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ABSTRACT

Attributes of multimedia learning resources are explored, considering the physical resources, the learners, and the instructional design factors that appear to be crucial in determining interactive capability and potential for instruction. The first significant dimension that is discussed is the sensory dimension, which includes structural media attributes and also incorporates the imposed communication variable, message treatment. A processing dimension is discussed, which relates more closely to the functional attributes of media, and is approached from the viewpoint of what the learner brings to the media. A control dimension is also introduced, represented by a continuum from total control exercised by the program designed to the ability of the learner to manage the learning situation completely free of program control. Inquiry in these areas of education and instructional technology has the potential for being translated into practical guidelines for multimedia development. Two figures illustrate the discussion. (Contains 46 references.) (SLD)

Title:

Interactivity and Multimedia Instruction: Crucial Attributes for Design and Instruction

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INTERACTIVITY AND MULTIMEDIA INSTRUCTION: CRUCIAL ATTRIBUTES FOR DESIGN AND UTILIZATION.

Increasing interest in currently available multimedia technologies capable of providing interactive learning experiences has resulted in widespread enthusiasm. This has been particularly true of technologies incorporating the laser videodisc interfaced with a computer and other optical disc technologies, including configurations commonly identified as multimedia systems. Electronic multimedia does hold the promise of providing easy access to information that has untold richness of multiple images and sounds (Ambron, 1988). Multimedia certainly provides the ability to illustrate ideas with pictorial, audio, text, or any combination of stimuli.

On the other hand, we continue to read claims that research suggests no learning benefits can be gained by employing a specific medium to deliver instruction, regardless of the learning task, learner traits, symbolic elements, curriculum content, or setting. (Clark, 1983; Clark & Salomon, 1987; Clark & Sugrue, 1988).

When the psychological effects of a presentational medium are considered in terms of the contribution they make to specific educational outcomes, the concern is with the effects of specific media characteristics on specific individuals and with the functions they accomplish relative to given instructional tasks (Salomon, 1974). Recently the assumption that there is a one-to-one correspondence between coding elements and afforded activities, on the one hand, and specific modes of mental representation on the other has been questioned (Clark & Salomon, 1987). Still, a useful classification distinguishes *structural* media attributes from *functional* media attributes to facilitate differentiating media on the basis of their function for influencing and activating different kinds of learning processes (Heidt, 1977,1978).

The goal of this paper is to explore attributes of multimedia learning resources: the physical resources; the learners; and instructional design factors which appear to be crucial in determining interactive capability and potential for instruction.

Three significant dimensions will be examined, beginning with a **Sensory Dimension**, which includes structural media attributes and also incorporates an imposed communication variable, message treatment. Next a **Processing Dimension**, which relates more closely to the functional attributes of media. This dimension will be approached primarily from the perspective of what the learner brings to the media. Finally, a **Control Dimension** is introduced, represented by a continuum from total control exercised by the program designer to the ability of the learner to manage the learning situation completely free of program control.

In terms of the internal operations of the learner, we need to consider how the structural attributes of a medium used as a technology for instruction can be utilized as functional attributes which facilitate effective mental processing. Based on the assumption that the factors which underlie the use of media for instruction are the symbol system, the message, the learner, and the educational task (Salomon, 1974), our Sensory Dimension relates to both the symbol system and the message. The Processing Dimension essentially treats the learner's interaction with the symbol system, the message, and the task. The Control Dimension deals with selected aspects of the task, although overlap with the message is obvious.

Each of the dimensions represents a continuum. A cube diagram (Figure 1) presents possible interrelationships among the various dimensions.

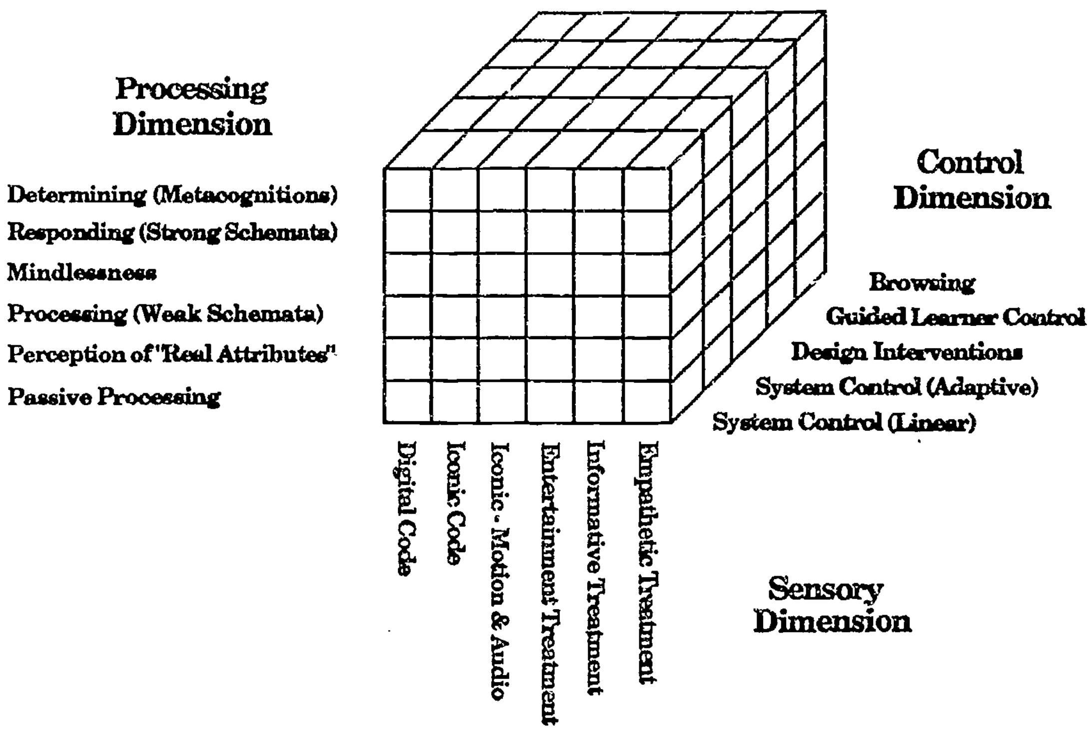

Figure 1. Crucial Attributes of Interactive Instruction.

THE SENSORY DIMENSION

The Sensory Dimension suggests the possibility that as each additional structural media attribute or communication treatment variable is utilized, the potential for perceptual saliency is increased. Salomon's conclusions that it is the symbol system rather than the technology of transmission which is crucial for instruction, and that symbol systems are the primary, most essential attributes of media (1974, 1979), provided a point of departure from treating media as global, holistic entities. However, other aspects of symbol system theory may be less secure. In particular the assumption "that cognitive representations and processing are carried out in *various* symbolic modes that are *influenced* by the symbol systems employed by media, that some of these cognitions are *unique* counterparts of communicational symbol systems, and thus can be cultivated by symbol systems" (Clark & Salomon, 1987, p. 469), has been challenged.

For the purpose of examining the attributes of instructional systems, the concept of symbol systems is useful. Based on Goodman (1968) an important means of analysis is notationality. A notational system (e.g. languages; musical notation) consists of a set of separate, discontinuous characters correlated with a field of reference which is further segregated so that any character in the system isolates the object or objects it stands for. In contrast, nonnotational systems (e. g. pictures) are continuous and unsegregated with no set of isolated characters (Gardner, Howard & Perkins, 1974).

A related aspect of the Sensory Dimension has to do with perceptions of reality in the light of potentially vicarious mediated experiences. Several researchers have studied the perceptions of reality of television viewers. Dorr (1983) suggests various criteria which people use to judge reality: reality can represent a simulated experience in which characters, actions, messages, or themes in some way conform to real life; something is judged real if it is deemed possible; and a presentation is only judged real if it is considered probable or representative of reality. Considered from the viewpoint of the phenomenological school of philosophy, perceived reality can evolve through "bracketing" or the willing, but temporary, suspension of disbelief. The physical world isn't eliminated, but people simply disengage from it by bracketing it out and accepting the content and context of the media as real (Jonassen, 1984).

A classification placing symbolic modalities into categories of digital signs and iconic signs (Levie, 1978) will be familiar to most readers. As noted by Knowlton (1966), digital signs are essentially arbitrary and do not have natural referents, while iconic signs tend to bear a concrete resemblance to something for which they stand.

Digital Codes

Digital signs should be considered in terms of sensory modality. Common examples of digital signs in the visual modality are printed words, numbers, and semaphore code. Spoken words represent by far the most common auditory form of digital signs, although Morse code and alarms of various types constitute other examples (Levie, 1978).

Of much interest to our search for crucial interconnections among attributes of interactive instruction is the concept that human information processing involves the verbal symbolic system in interaction with an imaginal symbolic system (Paivio, 1971). "Thus, language can activate representations of nonverbal objects and events, which may be experienced in the form of mental imagery. Conversely, nonverbal objects and events, or mental images, can be described" (Paivio, 1983, p. 206).

Iconic Codes

The human imaginal system is specialized for processing spatial, simultaneous information of a relatively concrete nature. The system is also considered to perform independent operations, called "mental imagery", or "visual thinking". Iconic signs in the visual modality include pictures, statues, and gestures. Iconic signs in the auditory modality include sound effects and music (Levie, 1978). Although these symbol systems are low in notationality, they should not be considered easier nor more difficult to comprehend or learn than other systems (Gardner, et al, 1974; Clark & Salomon, 1987).

Iconic - Motion & Audio

Formal attributes of audiovisual presentations include action, pace, visual techniques, and verbal and nonverbal auditory events. Such attributes result from production and editing techniques and are defined independently of content.(Huston & Wright, 1983).

Several studies have analyzed the relationship between formal attributes and visual attention. Although many of the studies involved children, the results are interesting in terms of their potential relevance for learners of all ages. Production features which tend to maintain and elicit the attention of young children include motion, audio change, and sound effects (Anderson & Lorch, 1983).

Formal fe~'ures of television which possess the quality of perceptual salience were identified by Huston and Wright (1983). Attributes identified as salient included physical activity of characters, rapid pace, variability of scenes, visual special effects, loud music, sound effects and peculiar or non-human voices. Features identified as lacking perceptual salience include human speech, physical inactivity, and background music. Moderate action and zooms were classified as having moderate perceptual salience.

The effect of formal attributes is influenced by the learner's greater familiarity with a medium's attributes, and the learner's cognitive skills, linguistic and imaginal competence, and cultural knowledge. Huston and Wright (1983) discovered that perceptually salient attributes have much less influence on the attention and comprehension of older children and adults, compared with younger children.

Treatment: Entertainment; Informative; Empathetic

Cognitive social psychology suggests that people actively affect their environment through their personal and socially shared perceptions and they experience the consequences of their activity in a reciprocal, rather than linear fashion. "Thus, from the social learning perspective, psychological functioning involves a continuous reciprocal interaction between behavioral, cognitive, and environmental influences" (Bandura, 1978, p. 345). This reciprocal paradigm seems to imply a limited role for perceptually salient media attributes, however, communicational treatment provides one possible area of influence.

The concept of treatment relates to the manner in which the content, code, and structure of an instructional system is organized and presented. One classification of treatment forms identifies: "expository"; "dramatic"; and "personal involvement" (Kemp & Smellie, 1989).

Treatment can also be considered an aspect of communicational intent. It is possible to distinguish between different kinds of communicational events according to their perceived intent: intent to entertain; intent to convey (inform or share); and intent to change (Salomon, 1981).

Familiarity with the formal attributes of popular media could be a possible recommendation for using an entertainment treatment for instruction. Research results suggest otherwise. For example, Ksobiech (1976) found that university undergraduates who were told that a televised lesson would be entertaining performed poorly on a subsequent exam, compared to a group who were told they would take a test following the presentation, and another group which was told they were to evaluate the lesson.

Messages with treatments which convey the perception that the communicator is definitely attempting to influence or persuade the receiver will tend to be seen to limit one's freedom of thought or choice, and consequently are likely to be countereffective. Events which convey the perception that the only intent is to convey, or share information are considered more effective (Salomon, 1981). However, potential problems with excessive use of sterile information treatments could exist. Informative and interesting would seem to be a minimal guideline, calling upon the creative talents of instructional designers. A possible approach involves dramatic treatments which convey the communication intent of conveying information.

Some of the communicational intent of designers, even when the principal goal is to inform, includes persuading (motivating) the learner to accept the message as well as processing the information. The personal involvement treatment could counteract negative effects, but is difficult to carry out. An area of possible exploration would be to attempt what might be called an empathetic treatment. The goal would be to demonstrate the personal value of the communication to the receiver, in order that the attribution of intent would not be perceived as promoting the vested interests of the communicator.

THE PROCESSING DIMENSION

A popular assumption suggests that external forces strongly influence an individuals knowledge acquisition, attitudes, behaviors, and cognitive skill mastery. Learners are considered to be reactively controlled by media and instructional displays and the learner is perceived as an active responder to the medium's demands. The medium can be said to differentially activate cognitive or emotional responses from individuals with particular cognitive abilities or tendencies. The nature of the responses depends jointly on the attributes of the medium and on those of the individual (Salomon, 1983; Anderson & Lorch, 1983).

An alternative view contends that attention to instructional displays is actively under the *control* of the learner. The learner is perceived not only as a responder, but also as a potential determiner of the experience. Learners do not necessarily respond to the "real" attributes of the medium, but apply their own often culturally shared perceptions and attributions (the partial results of prior exposure to the media), which in turn affect the kind of experiences the learner realizes (Salomon, 1983; Anderson & Lorch, 1983).

There is reason to believe that the two perspectives are complementary. People are affected by their environments, but they actively influence their environments through their personal and socially shared perceptions. This reciprocal viewpoint implies that efforts to account for the impact of multimedia instructional systems should consider what the learner brings to the setting at least as much as what the system presents to the learner (Anderson & Lorch, 1983).

The initial stages on our continuum of processing: Perception of "Real Attributes" and Processing (Weak Schemata) basically represent a traditional S-O-R model of learning where the "O" represents internal processing which links the stimulus and the response. Here attention and reaction to the environment and its displays is dominant. The stages: Responding (Strong Schemata) and Determining (Metacognitions) represent a cognitive processing paradigm where previously developed schemata incorporating previous skill, information, and knowledge guide the learner's perception and largely determine present and future interactions. The stages: Passive Processing and Mindlessness represent aspects of each paradigm where superficial, automatic, or an absence of processing takes place.

It is suggested that both stages of the processing continuum operate when a learner encounters instructional displays and that they usually act in concert (Salomon, 1983). Top-down processing is guided by anticipatory schemata typical of search behavior , while bottom-up processing is guided mainly by the saliency of stimulus properties. "Apparently, the more one knows about a topic, and the better a new unit of material fits into a preexisting frame, conception, or schema, the more top-down processes dominate (assimilation); when the material is relatively novel (but not too novel) and being handled by impoverished schemata, bottom-up processes dominate (accommodation)" (Salomon, 1983, pp. 185-186)

Passive Processing

Instructional media and instructional systems have often been classified as "message or stimulus" oriented or as "response" oriented. Stimulus oriented media are characterized by their emphasis on input to students, the message and its' design, with very little concern for the explicit nature of the response(s) students are to make to a particular message or portions of it (Gropper, 1976). While clearly taking a response oriented approach, Gropper labeled media which do not themselves impose the conditions thought to be necessary for learning, such as use of feedback, as passive. Such media as films, television, radio, slides, slide-tape, audiotape, and print were identified as passive carriers. Active carriers (e.g. programmed instruction, CAI) deliberately and systematically dictate particular conditions for learning. Such classifications may have contributed to common perceptions that motion pictures, television and other presentation media facilitate only passive processing.

Termination of attention, the equivalent of passive processing, would be expected to occur if presented material were sufficiently unfamiliar or difficult and the learner was unable to activate and apply a comprehension schema (Anderson & Lorch, 1983).

Perception of "Real Attributes"

Processing of popular media has been considered, if not passive, at least reactive as opposed to active. Extrapolation of this approach to instruction suggests that an audiovisual medium elicits and maintains attention via salient formal features, both visual and auditory. The direction of influence is from the medium to the learner. The influence of learner intentions, plans, strategies, and previous experience are minimal. Relatively automatic comprehension and retention processes are assumed to occur, once attention has been gained (Anderson & Lorch, 1983).

Salomon (1981) suggests that media can induce "naive changes" to schemata when the schemata are weak, poorly integrated, isolated, not salient, not important, or not readily available. Perception of the content of an instructional presentation may occur when the salience of the formal features elicits and maintains attention to the system. This has been equated with a type of "exploration" as the learner responds to immediate, salient, discrete aspects of the stimulus setting. Exploration is most common when the learner is unfamiliar with the situation being presented (Huston & Wright, 1983).

Processing (Weak Schemata)

Exploration may be said to move gradually to perceptual search when the learner is guided by internally generated goals, rather than by external sensory events. At this stage some of the features that attract attention may be perceptually salient, but learners are attracted to the display features because of their informativeness or relevance to personal goals, rather than on their perceptual characteristics (Huston & Wright, 1983).

Even though the schemata may be well integrated, salient, and important in the learner's repertoire, media can influence changes to schemata which are insufficiently developed to handle certain novel events. Such actions have been characterized as information seeking processes (Salomon, 1981).

Mindlessness

Mindlessness, or stereotypical reenactment represents the absence of active conscious processing. It has been shown that people engage in mindless behavior when they encounter events that appear to them as highly familiar, overlearned, and repetitious. Individuals engaged in mindless activity may give the appearance of mindful action, but new information is not actually processed. In particular, when the structure of a communication is congruent with a receiver's past experience, it may result in behavior which is "mindless" of relevant details. (Langer, Blank & Chanowitz, 1978). Thus what learners are capable of doing is not necessarily what they actually do. The mindlessness phenomena would seem to account for the performance of learners who appear quite capable, but continually fail to master curriculum goals, despite repeating the same material several times.

Responding (Strong Schemata)

It is at this stage that prior knowledge and skills, which are stored in the schemata and are available for processing come into play. Thus, the essence of the *reciprocal paradigm* which "postulates that personal dispositions, attributions of intent and meaning, communicational behaviors, and educational outcomes are reciprocally related to each other. We are influenced by others' messages, but it is our (often a priori) interpretation of the messages that influence the way we are influenced" (Salomon, 1981, p. 211).

Determining (Metacognitions)

Metacognitions tell us when, under what conditions, and for what purposes we are to apply schemata. Learners influence the way they interact within an instructional system, not just by responding through the skills and knowledge the system evokes in them, but also through metacognitions that they apply to it. Learners may also develop new internal strategies about how to learn as they interact with an instructional system. At this stage the learner is *determining* not only *what* material will be processed, but also *how* it will be processed. We could expect learners to apply alternative schemata, if available, depending upon their intentions, goals, and the perceived demands of the setting (Salomon, 1981; 1983).

THE CONTROL DIMENSION

A crucial aspect of interactive instruction which relates to the learner's processing of the media within a complex instructional system is the manner in which the system permits control during learning. Under learner control, adaptive instructional decisions are made by the student, in contrast to system control where instructional decisions (adaptive or linear) are made for the student. Design decisions along this dimension, in interplay with the learner and the medium would seem to determine the true nature and quality of the interaction involved.

If we accept the principles of interaction implied in the "Reciprocal Paragigm" and current claims of cognitive learning theory: constructivistic (Bednar, Cunningham, Duffy, & Perry, 1991; Duffy & Jonassen, 1991) and generative (Wittrock, 1977;1979), it seems evident that even in situations in which the presentations are selected, sequenced , and paced for the student, a great deal of learner control will still be exercised by the student. Concluding that all instruction involves some learner control, Merrill (1984) suggested that "the challenge is not whether or not learner-control should be made available, but rather how to maximize the student's ability to use the learner control available (1984, p. 239). There is little positive evidence favoring total, unaided learner control. Research indicates that learner control with some form of coaching has been consistently superior to unassisted learner control (Hannafin, 1985). Thus, "The capabilities of the *learners* to use control options effectively is a more salient consideration than the capability of the *technology* to permit control" (Hannafin, 1985, p. 243).

Perhaps predictably, the research has begun to suggest that "learner control is not a unitary construct, but rather a collection of strategies that function in different ways depending on what is being controlled by whom" (Ross & Morrison, 1989, p. 28). Thus, a continuum of instructional control is implied (Figure 2), and indeed the research continues to feature attempts to identify specific situations in which learner control or program control, or some combination along a continuum, is most effective.

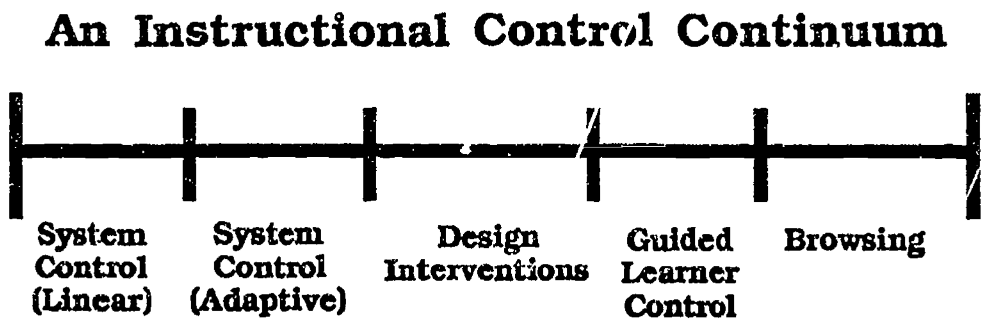

Figure 2. Representation of a Continuum of Instructional Control.

System Control (Linear)

System control of instruction is characterized as external, and is identified with instruction in which all learners follow a predetermined route established by the designer without using individual judgement as to the appropriateness of the path (Hannafin, 1984). Externally controlled CAI has proven effective in drill and practice tasks involving lower order intellectual skills (Hannafin, 1984), however the evidence suggests that contextual and substantive information and higher order skills may be best taught using learner control (Kulik, Bangert, & Williams, 1983).

System Control (Adaptive)

Although some CAI and Interactive Video instruction has been designed along the lines of a linear programming model, system control does not necessarily connote a linear approach. Tutorial CAI is more the ideal. An example of rigid system control is a version of tutorial CAI, based on a performance or response driven adaptive instructional model. The learner is given practice problems as part of the presentation and the next display is determined from the response. Any adaptation is the same for all learners, but if some branching is used, a learner would see one display if the response to the previous frame was correct, and a different one if it was incorrect. It has been suggested that provided the content is fixed, such a system is similar to a lecture, and even more limited than a textbook in providing the opportunity for the learner to override the system . Even systems which incorporate an idiosyncratic adaptive model for each student have been programmed in such a way that learner control is very limited (Merrill, 1984).

Design Interventions

Several design enhancements within a system control approach are supported by research evidence. Learning has been shown to be most effective when criterion questions are embedded throughout the lesson. As well, questioning and response feedback procedures have been shown to increase comprehension and attention to instruction using interactive video (Hannafin, 1985). Providing examples in a variety of contexts has been identified as a promising strategy which facilitates independent adaptive decision making by learners (Ross, Morrison & O'Dell, 1989).

Idiosyncratic adaptive instruction, and instruction utilizing the above design enhancements may each be seen as an attempt to assist the individual to most successfully achieve desired program goals and objectives. Thus both may be more effective in situations where there is clear agreement on the desirability of all students mastering relatively specific instructional outcomes.

Guided Learner Control

Situations in which considerable learner control is afforded, but with advice given to the learner (internal program guidance) is a promising approach. Research evidence verifies the desirability of including some form of "coaching" to assist learners in making informed decisions (Hannafin, 1984; Ross, 1984; Tennyson and Buttrey, 1980). Successful procedures have been developed in research settings which offer guidance upon which individual student's decisions can be based. The program can advise the learner as to the number and types of practice items or examples recommended, current mastery status, and other performance features. The advisement is based upon the individuals past, current, or cumulative performance during a given lesson. The learner maintains control by being able to accept or reject the offered advice (Hannafin, 1984; Hannafin, 1985).

Emerging learning theory suggests that even in settings where instructional displays are selected for, sequenced for, and paced for the student, a great deal of learner control will still be exercised by the student. While engaging in a lesson, learners acquire internal strategies about how to learn, in addition to subject matter. This *metacognition* refers to the "how to study" model which the student uses to guide interaction with the instructional system (Merrill, 1984). According to Merrill "the challenge is not whether or not learner-control should be made available, but rather how to maximize the student's ability to use the learner-control available" (1984, p.239).

A major thrust of research by Merrill and associates with adaptive CAI featuring internal learner control involves attempting to guide the learner by providing carefully defined strategy options for controlling display presentation. They suggest that students can be taught more appropriate processing procedures and encouraged to use the strategies (metacognitions) where appropriate. A promising early result was the conclusion regarding the hypothesis: "Students who are provided directions for conscious cognitive processing of the information presented will perform better than will students who are left to their own internal processing strategies". Students who received directions about how to process the information scored higher on the posttest than students who didn't receive the directions.

Browsing

Browsing is the label used to subsume the variety of things which could happen at the end of the continuum where the learner is generally considered to be in control, or at least interacting directly with the system. One attempt to define browsing describes it as the intellectual process of acquiring individualistic knowledge (Jonassen, 1989). A total learner control orientation would imply allowing learners to make decisions about what they want to learn by selecting options which are presented at different points in the lesson (Ross, 1984). The least sophisticated use of multimedia as an *information reference tool* might be termed *nibbling*, with the user aimlessly probing through a dense information base.

However, it is necessary to consider other approaches to learning, as well as other approaches to utilizing the information potential of multimedia systems.

Recent controversy over the instructional design model commonly employed within the field of instructional technology has implications for interactive multimedia. Claiming that instructional technology had accommodated cognitive psychology in its theory, but very little in its practice, Jonassen (1990) urged the field to move toward a *constructivist* view of instructional design. He pointed out that cognitive information processing is not fundamentally different from behaviorism, since both rely upon an objectivistic conception of knowledge.

A definition of constructivism provided by Jonassen (1990) will be useful to a further discussion of the issue:

> Constructivism is the belief that knowledge is personally constructed from internal representations by individuals using their experiences as a foundation. Knowledge is based upon individual constructions that are not tied to any external reality, but rather to the knower's interactions with the external world. Reality is to a degree whatever the knower conceives it to be (p. 32).

An extreme position on constructivism advocates that it become the sole basis for instructional design. It is claimed that since the goal of instruction for both behaviorist applications and cognitive information processing is to communicate or transfer knowledge to learners in the most efficient, effective manner possible, it is not tenable to add constructivist theory to the "smorgasbord" of behaviorism and cognitive information processing (Bednar, Cunningham, Duffy & Perry, 1991).

Reigeluth (1991) responded to Bednar, *et al*, as well as other writers who suggest such an extreme view of constructivism. He pointed out that constructivism does have much of value to educators, but that other perspectives do as well. Some of the major tenets of constructivism have long been espoused by instructional technology. For example instructional designers "have for some time advocated 'situating' learning experiences in authentic activities" (1991, p. 34). The need to couch instruction in a context that is meaningful to learners has been identified as perhaps the most significant aspect of constructivistic design (Jonassen, 1991). Certainly most instructional designers and teachers would not disagree, but they might also report much frustration from attempts at trying to situate their instruction in appropriate contexts.

Recent interest in multimedia has been accompanied by claims and suggestions of potential user empowerment. We agree with Merrill (1991), who advocated that moderate constructivism has much that should be considered by instructional designers, and pointed out that much of his own work in developing ID_2 is an attempt to provide tools that enable the development of the type of learning environments that they describe. Merrill argued, however, that the assumptions about the learning process made by extreme constructivistic authors as Bednar, *et al* (1991) are unnecessarily restrictive and may actually prevent the more effective instruction they advocate.

Much of the enthusiasm for multimedia is for purposes other than intentionally created learning environments. It is multimedia systems which are designed to be used as information reference tools which actually represent the focus of much of the discussion relating to learner empowerment and freedom.

Learners using hypermedia are said to be freed from the linear tradition of printed text. "They are encouraged to browse a hyperdocument, move easily among vast quantities of information according to plan or serendipity, follow relationships pre-coordinated by the author or create their own paths through the information" (Marchionini, 1988, p. 8).

Freedom and empowerment mean that learners, particularly where specific instructional outcomes are an issue, require new strategies and tools for making the best use of their time and effort. The challenge to designers is to devise ways to help learners manage this freedom of learning (Marchionini, 1988). Thus, the importance of careful design and development is no less critical in the design of instructional hypermedia environments than for other learning formats. "In order to successfully use a hypermedia application, learners must be provided with appropriate and clear navigational and conceptual tools in order to explore even the best-designed systems" (Morariu, 1988, p. 19).

Given the power of emerging technologies, would it not be possible for a multimedia system to provide in effect a continuum of experiences? Could not the potential resources for structured and unstructured experiences alike reside within something called an intelligent hypermedia knowledge system for learning? And could not such a system accommodate objective instruction in well-defined domains as well as provide an open environment for active learning which enables learners to make their own decisions

Most of this discussion has dealt with inquiry in various areas of education and instructional technology in the belief that it has the promise of being translated into practical guidelines for multimedia development. Inquiry specific to multimedia is beginning to appear in the literature, much of which suggests careful and systematic research on specific aspects of hypermedia. For example, Story and Harvey (1991) reviewed existing research on hypermedia browsers (structural iconic browsers, or maps intended to facilitate navigation through a hypermedia system). However, much of the literature deals with development, which as Park (1991) suggests, essentially involves hypertext and not true hypermedia or multimedia at all.

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