DOCUMENT RESUME

ED 397 805 IR 017 993

AUTHOR Knupfer, Nancy Nelson; Clark, Barbara I.
TITLE Hypermedia as a Separate Medium: Challenges for Designers and Evaluators.
PUB DATE 96
NOTE 18p.; In: Proceedings of Selected Research and Development Presentations at the 1996 National Convention of the Association for Educational Communications and Technology (18th, Indianapolis, IN, 1996); see IR 017 960.
PUB TYPE Reports - Descriptive (141) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Access to Education; Computer Graphics; *Computer System Design; Content Analysis; Cultural Differences; Designers; Design Preferences; Educational Technology; Formative Evaluation; Guidelines; Hypermedia; Instructional Improvement; *Instructional Materials; Metaphors; *Multimedia Materials; Preservice Teacher Education; Professional Development; Sex Bias; Summative Evaluation
IDENTIFIERS Competency Needs; Graphical User Interfaces; Interactive Systems; Visual Displays

ABSTRACT

This paper addresses some of the challenges and dilemmas faced by two instructional designers as they incorporated visual imagery and audio components into the design of two distinct interactive multimedia products. Each instructional product was designed as a professional development seminar or series of instructional seminars for two distinctly different groups of adult learners. One product was designed for preservice teachers who spend a significant amount of time on campus and in classes, while the other was designed for practicing social workers who are employed in isolated, rural areas where access to professional development is extremely limited. The following considerations which were identified as essential to any improvement of instructional design guidelines are discussed: (1) how the visual elements of hypermedia should be structured; (2) proper uses of visual metaphors; (3) formidable questions inherent in the presentation of content and images; (4) when design supersedes content; (5) the importance of the instructional designer's familiarity with new models of instruction and learning theory; (6) theoretical elements appropriate for the graphical-user interface; (7) images, language, and content that are free of cultural and gender bias; (8) how images, language, and content accurately represent the cultural and gender variables; and (9) how formative and summative evaluation should occur. (Contains 40 references.) (AEF)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

ED 397 805

Title:

Hypermedia as a Separate Medium: Challenges for Designers and Evaluators

Authors:

Nancy Nelson Knupfer, Ph.D.
Associate Professor
College of Education
Kansas State University

and

Barbara I. Clark, Ph.D.
Assistant Professor
School of Education
Gonzaga University

IR017993

BEST COPY AVAILABLE

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

M. Simonson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

ERIC

Recent developments in hypermediated software suggest new challenges for instructional designers of interactive multimedia. Product enhancements provide authoring software with increased capabilities for designing and producing multimediated instruction. The enhancements permit new possibilities for the appearance and functionality of courseware, and thus pose new challenges for instructional designers.

Further, the increasing ease with which the improved authoring software can potentially be used, could lead to a situation in which people produce instructional courseware without the aid or advice of instructional designers. Products that result, whether stand-alone desktop systems or those that incorporate other resources such as material from the world wide web, have vast potential. Yet the new technological enhancements will not necessarily be applied in a way that truly improves the instruction.

Technology offers "bells and whistles" that seem to have great potential but often take the lead and interfere with instructional design. Indeed, if misapplied, the software enhancements could actually befuddle the learning process. A framework is needed to provide guidance for people who must produce instructionally sound products that utilize a mix of stagnant text, text as a dynamic visual image, still and motion visual images, and audio within a hypermediated format. Such a framework can provide the necessary guidance to make wise use of the new enhancements to the technology.

The processes of linking visual images with visual text, and making connections between realia and the meaning of the images in a hypermediated format, lead to questions about effective instructional design of courseware that incorporates those processes. Moreover, those processes cause software evaluators to rethink the standard for effective and appropriate presentations.

This paper addresses some of the challenges and dilemmas faced by two instructional designers as they incorporated visual imagery and audio components into the design of two distinct interactive multimedia products. Each instructional product was designed as a professional development seminar or series of instructional seminars for two distinctly different groups of adult learners. One product was designed for preservice teachers who spend a significant amount of time on campus and in classes, while the other was designed for practicing social workers who are employed in isolated, rural areas where access to professional development is extremely limited.

The multimedia products present content-specific information pertinent to learners through the use of visual text, still images, still and animated graphics, sound, and full-motion video vignettes contained on a laser videodisc or CD-ROM. The two programs provide learners with new information, observational examples, and interactive practice about content specific to their fields, either teaching or social work. There are many similarities shared between the instructional needs of the two products and so many design aspects are common to both, however the graphical-user interfaces between the two programs are very different.

The teacher's product contained content about the National Council of Teachers of Mathematics' Standards (NCTM, 1991). Students normally would cover this material in class as part of their regular coursework and through other techniques of instruction. The social worker's product differs in purpose. It offers ten different topics of study that are not addressed within the course of regular university preparation for social workers. The topics were determined by conducting a needs assessment with practicing social workers.

The social worker's program is quite extensive and is being developed as a series of ten separate modules with similar functionality to accommodate people who have very limited computer skills. It uses standard design elements such as text-based menus, buttons, pop-up text boxes, concept maps, and the choice of receiving audio-based, text-based, or a combination of audio and text within the instructional interface.

The teacher's program replaces text menuing with a graphical user interface (GUI) that presents familiar objects within a traditional school setting. The main menu is a graphic of a school hallway lined with doors and an exit sign. Each door leads to a room that contains desks, books, and chalkboards to access information. This program also contains an electronic notebook in which the learners can write their questions and reactions to their observations. Both programs are hypermediated, employ video vignettes, and contain a presentation component, an application component, and an assessment component.

Both product design teams were able to follow some common theoretical elements of interactive system design, yet both broke new ground in their own way as they strove to create a product best suited to their given audience and instructional needs. Formative evaluation was conducted on both programs (Clark, 1995; Knupfer, Barrett, & Lee, 1995). In addition, summative evaluation was conducted on the product designed for teachers (Clark, 1995). Results of the summative evaluation of the teacher's multimedia product indicate that significant differences occurred in the abilities of teachers who used this program to identify, understand, and explain specific teaching strategies they observed in the video vignettes as compared to those who did not use the multimedia.

The product designed for social workers is much more extensive; it represents a series of ten distinct topics of study that each carry three continuing education units of credit. Each topic is considered as a unique course of study and is contained in a separate, but coordinated module like one title in a series of books written by different authors but with a single series editor. Although the ten modules are designed as a set of training for social workers, the modules can be studied in any order and in any amount. The criteria for receiving credit for each module rests in completion of an on-line test with a passing grade.

The social work modules are being phased into numerous communities as the development progresses and eventually all ten modules will be in place in numerous locations. As each module of the series is developed, it goes through formative evaluation and field testing. Summative evaluation will be conducted after several modules have been placed into the social work offices in various communities. This paper limits discussion to the first module, *Child Development*, for the sake of simplicity and clarity.

Success of any product's effectiveness will be affected by the learners' acceptance or attitude toward the product, the product's match with learners' needs both in a technical sense and in terms of content, and the product's ability to be used within a given environment. Therefore any evaluation must also consider the reactions of both the social workers and preservice teachers to using the hypermedia. Results of the evaluations to date suggest some guidelines that instructional designers should consider when designing such products. Further, as we think about ways to improve those products and enhance their content and functionality with material from outside sources, such as those from the internet, we need to be able to evaluate the quality of the outside resources as well.

Interactive multimedia computer tools can expand our ways of thinking and perhaps encourage metacognition, more deeply than software that contains only standard text, few images, or non-interactive video. In interactive multimedia contexts, learners browse and search through video, images and text; form interpretive thoughts; make connections between visual text, still images, and full-motion video images; and cluster discrete fragments of information into meaningful ideas. The challenge for instructional designers is to take the set of guidelines that has been developed for interactive, computer-based instruction, and extend them to include guidelines that consider the dynamic nature of the myriad possibilities that become available with new technological tools, resources, and techniques.

As authoring tools become more transparent and more people become skilled at incorporating the internet into their work, the volume of interactive, multimediated software intended for self instruction is likely to increase. This increase signals two things: more software that is produced by novice instructional designers or people who have limited knowledge of techniques appropriate to efficient learning, and the need for guidelines to use in the production and evaluation of the hypermediated software. Such a design framework will go beyond the guidelines used for computer-based instruction as we knew it a few years ago and if not able to provide succinct answers, will need to at least address additional areas of possibilities.

Designing hypermediated instruction is a formidable process. It calls for deep analysis of many interconnected and dynamic components, and results in a set of organized activities and processes (see Andrews & Goodson, 1980, and Gustafson & Powell, 1991). One critical component of hypermediated instruction is the use of visual imagery. Knupfer has suggested guidelines for employing visual imagery within computer-based local and distance instruction that incorporate some of the well-established standards for instructional television production (1994a; 1995). There is a need to take that set of guidelines and extend it even further. In doing so, the following questions seem essential to any improvement of instructional design guidelines for interactive multimedia. Their answers help to construct a possible framework to guide future designs for hypermediated learning:

- How should the visual elements of hypermedia be structured?
- What are the proper uses of visual metaphors?
- What are the formidable questions inherent in the presentation of content and images?
- When does design supersede content?
- What is the importance of the instructional designer's familiarity with new models of instruction and learning theory?
- What theoretical elements are appropriate for the graphical-user interface?
- Are the images, language, and content free of cultural and gender bias?
- How do the images, language, and content accurately represent the cultural and gender variables?
- How should formative and summative evaluation occur?

Although there are no answers that will work in all situations, for all audiences, there are some considerations that designers can incorporate into the planning process. Further, as hypermedia takes fuller advantage of on-line resources it will be important for designers to consider strategies for handling dynamic information and images from outside sources, such as the internet.

CONSIDERATIONS

How should the visual elements of hypermedia be structured?

Visual imagery is one of the most important elements of hypermediated instruction, yet many designers fail to incorporate it to it fullest potential. If used wisely the visuals can greatly enhance the instructional message. Like other elements within the product design, visual information needs to be applied in a consistent manner yet with attention to a comfortable blend of variety and aesthetics. Both of the products evaluated for this study did an excellent job of applying visual elements to a certain extent, and both have areas in which they can be improved.

The greatest weakness of both products stemmed from the limited experience of certain key decision makers who lacked enough skill to visualize elements of the learning process. Having not been trained in instructional design, nor visual learning, nor graphic design, nor aesthetics of art and so on, some key leaders were greatly limited in their ability to imagine the potential of the visual messages within each product.

Certain weaknesses within each product, both in terms of adding time to the production and in the final visual message, were the direct result of decisions made by project leaders who did not understand how to take advantage of the medium to enhance learning, tried to save time by skipping steps in the design phase, and placed too much responsibility on programmers to provide design solutions toward the end of the development cycle. The complexity of reasons for these weaknesses are beyond the scope of this paper, but the resulting compromise in potential learning is most evident in certain mismatches between video imagery or graphics and the content or tone of the script.

There is no doubt that the single most important factor in the successful instructional design and imagery used was the result of teamwork that drew on the talents of a variety of people. Communication among the design team was essential.

Successful visualization within each of the products was the direct result of being able to work with a talented artist who was able to shape the ideas into visual form that carried meaning into the instructional process. In order to do that, the artists needed to be emersed in the design process from the beginning. They turned ideas into images that communicated visually. Their choices of shapes, colors, representations, animations, morphing, and transitions had a major influence in each of the final products. The visual elements that seem most important are those that comprise the basic structure of the image, add meaning to the message, and employ the power of visual impact when appropriate (Knupfer, 1994b).

The Structure of the Image

The structure of the image first considers the visual as a whole, then its components and the elements of good screen design. In order for the various image components to work together, elements of well-planned screen design must weave the components together in an aesthetically pleasing and understandable format. Thus, one must consider both the separate image components and the screen design as a whole.

The Image

The image contains a mix of components that can work together or separately to modify the intended message. Text, color, graphics, animation, the multimedia mix, size, special effects, and the dynamic nature of the components all will influence the message delivery and resulting interpretation.

Text. In the late 1980s, text dominated computer-based instruction (Soulier, 1988). Improved technology and attention to visual design offer the potential for more variety within the imagery, and many courseware designers have incorporated more graphics. Yet it appears that much of the information available from computer courseware and from internet resources, does not take advantage of this capability and seems to use text-intensive screens.

Analysis of the social worker's courseware revealed a strong effort at visual design. Graphics and video were incorporated throughout the courseware, yet the majority of information was contained within the text, with the imagery used for emphasis, reinforcement, or aesthetic value. Analysis of the teacher's courseware revealed that graphics were used to carry the message in certain places and to support the textual message in other places. Both the social worker's and teacher's courseware depended heavily on the audio script to support video imagery. In addition, the social work material offered the learners the ability to view the text of any audio script in addition to hearing it. None of the learners utilized this feature, yet it was left in the product to accommodate learners who might be hearing impaired or use the material in an office with environmental noises that might interfere with their ability to hear the audio. Both products incorporated volume control.

When graphics alone are used to carry the message, the graphics must be concise enough so that learners are able to understand the message. Likewise, when large amounts of text are presented, it is important to design text displays that communicate clearly to the reader. With appropriate fonts and spacing, computer screens can work very well for presenting limited amounts of text. Large amounts of text work better in printed form (Soulier, 1988) since they induce eye fatigue (Hathaway, 1984; Mourant, Lakshmanan, & Chantadisai, 1981) and are likely to be forgotten when presented on the screen (Wager & Gagne, 1988).

In addition to the amount of text, its density, along with typographic cueing and the mix of upper-case and lower-case characters can affect legibility (Hartley, 1987; Hathaway, 1984; Morrison, Ross, & O'Dell, 1988; Ross, Morrison, & O'Dell, 1988). Variations in font type, size, and density along with direction and screen placement can add meaning to the text image. With the exception of selected levels of titles and headings, or special effects, the text should contain a mix of upper and lower case letters.

The teacher's product did not contain titling and depended upon the graphics of the user interface to act as a map for the learner. For example, starting with a hallway lined with various doors, the learner would click on a doorway of a specific room and by moved into that room. From that point, the learner used objects within that room until the hallway pass was chosen to exit that room and return to the hallway. The social worker's material began by using a single level of titling, but changed to a more precise title plus subtitle system after formative evaluation revealed confusion.

No matter what the screen design, legible text requires an appropriate font that is properly spaced. There is disagreement about the appropriateness of serif or sans serif style fonts. Some authors claim that fonts with serifs, as opposed to block-style lettering, are a better choice for computer screens (Soulier, 1988). Yet others believe that sans serif fonts with proportional spacing provide a cleaner effect that is easier to read than their seriffed counterparts (Gibson & Mayta, 1992; Kemp & Dayton, 1985). Fonts with small serifs can add interest to the display, while elaborately-seriffed fonts are difficult to read, especially if the image is to be viewed on television or projected in a large room.

Text legibility also depends upon the point size of the font. The point size of text on a computer screen can range from 12 to over 100 points per inch and remain legible. However one should consider the intended usage when selecting point size. Images that are likely to be projected for large audience reading should not use a point size smaller than 26 (Gibson & Mayta, 1992) and images that are not likely to be projected or broadcast will seldom require an extremely large font. Also consider the user; when designing screens for young children or people with visual impairments, use a larger font.

In addition to style and size of the font, the weight of the typeface, line length, phrasing, and spacing between lines of text affect the legibility of computer screens (Jonassen, 1988; Morrison, Ross & O'Dell, 1988). The weight of a font

can vary from light, narrow, fine lines to heavy, broad, bold lines. A medium to bold weight is very good, depending upon the mix of elements on the screen. Gibson and Mayta (1992) recommend that bold typeface be used throughout all computerized screen images that are intended for broadcast so that the text shows up against the graphics. At the least bold fonts should be used for all titles and headings as well as for particular words that need emphasis in a projected image. Bold fonts are not necessary if the image is to be viewed on a single computer screen. Medium weight fonts are quite legible if the color mix and font style are compatible. If using a small font to preset a large amount of text on an individual screen, a lighter weight font will be more legible.

Drop shadows behind the text characters can add legibility if used carefully, but they can also interfere with legibility. Therefore it is important to check legibility prior to applying drop shadows throughout the courseware.

The design of hypermedia resources must consider the effects of mixing text in a way that follows known layout practices to aid learning and retention, while attending to individual preferences, habits, and usage situations. All of this must consider mixing media in a way that allows learners to recheck information that they do not commit to memory.

Text that is designed as part of the visual imagery can add impact to the on-screen presentation. This visual text can be stagnant or dynamic and has the ability to add meaning to the message. Text can employ hotlinks to more information and color-coding to suggest meaning and serve as an aid to navigation. Although it is tempting to use flashing text as a way of getting attention or using a fancy technique, this should not be done. The flashing can interfere with the brain functions of people who are light sensitive or who have a seizure disorder.

No matter what exact techniques are used from the range of possibilities, learners seem to be more able to find their way around when the user interface is simple and consistent so learners know what to expect. Thus for text-dense sections, it is better to design screens that present categories of information concisely with links to other screens rather than presenting long scrolling screens of text. If the navigational interface includes consistent return paths following each section, then the learners can navigate with less chance of getting lost.

Color. Specific educational objectives can be enhanced by using color in visual illustrations (Dwyer, 1978), but while a few colors can cue the learner about the intended message, too many colors can be confusing. Color should assist the user in focusing on the material; it should never be a distraction (Gibson & Mayta, 1992). Accordingly, Hannafin and Peck (1988) suggest using a bright color to cue the learner for new information, while presenting the remainder of the information in standard colors consistent with the rest of the screen. Soulier (1988) recommends checking the program on a monochrome monitor and when in doubt about legibility, use a different color or employ patterns as a backup technique to aid those people who are color blind.

Color can be used as a visual cue to indicate hot words, type of multimedia activity or link, flow of information such introductory or summary sections, or as a navigational aid to highlight menu choices, content maps, and so on. Whenever possible, it is helpful to use colors in a way that does not conflict with outside materials that are likely to be incorporated as part of the instructional flow. For example, if learners will search the internet as part of the instruction, then color coding of hot links should be used in a way that is likely to be employed in those materials as well as opposed to simply choosing your color coding independently of that situation.

A few colors with good contrast values will show up well on both color or monochrome displays, but an extreme contrast like stark white on a black background will cause bleeding and illegibility; it is better to use light gray to achieve the desired effect. Also avoid high values of red and orange because they can bleed into the surrounding colors.

In addition, certain colors that look ideal on an individual computer screen tend to flare or wash out when they are projected to a large screen or transmitted over a distance. To avoid disappointment it is best to experiment with a few color combinations using the equipment that will support the image when it is actually projected. Complementary colors with low saturation would have a good chance of working.

Graphics and Animation. Graphics add interest to the screen by providing visual variety (Kemp & Dayton, 1985) and offer another opportunity to suggest meaning to the learner. There are many ways to incorporate graphics into learning, yet designers often forget to determine the instructional reasons for using graphics prior to making decisions.

BEST COPY AVAILABLE

Five main categories of instructional applications of graphics include cosmetic, motivational, attention-gaining, presentation, and practice (Rieber, 1994). Possible graphic treatments range from simple to complex, from small monochromatic embellishments to dramatic, richly-colored, full-motion video images complete with sound effects. Prior to deciding on uses of graphics, it is important to consider the instructional meaning of the graphic. In the social work project, this guideline was extremely difficult maintain because like many others, key people in authority positions had been fooled into thinking that dramatic visual effects translated into dramatic learning, regardless of instructional purpose.

Graphs that display data depend upon the reader's thought processing, interpretation, and comprehension; to be effective they must consider the intended visual message carefully. Sophisticated graphic displays that are designed to suggest inferences, generalizations, and evaluative interpretation can help students interpret meaning (Reinking, 1986; Singer & Donlan, 1980). High-level instructional graphics, such as symbolic, schematic, or figurative displays can be effective in teaching, and the visualization of abstract ideas through figurative displays may very well enhance learning (Nygard & Ranganathan, 1983). All graphics do not require the same level of detail and clarity, but even simple, decorative graphics at the pictorial level have their place. Indeed, Boyle (1986) suggests a need for designers to address cognitive processes by developing more materials for graphic thinkers, not just graphic readers.

The *Child Development* module contained a challenge that was nicely resolved through visual graphics. Rather than simply presenting a growth chart as a line graph, the information was displayed interactively. Two figures, one girl and one boy, were compared side by side on the screen. Learners could enter information about age, height, or weight and see visual representations that compared boys to girls at key stages of growth. The combination of interactive visualization seemed to help learners conceptualize important stages of physical development.

To assist with designing computer graphics, Soulier (1988) offers the following guidelines: keep illustrations appropriate for the audience; use simple line drawings when possible; preload graphics into the program so that they appear quickly on the screen; use standard symbols and symbolic representations; and keep graphics on the same screen in close proximity to the corresponding text message. These few tips can greatly improve the aesthetic appeal of a graphic and promote clarity of the message. Even though multimedia supports elaborate graphics with a host of detail and many colors, use care in developing those graphics so that they fit the need. Sometimes it will be important to provide near photographic quality images, but other times that is completely unnecessary and only takes up memory while slowing the program processing.

Most development software allows the use of simple animation to illustrate a motion, provide interest, or draw attention to particular areas of the screen (Kemp and Dayton, 1985). Although it is tempting to embellish the graphic, it is important to use animations only when appropriate and keep them short (Soulier, 1988).

In order for animations to be effective, there must be a need for visualization. Animate only a few graphics that will aid the learners' comprehension of the material by, for example, gaining attention, illustrating a concept, or showing direction. When used sparingly animations can be effective, but they can become irritating, distracting, or disruptive to the thought process if overused or left on too long. Whenever possible, allow the user to interrupt the animation.

Screen Design

Good screen design aids the learner by using visual components to portray the message in a way that provides both clarification of information and visual interpretation. To visually aid the learner, it is necessary to consider the specific elements of good screen design as well as the general screen layout.

Elements of Good Screen Design. Interesting screens are composed of a variety of elements that work well together. Many of these elements are equally important so they are presented here in no particular order. The goal of good screen design is to use the various elements together to compose a simple, consistent design that provides sufficient information while avoiding clutter.

Unlike printed material which can be skimmed at will the computer screen limits the learners' view of the overall content. Screen designs that are simple, straight forwa d, and consistent can help lead learners through the material, while complicated designs can lead to frustration. The basic simplicity of frame layout and user options does not restrict the ability to add interest and meaning with a full range of simple and complex graphics.

The graphic user interface in the teacher's multimedia project presented a simplified view of a school. Each room contained certain information that would be familiar and suggest meaning to the learners, but extra elements were left out. Possible problems with such a graphical user interface are likely arise when the imagery or graphical metaphor presents an environment that is unfamiliar to the learners. Also, it is important to establish patterns of linkages within the graphics so that the learners know what to expect. For example, the images that contain hotlinks should be obvious to the learners. They should not have to makes guesses about which images are active and which are not active.

Certain user options should always be available. For example, status lines at the top or bottom of the screen that contain consistent information help the learner assess progress and maintain some control over the program direction. The reader should control the display rate when possible so that there is adequate time to read the text, interpret the graphics, and consider the meaning of the message. A few standard templates will aid programmers and learners. Programmers can easily update images or text if fits into a template without experiencing misalignments. If designed consistently, learners know what to expect from patterns of information and program functionality within template areas.

Menus should be clear, concise, uncluttered, and consistent. Icons within menus can be very helpful if the meaning of the icon is readily apparent. The range of possible choices in some programs can lead to cluttered or excessively layered menus; pull-down menus can be a solution. Highlighting or fading some menu choices will quickly give a visual cue about which items are currently available.

Careful positioning of text on the screen can add to its aesthetic appeal and legibility. Although centering can work for lists, diagrams, or graphic mixes, most text should be left justified and limited to 65 characters per line or 25 characters per line for projected images (Knupfer, 1994a). Partitioned screens in which text is confined to specific areas, can work very well.

Ross and Morrison (1988) suggest using a hierarchical text display that is vertical and uses indentations similar to an outline. They further recommend a low-density text display with reduced wording and sentences limited to one main idea. Also, it is important to use care when splitting lines so that phrases remain complete Soulier (1988). Personal preference varies concerning the spacing of text as long as it is legible, but do provide text breaks where the content allows. In the case of a completely graphic menu, the images should be limited to those that are necessary and should also suggest an obvious meaning. There is disagreement about whether icons should be labeled, but one compromise we can suggest is to provide labels within balloon help. The social worker's product incorporated icon labeling in that manner so that a label appeared only when the mouse passed directly over an icon.

In addition to font size, the text legibility is influenced by contrast with the background. Common considerations for both computer screens and video images suggest cool, neutral background colors like gray or blue instead of bright, very light, or very dark backgrounds. Tasteful use of enhancements such as outlined, inversed, flashing, or drop shadowed text can add to legibility. The wide variety of patterns available for backgrounds can create visual interest, but those background patterns can also interfere with the legibility of text.

Special techniques for changing the screen display, such as zooming, panning, tilting, and wiping onto the screen, can vary the viewer's perspective of the image. For example, a section of the screen can be enlarged to give a close-up view of specific details. Or the image can change from a long shot displayed in a small part of the screen to an extreme close-up showing part of the same image displayed in full screen mode. This technique can give the learner the sense of moving in to take a close look at the image. Imagine, for example, the visual effect of looking at a long shot of a group of trees in a small box on the screen and then changing to a full screen display of a close-up shot of leaf on one of those trees.

When projecting computer images to a large screen system, overscan and underscan considerations become important (Knupfer, 1994a). Overscan fills the screen beyond the edges so that no blank space will show around the edge when the image appears on a television monitor; computer graphics need to be produced in overscan mode so that no blank edges or distracting video signals will show around the edges during transmission (Gibson & Mayta, 1992). Underscan protects a blank area around the screen edge so that images don't get cut off during the transmission process; important

BEST COPY AVAILABLE

information should be placed within a safe area, usually the middle two-thirds of the screen (Kemp, 1980). This is especially important when determining proper placement of navigational aids at the screen edges.

Both the social worker's and teacher's multimedia products in this study, were designed with for use by individual learners, but the products also needed to function for large group presentation in certain situations, so issues of text size, overscan and underscan were important. A second common problem with computer-produced screens is changes in color that emerge as the image passes through different equipment. For example, color selection might not hold up during projection, colors might appear different or even washed out on different screens. Even if it looks wonderful on the production machine, always check your images on equipment and situations available to the end users.

Screen Layout. The elements of good screen design work together to build a cohesive screen layout. The computer screen layout should never be visualized as a printed page filled with text, but guidelines similar to those offered for desktop published materials can be helpful. These include balancing text with white space, improving the aesthetics of the page, and positioning graphics as the dominant visual element (Parker, 1987). Designing the display with attention to legibility, the purpose of the particular frame, and consistent protocol, can result in visually interesting computer screens. Avoid cluttering the screen with too many images; provide print copies of complicated images that are important to remember. The social worker's project produced a workbook with text intensive and supporting materials that were best offered in print. Support material included pages about child development that could be Xeroxed and set home with parents. These worksheets would be especially valuable to parents who are tracking patterns in children suspected of having delayed physical, mental, or emotional development.

Like silence within oral communication, empty spaces can be used to advantage on the computer screen. For example the screen can be used to organize or highlight information, to draw attention to particular parts of the frame. The mix of graphics and text can provide a visual cue; so can boxing and grouping of information. Partitions, borders, standard icons, and consistent placement of common elements will visually aid the reader.

While partitions and borders can draw attention to an area, artistic sense can still flourish. Double borders or pseudo bordered areas can create an interesting effect, but use care when partitioning screens. Screens areas can help learners know where to look for certain types of information, but excessive use of boxes and boarders can also disrupt the flow of information and signal novice design skills.

Headings are often centered and bold, or sometimes even boxed. Although this is not necessary for nonbroadcast multimedia, headings should at least be used consistently. For long or complicated sequences of instruction, subheadings can be used that include numbers or roman numerals to aid the reader in visually following the general flow of information. As a general rule, information should flow from the top, left part of the screen to the bottom, right part of the screen because that is the way people in our culture read. Variations in standard layout can work if they are with purpose and fit the situation. Challenges in this area are likely to arise when incorporating information from outside sources or designing information for a wide variety of users, in a multicultural or world-wide sense. The projects in this study applied limited resources to specific and known audiences, so this did not become an issue beyond the normal attention to gender and culture within the language, imagery, and examples employed.

Good layout technique depends upon an understanding that not all computer frames are alike. Hannafin and Peck (1988) address transitional, instructional, and question frames. Transitional frames are used to tie together the different parts of the a computerized lesson: they provide an orientation to the beginning of, and various sections within, the program; they serve as bridges between various topics or sections; they provide feedback, directions, and instructions; and periodically, they present a progress report to let the learner gauge success. Instructional frames present basic information to the learner: these frames can alert the student to a need for prerequisite information; provide links between relationships from past and current learning; and provide definitions, examples, and rules. Question or criterion frames solicit input from the student to help individualize the instruction; these frames usually are based upon a true or false, yes or no, multiple choice, completion or short answer, or a constructed response which is considered to be a more open-ended answer.

There are also variations to the general type of frames. For example, sometimes a frame contains both instruction and a question. Copy frames, prompt frames, hint frames, and interlaced frames are some types of variations (Hannafin &

Peck, 1988). Copy frames provide information and a question about that information in the same screen. This type of format can be helpful in directing student attention, emphasizing important points, and for assuring a high degree of success for particular students. But because they are so obvious, copy frames are considered very elementary and need to be used sparingly.

Prompt frames direct the learner to supply input; these can be used effectively for questions as well as instructional screens. Hint frames are usually provided after a student has failed to enter an expected response; they offer guidance but do not supply the correct response. Interlaced frames are hybrids which combine various components from the standard frame types; they might include instruction, question, and feedback all on the same screen. This design can appear cluttered if not presented carefully but it has the advantage of allowing the student to visually examine and compare the question and feedback.

Each type of frame depends upon grouping of information in a way that visually aids the reader. To make optimal use of visual cues, it is helpful to design standard protocol for each type of frame and use it consistently throughout the program. Whatever protocol is chosen will need to comply with the overall program design. Programs that vary the screen location of pertinent information or procedures used to advance throughout the program can be confusing and frustrating (Mackey and Slesnick, 1982). Although standard protocol is necessary (Apple, 1992; Heines, 1984; Jonassen, 1991; Lentz, 1985; Simpson, 1984) designers can provide artistic variation to other parts of the screen to suggest meaning.

The Meaning of the Image

Information becomes valuable as it takes on meaning for an individual. Since visuals are meant to aid in the discovery of meaning, it follows that well-designed visuals will help students interpret the meaning. Computer images vary widely in potential design and usage. Images can be static or dynamic, concrete or abstract, and they can change as a result of user interaction with the program. A learner's interpretation of the image can be affected by the text, type of graphic, and layout employed.

Layout must consider the principles of perceptual organization, which include similarity, proximity, continuity, and closure (Bloomer, 1976). These four processes, by which the mind organizes meaning, depend on how physically close the objects are, how similar they are, whether there is a continuous line to guide the eye, and whether the minimal amount of information is present that is necessary to obtain meaning or closure. Comprehension is directly affected by the way the mind organizes meaning from the placement of graphics and text (Norman, 1993) and in the process of linking information.

The Power of the Image

Computer graphics and appropriate screen displays can lend power to communications by adding vivid imagery to the text. Visual images can aid message interpretation and enhance learning. They can also add power to the message by providing an emotional element that is beyond that of other communication strategies. Realism can be enhanced by providing a graphic component. Images can represent realistic data ranging from simple sketches or graphs to intricate displays or vividly emotional scenes. Virtual reality can even conjure up imaginary situations through artificial imagery.

Brenda Laurel compares computer programs to theatrical plays and describes several similarities between the two (1993). Although computer programs can allow different paths to completion, they are similar to plays in that they should have a beginning, middle, and end. In addition, both can provoke emotions.

Emotional impact can be added to hypermedia by using graphics that evoke feelings or encourage learners to imagine certain situations. Size, color, shape, dynamic images, and special effects can be employed to evoke emotions, but it is wise to use a conservative approach and not overdue these techniques.

Hypermedia can display still or dynamic photos of real or imaginary events. These events and their results can combine with text and audio segments to provide a sense of realism to the user that otherwise would not be possible. The *Child Development* product evoked emotional impact by showing still and motion images of children in real situations of school, play, homes, and hospital settings. The teacher's product showed real classroom scenarios. Along with the understanding provided by the realism of these events, comes the potential to stir emotions for various reasons.

What are the proper uses of visual metaphors?

Like verbal metaphors, visual metaphors can help us to understand an unfamiliar concept. Metaphoric graphics (Soulier, 1988) may be used to clarify a meaning within the computerized message, or they can guide the user through the mechanics or functionality of using the software. For example, standard male and female icons represent content in the growth chart portion of the *Child Development* product while an exit sign icon symbolizes the functionality of both products. Both products in this study used a typical "VCR" control panel to manipulate viewing of the video clips.

Metaphors are only as good as a situation allows. Metaphors can work well in a variety of situations, but in all cases must provide an appropriate match between the topic, the learners, and the way the metaphor is applied to the design. If learners cannot relate to the metaphor, then the instructional message will be lost. But if they can relate to the metaphor, then the instructional message can be enhanced.

Metaphors are used to some degree in both the social work and the teaching multimedia projects, but they are applied with differing intensities. The social work project incorporates a variety of limited metaphors into the modules, but does not place heavy emphasis on does not carry any one, single metaphor throughout the entire series other than in the overall functionality of the user interface. For example the legal module was developed by different design team members and contains different metaphors than the stress module, yet the general functionality of the user interface remains consistent.

The metaphor within the teacher multimedia worked well with the student teachers it was intended to be used with, but other learning audiences have reacted with confusion and frustration . Objections to the completely graphic interface arose because some learners could not relate to the school scenario, needed more preliminary interpretation of the graphical user interface, or preferred environments that were more text-based. General comments about desiring more text indicated some potential for confusion with interpreting the school metaphor as well as unclear functionality of each graphic. Learner who re willing to explore will probably feel more comfortable in this type of environment.

What are the formidable questions inherent in the presentation of the content and images?

How many links per screen are appropriate? The number of text links per screen can become quite dense, depending upon the situation at hand. When there is information that is critical to the instruction, designers need to weigh the consequences of allowing learners to explore branches of that information in-depth or finding extraneous information versus concentrating on a limited amount of critical information.. We found that time and concentration efforts were limited in both the social work and teacher subjects who used these products, so they choose to get through the instruction in the quickest way possible, ignoring many links.

The number of links per screen certainly will depend upon the purpose of the instruction, the audience involved, time available, consequences of learning more or less information about the topic, and whether the links confound or enhance the potential learning. It appears that a screen can have numerous links as long as there is an obvious way to return that screen, to exit a link that is erroneously chosen, to indicate which paths have already been taken, and to aesthetically work the links into the screen without adding clutter that distracts from the main flow of information.

The balance of images per screen will not be determined by a precise definition, but will depend upon the purpose of the imagery, the balance of the screen design, and the functionality of the images. It is perhaps better to design one complex but integrated set of images as opposed to independent, cluttered, or conflicting images. In addition, the meaning of the images is important. All images should fulfill a specific purpose. That purpose might be to get attention, enhance meaning, make a powerful statement, add variety, and so on, but it clearly should not be simply to fill a blank space on the screen.

The length of the video vignettes was a topic of debate with both of the projects at hand. While the vignettes need to be long enough to provide meaningful scenarios that portray information clearly, they need to be short enough to allow user interaction, practice, and feedback at appropriate places. Large amounts of video information can be incorporated as smaller video clips as long as there is a common thread that laces the information together and promotes interaction that

helps learners make the cognitive link between pieces. If video is shown in smaller clips, the challenge becomes one of determining proper entry and exit solutions. Transitions become very important yet need to accommodate learners in a hypermediated context, not in a linear sense. Novices on our projects had difficulty designing a product with a beginning, middle, and end that is was not linear.

When does design supersede content?

Some people might say *never*, but there are times when the design needs to supersede content. Courseware must show consistency within the user interface, so once a design standard is decided upon it must be maintained in a similar manner throughout the instruction. In addition, designers need to be aware of standards and common practices that have been incorporated into other software that the learners have used in the past. If learners expect the software to function in specific ways, then it is best to incorporate standard practices when possible so that learners can concentrate on the content and not be confused by inconsistencies of functionality.

In a case where the instruction is designed as a series of modules, learners expect one module to function in a similar manner as another. Like a series of books in a set, learners expect certain consistencies within the look, feel, tone, instructional approach, and functionality of the courseware.

When content can be delivered in a variety of ways, design can determine final decisions about how content is delivered and how much detail is appropriate. Because hypertext allows hotlinks to be made, designers are not pressed to include all details about a subject within the main part of the courseware, but can use links to outside resources as necessary, thus enabling learners to choose more or less detail, depending on how much information they need about specific topics and how much time they can spend at the given moment.

Screen design enters into consideration as well. Good screen design allows adequate white space so that the eye has a resting place and incorporates imagery in a meaningful way. Rather than filling the screen with text, designers often need to reword and abbreviate text so that it fits well within the visual design of the screen and in so doing, need to consider grouping of words, phrases, and lists in the best way to enhance the mental processes. Substituting imagery for text can add power to the message.

Product design should to meet the needs of the intended audience. Products need to fit within the intended learning environment in numerous ways and in so doing, consider the hardware available, the physical work environment, and the emotional state of the learners. The best products will fall short of intended results if people need to struggle with hardware, can't hear the audio, can't fit instructional sequences into available timeframes, and so on.

The audience might expect media to contain special effects like they see at the movies or on television. The maturity of the audience could very well be a factor in this regard and should be considered. It will be important to use special effects wisely so that they add to the purpose of the instruction.

What is the importance of the instructional designer's familiarity with new models of instruction and learning theory?

Design team members debated about whether the same instructional approach could be used for everyone who will use the courseware. If not, then how could the designers accommodated different learning styles within the courseware?

Like other types of instruction, hypermediated instruction can provide examples, practice exercises, and feedback that will use a variety of instructional techniques and appeal to different styles of learning. As hypermedia becomes more sophisticated and gains capability of incorporating outside resources, designers can leave more discretion to user preferences. It remains a challenge to design for the type of cognitive processing allowed by hypertext while including some sound design practice from standard computer-based instruction. Even though hypermedia links and standard computer-based instruction seem to approach design in opposite ways, cognitive interpretations of instructional design reveal many similarities (Jonassen, 1991).

It will be important that designers break free of behaviorist models to the extent that the courseware does not rely so much on that approach. Hypermedia allows a much more creative approach to instruction than the drill and practice style of learning, so designers can incorporate more constructivist approaches to courseware design and student evaluation.

Designers can do such things as provide more choices within the user interface. Those choices could allow learners to move in different paths through the material and incorporate more or less information into the lesson as needed. In addition, learners should not be forced to listen to audio or to read text verbatim at all times, but should be allowed choices to hear, read, or hear while reading text in specific situations within the learning. Thus learners can choose to receive information in a way that is most comfortable at a given time.

Expectations for the potential of hypermedia are high, yet learners in both the social worker's and teacher's products experienced a certain level of disorientation and they tended not to use fancy features and graphic links. This raises questions about the need to prepare learners to better use hypermedia and to better read visual imagery.

What theoretical elements are appropriate for the graphical-user interface?

It is important to match the instructional design to the situation at hand. This means considering the goals of the instruction, the needs of the learners, the environment, and so on. While doing so, designers must ask whether situated-learning metaphors are appropriate to the audience and the content. If so, what situations are suggested or accommodated?

Another question that is important to answer in the design phase is how the learning is expected to be constructed. What design elements related to learning theory should be evident within the courseware? Is there evidence of learner control and autonomy, or is the program designed in a more behavioristic, directed structure?

How does guided learning fit into the courseware? Is learning guided in a systematic way, a tightly controlled way, not at all, or something in between? What evidence is there of motivating learners and attending to various learning theories? Does there seem to be a match between the courseware's purpose, the audience, skill level, and instructional approach? How does the system work together as a whole?

The new hypermediated courseware could incorporate information from outside sources that the designer cannot determine or control. For example, learners could potentially go to certain pages in the World Wide Web (WWW) to get information. The problem here for instructional designers will be the dynamic nature of such material; it could be here today and gone tomorrow, or changed tomorrow. If WWW resources are incorporated, how will it be managed?

As more sophisticated graphics are incorporated, it will be important to determine how to manage the complexity created by the imagery. How much importance can be placed on a learner's ability to read visual imagery? What things can we do to enhance visual literacy? How will windowing inhibit or enhance learning? Will windowing serve as a way of separating information visually or will it interfere with the flow of thought? In what ways can visual text and visual graphics help learners maintain a sense of direction as they move through various links?

There are many questions that lead good instructional design efforts. Although there are no set answers to all of these questions, instructional designers can at least address the questions to determine what guidelines will lead the design efforts.

Are the images, language, and content free of cultural and gender bias?

Media often portrays people in stereotypical roles. Movies, television programs, advertising, books, and now even clip art are fraught with stereotypes based upon cultural background, race, and gender (Binns & Branch, 1995; Couch, 1995). As courseware developers think about designing, scanning, or downloading images into the courseware, they should consider what messages are implied by the images.

Are the men portrayed in leadership positions, while the women appear in subordinate roles? Are men portrayed in work situations or using technology, while women are portrayed in nurturing roles? Are women portrayed as either older and overly-grandmotherly, or young and overly-sexy?

Are colors and tone used to add feeling or draw attention to an image in a suggestive way that might bias the learners? Examples of this are the darkening of O. J. Simpson's face on the cover of Time magazine (1994) and the bright red coloration applied to the woman figure's nipples in an otherwise dark and muted image depicting a male and female within a recent New York Times (1996) report on cancer. The former suggests a guilty verdict prior to the trial while the latter continues the American male fixation on women's breasts as sexual objects, even within an article focused on medical education.

Do sports analogies or competition appeal more to males than females. Are cultural groups represented in true proportions and in accurate situations with the examples, imagery, and prerequisite knowledge necessary for successful completion? Can the courseware be used in different cultures without bias? This question raises issues of cultural sanitation versus lack of bias; where is the line drawn?

How do the images, language, and content accurately represent the cultural and gender variables?

This question goes deeper into the underlying messages portrayed through the images, language, and content. Rather than simply avoiding stereotypes, it is important to keep the messages in proper context in terms of culture and gender. For example, does the design go the extra step to consider and include examples from the cultural group that the courseware will be used with? Certain examples will make better sense if the learners can relate to them.

Messages intended to influence attitudes toward using birth control and planned parenting, need to consider the cultural underpinnings of such issues as within the learning group. In cultures where a people's status is influenced by the number or gender of their of children, any attempt to curb birth rates would need a very sensitive approach. Likewise, portraying value systems of rural American within inner city schools and vice versa, could make the instruction fall flat.

Icons and symbology can be problematic. While some icons and symbols are interpreted with similar meanings, others will take on different meanings within different international audiences. A dragon, for example, is thought of as a scary and evil presence in Western culture, while it is believed to be powerful and even protective in Eastern cultures.

both the social worker's and teacher's products were designed to be used in American, multicultural situations. The social work product contained examples form both rural and urban situations to allow more flexibility in meaningful usage.

How should formative and summative evaluation occur?

The main questions here include the logistics of conducting formative and summative evaluation in a way that produces valid results, questions about how the visual elements actually enhance the learning, and determining what questions regarding visually literate learners are appropriate in formative and summative evaluations. The evaluation processes for both products in this study included written questionnaires, interviews, pretests and posttests, and observations. Yet the evaluations to date raise addition questions about hypermedia design.

Prior to designing the courseware, it will be important to determine what is important at the evaluation phases. What will be considered successful and what will be considered problematic? How should the visual elements be evaluated? How will designers determine the quality of the use of such things as color and contrast, or whether the design of the user interface and examples are appropriate to the content? Certainly it will be important to consider the instructional goals, the audience, and the situation in order to answer these questions.

In addition, how are the functions of the courseware evaluated? What will determine success when measuring links with other images and text? What changes are expected in images to enhance the learning? For example, will there be visual cues such as a color change to indicate that a section has been completed so that learners will be able to determine their position within the user interface?

What questions regarding visually literate learners are appropriate in formative and summative evaluations? What is the best way to determine learner understanding of the importance of the image or video to the content? How can an evaluator determine a learner's ability to "read" the image or video in context with the text and other elements in the graphical-user interface? What standard will determine the learners' acceptance level and comfort with the graphical-user interface?

All of these questions are difficult to answer because they depend on specific situations at hand. Even though hypermedia employs new techniques and holds the potential to incorporate dynamic resources from the internet, a good deal of design and evaluation standards carry on from current practice. It will be important to note where differences are important to learning while designing for the new hypermedia enhancements and plan to work within a framework that accommodates them as well.

In addition, the hypermedia links create an element of possibility that takes the learning process into a different dimension, thus calling upon different ways of learning, using different strategies and different ways of moving between topics. Designers can no longer simply assume that learners will move through topics in any given order, but must allow them to move around more freely. This implies designing information in smaller, more independent sections, that cannot depend on sequence nor amount of information covered to be considered complete. Designers will need to find ways to allow learners to enter and exit software with ease enough to accommodate the hypermedia, while attending to the completion of cognitive processing of chunks of information that belong together.

Understanding and emotional impact can be enhanced through powerful computer imagery. The imagery can represent real situations or it can create an artificial situation that appears to be real. Hypermedia has tremendous potential in terms of visual communications and educational impact, yet we have just begun to find ways to design courseware that takes advantage of some of that potential. Continued evaluation is need to examine learner's beliefs about their success with learning in hypermediated environments. There is a need to look not only at the way that instructional designers use graphical interfaces to produce hypermediated courseware, but also the way that students employ the graphics and spatial organization to construct meaning or knowledge.

REFERENCES

Andrews, D. & Goodson, L. (1980). A comparative analysis of models of instructional design.. *Journal of Instructional Development*, 3(4), 2-16.

Binns, J. C. & Branch, R. C. (1995). Gender stereotyped computer clip-art images as an implicit influence in instructional message design. In D. G. Beauchamp, R. A. Braden, & R. E. Griffin (Eds.), *Imagery and visual literacy* (pp. 315-324). Rochester, NY: International Visual Literacy Association.

Bloomer, C.M. (1976). *Principles of visual perception*. New York: Reinhold.

Boyle, M.W. (1986). Hemispheric laterality as a basis of learning: What we know and don't know. In G.D. Phye & T. Andre (Eds.), *Cognitive classroom learning: understanding, thinking, and problem solving*. San Diego, CA: Academic Press, Inc.

Clark, B.I. (1995). *Understanding teaching: An interactive multimedia professional development observational tool for teachers*. Unpublished dissertation completed at Arizona State University, Tempe, AZ.

Couch, R. A. (1995). Gender equity & visual literacy: Schools can help change perceptions. . In D. G. Beauchamp, R. A. Braden, & R. E. Griffin (Eds.), *Imagery and visual literacy* (pp. 105-111). Rochester, NY: International Visual Literacy Association.

Dwyer, F.M. (1978). *Strategies for improving visual learning*. State College, PA: Learning Services.

Gibson, R. & Mayta, M. (1992, August). *Designing computer-based instructional graphics for distance education*. Paper presented at the Eighth Annual Conference on Distance Teaching and Learning. Madison, WI.

Gustafson, K. & Powell, G. (1991). *Survey of instructional models with an annotated ERIC bibliography* (2nd ed). ERIC Document Reproduction Service No. ED 335 027.

Hannafin, M. & Peck, M. (1988). *The design, development, and evaluation of instructional software*. New York, NY: MacMillan Publishing Company.

Hartley, J. (1987). Designing electronic text: The role of print-based research. *Educational Communication and Technology*, *35*(1), 3-17.

Hathaway, M.D. (1984, January). Variables of computer screen display and how they affect learning. *Educational Technology*, 7-11.

Heines, J. (1984). *Screen design strategies for computer-assisted instruction.* Bedford, MA: Digital Press.

Jonassen, D.H. (1988). *Instructional designs for microcomputer courseware.* Hillsdale, NJ: Lawrence Erlbaum.

Jonassen, D.H. (1991). Hypertext as instructional design. *Educational Technology Research and Development, 39*(1), 83-92.

Kemp, J. & Dayton, D. (1985). *Planning & producing instructional media. Fifth edition.* New York, NY: Harper & Row, Publishers.

Knupfer, N. N. (1994a). Enhancing local and distance education with computer-produced visuals. In N. Metallinos (Ed.) *Verbo-Visual literacy: Understanding and applying new educational communication media technologies*, selected readings from the tri-annual summer symposium of the International Visual Literacy Association (IVLA) in Delphi, Greece, June 25-29, 1993. Montreal, Quebec, Canada: 3Dmt Research and Information Center of Concordia University, pp. 73-89.

Knupfer, N. N. (1994b). Computers and visual learning. In D. M. Moore & F. M. Dwyer (Ed.), *Visual literacy: A spectrum of learning.* Englewood Cliffs, NJ: Educational Technology Publications, pp 209-234.

Knupfer, N. N. (1995). Developing hypermediated, videodisc training for child welfare personnel: Bringing visually rich training to rural areas. In D. G. Beauchamp, D. A. Braden, & R. E. Griffin (Eds.) *Imagery and visual literacy.* Corsicana, TX: The International Visual Literacy Association, pp. 351-363.

Knupfer, N. N., Barrett, D. & Lee, O. H. (1995). A collaborative multimedia development project for rural training: Results of a beta test and adjustments to design. In M. R. Simonson & M. Anderson (Eds.) *Proceedings of selected research and development presentations the 1995 national convention of the Association of Educational Communications and Technology (AECT)* at Anaheim, CA, February. Ames, IA: Research and Theory Division, AECT.

Laurel, B. (1993). *Computers as theatre.* Reading, MA: Addison-Wesley Publishing Company.

Lentz, R. (1985). Designing computer screen displays. *Performance and Instruction, 24* (1), 16-17.

Mackey, K. & Slesnick, T. (1982). A style manual for authors of software. *Creative Computing*, 8, 110-111.

Morrison, G.R., Ross, S.M., & O'Dell, J.K. (1988). Text density level as a design variable in instructional displays. *Educational Communication and Technology*, *36*(1), 103-115.

Mourant, S.J., Lakshmanan, R., & Chantadisai, R. (1981). Visual fatigue and cathode ray tube display terminals. *Human Factors*, *23*, 529-540.

National Council of Teachers of Mathematics (NCTM) (1991). Professional Standards for teaching mathematics. Reston, VA: Author.

New York Times Magazine (Feb. 11, 1996). Leading causes of death from cancer in men and women.

Norman, D.A. (1993)..*Things that make us smart: Defending human attributes in the age of the machine*. Reading, MA: Addison-Wesley Publishing Company.

Nygard, K.E., & Ranganathan, B. (1983, Spring). A system for generating instructional computer graphics. *AEDS Journal*, *16*(3), 177-187.

Parker, R.C. (1987). *The Aldus guide to basic design.* Seattle: Aldus Corporation.

Rieber, L.P. (1994). Computers, graphics, & learning. Madison, WI: Brown & Benchmark.

Ross, S.M., Morrison, G.R., & O'Dell, J.K. (1988). Obtaining more out of less text in CBI: Effects of varied text density levels as a function of learner characteristics and control strategy. *Educational Communications and Technology Journal*, *36*(3), 131-142.

Reinking, D. (1986). Integrating graphic aids into content area instruction: The graphic information lesson. *Journal of Reading*, *30*(2), 146-151.

Ross, S. & Morrison, G. (1988). Adapting instruction to learner performance and background variables. In D. H. Jonassen (Ed.) *Instructional Designs for Microcomputer Courseware* (pp 227-245). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc., Publishers.

Simpson, H. (1984). A human-factors style guide for program display. In D. F. Walker and R. D. Hess (eds.) *Instructional Software: Principles and Perspectives for Design and Use.* Belmont, CA: Wadsworth.

Singer, H., & Donlan, D. (1980). *Reading and learning from text.* Boston: Little, Brown.

Soulier, J. S. (1988). *The design and development of computer based instruction.* Newton, MA: Allyn and Bacon, Inc, a Division of Simon and Schuster.

Time Magazine (1994). Cover Illustration

Tufte, E. (1983). *The Visual Display of Quantitative Information.* Cheshire, CN: Graphics Press.

Wager, W. & Gagne, R. (1988). Designing Computer-Aided Instruction. In David H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware* (pp 35-60). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc., Publishers.