Design and Development Factors in the Production of Hypermedia-based Courseware

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Abstract: Hypermedia are becoming increasingly popular tools for courseware authors to use In the design and development of com puter-based instruction. This article assembles guidelines, which have been derived from cognitive and constructivlst learning theory and Instructional design literature, for designing effective hypermedia-based courseware.

Resume: Les auteurs de loglciels d'enseignement utlllsent de plus en plus les hypermedia commes outlls poputaires dans la conceptbn et le perfecttonnement de l'enseignement automatise. Get article reunit les lignes directrices quiproviennentde la theorie d'enseignement congnltif et constructivistes et de la litterature de creation educative dans le but de concevolr du materiel utile artlcule sur rhypermedta.

The development of courseware has been aided by the employment of various authoring systems and languages. One example of a programming language being used as an authoring system is the HyperCard application program for the Apple Macintosh computer platform (Goodman, 1990). HyperCard combines the functions of a database management system, courseware authoring environment, multimedia controller, and computer programming environment (Robinson, 1990). While HyperCard is relatively easy for the novice developer to use, to achieve proficiency in this sophisticated environment requires a considerable investment of time and effort. However, as Clark (1984); Jonassen (1988a); and Roblyer (1988) have pointed out, the effectiveness of instruction is a function of the design of the instruction, not the choice of medium used to present the instruction. Therefore effective HyperCard-based products should be designed by following accepted instructional development guidelines (Smith, 1989).

The application of hypermedia in education settings is relatively new. Given the amount of research about instructional design procedures it seems reasonable to select an appropriate model and apply it to CAI. Unfortunately this procedure does not usually work. Known procedures can only provide valuable guidelines, but none of them can be applied directly (Steinberg, 1991). A review of the literature indicates isolated, disparate sources of information regarding the development of instructional hypermedia-based products. The intent of this paper is to bring together many of the available sources of information in order to provide novice developers who choose to use HyperCard as an authoring environment with some courseware development guidelines.

The Influence of Learning Theory

The idea of teaching with machines is not new. Pressey, during the mid 1920s, was one of the first researchers interested in integrating the use of teaching machines into the learning process. He was also responsible for the introduction of a mastery learning paradigm. In this approach, content was broken down into small blocks or units of instruction and presented to the learner in a linear, sequential manner. Each programmed lesson was individualized, self-paced and characterized by immediate reinforcement and active student involvement in the learning process. Although the early machines were mechanical, many of the behaviorist principles developed during their use were carried over and applied to the first generation of computer-based instructional systems (Pagliaro, 1983; Reiser, 1987; Niemiec, and Walberg, 1989). While we do not yet fully understand how people learn, principles derived from learning theories have been employed to produce measurably better instruction (Hannafin & Peck, 1988; Hannafin and Reibner, 1989a)

During the 1970s, cognitive learning theory began to displace behavioral theory in instructional design (Case and Bereiter, 1984). Cognitive theory emphasizes the activity of the learner in acquiring, processing, and structuring information (Fosnot, 1984). Learner activity is based on various processes such as perception, thinking, memory, and the representation of knowledge (Shuell, 1986). Some examples of this approach to teaching and learning include Ausubel's progressive differentiation, Merrill and Scandura's path analysis, and Reigeluth and Men-ill's elaboration theory (Reigeluth & Curtis, 1987). Gagne's events of instruction, which are based on his events of learning, were derived "directly from information-processing theories of instruction" (Steinberg, 1991, p. 38).

In more recent times, the constructivist paradigm has begun to exert some influence on the design of CBI. The constructivist view of education "insists that learning involves discovery, creation, or active reconstruction in an essential way" (Hofmeister and Rudowski, 1992, p. iii). Again, this idea is not new. Piaget was one of the better known theorists who espoused the constructivist view of education (Jonassen, 1990). In this paradigm, the teacher functions as a learning guide and provider of learning environments that are responsive to learner exploration (Seels, 1989). Current developments in mass storage technology and a steady increase in available computing power have prompted the development of large knowledge-bases (Delany and Landow, 1991). If this trend continues, then teachers will have access to the tools to employ a constructivist's approach to computer-based instruction.

Hypertext and Hypermedia

Hypertext is non-linear text. This means that the information is broken into pieces or chunks called nodes, rather than being composed of the more traditional linear form of sentences and paragraphs (Wang & Jonassen, 1990). A node usually consist of a single concept or idea. Physically they are often limited to the amount of information that will fit onto a computer screen (Fiderio, 1988). The nodes are linked together in a logical manner, and the user is often able to decide which link to follow to encounter a related node (Tsai, 1988). A link will frequently lead to nodes that contain information which is related to, or enhances the understanding of the current topic content (Fiderio, 1988).

Hypermedia is a combination of the hypertext idea of logical links and the use of multimedia (Horn, 1989). Multimedia entails the use of the computer to integrate and control electronic media devices such as monitors, videodisc players, CD-ROM players, and other electronic equipment. A more detailed definition has been offered by Locatis, Letourneau & Banvard (1990) where hypermedia is "a computer-based approach to information management in which data are stored in networks of nodes connected by links. Nodes can contain text, graphics, audio, video, source code, or other data that are meant to be viewed through an interactive browser and manipulated with a structure editor" (p. 65). As the authors have suggested, the term hypermedia can be used as an umbrella term for any electronically stored information that is logically linked.

There are many benefits that are possible from the use of hypermedia. The users can access the information in a manner that supports their associative thinking processes, and therefore individualization can be maximized (Tsai, 1988). Hypertext is able to more easily convey knowledge, instead of just information, because the nodes represent concepts and the links are relations between the concepts, much like the semantic network discussed in cognitive psychology (Denenberg, 1988). Users are able to contribute their own knowledge and ideas, and make changes to the information system (Jonassen, 1986). The ease of delivering information in various forms allows the use of the most appropriate media to suit the information content and learner audience (Tazelaar, 1990). The interactivity built into hypermedia systems promotes learner control and fosters the development of positive teacher/learner relationships (Marchionini, 1988).

The influence of cognitivism on learning theory has resulted in a stronger emphasis on the activity of the learner in the processing and structuring of information (Foster, 1986; Gagne & Glaser, 1987), and some researchers even suggest that students are likely to be more capable than teachers at directing their own learning (Laurillard, 1987). While the research regarding the most appropriate quantity and quality of learner control over the learning environment is mixed, there is general agreement from many sources that learners should be more involved in the process (Ross & Morrison, 1989; Schwier & Misanchuk, 1988; Schwier & Misanchuk, 1993; Jonassen, 1988c; Bowers & Tsai, 1990). Most hypermedia systems allow, or encourage, a considerable amount of user interaction and control over the instructional process.

Cognitive researchers suggest that learners use semantic networks, i.e. associative representations of knowledge for the storage and retrieval of information (Denenberg, 1988). A hypermedia system, analogous to a semantic network, can be designed to allow the learners to access information using paths that reflect and support their own associative thinking processes (Tsai, 1988). Each hypermedia stack has nodes (or screens) that contain information or concepts, and links (or buttons) that represent relationships between the information or concepts (Locatis, Letourneau & Banvard, 1990). The learner, through using and browsing such a system, soon learns that "the meaning of any topic is not absolute but relative to its relationships with other topics" (Denenberg, 1988, p. 325). Megarry (1988) suggests that "knowledge is not merely a collection of facts. Although we may be able to memorize isolated facts for a short while at least, meaningful learning demands that we internalize information; we break it down, digest it and locate it in our pre-existing highly complex web of interconnected knowledge and ideas, building fresh links and restructuring old ones" (p. 173).

Hypermedia systems can be easily designed to allow the learners to add or modify information in the system (Bowers & Tsai, 1990). Scardamalia, Bereiter, McLean, Swallow and Woodruff (1989) have suggested that the use of a properly designed hypermedia system should be capable of creating, or positively influencing, the following cognitive-based principles of learning: make knowledge-construction activities more overt, encourage the development of student-created goals, encourage questioning and allow the learner to more easily find answers to the self-generated questions, encourage learning strategies other than rehearsal, encourage multiple passes through material, support varied ways of organizing knowledge, encourage use and exploration of related knowledge, provide opportunities for individual learning styles, provide time to reflect on the knowledge, and finally, facilitate transfer of knowledge across contexts.

Hypertext allows a great deal of user control. Although this is often good there is a genuine danger that the user may get disoriented or "lost" while traversing obscurely-linked information (Barden, 1989). Programs often lack visual and spatial cues to give context and orientation to the user (Fidero, 1988). The quality of user control is as important as the quantity of user control, and educators must learn how to maximize the effective use of learner control in hypermedia systems (Marchionini, 1988). Research evidence suggests that some learners, especially those with less ability or no prior knowledge of the content area, are unsuccessful in learning from unstructured learning environments (Tsai, 1988; Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989). Hypermedia systems have the potential for storing huge amounts of cross-referenced information. The high level of learner control may result in distraction, missing relevant or important information, or forming wrong interpretations from the information (Jonassen, 1988). As well, research suggests that some students, especially those lacking understanding of the basic concepts of the information being presented, fail to make effective use of the extra information or freedom available in hypermedia systems (Sales & Williams, 1988; Gray, 1989).

Another potential problem with hypermedia is the need for breaking content into manageable-sized chunks or pieces for storage and/or representation in the hypertext system. Breaking certain themes or thoughts into discrete nodes may be detrimental to comprehension of the material by the user. Therefore some types of information may not be easily handled by using hypermedia (Begeman & Conklin, 1988). Generally, information that is inherently non-linear, easily modularized, and voluminous in size is well suited to hypertext development. For example, reference works such as dictionaries, thesauri, encyclopedias and other technical documents are good candidates, while literary works that require character development or a story line are best presented in a traditional, linear manner (Locatis, Letourneau & Banvard, 1990).

Courseware Design Factors

A primary purpose of individualized instruction is to present information that is relevant to the needs of the learner (Jonassen, 1986). Although there are many factors to consider when designing and developing courseware, the issue of how the user interacts with the instruction is of utmost importance (Schwier & Misanchuk, 1988; Hannafm, 1989; Hannafm & Rieber, 1989b; Steinberg, 1991). Learner interaction variables included in this review are learner input, questions, response, feedback, and control. Learner motivation and expectations are learner variables that have not been included in this review. Another important class of variables related to effective courseware design is how the information is presented to the learner (Hartley, 1987). Factors included in presentation design include screen design variables, the size of the informational chunks, and frame variations. The following sections will address these courseware design issues.

Learner Interaction Variables

User interactivity refers to the ability of the learner to exert control over the instruction, in order to accommodate individual differences and needs (Weller, 1988; Jonassen, 1985). This includes active roles for both the learner and the computer system in regard to learner input, practice, feedback, and learner control (Hannafm, 1985; Clark, 1984). Schwier andMisanchuk(1988), citing research from several sources, have suggested that effective learners actively interact with the instruction. The inherent assumption here is that meaningful interactivity should lead to greater learning.

Interactivity imposes active roles on both the computer and the learner

(Jonassen, 1988c). Therefore there must be some facility to allow the user to communicate with the courseware. Generally, the learner interacts with the courseware by typing commands or messages using the keyboard or by using an input device such as a mouse or tablet. The two general types of keyboard-based interaction for learner input include the use of multiple choice response or free-form response (Weller, 1988).

There are also several less commonly used forms of user input. Examples are touch screens and other sound, motion, or light-activated controls, and joystick or paddle. A relatively new input device is the hand-tracker, a glove-like device that allows learner control of the computer or application (McAvinney, 1990). Research has been conducted on using AI techniques to develop speech recognition and speech synthesis systems and natural language interfaces. For the most part, these systems are still in the research stage and not available for general use in education, although some systems may become available in the near future (Lee, Hauptmann & Rudnicky, 1990).

Practice

Research in learning theory suggests that effective practice is one of the fundamental principles influencing human learning (Gagne & Glaser, 1987; Shuell, 1986; Salisbury, 1988). Effective practice is related to the level of learner processing produced by the practice, not the amount of practice (Jonassen, 1988b; Weller, 1988). For example, when measuring the effects of embedded questions in CBI, Hobbs (1987) found that application questions were much more effective in promoting recall and comprehension than simple questions that could be answered from rote memory. Salisbury (1988) has pointed out that skill learning includes three stages. In the first stage, called the cognitive stage, the student learns to perform the skill accurately. The second stage, called the associative stage, includes practice and continues until performance is both fast and accurate. In the final or autonomous stage, the performance of the skill becomes more automatic and rapid.

Salisbury, Richards and Klein (1985) have offered the following list of recommendations for the design of effective practice, based on cognitive learning theory and research (see TABLE 1).

The use of distributed practice activities, varying the rate and type of practice, and the use of a variety of types of questions is motivating and more interesting. The demand on short term memory is also reduced and recall is facilitated (Hooper & Hannafin, 1988). In a study involving college students and interactive video, Philips, Hannafin, and Tripp (1988) found that embedded questions were most effective and that practice was most useful for factual knowledge, rather than higher level learning.

TABLE 1
Recommendations for Effective Practice Drawn from Cognitive Learning Theory

Principle	Design
1. Automaticity of subskills	Accuracy, speed, and the ability to perform the skill without a secondary task causing interference should be used as criteria for mastery.
2. Interference	Have students drill on only a small subset of items at a time. Provide review of old items as new ones are introduced. Initially use cues to emphasize differences among competing stimuli and then fade the cues gradually.
3. Spaced practice	Allow students to specify the difficulty level at the beginning of each session or provide a mechanism to keep track of the items that a particular learner was working on during the last session.
4. Spaced review	Gradually increase spacing between practice of mastered items. Utilize increasing ratio-review.
5. Making meaningless material meaningful	Help students add meaning to the material by utilizing mnemonic devices, mediators, or other memory or organizational strategies, or empha size networks inherent in the content.

Feedback

Feedback is information given to the learner by the courseware, about the appropriateness of the learner's response. Several factors can determine the effectiveness of feedback such as the type of feedback given, the frequency of the feedback, and the delay between the feedback and the instruction (Jonassen & Hannum, 1987). Feedback should provide occasional motivational messages, as well as information about the correctness and/or appropriateness of the response. For example, the use of cumulative records of student performance on questions, and frequent reporting of that performance, provides more effective learning (Schloss, Wisniewski & Cartwright, 1988). Feedback should be mature, positive, and varied. Feedback for an anticipated incorrect response should provide corrective or remedial information, complete with hints, explanations, or cues towards the correct response (Weller, 1988). Cohen (1985) suggested that feedback for correct responses must be suitable for the type of learner. For example he found that, for motivated and knowledgeable learners, feedback after correct responses interfered with the learning process.

Most research indicates that feedback should be frequent, precise, and occur immediately after the instruction (Grabinger & Pollock, 1989; Jelden, 1987), although some researchers feel that brief delays between the instructional event and the feedback promotes more effective learnirigbf Higher level cognitive information (Hooper & Hannafin, 1988). The delays give the learner more time to place the information into context and thereby assist in effective processing (Hannafin & Rieber, 1989b). The quantity of feedback should be sufficient to help comprehension of the material, but not so much as to overburden the learner (Stead, 1990).

Learner characteristics, subject content, and delivery mode all affect the type, amount, and timing of the feedback (Schimmel, 1988; Wager & Wager, 1985). Feedback should be tailored to match the needs of the learners and the desired learning outcomes by using elaborative feedback techniques such as explaining why an answer is incorrect and providing guidance on how to find the correct answer (Sales & Williams, 1988; Sales, 1988).

Jonassen and Hannum (1987) have offered general guidelines for use of feedback (see Table 2).

TABLE 2
Guidelines for the Timing and Frequency of Feedback in Instruction

Provide feedback immediately after a learner's response when new material is being presented.
Feedback may be given after each response or after a group of responses to similar questions when previously learned material is being reviewed.
Vary the placement of feedback according to the level of objectives.
Provide feedback after each response for the learning of lower level objectives.
Provide feedback at the end of a session for the learning of higher level, more abstract objectives.
Consider providing feedback to higher achieving learners after each group of responses rather than after each response (p. 12-13).

Learner Control

The use of hypermedia in education may require a change in the design of learner interaction with the instructional materials. According to Bowers and Tsai (1990), a concept such as hypertext may force a re-examination of the current concept of learner control in educational materials. The use of hypertext allows the student to control the creation of links and connections within diverse pieces of information and therefore "the learner is actively involved in building the learning environment" (p. 22). Jonassen (1986) has made the same point in his discussion about hypertext design principles.

According to Snow (1980) learner control is based on two assumptions; that learners know what is best for themselves during instruction, and that they are capable of acting appropriately, according to the instructional events. Therefore, the argument for learner control requires that the learner be self-determined, autonomous, and responsible. Jonassen (1986) cited several studies that suggest that the availability of learner control does not necessarily improve learner achievement, but that most learners will learn regardless of the instructional method. There is research evidence to suggest that learners may monitor their own performance and make deliberate changes in their learning strategies during instruction (Winn, 1986). These metacognitive processes are facilitated by experience and training in higher order problem solving skills (Armour-Thomas & Haynes, 1988).

Many researchers feel that greater learner control over the instructional environment is both pedagogically and philosophically appropriate (Jonassen & Hannum, 1987; Ross & Morrison, 1989). Learner control over sequencing and pacing of instruction can be motivating, reduce anxiety, and improve attitude (Weller, 1988). For example, learner versus program control of pacing and sequence in an interactive video lesson on photography was studied by Milheim (1990). Learner control of pacing resulted in significantly higher posttest scores and decreased time on task. There was no significant difference for learner control of sequence. In another study, students who had the option to review, following errors made in CBI lessons, took less time to complete the module than those with forced review (Schloss, Sindelar, Cartwright & Smith, 1988).

Laurillard (1987) suggested that learners should be given more control over the content, their access to the content, and their interaction with the content. Research suggests that learners should be exposed to environments that "foster rather than presuppose the ability of students to exert intentional control over their own learning" (Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989). Reglin (1989) stated that learners oriented towards high internal locus of control prefer to control their environments and that appropriate treatment can affect locus of control. Isaacs (1990) suggested that, by giving students increasing levels of control in an environment that supports the idea of learner control, the students will learn effective control techniques.

On the other hand, Ross and Morrison (1989) have cited several sources that suggest that more learner control is not necessarily better for all learners, especially low achievers. Kinzie and Sullivan (1989), in a study with high school science students, found that a high degree of learner control in the delivery of CBI caused much more continuing motivation and the ongoing willingness to learn, when compared to program control. But the difference in post test performance and performance during instruction was not significant.

Ross, Morrison and O'Dell (1989) found that undergraduate students in a statistics course had no difference in performance, given varying amounts of learner control. Students who could choose the context of the examples selected a greater number of examples than those who received prescribed contexts, and achievement was positively related to the variety of practice examples chosen by the students.

The amount and type of learner control is dependent on several variables such as learner characteristics, content, and the nature of the learning task (Jonassen & Hannum, 1987; Hannafin, 1984; Steinberg, I'989). Learner characteristics include variables such as internal versus external locus of control, age, or cognitive capability. Content that must be mastered often requires more program control, compared to content with no qualified mastery levels. Familiar learning tasks are best presented with more learner control than totally unfamiliar tasks. Ross and Morrison (1989), have offered a general list of situations where learner control is more appropriate than program control (see Table 3).

TABLE 3
Favorable Conditions for Learner Control in Courseware

- Learners are older and more mature.
- Learners are more capable.
- Higher order skills rather than factual information are being taught.
- Content is familiar.
- Coaching or advisement is provided to assist learners in making decisions and in using strategies known to be effective.
- Learner control is used consistently within a lesson.
- Provision is made for switching unsuccessful learners to program control strategies.
- Learner control is combined with formative evaluation to identify and base revised designs on paths used by effective learners.
- Give special consideration to learner-control strategies that allow learners to select contextual properties of lessons according to individual learning styles, preferences, and interests, (p. 28)

Presentation Variables

Presentation variables include screen design and layout, graphics, text display, chunking of the information, and the type of frames or screens used. Research suggests that learners may read electronic text more slowly than print-based text, and that learners may process electronic text differently from printed text in regard to other factors as well. Some of the learning theory and design criteria used in courseware presentation design originate in text-based research, and as such, may not be directly applicable to the design of courseware without further research.

Screen Design Variables

The effective design of computer-generated text is affected by many variables such as the type, style and size of font used, text density levels, and layout variables such as justification, line length, leading, and spacing (Morrison, Ross, Schultz & O'Dell, 1989; Ross, Morrison & O'Dell, 1988; Hannafin & Rieber, 1989b). The overall look of the screen should provide several functions such as informing the learner of the type of information that is displayed, in what order the information should be processed, and how the information should be used (Gropper, 1988).

Hooper and Hannafin (1986) found that text is processed faster and more efficiently when the text is left-justified, characters are relatively small (approximately 11 point), longer lines are used instead of short lines, and spacing (leading) is increased as the text density is increased. Generally, these factors suggest that low density screens, which have a relatively large amount of white space compared to the actual information, are preferable. These findings were confirmed in a study by Hartley (1987) and in a 1988 study by Morrison, Ross, and O'Dell. In contrast, in a more recent study, Morrison, Ross, Schultz and O'Dell (1989) found that learners preferred high density screen designs, that is less white space in relation to the textual and graphical information. In this study, realistic display materials were used, in contrast to the other studies which used artificial display information, and the authors feel that "it is not clear that preferences for low-density screens similarly apply to realistic lesson materials, especially since the low-density designs present the material in smaller thought units and consequently require an increased number of lesson frames" (p. 54). The authors hypothesize that the contextual properties of the information, as well as the type of information, may affect how the learner perceives the density of the screen, and that more research is needed in this area. Isaacs (1987) suggested the use of syntax and context to determine the length and the end of text lines. This idea was supported by Hartley (1986).

The type of font to be used is often determined by the capabilities of the computer platform. Generally, it is suggested that no more than two or three types and sizes of fonts be used per screen. Often san-serif fonts work better on the computer screen than serif fonts. Use a combination of upper and lower case letters, rather than only upper case letters, with lower case fonts being the easiest to read and understand (Faiola & DeBloois, 1988). For the Macintosh computer platform, Misanchuk (1989) recommended the use of the Geneva font, with Boston as a second choice, and the avoidance of Chicago and Courier fonts.

The use of visual cues such as color (Hativa & Teper, 1988), emphasizing text by underlining or using italics, or using headings or pictorial cues such as arrows or labels can be effective in gaining and keeping the learners' attention during instruction (Faiola & DeBloois, 1988). Bernard, Peterson & Ally (1981) have suggested that pictorial cues provide a meaningful context for abstract verbal information and can enhance learning and retention. Hartley and

Trueman (1985) found that headings aid in search, retrieval, and recall activities by learners. Researchers suggest that it is important to tell the learners, especially when they are young, the significance of the particular visual cue. And it is equally important not to overuse visual cues; only use enough to get the message across effectively and efficiently (Hooper & Hannafin, 1988).

Often drawings, cartoons, animations, illustrations, and graphics are included along with the textual information. In general, graphic embellishments should be simple, clear, and consistently presented (Hartley, 1987). In a review of the literature about illustrations in print-based text, Levie and Lentz (1982) found that under ordinary circumstances illustrations do not enhance the learning of information in the text. The researchers did find that illustrations may be helpful for under-advantaged learners, may provide enjoyment and motivation, may provide reinforcement, and that effective illustrations could be used as substitutes for verbal information. Alesandrini (1984) found that all types of pictures, whether representational, analogical, or arbitrary, helped adults to learn. Anglin (1986) found that prose-relevant pictures helped older learners to recall prose material. Hurt (1987) suggested that literal illustrations are more effective than analogical illustrations. Generally, simplistic illustrations were found to be more effective than realistic illustrations although in some situations, when given enough time, learning was enhanced by realistic materials (Dwyer, 1987).

Animation can serve motivational and attention-getting functions but, according to current research, no extra learning effects can be attributed to the use of animation (Hannafin & Rieber, 1989b), although Zavotka (1987) found that animation improved student performance in interpreting orthographic drawings. Reed (1986) found that graphics in algebra studies were useful in order to supplement the verbal information, provide motivation and attention, and provide learner interaction with the materials. Duchastel (1988) suggested that animation can be very important for comprehension when modelling an unfolding process or procedure.

Chunking

If a learning task involves memorizing strings of text or a list of numbers, mature learners often employ chunking as a strategy to help them overcome the natural limitations of the human memory (Steinberg, 1991). Chunking is the process of organizing, indexing and storing information in such a manner that it can be easily accessed and used for problem solving (Harmon, 1987). This is often accomplished by organizing the information into meaningful or logical sections or "chunks", which facilitates the transition from receiving the information to understanding the information (Casteel, 1988). Computer graphics, diagrams, and illustrations can also be seen as a form of chunking because we see pictures as organized wholes, not dissociated parts (Steinberg, 1991). The chunks are presented on the screen with sufficient white space around the information to provide separation from adjacent information

(Morrison, Ross, Schultz & O'Dell, 1989; Faiola & DeBloois, 1988). In a hypertext database each chunk represents one topic, theme, or idea and is represented by a node or document in the database (Kearsley, 1988).

In order to enhance the effect of chunking, Faiola and DeBloois (1988) suggest that it is important to have a well developed framework or "access structure", which refers to the "coordinated use of typographically signalled structural cues that help students to read texts using selective sampling strategies" (p. 15). The use of headings, indentation levels, spacing, and other such typographical structures would help learners discriminate among different contextual elements. For example, Jandreau, Muncer & Bever (1986) found that phrase-spaced text made a considerable improvement in the comprehension and the speed of reading for poor readers in a research project in England. Casteel (1988) found the same effects among learning disabled students. McBride and Dwyer (1987) found that chunking resulted in a more efficient learning strategy, compared to conventional presentation, although there was no significant difference on a performance task after the instruction. Horn (1989) has made extensive use of the principle of chunking in his method of argumentation analysis. Pre-chunking information into blocks not only helps the reader to comprehend the information, but also helps the writer or author in his or her analysis of the information.

Frame Variations

The idea of frames originated in the programmed learning model of instruction, and modern microcomputer technology, according to Jonassen (1988b), has outgrown this theory. In modern courseware designs a frame represents a computer screen that contains a planned amount of information (Bonner, 1987). Frame protocol refers to the way the screen display area is divided into functional areas used to present the learner with directions, messages, options, and to provide an area for dialogue between the courseware and the learner (Hannafin & Rieber, 1989b).

Generally, a frame consists of a stimulus with some information, a response to be made by the learner, and a prompt that gives feedback to the learner (Leith, 1966). There are six general types of frames used in CBI: information, question, remediation, feedback, menu, and subroutine frames (Morrison & Ross, 1988). Frame-based CBI usually consists of either drill and practice, tutorial, or simulations, and provides for considerable learner interaction. The instructional designer must anticipate learner response and provide suitable responses and motivation through the use of visuals, questions, humour, and other techniques (Bonner, 1987).

Tessmer, Jonassen and Caverly (1989) have pointed out that classroom learning contains a great deal more interactivity between the teacher and the learner than is usually exhibited between a learner and display-question-feedback CBI. In addition to the delivery of text and graphics to appropriate areas of the screen, good courseware should promote learner interactivity by always providing access to some or all of the following options (see Table 4).

TABLE 4
Guidelines for Interactivity

Help key to get procedural information.
Answer key for answering a question.
Glossary key for seeing the definition of any term.
Objective key for reviewing the course objective being worked on.
Content map key for accessing an overview map of the content in the course or lesson.
Options key for seeing a list of learner commands or options available to the learner.
Overview or introduction key for reviewing the introduction to the unit.
Menu key for exiting the lesson and returning to the menu.
Exit key for exiting the course.
Summary key for seeing the summary or conclusions of the lesson.
Review key for reviewing parts of the lesson.
Comment key for recording a learner comment about the lesson.
Examples key for seeing examples of an idea.
Previous frame or next frame for moving forward or backward in a lesson.
Test key for letting the program know when the learner is ready to take a test.
Next lesson key for accessing the next lesson in a sequence (p. 198).

Conclusion

Cognitive learning theory has had a major influence on courseware development guidelines. Although some of the ideas derived from behaviorism, such as feedback, self-pacing, and learner interaction are still relevant today, cognitivism emphasizes an active, aware learner who brings important personal characteristics that influence learning outcomes. Constructivism may further challenge the developer to capitalize on the learner's ability to construct knowledge by using personal experience and interpretation of that experience. Good hypermedia-based instruction may need to be redefined to include building on the prior experiences of the learner, being organized in a manner that is appropriate to the individual, and being set within the context of real-world projects or activities.

CBI authors who choose to use HyperCard as their development tool would be well advised to adopt Apple's policy of maintaining a consistent look and feel for applications by following the Apple Desktop Interface guidelines (Apple Computer Inc., 1989). The larger the stack, and the younger or more disadvantaged learners are, the more important effective stack navigation aids become. In all situations it is of the utmost importance to know the intended audience, the content, the design plan and the capabilities of the development tool well before any extensive projects are begun. Teachers at all levels are in an excellent position to play a key role in the development process.

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