Learning Strategies for Interactive Multimedia Instruction: Applying and Spatial

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Abstract: Current interactive multimedia instruction often takes the form of an open-ended, unstructured database. In many systems, learners are guided to manipulate the lesson content through notetaking. The learner is able to open a notetaking screen by clicking a button, type in notes about the current topic being explored, or copy sections from different screens into the notebook, and either print or save these notes to disk. Guidance on taking notes is rarely given. This presents a problem since learners frequently do not incorporate structure in their notetaking or fail to elaborate on the new information. Since research has indicated that students are generally incomplete note-takers (Kiewra, 1987, 1988). this may represent a serious design flaw. A number of notetaking techniques have been proposed which could be incorporated into interactive multimedia to enhance learner encoding in a more structured fashion. These include linear approaches like outlining and spatial learning strategies like concept maps.

This paper provides an overview of the research on notetaking and two related learning strategies- outlining and concept maps. It examines the potential effectiveness of the approaches to aid the learner in encoding new information, examines current uses of these strategies in interactive multimedia instruction and offers suggestions for the incorporation of these learning strategies into future designs. Examples of strategy use in current programs are provided.

Résumé: L'enseignement interactif multimédia se présente souvent sous la forme d'une base de données non-structurée. Fréquemment, afin d'assimiler le contenu d'une leçon, les apprenants et les cpprentantes sont amenés prendre des notes. On peut alors ouvrir un bloc-notes en cliquant un bouton, écrire ses idées sur le sujet exploré ou copier, dans le bloc-notes, des sections provenant de différents écrans. On peut aussi imprimer ces notes ou les sauvegarder sur un disque.

On ne donne presque jamais de directives sur "comment prendre des notes. AE Ceci constitue un problème parce que, fréquemment, les apprenants et les apprenantes ne structurent pas leurs notes et ne détaillent pas la nouvelle information. On reconnaît dans la littérature que les étudiants prennent des notes incomplètes (Kiewra, 1987, 1988), ce qui constitue, un défaut majeur de conception. Certaines techniques de prises de notes ont été proposées et peuvent être incorporées dans l'enseignement interactif multimédia de façon à permettre l'apprentissage d'une manière plus structurée. Ceci comprend les approches linéaires comme l'écriture des titres et des passages imporants et ds approches spatiales comme les cartes

Cet article founit un aperçu de la recherche sur la prise de notes et sur deux approches particulières : l'écriture des titres et des passages importants et l'elaboration de cartes conceptuelles. On examine l'influence de ces techniques d'aide a l'encodage de nouvelles informations et les usages courants de ces strategies dans l'enseignement interactif multimedia et presente des suggestions quant a l'utilisation de ces sfrated'apprentissage dans le design d'activites. On foumit aussi des exemples de strategies utilisees dans des programmes en vigueur.

INTRODUCTION

With a growing interest in interactive multimedia comes an increased requirement for research on instructional design strategies for this hybrid technology. Although a universal definition of multimedia has eluded even technology experts (Galbreath, 1992), the term "interactive multimedia instruction" is generally taken to describe a computer-controlled system which provides the possibility of varying combinations of digitized audio, graphics and text, analog and digitized video, accessed through the computer itself and/or a variety of peripheral devices such as videodisc players, compact disc players and music synthesizers (c.f., Schwier and Misanchuk, 1993; Gayeski, 1993). As such, the term incorporates related terminology such as interactive video and hypermedia.

Interactive multimedia instruction can be linear and/or structured or more non-linear, resembling a database incorporating multiple formats. The organization of the information in a tightly structured program, those designed for a specific instructional purpose or objective, is generally very clear. Programs such as Eduquest's *Stories and* More, a literature-based curriculum system, offer information in multiple formats (digitized audio, graphics, text), allowing the learner choices, but still guide the user in a structured fashion. However, many of the newest programs, such as IBM's *Illuminated Manuscripts* and Intellimation's *Letter from Birmingham Jail* are basically open-ended, with the structure of the information less obvious to the user. These represent multimedia databases where the user selects the path, information, and format to view.

Such open-ended approaches are consistent with a constructivist view of learning which holds that the learner individually constructs knowledge through interpreting perceptual experiences of the external world (Jonassen, 1991). Learners develop unique associations between prior knowledge stored in long term memory structures and new information. Constructivists encourage inductive, or discovery, learning in which learners engage a domain and "construct their own concepts and rules based on their interpretation of the instances encountered' (Rieber, 1992, p.96).

Interactive multimedia instruction can provide the rich learning environment central to a constructivist view of learning by furnishing databases of information in multiple formats and perspectives which nurture incidental learning. However, such environments necessarily provide a limited amount of structure and require learners to create their own. Learners may benefit from incorporated learning strategies that help them organize, encode, and integrate the information they encounter in interactive multimedia instruction, strategies such as paraphrasing, generating questions, outlining, cognitive mapping, creating images and summarizing. These activities could be supplied by the instructional system or generated by the learner.

This paper will provide an overview of the research on three widely used learning strategies: notetaking, perhaps the most frequently used strategy of all, and two related techniques, outlining and concept mapping. It will provide an analysis of their effectiveness to aid the learner in encoding new information, examine current uses of these strategies in interactive multimedia instruction, and offer suggestions for the incorporation of these learning strategies into future designs.

LEARNING STRATEGIES TO FACILITATE ENCODING

Bruning (1983, p. 93) defines learning strategies as "any internally or externally mediated cognitive process that will facilitate transfer of information to be learned from short-term into long-term memory". Information-processing theory holds that short term memory has a limited processing capacity such that learners are forced to select from all possible information perceived for processing. Short term memory holds information for only seconds before it is lost or encoded for storage in long term memory. Learning strategies are generally called into use at this point to facilitate this transfer of information (Bruning, 1983).

Weinstein and Mayer (1986) also link learning strategies to encoding. Using Cook and Mayer's (1983) analysis of the encoding process, they describe encoding as comprised of four components: a) selection- the learner actively pays attention to some of the information impinging on sense receptors and transfers it to working memory; b) acquisition — the learner actively transfers information between working and long-term memory for further study; c) construction — the learner actively builds internal connections between ideas in the information that reaches working memory; and d) integration- the learner actively searches long-term memory for prior knowledge and transfers it to working memory to construct external connections with the new information.

Learning strategies are used to assist the learner to rehearse, organize, and elaborate information to make it more meaningful. Rehearsal strategies, such as underlining and repetition, help focus attention on important information and encode it in short term memory (selection and acquisition). Organization strategies, such as outlining, categorization, and mapping, help in selecting appropriate information and constructing connections among the ideas (construction). Elaboration strategies, such as mental imagining, forming analogies, inserted questions, paraphrasing and analyzing key points, help transform information by making the material more meaningful and building connections among new ideas and prior knowledge (integration).

Notetaking

The majority of the research has focused on notetaking from such linear presentations as oral or videotaped lectures (e.g., Hartley & Davies, 1978; Carrier and Titus, 1979; Rickards, 1979; Kiewra, 1985,1987) or on notetaking from text (e.g., Kiewra, DuBois, Christensen, Kim & Lindberg, 1989; Wade & Trathen, 1989). Notetaking from non-linear approaches such as interactive multimedia has yet to be studied. To date, the authors are aware of only two studies which have broached the topic indirectly through studies of the use of participatory graphic organizers with interactive video (Kenny, Grabowski, Middlemiss, &Van Neste-Kenny, 1991; Kenny, in press).

The graphic organizer was derived from the advance organizer and is more pictorial, visual, or chart-like in structure. It can be participatory — students participate in the completion of the organizer — or given to the student completed (the final form organizer). The participatory graphic organizer, in effect, engages learners in a form of structured notetaking. Kenny et al. (1991) compared participatory graphicorganizers to the identical final form versions on the learning of nursing students from an interactive video program onnursing elderly patients withpulmonary disease. The participatory graphic organizer group substantially outperformed the final form group on a test of learning, scoring an average of 1.77 points higher on an 18-question multiple choice test. The difference, however, was not statistically significant. Considerable extraneous notetaking by subjects in both groups likely confounded any differences that might have been fostered by the structured notetaking treatment.

In the second study, Kenny (in press) compared the use of an advance organizer to that of participatory and final form graphic organizers with interactive video on cardiac nursing. This time, extraneous notetaking was controlled., The final form graphic organizer proved most effective, garnering the highest mean scores on both tests of learning and retention, while the participatory version group had the lowest mean scores. The difference between the final form and participatory organizer group means was statistically significant at the $p<0.01$ level for both learning and retention. This study, then, like the first, provided no- support for the use of structured notetaking with a non-linear medium.

The encodingand external storage hypotheses. Two hypotheses (Divesta & Gray, 1972) have been advanced to explain the potential effectiveness of notetaking to facilitate learning: (a) notetaking assists initial encoding (the encoding hypothesis), or (b) notetaking provides a product which can be reviewed later (the external storage hypothesis). The encoding hypothesis or process function holds that notetaking is beneficial, independent of review, because it increases attention during the lecture and, therefore, facilitates the initial encoding of lecture ideas into long term memory (Kiewra, 1985, 1987; Hartley &Davies, 1978). Peper and Mayer (1986) advance three sub-hypotheses to explain why the encoding hypothesis may or may not be true. The first two are based on how much is learned while the third focuses on the degree to which the learner is able to actively relate material to existing knowledge. The attention hypothesis states that notetaking facilitates learning by forcing the learner to pay more attention to presented material or to process presented material more deeply. The distraction hypothesis holds that, on the contrary, notetaking actually impedes learning by forcing the learner to concentrate on the motor act of writing instead of more fully listening to lecture. The generative learning hypothesis (Wittrock, 1974), claims that notetaking helps the learner to generate meaning by relating presented information to prior knowledge and thus building amoreintegratedlearningoutcome.

The external storage, or product, hypothesis holds that notetaking is beneficial because the notes comprise a tangible product which can be retrieved and used once the instructional event has passed. Rickards (1979) suggests two possible functions for the external storage idea: (a) a rehearsal function where enhanced recall is only due to remembering material from the notes just reviewed (the notes provide the learner with more information) and (b) a reconstruction function in which recall of notes allows learners to reconstruct parts of the passage on which no notes were taken (the notes help the learner to recall other information).

The effectiveness of notetaking. Research evidence for the encoding hypothesis is mixed. Combined findings (Kiewra, 1987) of review papers by Hartley and Davies (1978) and Kiewra (1985) reported 35 studies on notetaking from lectures supporting the initial encoding function, 23 indicating no significant differences between those who do and those who do not record notes and 3 indicating the activity of notetaking to be dysfunctional relative to listening only. For notetaking from text material, there is some evidence that notetaking served a minimal encoding function and may even have interfered with processing (Kiewra, DuBois, Christensen, Kim & Lindberg, 1989). Also, a study by Wade and Trathen (1989) indicated that noting information (including notetaking) has little effect on the recall of that information.

Initial research findings appear to strongly support the external storage hypothesis. Combined findings (Kiewra, 1987) of review papers by Hartley and Davies (1978) and Kiewra (1985) reported 24 studies on notetaking from lectures supporting the product function (those who reviewed their notes achieved more), 8 studies indicating no significant differences between reviewers and non-reviewers and no study indicating reviewing notes to be dysfunctional.

However, Kiewra and his associates (Kiewra, DuBois, Christensen, Kim & Lindberg, 1989; Kiewra, DuBois, Christian, Mcshane, Meyerhoffer and Roskelly, 1991) claim that what has traditionally referred to as “external storage” is actually a combination of encoding and external storage. External storage treatment groups have consisted of students both making their own notes (encoding) and later reviewing them. Learners had, in effect, two chances to process the information (a repetition effect). When “external storage” is redefined as those who review notes created by the instructor but who have not previously viewed the lecture, the results appear less conclusive. This reformulated product function was shown to be less effective for factual recall and recognition than anencodingplus storage treatment condition, although not for higher order (synthesis) performance. Encoding only was consistently the least effective treatment and no more effective than listening to a lecture without notetaking. Thus, notetakers who review outperform notetakers who do not review.

Further, the encoding process per se (without review) did not appear to be aided by recording notes on linear or matrix frameworks (Kiewra, DuBois, Christian, Mcshane, Meyerhoffer & Roskelly, 1991). This is consistent with results from a study (Kenny, in press) of fill-in versus completed graphic organizers used with interactive video where the notetaking treatment appeared to interfere with, rather than facilitate, learning from the program. In fact, when learning from text was tested, students who read twice from the material but did not take notes outperformed those using any form of notetaking (Kiewra, DuBois, Christensen, Kim & Lindberg, 1989). Other studies comparing notetaking to repetitive reading (Hoon, 1974; Dynes, 1932; Stordahl & Christensen, 1956) foundnotetaking no different from reading alone. Notetaking, whether from lecture or text, may be a sufficiently demanding process that relatively little encoding actually occurs during the act of notetaking (Kiewra, DuBois, Christian, Mcshane, Meyerhoffer & Roskelly, 1991; Kenny, in press). Not only does little encoding take place, but the students' notes are generally incomplete (Kiewra, 1987; Kiewra, DuBois, Christian, Mcshane, Meyerhoffer & Roskelly, 1991). In fact, the review of detailed instructors's notes provides the best results (e.g. Kiewra, 1985, Kiewra & Frank, 1988; Risch & Kiewra, 1990), probably due to their completeness and accuracy. Overall, notetaking seems to function best as a rehearsal strategy using an accurate, detailed product after the student has engaged the material through reading or listening.

Outlining

Although the product/process research has not been extended to other learning strategies, there has been research on the efficacy of strategies such as outlining. Outlining is defined as "a high level skill which involves identifying relationships between concepts and arranging those concepts in an order which demonstrates the superordinate and subordinate nature of the concepts involved' (Anderson-Madaus, 1990, p. 3). Outlining: (a) causes focusing on important points, (b) helps students gain familiarity with text structure, (c) aids retention, (d) generates useful alternative texts to supplement materials read, and (e) causes active participation in learning (Bianco & McCormick, 1989). However, outlining, like strategies such as imaging and paraphrasing, requires a major intrusion in the reading processes and also necessitates a significant amount of training to use properly (Anderson, 1980).

The effectiveness of outlining. Several studies have shown that outlining results in improved recall of facts (Barton, 1930; Annis & Davis, 1975; Glynn &

DiVesta, 1977; Shimmerlik & Nolan, 1976). The use of a hierarchical summarization strategy, a form of outlining, improved comprehension and recall in the middle school students (Taylor &Beach, 1984), while ninth-graders who completed an outline grid when reading did better on multiple choice recall tests (Slater, Graves, & Piche, 1985). Further, research asking students to generate outlines provides some support for their facilitation of recall. For example, Tuckerman (1993) studied coded elaborative outlines, a method which involves outlining chapters, coding the main points using a six-code scheme, and adding elaborations of main points, such as examples and explanations. College students required to create coded elaborative outlines of chapters performed significantly better than students who did so voluntarily, those who created standard outlines, and those who did not outline (Tuckerman, 1993). Students given the option of outlining generally chose not to do so, but those not required to write these outlines performed better the more they outlined.

Outlininghas also beencompared to other learning strategies. Some studies report no advantage of outlining over other strategies when the subjects were not instructed in the strategy (Arnold, 1942; Stordahl & Christensen, 1956; Todd & Kessler, 1971; Willmore, 1966 cited in Iovino, 1989) or a marginal advantage for outlining in writing papers (Branthwaite, Trueman, & Hartley, 1980; Emig, 1971). The main difference between these and earlier studies is the lack of training in the strategy before use. However, more recent studies appear to support the use of the strategy, especially where trainingisprovided (Palmatier, 1971; Snyder, 1984; Iovino, 1989; Kellogg, 1990).

Thus, Palmatier (1971) found that college students using outlining had the highest level of essentialcontent in their notes compared to those using a three-column method, the Bartush Active Methods or no method, while Snyder (1984) found a significantly higher recall performance for the outlining method in a study comparing the use of SQ3R and underlining to study college textbooks. Iovino (1989) found that, after being taught the techniques, outlining significantly helped academically under-preparedcollege students to achieve higher immediate recall than did networking, but networking significantly improved their ability to retain information over time. In a study of the use of outlining and clusteringinprewriting (Kellogg, 1990), outlining was most beneficial when only the topic was provided and students had to generate and organize ideas, but did not help if the topic, ideas, and organization were given.

Tenny (1988) and Anderson-Inman and others (1992) have studied computer outlining in low achieving high school students and have found the technique effective. Tenny (1988) found that such outlining was significantly more effective than rereading for all his subjects. He suggests that it is an effective study strategy because it allows students to manipulate information and put it in their own words, to monitor their own learning, and to take personalresponsibility for their learning. Anderson-Inman and others (1992) found that the strategy was successful for only some of their subjects, generally those with more experience with the strategy, who had a more positive attitude toward it, who could complete it easily, who saw it as part of the study process, and who were reflective on the process.

Overall, then, it appears that outlining can aid in both organizing new information and integrating new knowledge into one's personal knowledge structure. Learners should, however, be taught to use the outlining strategy correctly (e.g. focusing on main ideas, organizing from abstract to concrete in the hierarchy, working from a classification of concepts) and should not perceive the strategy as being too intrusive in the study process, (Hoffler, 1983; Anderson 1980).

Concept Mapping

An outgrowth of schema theory (Kiewra, 1988) is the study of learning strategies involving the reorganization of linear information into a spatial representation that specifies relationships among concepts. The process of creating a spatial arrangement requires a relatively deep level of processing aimed at determining internal connections among ideas.

Perhaps the most widely known and researched spatial learning strategy is concept mapping (Novak, Gowin & Johansen, 1983; Novak & Gowin, 1984; Heinze-Fry & Novak, 1990; Novak, 1990). Concept mapping was developed as a spatial knowledge representation technique based on Ausubel's Theory of Meaningful Learning which holds that knowledge in memory is hierarchical, with more general, more inclusive concepts subsuming progressively less inclusive, more specific ones (Novak & Gowin, 1984). Concept maps, then, are drawn hierarchically, with more inclusive concepts at the top of the map and progressively more specific ones arranged below, linked by labelled lines to form semantic units.

Concept maps are viewed, first and foremost, as a tool for negotiating meanings. Maps are constructed collaboratively by the instructor and the learner(s). However, they can also be used as a pre-instructional tool in the form of an advance or graphic organizer and as a notetaking technique for extracting key concepts from printed or oral material (Novak & Gowin, 1984).

The effectiveness of concept mapping. A recent meta-analysis of nineteen studies (Horton, McConney, Gallo, Senn & Hamelin, 1993) provides an overview of the general effectiveness of the technique. Meta-analysis is a technique which permits quantitative reviews and syntheses of the researchissues (Wolf, 1986) and Glass' effect size statistic (E.S.) in particular (e.g., Glass, McGaw, and Smith, 1981). The E.S. allows the comparison of studies which vary in design, sample selection, and setting in order to form conclusions and, because it is based on standard deviations, also permits an assessment of degree of effect. Thus, for t-testsofindependentmeans, anE.S. of 0.20 could be considered of mild strength (i.e. the mean of the population with the higher mean score exceeds the scores of 58% of the group with the lower mean score), and E.S. near 0.50 moderate (mean of upper group > 69% of lower group scores) and those 0.80 and above as strong (mean of higher group > 79% of lower group) (Cohen, 1988, pp. 25-26).

Studies occurred in actual classrooms and used concept mapping as an instructional tool compared to an alternate technique as a control. Nearly all studies examined involved science content, material which could be argued lends itself to a hierarchical depiction. In 15 of the 19 studies, the students prepared the maps. Effect sizes (ES.) for achievement ranged from -0.31 to + 2.02 with a mean E.S. of 0.46. For measures of student attitude towards the particular subject matter, E.S.'s ranged from 0.05 to 4.88 with a mean E.S. of 1.57. The investigators concluded that concept mapping has medium positive effects on achievement and large positive effects on attitude.

Research results also indicate that the primary benefit of concept mapping accrues to the person who constructs the map (Novak, 1990; Horton et al., 1993), that teacher-prepared maps may be helpful to students, but only after they have had practice preparing their own maps and that, at first (for 2-4 weeks), there is generally an average decline in performance for strategies that require meaningful learning although they finish up significantly higher (Novak, 1990). The implication is that time is needed for students to learn and learn to appreciate meaningful learning strategies such as concept mapping. Concept mapping, then, can function as a rehearsal, organizational, and/or elaboration strategy. In its most effective form, it represents a combination of all three.

INTEGRATING LEARNING STRATEGIES IN INTERACTIVE MULTIMEDIA INSTRUCTION

As discussed previously, current interactive multimedia instruction often takes the form of a multiple format database. In many systems, learners are guided to manipulate the lesson content through notetaking. The learner is able to open a notetaking screen by clicking a button, type in notes about the current topic being explored, or copy sections from different screens into the notebook, and either print or save these notes to disk. Guidance on taking notes is rarely given. This presents a problem since learners frequently do not incorporate structure in their notetaking or fail to elaborate on the new information. Since research has indicated that students are generally incomplete note-takers (Kiewra, 1987, 1988), this may represent a serious design flaw. A number of notetaking techniques have been proposed which could be incorporated into interactive multimedia to enhance learner encoding in a more structuredfashion (Anderson-Inman, Redekopp, &Adams, 1992). These include linear approaches like outlining (Kiewra, DuBois, Christian & McShane, 1988) and spatial learning strategies such as concept maps (Novak & Gowin, 1984).

Notebooks or notepads included in programs are often fairly rudimentary and if used by students as is, risk replicating the same shortcomings of notetaking, outlining and mapping on paper. The computer offers capabilities that might be used to incorporate the best aspects of each of these learning strategies while avoiding some of their pitfalls. It also offers the ability to offer a degree of guidance to the user if necessary or if desired by the instructor. Capabilities that might be exploitedinincorporatinglearning strategiesinto a notebookinclude:

- using screen titles and/or topics to organize information;
- cutting, pasting and manipulating text and media (graphics, sound, video);
- the ability to connect and manipulate ideas and pull them together into a spatial map;
- creating a multimedia document from information gathered.

Anderson-Inman and Zeitz (1994) add global expansibility (i.e. the ability to automatically expand to accommodate inserted material anywhere), infinite modifiability, and focusability (i.e., the ability to hide unwanted detail). Kozma (1987) has also proposed the idea of anelectronic notebook. The *Learning Tool* by Intellimation and *Inspiration* by Inspiration Software for the Macintosh are examples of such programs. They present the learner with blank workspaces and tools to develop key points, connect them in networks, and provide textual and graphic information about each. The program cues, evokes, models, and supplements the learner's thought processes and, in effect, it provides a tool for outlining, concept mapping, and related spatial notetaking techniques.

Outlining in a computerized environment can add several new features to print-based outlining. Students can incorporate text as well as various other media types in a outline, by either cutting and pasting or linking to external resources. When using an interactive multimedia program, all the information can be included, no matter what the format. Applications such as *Mediatext, WordPerfect* and *Microsoft Word* already offer these features.

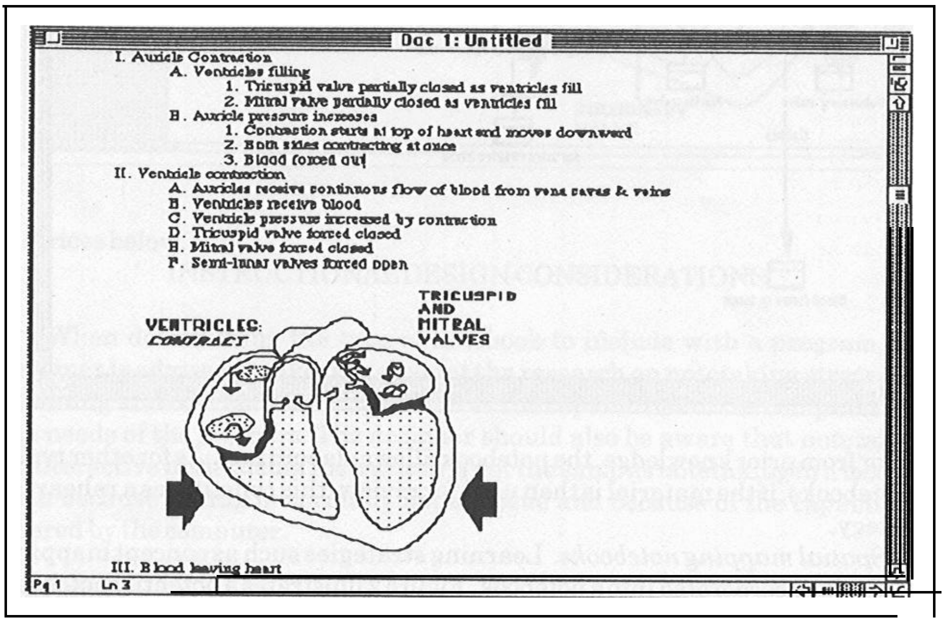
Many word processors also offer the ability to expand and compress outlines. If this feature were incorporated into a program's notebook, students could view their information at different levels of the hierarchy, for example, the degree of abstraction or detail. Instructional designers could provide an intact outline in which to take notes and include media, acting as guide through the system and showing one view of the overarching structure in a linear, hierarchical fashion. Different outlines might be available to show different perspectives on the information providedin the interactive multimedia instruction. Students might chose to view or not to view this as desired. Concept mapping tools add the ability to label the relationships between concepts, use different shapes for different concepts, create crosslinks, andindicate unidirectional or bidirectional links on top of the features of outlining (Anderson-Inman & Zeitz, 1994).

Types of Notebooks

The design of notebooks for interactive multimedia systems can incorporate some or all of the above features. These allow learners to use strategies that assist in rehearsing, organizing and elaborating information to make it more personally meaningful.

Standard notebooks. The most common types of notebook either allow users to make their own notes on program material, to copy and paste text from the instructional program to the notebook, or both. Sometimes, they also permit the copying of graphics and other media. While making one's own notes may facilitate encoding, the act of cutting and pasting requires little or no cognitive effort on the part of the student, other than selecting the information. This would represent a true product function of notetaking. However, later review of the notes produced by the student would constitute a form of rehearsal strategy. If this same notebook allows the user to arrange and rearrange the text and graphics, its use could be considered an organizational strategy. The use of notebooks that allow learners to add their own text and graphics acts as an elaboration strategy where the learner incorporates prior knowledge and relates new with old information. The notebook then incorporates both the process and product function of notetaking.

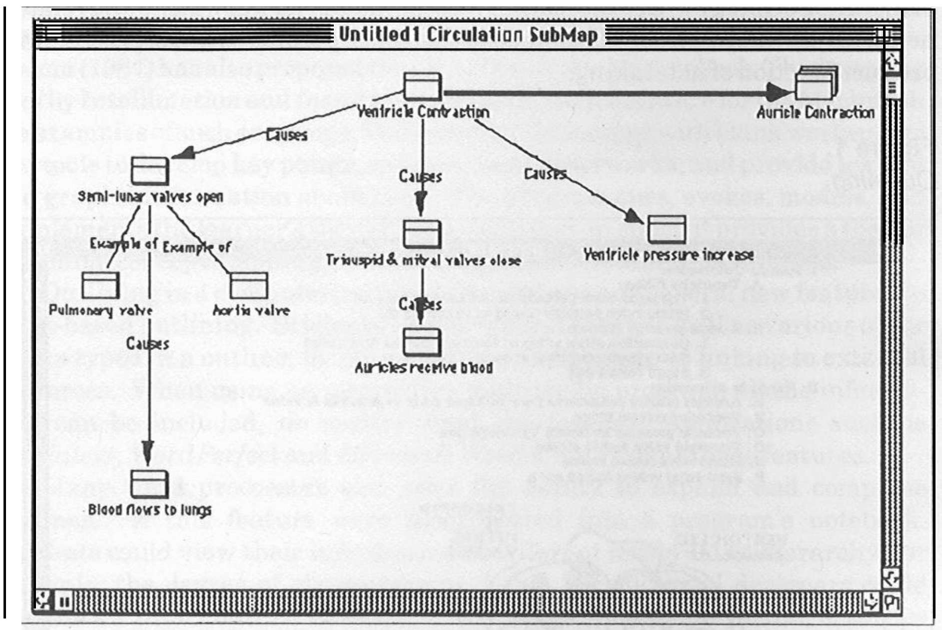
Figure 1.
Outlining



Outlining ***notebooks.*** A notebook could also provide outlining capabilities where the learner can easily arrange information in a hierarchical fashion. Here learners create their own hierarchies of information and use the notebook for organization. Learners can also incorporate prior knowledge in either text or graphic form and link it to the new information, thus using the notebook for elaboration. When the notes produced are reviewed by the learner at a later time, this use constitutes rehearsal. Figure 1 displays a sample screen from a hypermedia program on the circulation of blood through the heart, based on the materials of Dwyer and Lamberski (1978). The material has been organized into an outline.

The structure of the instructional program itself may be automatically incorporated into an outline in a notebook, acting as a supplanted organizational strategy. If learners can add text and graphics to this from the program itself

Figure 2.
Concept Mapping

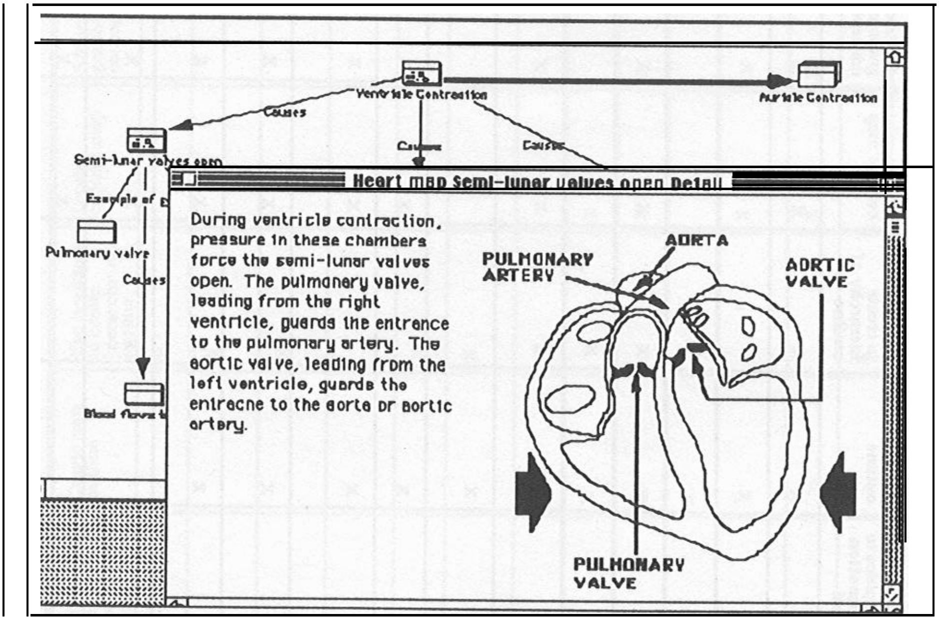


and/or from prior knowledge, the notebook allows elaboration. As for other types of notebooks, if the material is then used for review, this constitutes a rehersal strategy.

Spatial mapping notebooks. Learning strategies such as concept mapping can also be incorporated into a notebook. Figure 2 illustrates a potential notebook created using *Learning Tool.* The information selected can be incorporated into a concept map that can be manipulated as desired with links between concepts described. This type of notebook permits organization. Additional text, graphics, and media can be added to each concept (See Figure 3). This feature acts as an elaboration strategy where the user can add his/her own knowledge.

Each of these notebooks can also be incorporated into a student multimedia production where the information is analyzed, organized, synthesized, supplemented, and presented by the individual. The features of these notebooks each have their strengths and weaknesses. Several possibilities are detailed in the

Figure 3.
Concept Map with Additional Text and Graphics



matrices below.

INSTRUCTIONAL DESIGN CONSIDERATIONS

When determining the type of notebook to include with a program, the designer is advised to take into account the research on notetaking strategies, outlining and concept mapping as well as the capabilities of the computer and the needs of the learners. The designer should also be aware that notetaking in interactive multimedia instruction is not the same as note taking in a lecture, both because pacing is normally not an issue and because of the capabilities offered by the computer.

Advantages

When working with interactive multimedia instruction learners have time to copy text and elaborate, similar to underlining with margin notes or two-column notetaking, and then to elaborate withtheirown text and graphics. Further, the ease of cutting and pasting allows learners to organize or categorize information either as they navigate the program or after gathering all desired information. They can also create graphical representations of the information or use the potential ease of expanding and collapsing outlines to assist them in perceiving the structure of the information at various levels. Tuckerman's (1993) research on coded elaborative outlining provides a basis for this use of a notebook.

Table 1. Advantages of different types of notebooks.

ADVANTAGES	Copy & paste whole screen of text & graphics	Copy & paste selections of text & graphics	Arrange & rearrange text & graphics	Add own text & graphics to information copied	Create own outline	Use headings to create hierarchy of outline	Create concept map	Add text & graphics to concept map
Learner actively selects relevant information	X	X	X	X	X	X	X	X
Includes media as well as text in notes	X	X	X	X	X			X
Recording of information accurate	X	X	X			X		
Can select only needed information		X	P	P	X	X	X	X
Accurate depiction of developer's organization						X		
Can create unique structure via selection of headings/concepts						X	X	X
Can reorganize information to create own personal meaning			X	X	X			
Can display own conception of relationships			X	X	X		X	X
Can elaborate on new information with prior knowledge to make meaningful				X	X		X	X
Can create own knowledge framework to use in program				X	X		X	X
May be able to hide or display layers of hierarchy as needed					X	X	X	X
Instructor can create initial framework as organizer				X		X	X	X
Graphical portrayal of relationships (hierarchical or heterarchical)							X	X
Can paraphrase to add own retrieval cues				X	X			X

Note: X=likely, P=possibleNote:

2. Disadvantages of different types of notebooks.

DISADVANTAGES	Copy & paste whole screen of text & graphics	Copy & paste selections of text & graphics	Arrange & rearrange text & graphics	Add own text & graphics to information copied	Create own outline	Use headings to create hierarchy of outline	Create concept map	Add text & graphics to concept map
Requires little depth of processing	X	X				P		
Encourages external storage of information, not encoding	X	X				X		
Organization shown/created not personally meaningful	X					X		
Difficult to get overview of organization of information	X	X	X	X				
No personal elaboration of material	X	X	X			X		
Cannot reorganize information to create own personal meanings	X	X				X		
No inherent way to show relationships	X	X	X	X				
May need training to use strategy					X		X	
Strategy format may be cumbersome					X		X	X
Material may not be suitable to hierarchy					X	X		
May be difficult to incorporate non-text into outline or map					X		X	
User may not be graphically oriented							X	X
Superfluous information may be included	X					X		
Inaccurate information may be included				X	X		X	X

Notebooks can even be provided which allow learners to use them to create more elaborate multimedia presentations. The notebook could be used as an organizer for drafting such a presentation and, ideally, would make the transition to a finished multimedia product seamless.

The previous review of research has provided evidence that the combination of the encoding and external storage function of notetaking is most valuable. Electronic notebooks provide learners with the capability to gather and later review organized and elaborated information. This allows them to process the information again and assists by cuing retrieval. The generative learning hypothesis (Wittrock, 1974), in particular, supports the use of a notebook to copy text, graphics, etc. and then to add one's own elaborations. Learners can then arrange information into their own framework, be it outline or spatial map. This allows for both repetition of the information and additional processing. Notebooks can also be used to supply learners with teacher-provided questions, outlines, frameworks, or keywords. Any of these strategies can act as an advance organizer for the learner, especially those with low prior knowledge. They can provide a framework for gathering information and stimulate recall of prior knowledge. Learners could also be asked to generate their own outline or framework of prior knowledge before commencing interactive multimedia instruction in order to stimulate recall and provide hooks for integrating the new information. They could even generate their own questions to be answered at the start and fill in the blanks as they go through the program.

Disadvantages

While notetaking in interactive multimedia offers these varied expanded capabilities, designers are advised to use them with caution. The notetaking research reviewed above has also indicated that learners who elaborate on the information recorded interact more with the new material and link it to their existing knowledge. Learners need to go beyond mere recording of information to organizing and elaborating on the program's information to help them to encode it, relate it to prior knowledge, and to make the new information personally relevant. While elaboration may be an effective learning strategy, designers providing such features in a notebook may well find that learners need to be convinced to use them. They may also find that learners using complex materials such as interactive multimedia instruction prefer to read and reread the information as their strategy of choice, even in lieu of standard notetaking. Approaches like outlining, and especially concept mapping, may not be in learners' repertoires of strategies. Even if learners are aware of a particular strategy, they may tend to use those they feel most comfortable with, even if it may not be the best for the situation.

A notebook, then, may be provided, but not used especially in the case of a notebook that provides some of the more sophisticated features such as concept mapping. Designers incorporating such features are advised to include an introduction to the particular elaborative technique, or even tutorial instruction, to ensure that learners use the notebookin other than simple cut and paste mode. Such guidance could be made available and then extinguished as the learner becomes more comfortable with its use. No matter what type of notebook is incorporated, there is a need to teach use of the learning strategy. Students using even simple notetaking have difficulty selecting the major concepts and including the appropriate level of detail. Many simply copy verbatim and never elaborate with their own prior knowledge, a strategy provenineffective. Outlining and concept mapping are even more challenging. Unless the strategies are understood and carried out correctly, they will be ineffective, considered burdensome, and probably not used.

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