SUPPORTING AND EVALUATING METACOGNITION IN HYPERMEDIA/MULTIMEDIA LEARNING PRODUCTS

Ward Mitchell Cates
Design & Development Group, Lehigh University

Abstract

Determining learner metacognitive sufficiency and identifying appropriate strategies for helping learners depends first upon knowing the types of monitoring skills learners use and then in being able to identify from learner behaviors when they are having metacognitive difficulties. While hypermedia/multimedia learning products offer promise for helping support learner metacognitive sufficiency, they also pose challenges for software designers. This article identifies eleven separate metacognitive skills clustered in six categories. For each skill, approaches learning products could use to support metacognition are discussed, as are indications of learner metacognitive sufficiency or insufficiency that could prove useful in evaluative research.

Keywords: Metacognition, Hypermedia/multimedia, Evaluative research, Software design

The nature of educational learning products appears to be changing. Where they once focused primarily on the transmission of knowledge to the learner, they now seem increasingly focused on learners' investigating, manipulating, and transforming knowledge in a constructive process (Jonassen, Mayes, & McAleese, 1993). This constructivist approach makes new demands on learners who are expected to be more self-directed and more reflective as they learn (Honebein, 1996). Entwistle, Entwistle, and Tate (1993) and Lin et al (1996) noted, however, that these are not skills today's learners automatically bring to the learning situation. Hypermedia/multimedia products (and their Web-based hot-linked equivalents) often supply learners with numerous nodes (individual pieces of information or clusters of information) connected by multiple linkages. Such informational data sets are intended to allow learners to make new and spontaneous learning connections (Spiro & Jehng, 1990). Learners are asked to distill knowledge from larger and larger data sets, often accessed over the World Wide Web, and may well find themselves experiencing cognitive overload (too great a demand on working memory), becoming disoriented, and losing their sense of location or purpose (Fleming & Levie, 1978; Gygi, 1990; Heller, 1990; Lanza & Roselli, 1991; Marchionini, 1988; Miller, 1956; Young, 1996).

Some writers argue that we need either to develop a new set of skills specifically designed to help learners handle the cognitive demands of the "information age," or to refine current skills to meet those demands (see for example, Card, Moran, & Newell, 1983; Case, 1980; Hannafin & Rieber, 1989a; Robert-Jan Simons, 1993; White, 1988). The global term used to refer to the set of skills and strategies one uses in monitoring and modifying how one learns is *metacognition* (Flavell, 1976).

This article addresses ways in which hypermedia/multimedia learning products might be designed to enhance the metacognitive abilities of their learners, approaching the topic from an evaluative researcher's point of view. That is, this article seeks first to identify key issues and approaches to metacognition and then examines metacognitive skills under six broad headings: *Task Analysis, Goal Setting, Strategic Action, Load, Persistence and Responsibility,* and *Growth.* Within each heading, specific metacognitive skills to enhance learners' use of hypermedia/multimedia learning products are examined. For each skill, the article examines two approaches that such products could use to encourage the development of that skill. The article next addresses which types of data evince operation of that skill. Along the way, issues of import in identifying, testing, and evaluating learner metacognition are discussed.

Although this article does not specifically address Web-based learning, the concepts, practices, and concerns discussed should apply there as well. At present, however, Websites are less likely to support audit-trail capture or to provide electronic journal/notebook functions, although there is evidence that such capabilities should soon become more common; (see *Editorial Overview*, 1999-2000).

Types of External Support

In a hypermedia/multimedia product, external support (metacognitive scaffolding) can be supplied in a variety of ways. For purposes of this article, these ways will be classified under two categories: *Static/Directive Support* and *Dynamic/Interactive Support.* The two category names are intended to describe the underlying philosophies and approaches employed by the two types of support. *Static* refers to something that shows little change and tends to remain in the same location, while d*irective* refers to something that serves to direct, guide, govern, or influence (*Webster's*, 1976). Thus, static or directive support devices would be those evidencing the following characteristics:

- They are almost always displayed on screen or are almost always available.
- They are generally under program control rather than learner control (Belland, Taylor, Canelos, Dwyer, & Baker, 1985; Kinzie, Sullivan, & Berdel, 1988; Yore, 1986).
- They are usually generic rather than specific in nature (Shneiderman, 1998; Microsoft, 1995).
- They favor formal instruction over indirect instruction or modeling (Parker, 1991).
- They are usually displayed in the same form each time that they appear, regardless of the identity of the learner or the number of times they have appeared previously to the same learner.

Dynamic devices are active and adaptable, while i*nteractive* refers to something characterized by mutual or reciprocal action or influence (*Webster's*, 1976). Thus, dynamic or interactive support devices would be ones evidencing the following characteristics:

- They are usually context-sensitive and appear only when appropriate (Hutchings et al, 1992; Schwier & Misanchuk, 1993).

- They are generally under learner control rather than program control (Hannafin & Rieber, 1989b; Kinzie & Sullivan, 1989; Lee, 1990; Milheim & Martin, 1991; Whitener, 1989).
- They usually offer specific advice rather than generic advice (Lee, 1991; Wilson & Cole, 1991).
- They favor modeling and illustration (indirect instruction) over formal instruction (Brown, 1987; Parker, 1991).
- They may be adaptive across repeated use by a single learner or across different learners (Keller, 1987; Lehrer & Randle, 1987; Ross & Morrison, 1989).

Data Sources

This section addresses only the question of how to measure the extent to which learners' metacognitive activities are stimulated, exercised, and developed in hypermedia/multimedia learning products. It does not address the thorny issue of whether metacognitive activity, in and of itself, produces higher levels of learning of content material. For purposes of this article, we will assume that learners so stimulated will complete the materials at an acceptable level of performance in ways that meet the objectives or intents set for them, and that they will do so within an acceptable range of completion times. While these are indeed grand assumptions, they are made here solely for the purpose of isolating the issue of identification and measurement from the broader issue of effectiveness, an issue for future research studies.

Further, this article considers measurement in relation to two data categories: *process evidence* and *product evidence*. Process evidence represents data gathered during the learning process. Since such evidence often does not produce tangible products, it frequently is overlooked. Pressley, Borkowski, and O'Sullivan (1985) and Slee (1989) argued, however, that these data are of great value in evaluating learner metacognition. Product evidence consists of materials produced during or at the end of the learning process. Of the data sources discussed below, oral discussion is the only one that represents process evidence exclusively. The other three sources provide both process and product evidence.

Journal Entries

Many hypermedia/multimedia products incorporate an electronic journal function, actually a small word processor in which learners can write notes to themselves, retain copies of materials in the product (such as text or graphics) for their own use, or print out copies of materials for use outside the product. If a product does not provide an electronic journal, a traditional paper-and-pencil journal plays the same role. There is a long tradition of the use of journals in a variety of subject areas, particularly the humanities, and the inclusion or use of journals is often justified on the grounds that it encourages "reflection," "insight," or metacognitive awareness (Bransford & Vye, 1989; Collins, Brown, &

Newman, 1989; Glatthorn & Baron, 1985; Jones, 1992). Journal entries, whether they be recorded electronically or mechanically, seem to offer a legitimate source of evidence of metacognitive activity.

Analyzing journal entries as evidence of metacognition is not without problems, however. First, researchers analyzing such data need to establish clearly which types of entries are indicative of which types of metacognitive activity. Although this introduces a large measure of subjectivity in analysis, subjectivity is not necessarily problematic, provided that researchers make clear the bases for their interpretations (Bogdan & Biklen, 1982; Borg & Gall, 1989; Willis, 1995). Second, learners are not always conscientious in writing in their journals and much data that illustrates metacognitive activity may go unrecorded. Third, learners may lack candor in their entries, particularly if they know (or think) that their entries will later be subject to another's scrutiny. Fourth, many learners, particularly younger learners, lack the maturity, insight, or writing skills to express what they are thinking or feeling. When this is the case, journal entries will offer an impoverished resource for researchers. This impoverishment may be further complicated if journals are maintained electronically, since the impediment of keyboarding or using the features of a word processor is inhibiting for some students. It is difficult for these students to concentrate on their own mental operations when almost all of their spare mental capacity is consumed by the mechanical task of making journal entries (Sweller, 1989).

Audit Trails

Audit or *transaction shells* operate in the background while a learner works with a product. They record where a learner has been and what he or she did while there. Such data can be saved to disk for later analysis. Audit trails allow researchers to reconstruct the paths learners take through a program and can help researchers infer the metacognitive activity involved in the actions learners took at various points in the program.

Oral Discussion

A third source of data on metacognitive activity is oral comments made by the learner, either in conversation or in isolation. Day, French, and Hall (1985) argued that metacognitive skills are refined in social interaction. This contention finds much support in the professional literature (see for instance, Baron & Kallick, 1985; Bransford & Vye, 1989; Brown, 1987; Costa, 1985a; Gavalek & Raphael, 1985; Prawat, 1989). One source of such refinement is the use of cooperative groups which interact with one another while working on computer (Dalton, Hannafin, & Hooper, 1989; Del Marie Rysavy & Sales, 1991). Photographic, videotaped, audio-recording, or simply overheard versions of oral transactions offer rich sources of research data (Baron & Kallick, 1985; Tucker & Dempsey, 1991).

Learner-created Materials

Learners often create a variety of materials for their own use as they work through hypermedia/multimedia products. These materials also act as data sources for researchers.

Specific Metacognitive Skills:
Support Strategies and Possible Evidence of Metacognitive Activity

This portion of this article addresses eleven specific metacognitive skills falling into six broad categories. A separate section is devoted to each of the six broad categories. Each section utilizes a similar structure of subsections. It begins by identifying a metacognitive skill, with the next two subsections identifying specific ways in which a product could address this skill, first using static/directive support and then dynamic/ interactive support. The next two subsections discuss anticipated process and product evidence of the operation of the metacognitive skill. The final subsection for each skill discusses concerns related to the skill. If a section contains more than one metacognitive skill, each skill is addressed in the manner described, in turn, before going on to the next of the six broad categories. Where appropriate, relevant references are cited.

Task Analysis

Skill: **Recognizing the size and scope of a task** (Greeno & Riley, 1987; Lawson, 1980).

Static/directive support.

The key issue here is helping the learner get an adequate image of the product’s internal structure (arrangement and relation of the pieces of information), while at the same time focusing the learner's attention on the specific task at hand (Psotka, 1991). Support devices that may serve this purpose include various forms of advance organizers. Promising advance organizers include:

- Outlines of the steps or stages in the task (Krahn & Blanchaer, 1986);
- Content maps that attempt to make clear the interrelationships of the content to be examined (Collins et al, 1989; Heller, 1990; Marchionini, 1989);
- Learning objectives that specify exactly what the learner is to accomplish and how accomplishment is to be demonstrated (Hannafin & Rieber, 1989b; Ho et al, 1986);
- Supplied schedules or time estimates designed to help the learner project how long it will take to complete the task (Cates, 1991b);
- Adjunct questions that call for learners to formulate schemata (Klein & Pridemore, 1994; Schloss, Sindelar, Cartwright, & Schloss, 1986).

Dynamic/interactive support.

The key here is helping learners monitor their progress toward completion of the task. One promising approach is for the product to monitor learner progress and time expended. The product can then compare these data to averages of time and progress and offer advice to the learner on the basis of those comparisons. The intent is to alert the learner to the rate of progress and to offer advice that clarifies the scope of the task. Perhaps such advice should be modeled on the performance of three types of learners: beginner, intermediate, and expert. The advice could then be based on the match between the present learner's progress and that of the models (Carrier & Jonassen, 1988; Hannafin & Rieber, 1989b; Keller, 1987; Psotka, 1991).

Process evidence.

Audit trails: Evidence that the learner is exercising this metacognitive skill in the process of completing the task include records of transactions involving available advance organizers. Repeated access to these advance organizers, particularly those related to scheduling and time estimates, is particularly diagnostic, as is access to such devices when the learner resumes work following a break.

Oral: Process evidence here consists of discussions or comments about the nature and scope of the task. As is the case with all oral data, discussions or comments can occur in teacher-student interactions, in cooperative student task groups, in isolation, or in incidental conversation.

Product evidence.

Journal: Journal notes or entries referring to the nature, scope, or size of the task suggest the operation of this skill.

Learner-created: Learners sometimes draw representations of the task or attempt to create their own reconceptualizations of the task. Such representations, whether formally drawn or merely sketched out, suggest the operation of this skill (Goetz, 1984; Hannafin & Rieber, 1989a; Young, 1983).

Concerns.

Time and progress comparison values are difficult to derive. In addition, regardless of the accuracy of the comparison values, it is important to note that metacognition is not a normative activity. Consider for a moment the expression, "His mill grinds slow, but it grinds exceedingly fine." Speed is not automatically a measure of excellence, nor should it be assumed to be a measure of metacognition. Learner models will need to be well-designed and highly generalizable if they are to be valid and useful.

In order to make the most of the devices and advice offered, learners need at least minimal awareness of their own task behaviors (work habits, rate of progress). Otherwise, they may not recognize which advice to take and which to ignore (Cates, 1991a). Similarly, learners may need training in advance in order to know how to draw representations and reconceptualizations (Card et al, 1983).

Goal Setting

Skill: **Setting appropriate goals and subgoals** (Goetz, 1984; Greeno & Riley, 1987; Prawat, 1989).

Static/directive support.

The product suggests formal goals and subgoals (Baird, 1988). Formal instruction can point out how goals and subgoals contribute to completion of the task.

Dynamic/interactive support.

The product offers the learner a selection of possible goals and related subgoals, allowing the learner to select among them as desired. It then retains a record of the goals and subgoals selected and tailors the advice it offers to the selected goals and subgoals (Keller, 1987; Zellermayer, Salomon, Globerson, & Givon, 1991).

Process evidence.

Audit trails: Indications of the operation of this metacognitive skill include access or repeated access to formally presented goals or subgoals, selection of goals and subgoals from an offered list, or access to offered advice on goals and subgoals.

Oral: Comments or discussions relating to goals or subgoals suggest metacognitive skill activation.

Product evidence.

Journal: Entries address goals and subgoals. These entries merely list them, or comment on their formation.

Learner-created: Hierarchical layouts or network illustrations of the relationships of goals and subgoals suggest initial metacognition in goal setting.

Concerns.

Before we can expect learners to participate in setting goals, they must understand what goals and subgoals are, and how they relate to one another in leading to the accomplishment of a task. Learners may also need to be taught how to represent goals and subgoals in hierarchies and networks as part of understanding how they are related (Glynn & DiVesta, 1977).

Skill: **Revising goals and subgoals as necessary** (Gavalek & Raphael, 1985; Glatthorn & Baron, 1985; Weinstein & Mayer, 1986; Wellman, 1985).

Static/directive support.

The product provides learners with the ability to view goals and subgoals as they work toward completion of the task (Wolz, McKeown, & Kaiser, 1989), perhaps through a. goals/subgoals icon (Cates, 1991b). An intervening coach can impose external evaluation of goals and subgoals with mandated revisions (Cates & Bruce, 2000; O'Shea & Self, 1983; Marchionini, 1989; Poppen & Poppen, 1988).

Dynamic/interactive support:

The product monitors learner progress and suggest revisions at appropriate points. The locations of revisions points, the bases for monitoring learner progress, and the nature of the advice to be offered is once again be based upon comparison to the three learner models discussed earlier (Yordy, 1991). The product may pose a series of questions designed to help the learner assess the adequacy of the goals and subgoals currently selected (Bellanca, 1985; Costa, 1985a; Day et al, 1985).

Process evidence.

We would expect to see repeated access to goal and subgoal statements and to hear oral comments and discussions questioning the adequacy and appropriateness of those goals and subgoals.

Product evidence.

Journal: Entries address the adequacy of the goals and subgoals selected and suggest revisions.

Audit trails: The learner has reselected goals or subgoals or substituted a new set of goals and subgoals.

Concerns.

Learners need experiences in judging the adequacy and appropriateness of goals and subgoals. This will require many instances of exercise followed by debriefings. While exercise may occur in using hypermedia/multimedia products, it is unlikely that the computer program can do an adequate job of debriefing, and thus teacher intervention will be required (Cates, 1991a).

Strategic Action

Skill: **Selecting appropriate learning strategies** (Derry, 1985; Derry, 1989; Lawson, 1980; Pressley et al, 1985).

Static/directive support.

The product prescribes strategy. It can supply formal instruction in how to select and use strategies (Beyer, 1991; Parker, 1991) or it may impose strategy through an intervening coach (Bransford & Vye, 1989; O'Shea & Self, 1983).

Dynamic/interactive support:

The product offers strategic advice (Gavalek & Raphael, 1985) or offers learners opportunities to view modeling of strategic actions (White, 1989). The product poses questions designed to help focus the learner's attention on the key selection issues (Collins et al, 1989; Lin, 1993).

Process evidence.

Audit trails: There is evidence of learners having accessed offered presentations on strategy or advice on strategic actions.

Oral: Learners comment on or discuss possible learning strategies.

Product evidence.

Journal: There are entries on learning strategies.

Concerns.

Learners may have difficulty grasping what each strategy does and what makes a strategy appropriate in one context and not in another.

Skill: **Determining the effectiveness of a learning strategy or set of strategies** (Derry, 1985; Derry, 1989; Goetz, 1984; Lawson, 1980; Presseisen, 1985; Smith & Ragan, 1999; Wellman, 1985).

Static/directive support.

The product provides generic introductions on the use of strategies or provides formal instruction on evaluating strategies (Beyer, 1988).

Dynamic/interactive support.

Once again, the product offers strategic advice or offers learners opportunities to view modeling of strategic evaluations (Costa, 1985a). The product asks questions designed to help focus the learner's attention on key effectiveness issues (Bellanca, 1985; Day et al, 1985; Lin, 1993; Merrill, 1987).

Process evidence.

Audit trails: Learners access offered presentations on strategy or advice on strategic actions.

Oral: Learners comment on or discuss the adequacy of presently employed strategies.

Product evidence.

Journal: Entries address the adequacies or inadequacies of learning strategies employed. Journal comments also allude to encountered difficulties, thereby suggesting the learner's growing awareness of strategic insufficiency.

Concerns.

Learners must understand strategic applications and how to determine when a strategy is producing the desired results (Cates, 1991a, 1992).

Skill: **Revising a learning strategy or set of strategies as necessary** (Derry, 1985; Goetz, 1984; Greeno & Riley, 1987; Lawson, 1980; Presseisen, 1985; Pressley et al, 1985).

Static/directive support.

Once more, the product provides generic introductions on the revision of strategies, provides formal instruction on revising strategies, and/or uses an intervening coaching function to impose revisions (Bransford & Vye, 1989; Cates & Bruce, 2000; Marchionini, 1989; Poppen & Poppen, 1988).

Dynamic/interactive support.

Again, the product offers strategic advice or opportunities to view modeling of strategy revision (Beyer, 1991; Derry, 1989). The product uses questions to help focus learner attention on key revision issues (Day et al, 1985; Lin 1993).

Process evidence.

Audit trails: Learners have used offered presentations on strategy or advice on strategic actions. Learners have carried out purposeful backtracking, suggesting that a new learning strategy was being applied.

Oral: Learners comment on or discuss changes to current learning strategies.

Product evidence.

Journal: Entries comment on changes in strategic approach.

Audit trails: A changes in the learner's pattern of access suggests strategy revision. If the learner's previous strategy or set of strategies was retained by the product, the retained strategies now differ from the strategies currently employed.

Concerns.

Learners can become committed to strategies and not realize that they can change them any time they wish. Learners may believe they must complete a learning episode before revising their strategies.

Cognitive Load

Skill: **Minimizing cognitive load, particularly memory load** (Card et al, 1983; Cates, 1991b, 1992; Florin, 1990; Keller, 1987).

Static/directive support.

The product displays key information on the screen and on-line help is always available (Elkerton, 1989; Kearsley, 1988). The product makes related content available through multi-linked nodes. The product maintains a record of learner position and make a map of trail of recent navigational actions available (Cates, 1991b).

Dynamic/interactive support.

The product offers advice on sequence, path, or both. It matches its advice to the intentions and wishes of the learner. Advice is "localized" or "compartmentalized" so that it suits exactly the context in which it is sought (Baecker., Grudin, Buxton, & Greenberg, 1995; Oren, 1990). Learners are not presented with more material than they requested. When learners ask for advice or explanation a second time, that advice or explanation is rephrased (Hutchings et al, 1992). Where possible, the product employs multi-sensory (dual) encoding, usually through use of multiple media (Florin, 1990; Oren, 1990; Paivio, 1986).

Probably the best way to identify cognitive sufficiency is by noting the **absence** of cognitive overload. The following types of evidence suggest cognitive overload:

Process evidence.

Audit trails: There is much repetitive backtracking. Learners have repeatedly viewed navigation trails or maps or other product-supplied illustrations of the product's internal structure.

Oral: There are many oral requests for assistance and expressions of confusion or disorientation by learners.

Learner-created: Learners spend long periods of time reviewing representations of the product's internal structure (such as structural maps, diagrams, and flowcharts) that they have created.

Product evidence.

Journal: Entries express concern about confidence or confusion about the features or operation of the product. Such evidence is a negative (contra-) indication of cognitive sufficiency.

Learner-created: Sometimes cognitively overloaded learners create memory aids, including representations of the internal structure of the product or "quick reference" cards to assist them while they're using the product. Once again, this suggests that the product is placing a heavy burden on learner memory and that learners are attempting to compensate by creating external supports to reduce cognitive load.

Concerns.

Metacognition calls for an active learner. Learners need to learn memory "tricks." They may also need to become accustomed to the product's demands. Learners will need to determine the optimum combination of their own memory aids and the computer's external support mechanisms.

Persistence and Responsibility

Skill: **Recognizing the scope of mental effort required and distributing mental effort across the task as appropriate** (Costa, 1985b; Falhikov & Boud, 1989; Hannafin & Rieber, 1989b; Iran-Nejad, 1990; Milheim & Martin, 1991; Presseisen, 1985; Pressley et al, 1985).

Static/directive support.

The product projects time demands and the relative difficulty of material to be covered, perhaps in the form of time indicators (for example, clocks, stopwatches, calendar pages) (Cates, 1991b) or a difficulty rating score (perhaps from 1 to 10). The product displays progress gauges to inform learners of progress (Galitz, 1996).

Dynamic/interactive support.

The product makes encouraging comments as the learner works through the task (Costa, 1985a; Derry, 1989). The product's coach offers advice or guidance on how to handle tasks (Cates & Bruce,

2000) or presentations in which an experienced learner describes (models) how he or she persisted (Beyer, 1991; Florin, 1990). The product may employ adaptive difficulty levels as a way of assisting learners having troubles with persistence. Such adaptation can be under learner control (perhaps through a prompt and selection option) or may be triggered automatically by some symptom or set of symptoms that suggests flagging persistence (Cates & Bruce, 2000; Marchionini, 1989; Zellermayer et al, 1991).

Process evidence.

Audit trails: Persistence on task is evidenced by few breaks, lower response latencies, and times between screen changes that are comparable to those of learners who work consistently and persistently.

Oral: Discussions are focused with little sidetracking and few purely social interactions.

Product evidence.

Journal: Entries reflect persistence and continuing effort. Entry dates or times reflect a distribution of effort across the task.

Audit trails: Learners make continuing progress toward the goal. If items designed to test acquired knowledge or skill are embedded in instruction, learner performance on these items is generally consistent across all aspects of the task.

Concerns.

Lower ability learners or learners with lower levels of self-confidence or self-esteem may be easily discouraged. Computers programs are not ideally suited to providing the "warm" human support such learners may need.

Skill: **Taking personal control and responsibility for learning** (Falhikov & Boud, 1989; Keller & Keller, 1991; Prawat, 1989).

Static/directive support.

Phrases and expressions emphasize the centrality of the learner. For example, instead of having the product ask the learner to indicate "your choice" of some options, it asks the learner indicate "my choice" of options. In short, language used in the product is learner-referenced whenever possible. The product also evidences a philosophy that the learner is an active participant, most noticeably in phrasing, where the product uses active phrases for learner actions. So, instead of stating, "You will be asked to select one of the following and the program will then supply you with related materials," the program states, "Make your selection to view related materials" (Keller & Suzuki, 1988).

Dynamic/interactive support.

As was the case above, the product uses learner-referenced language and assumes an active-learner philosophy. The product offers choices, instead of imposing decisions (Yordy, 1991). The product is obedient, cooperative, and non-intrusive (Keller, 1987).

Process evidence.

Once again, learners exhibit signs of persistence on task. In addition, they use first person pronouns and possessives in oral discussions when referring to their progress. In general, overheard comments evince a sense of control and responsibility.

Product evidence.

Journal: Entries voice a sense of responsibility for completion of the task, a sense of control (effort related to outcome), and do not attribute outcomes to the behavior or control of others, nor express feelings of helplessness (Cates, 1981, 1991a).

Concerns.

It is not enough for the product to use the "correct" kind of language if it does not actually "practice what it preaches."

Metacognitive Growth

Skill: **Analyzing the success of a learning outcome** (Iran-Nejad, 1990; Presseisen, 1985; Robert-Jan Simons, 1993; Wellman, 1985).

Static/directive support.

The product maintains records of learners' previous performances and make these records available to learners.

Dynamic/interactive support.

The product comments on learner success (Costa, 1985a; Casey, 1996). Learners may be debriefed by a teacher or peer using questions and oral discussion (Baron & Kallick, 1985; Wilson & Cole, 1991). The computer can initiate or facilitate this debriefing process by printing out a "debriefing log" that details strategies, progress, and other relevant information which could assist in the debriefing.

Process evidence.

Audit trails: The learner refers to records of previous performances.

Oral: Learners participate in discussions of strengths and weaknesses of their task performance and discuss their perceptions of success.

Product evidence.

Journal: Entries refer to evaluation of performance in completing the task and directly address perceptions of success or failure.

Concerns.

Some learners may define success as simple completion of the task or as escape from it (Prawat, 1989). Others may feel they have failed even when their performance is acceptable because they compare themselves to more-expert models presented by the product or by the person doing the debriefing (Iran-Nejad, 1990). A common definition of success must be mutually agreed-upon in advance (Keller, 1987).

Skill: **Generalizing from one learning episode to others** (Falhikov & Boud, 1989; Gavalek & Raphael, 1985; Glatthorn & Baron, 1985; Tobias, 1989; Wilson & Cole, 1991).

Static/directive support.

Once again, the product maintains records of learners' previous performance and makes those records available to learners (Caffarella, 1987).

Dynamic/interactive support.

The product comments on learner success or cites earlier performances. Learners may work with a teacher or peer using questions and oral discussion to determine exactly which lessons have been learned from the experience. In these sessions, the results of several learning episodes are reviewed and a general principle to account for the performance in those episodes formulated (Cates, 1991a; Costa, 1985b). The computer "debriefing log" mentioned above should help in discussing multiple episodes, as should learners' journal entries.

Process evidence.

Audit trails: Learners refers to previous performance records.

Oral: Learners discuss extensions of practices and strategies used in the present learning episode.

Product evidence.

Journal: Entries discuss possible extensions of the practices and strategies used in the present learning episode.

Audit trails: If the learner has employed strategies or approaches not covered in the present learning episode, one could infer that he or she generalized such strategies from previous learning episodes.

Concerns.

We cannot know for sure if learners are generalizing from one learning episode to another unless we have opportunities to observe learners across multiple learning episodes. It may be that enhancing this metacognitive skill is accomplished more effectively in human-to-human discussion.

Final Thoughts

This article has examined metacognition, ways in which hypermedia/ multimedia learning products could stimulate, exercise, or develop specific metacognitive skills, and the types of evidence we might expect to confirm the operation of each skill. This article has attempted to consolidate a broad body of literature and to synthesize and apply it in new ways. The work started here is clearly foundational; that is, it is intended to serve as a base or reference for exploring through design and research how we might support and enhance learner metacognitive activity while working with hypermedia/multimedia products. Types of scaffolding (external support) suggested in this article should next be tested through incorporation in prototypes and studies should examine how the suggested data sources help to determine learners' metacognitive sufficiency.

Before this article concludes, there is one reservation about metacognition and learner dependency that should be noted. Gavalek and Raphael (1985) contended that "it is the transfer of control from another individual to the learner himself or herself that is one of the primary criteria suggested for determining whether metacognition is involved" (p. 111). In a similar vein, Wolz et al (1989) wrote, "While initial learning may require extensive supervision, once the key concepts are learned, users are expected to initiate their own goals and solicit expertise from others only when necessary" (p. 55).

It is unclear whether external support actually stimulates metacognition or merely substitutes for it. Derry (1985), Day et al (1985), and Wellman (1985) expressed concern that learners could become dependent upon the presence of external support and would not, therefore, attempt to internalize the skills. In fact, Yore (1986) and Whitener (1989) both concluded that too much external support could actually inhibit metacognitive development by short-circuiting the process by which learners formulate their own strategies. Kozma (1987) disagreed, however, arguing that external support can only help learners develop their own metacognitive skills. More research on metacognition and external support is needed. If we are to meet Gavalek and Raphael's dictum that control be transferred to the learner, researchers must attempt to identify techniques that exercise and develop students' metacognitive skills to the point where learners are no longer dependent upon the presence and aid of such external support.

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