but "any artifacts in the environment that afford support" (p. 183). Brown, Hedberg, and Harper (1994) assert that, "The instructor can support the development of metacognitive strategies in students either personally or through the use of cognitive support tools" (p. 9). Cognitive support tools are described as devices that help the learner to brainstorm, organize work, monitor performance, and develop new strategies. The two principles proposed in this paper advocate that in settings affording limited teacher/student interaction, cognitive support tools should be embedded into the instructional experience.

Principle 1: To foster development of organization and elaboration strategies for learners engaged in directed research activities in settings with limited teacher interaction, offer pre-constructed templates for data collection and organization.

Rationale

Organization strategies are cognitive strategies that help learners store new information in memory within a structure that supports easy retrieval. Elaboration strategies are cognitive strategies that help learners establish associations between new information and previously acquired knowledge (Smith & Ragan, 1993).

It seems reasonable to assume that learners who have developed organization and elaboration strategies will be more successful at directed research activities because they will have a "natural" affinity for organizing the data they collect and integrating it with prior knowledge. But what of learners who have not developed these cognitive strategies? *Principle 1* advocates providing cognitive support tools for these learners, in the form of pre-constructed templates that encourage expert organization and elaboration strategies.

Consider this simple example. Suppose students were engaged in an activity that challenged them to research a controversial topic and "take a stand." To encourage effective organization and elaboration skills, the instructional designer might include a matrix that looks something like this:

	Pros	**Cons**
Position 1:		
Position 2:		
Position 3:		

The instructional rationale for this approach is twofold:

1. Directed research activities that require data collection and note-taking

place a heavy demand on a learnerís working memory by requiring the acquisition of new learning while structuring the learning situation (Smith & Ragan, 1993). Data-collection templates, such as the one shown above, ease the burden on a learnerís working memory by serving as scaffolds to support the acquisition and organization of new knowledge.

2. A plethora of evidence suggests that successful strategy application is directly linked to a learnerís feeling of self-efficacy (Brown et al., 1994; Jacobson, 1998; Lake, 1988; Shin, 1998). Self-efficacy is, ". . . an individualís belief that he or she can successfully execute the behavior required to produce a certain outcome" (Shin, 1998, p. 38). Simply put, a student is more likely to attempt to apply cognitive strategies if she believes sheíll be successful. By providing scaffolds, such as the template shown above, a learnerís confidence in her ability to organize and elaborate on "found" data will likely be increased, thereby increasing the chance that sheíll apply these cognitive strategies in the future.

Caveats

The following caveats should be considered when applying *Principle 1*:

1. Development of a template to model "expert" cognitive strategies may be easier said than done. A thorough subject-matter analysis, including interviews with recognized subject-matter experts, is highly recommended. The instructional designer should never consider himself to be an expert at modeling cognitive strategies.
2. Providing only a single template might encourage a one-sided view of the content and discourage divergent thinkingóanother important cognitive strategy.
3. The instructional designer must know his audience. It is imperative that cognitive tools be appropriate to a userís skill set. If the cognitive load required to use the tool is too great, it may actually be detrimental (Brown et al., 1994).

All of the cautions described above could potentially be addressed by providing a variety of templates for data organization, each promoting a slightly different "construction" of the collected information. The benefits of this approach may actually transcend the primary goal of promoting organization and elaboration strategies and contribute to the creation of a more complete mental model. Cognitive psychologists advocate encouraging learners to represent data in multiple formats and view information from multiple perspectives in order to enhance their ability to later retrieve the information from long term memory (Winn & Snyder, 1996). By constructing multiple representations of the same information, a more complete mental model is createdóone with multiple "paths" for data retrieval.

Examples

One example of the application of *Principle 1* is the GuessTester activity template I developed for a class in the Department of Educational Technology at San Diego State University (Meyer, 1998). GuessTesters are directed research activities specifically designed to develop cognitive strategies including organization, elaboration, and divergent thinking. GuessTester activities provide access to several different on-line forms that students can use to help organize their notes while conducting Web research.

Another example of *Principle 1* in action is the Table/Graph tool that ships with the life science product designed and developed by Glencoe/McGraw-Hill ("Life Science," 1997). While engaged in exploration of a life science concept, the student is directed to gather data that is generated by the computer program and enter that data into the Table/Graph tool. When the student opens the tool, he sees a table with rows and columns, pre-labeled to help him organize his data-collection effort.

Principle 2: To foster the development of comprehension-monitoring strategies for learners in settings with limited teacher interaction, build metacognitive prompts into instruction.

Rationale

Comprehension monitoring strategies are cognitive strategies that help learners determine whether or not they understand what is being taught during the course of a lesson (Smith & Ragan, 1993). These types of strategies are often associated with self-directed, goal-oriented, successful learners (Ertmer & Newby, 1996; Lake, 1988; Zimmerman, 1990). Expert learners combine comprehension-monitoring strategies with cognitive interventions to reorganize their thinking while engaged in a learning situation. Several studies have shown that this technique results in improved academic achievement (Perkins & Grotzer, 1997; Shin, 1998).

Self-questioning is a frequently cited example of a comprehension monitoring strategy (Ertmer & Newby, 1996; Smith & Ragan, 1993). Students adept at self-questioning prompt themselves during the learning situation to determine whether or not they understand what is being taught. Examples of these questions might include, "Are there any words in this sentence that I donít know the meaning of?" or, "Will I remember that if I donít write it down?" As with other cognitive strategies, comprehension monitoring does not come naturally to all students, but can be systematically developed through instructional strategies, such as metacognitive prompting:

- . . . studies indicate that early adolescents may not naturally use formal thinking strategies, but they can do so when prompted. By providing ëprompts,í such as higher order questions, direct instruction and practice in thinking skills, and encouragement to reflect through discussion and ëthinking aloud,í teachers can help students operate at a higher cognitive level. (Lake, 1988, p. 5)

Although most research on instructional strategies designed to teach comprehension monitoring have focused on learning situations with a high level of teacher involvement, one recent study showed that metacognitive prompts improved studentsí comprehension-monitoring abilities and resulted in a more integrated understanding of the concepts being taught (Davis, 1996).

Caveats

Three caveats regarding the application of *Principle 2* warrant discussion:

1. Prompts that encourage strategies that are incompatible with a studentís learning style or natural inclination may actually hinder performance. For example, suppose Sandra has already developed this successful learning strategy:

   While reading, Sandra makes note of the main idea of each paragraph, placing a star next to all words that are unfamiliar to her. She then reads the entire passage before she looks up any of the unfamiliar words. Sandra has found that she can often determine the meaning of many of the words from the context provided by the rest of the passageówithout ever looking them up.

   Now suppose that Sandra encounters a reading program that prompts her to look up unfamiliar words as she comes across them. This strategy, although appropriate for some learners, may not work for Sandra. She may become so distracted from the reading passage that she loses the context and fails to comprehend the "big picture."

2. Procedural prompts that guide students through the steps necessary to complete an activity may tend to encourage a "piecemeal" view of the process, by emphasizing each step rather that how the steps work together to achieve a particular goal (Davis, 1996).Some have argued that cognitive strategies developed through embedded training methods may be less likely to transfer to alternate learning situations than strategies developed

through explicit training (Derry & Murphy, 1986).
3. This argument gains significant credibility when considered in light of the fact that research has shown strategies training to be most effective when learners attribute increased success directly to the application of the learning strategy, rather than to some other variable (Derry & Murphy, 1986; Pressley, Borkowski & Schneider, 1987). Note that this caution is also relevant to *Principle 1*.

Examples

Principle 2 has been applied with varying degrees of success in the tutorials offered with many computer software applications. For example, one of the manuals included with Macromediaís Director 4.0 product includes a chapter on basic animation techniques. The end of the chapter includes a section called "Checking Your Understanding" that includes these questions (and others) designed to help the learner determine whether or not he understands basic Director animation:

- Learning to read the score in Director is like learning to read music. Explain why this is so.
- Define "sprite" and explain how it differs from a cast member.

The journal prompts included with Glencoe/McGraw-Hillís earth science product ("Earth Science," 1997) demonstrate another application of *Principle 2*. For example, an exploration designed to teach the scientific method allows students to adjust three variables that affect the efficiency of a simulated garden compost pile. This exploration includes the following journal prompts (and others), designed to help students develop a high-level understanding of the scientific method:

- Make a hypothesis (a testable prediction) about how the efficiency of a compost pile would be affected by varying the ratio of green to brown material, the amount of water added, and the number of times a compost pile is turned (to supply oxygen).
- How will you use the computer model to test your hypothesis? What steps will you follow? What data will you record? Be specific about which of the variables you will adjust and when.

Conclusion

Cognitive strategies are, "Öintellectual capabilities that enable individuals to exercise executive control over how they think in problem-solving situations" (Derry & Murphy, 1986, p. 2). These strategies seem to develop naturally only in "good" students, however some argue that cognitive strategies can be systematically developed for any learner. Jacobson states that "if the use of multiplication can be taught to the extent that it is spontaneous, then learning strategies which are incorporated into the education process, can become a spontaneous response in any individual" (Jacobson, 1998, p. 582).

Much of the research surrounding cognitive strategy instruction has focused on learning situations with extensive student/teacher interaction. However, this instructional model is somewhat inconsistent with current educational trends, including larger class sizes and delivery of instruction at a distance. To support the development of cognitive strategies for learners in settings with limited teacher interaction, recent research has suggested embedding cognitive tools within the instructional experience (Brown et. al, 1994; Duffy & Cunningham, 1996). These tools act as "scaffolds" to support the acquisition of skills and knowledge.

Two principles intended to guide the design of embedded cognitive strategy instruction have been proposed in this paper. These principles have not been empirically tested, although they are supported by a wealth of related research. Directed research to support the validity of the proposed principles is highly recommended, as is the subsequent formulation and validation of related design principles.

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