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Conducting Research on Visual Design and Learning: Pitfalls and Promises

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The study identifies gaps in research using instructional technology with respect to the screen aspect of visual design. Theories of how learning takes place in a visual space are briefly reviewed. Several similarities and differences between views of designers of instruction and artists are identified. For illustrative purposes, an empirical study is summarized which suggests subjects who used a lesson created with good design principles require less study time, have a higher completion rate and achieve the same as those use a lesson created using poor design principles. Finally, a series of challenges to conducting research on visual and screen design are presented.

Cette étude identifie les écarts en recherche sur la technologie éducative, en fonction de l'écran que constituent les esquisses. On recense brièvement les théories sur l'apprentissage spatio-visuel. On décrit plusieurs analogies et plusieurs différences entre les opinions des créateurs de programmes de formation et les opinions des artistes. Pour fins d'illustration, on résume une étude empirique selon laquelle les sujets utilisant une leçon créée à l'aide bons principes de présentation ont besoin de moins de temps d'étude et ont un taux de réussite supérieur à ce qu'on observe chez les sujets utilisant un matériel dont qui ne respecte pas les principes d'une bonne présentation. Enfin, l'article expose divers défis que présente toute recherche sur des éléments visuels.

Introduction

The purposes of this paper are to (1) discuss the literature on visual design, visual cognition, and the principles of visual design (2) summarize the results of an experimental research study that was designed to determine if screens that use the principles of visual design influence the learning process, and (3) identify challenges encountered in conducting research on screen design with respect to achievement outcomes.

A review of the literature reveals that expert writers and designers of computer-based instruction recognize that effective programs are those that use both words and visuals to communicate and support the organization of material (Benson, 1985). The design of effective computer screens using both words and visuals, according to Heines (1984), requires knowledge of "the special characteristics of computer-driven screens, an artistic sense of layout and balance, creativity and sensitivity to the characteristics of the people who will be viewing the screens" (p. ix). Note that at one time, Heine's license plate read "CBI IS ART" (Heines, 1991). Faiola and DeBloois (1988) cite research that shows that good screen design is a critical interface factor and conclude that "thoughtful utilization of text and graphics has proven to be: (1) Significant in aiding insight and understanding the relationship between concepts, and (2) valuable in illustrating processes" (pp. 12-13). They further claim that proper screen design can result in improved performance through maintaining the interest of the learner, reduction of confusion, eye strain, and fatigue that is often caused by poor screen design. Adams and Hamm (1989) state that "studies confirm that the power and permanency of what we learn is greater when visually based mental models are used in conjunction with the printed word. Inferences drawn from visual models can lead to more profound thinking" (p. 7). Yang and Moore (1996) suggest that "to discover the meaning of abstract concepts, learners should have basic and concrete knowledge first . . . Graphics provide more cues, such as spatial and transitional relationships, to help learners decode and remember the knowledge content" (p. 9). Considine and Haley (1992) corroborate these statements; their studies show that "visualization often facilitates comprehension of verbal or printed language" (p. 28). Research by Teng-Mei Chao, Cennamo and Bruanlich (1996) show that graphics, when combined with text, "exert a positive effect, encourage deep processing, and improve fact retention. These findings are particularly true for poor readers. Recall is generally enhanced when graphics depict information central to the text, when they represent new important content, or when they represent structural relationships mentioned in the text" (p. 41). Alesandrini (1987) found that the use of visuals in the learning process increases the amount learned by adults; Pressley (1977) found this to also be true in children. Soulier (1988) states that learners are more likely to read text that is associated with a visual image and that the use of visuals is one of the most important ways to attract and hold a learner's attention. Reiber and Kini (1991) confirm that computer graphics, when designed appropriately, enhance learning in computer based instruction They also cite research that claims that graphics can aid in the visualization of spatial relationships between concepts and rules in short-term memory. In addition, according to Paivio and Caspo (1973) and Pressley (1977), graphics can act as powerful mnemonics for remembering verbal information and concrete concepts. Clearly, according to much of the literature, effective screen design uses both words and visuals.

Problems with the Research Literature

As is indicated in the introduction, there are substantial amounts of information in the literature on the topic of effective screen design which make claims that learning is enhanced with the use of text and visuals (see also Aspillaga, 1991; Baek and Layne, 1988; Duin, 1988; Gullingham, 1988; Livingston, 1991; Rubens and Krull, 1985; Steinberg, 1991). However, a closer look at the literature on screen design reveals that many authors cite and review previous authors' works-rather than providing a contribution to the literature with original research. Confounding this problem is another problem: much of the original research cited has been conducted on paper platform (not used on computer screens) and/or the computer equipment used in the research is outdated. Research conducted with computer screens prior to the 1990s may only marginally related and should be generalized with much caution. The reason, according to Misanchuk and Schwier (1995), is that technologies available today are considerably better at displaying visuals than in the 1980s when most computer monitors were either CGA or MGA with low pixel densities. On this topic Misanchuk and Schwier suggest that currency does not invalidate generalizations (or transferability), however, we need to question whether investigations conducted on hardware made prior to the 90s should be used in today's rapidly shifting technological world without proper validation. Specifically, according to Misanchuk and Schwier, "the rapid emergence and widespread dissemination of high resolution, bits-deep colour monitors throws into question generalizations derived from studies conducted on relatively coarse-grained monitors capable of displaying only six or eight colours" (p. 14). In addition, many of the research articles do not even state the type of hardware used for their research or the research cited.

Another problem area with determining the effectiveness of visuals in the learning process, based on current literature, relates to the *instructional situation.* Specifically, it is difficult to discuss research on screen designs out of the context that it serves (Misanchuck and Schwier, 1995). Specifically, what is effective screen design on a title page may be ineffective for content dissemination, databases, or testing screens. Moreover, much of the literature on this topic cites other research articles that are not sufficiently similar in tasks. There is a general consensus that "a high degree of similarity between a research task and real life is essential. That fact seems to have been glossed over in some of the recent research in screen design" (Misanchuk & Schwier, p. 17).

There is also some evidence in the research literature to indicate that the mere presence of visuals does not automatically guarantee better instruction (Steinberg, 1991): "Appropriately designed displays enhance learning. Designed without an understanding of how people gain meaning from them, displays can have no effect or can even interfere with learning" (p. 144). A study by Ruthkosky, O'Neil and Dwyer (1996) investigated the combination of an illustration with a verbal organizer; the results of this study provide support for Steinberg's claim. That is, the results of their study indicated that adding a visual to a verbal organizer "does not significantly increase the students' achievement of different educational objectives" (p. 38). Other studies indicate that not all visuals are equally effective in all instructional environments. For example, studies by Dwyer (1978) indicate that the effectiveness of visuals is primarily dependent upon: (a) The amount of realistic detail contained in the visualization used; (b) the method by which the visualized instruction is presented to students (externally paced vs. self-paced); (c) student characteristics, i.e., intelligence, prior knowledge in the content area, reading and/or oral comprehension level, etc.; (d) the type or level of educational objective to be achieved by the students; (e) the technique used to focus student attention on the essential learning characteristics in the visualized materials, e.g., cues such as questions, arrows, motion, verbal/visual feedback, overt/covert responses, etc.; and (f) the type of test format employed to assess student information acquisition, e.g., for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction (pp. xiiv-xiv).

Kirrane (1992) provides a summary of the research in visual learning that further supports some of these findings by Dwyer (1978). Studies cited by Crane (1992) have found that some pictures and graphics may be counterproductive for learning when they are excessively elaborate or too realistic.

However, these studies are in direct conflict with what graphic designer Tuft (1990) maintains are essential attributes resulting in effective visuals for envisioning information. For example, it is Tuft's opinion that when designers need to clarify a visual design, they should add detail. Specifically, Tuft states (in direct contradiction with Dwyer's research studies and the research cited by Kirrane):

> What about confusing clutter? Information overload? Doesn't data have to be "boiled down" and "simplified"? These common questions miss the point, for

> the quality of detail is an issue completely separate from difficulty of reading. *Clutter and confusion are failures of design, not attributes of design.* Often the less complex and less subtle the line, the more ambiguous and less interesting the reading . . . . Confusion and clutter are failures of design, not attributes of information. And so the point is to find design strategies that reveal detail and complexity-rather than to fault the data for an excess of complication. Or, worse, to fault viewers for a lack of understanding. (p. 50-53)

Although these claims by Tuft (1990) are not based on empirical research, they are supported by many critics and philosophers of art and design such as Lauer, (1979), Greenberg and Jordan, (199 1) and the seminal writings of Ducasse, (1955) and Graves, (1941). When these art and design critics evaluate visual images they do not look for and criticize designs with too much detail. These experts in the field of art and design look for the following principles of design: unity (harmony), focal point (dominance, emphasis), balance, and colour. These principles of design are achieved through the use of the following design elements (or tools) that a designer uses to express creative ideas: line, shape (form), texture, space, scale (proportion), and rhythm.

Could it be, then, that failure to use design principles are what make some visuals less effective than others in the learning process? And not, as Dwyer (1978) and others (Kirrane, 1992) claim: too much detail? According to Tuft (1990), "Showing complexity is hard work. Detail micro/macro designs are difficult to produce" (p. 50). Are the visual designs created by the researchers in these studies done without design strategies that resulted in a design failure-or what Tuft (1990) refers to as *confusion and clutter?* Was there harmony between the text and line that requires "sensitive appraisals of prolific interaction effects"? (Tuft, p. 62). In addition, even a design with too much white space can result in visual clutter: "It is not how much empty space there is, but how it is used. It is not how much information there is, but how effectively it is arranged" (Tuft, p. 50). Perhaps research on the use of visuals in the learning process needs to move toward focusing on how compositions are arranged, rather than the examination of the amount of detail, learner characteristics, and instructional environments. One empirical research study was found that investigated the placement between text and visuals. A study by Aspillaga (1991) investigated whether displaying text information overlapping onto relevant parts of a graphic enhances learning. The results showed that "learning was enhanced by the availability of the whole picture, plus the label, which was not blocking relevant aspects of the graphic" (Aspillaga, p. 91).

Visual Cognition

When trying to understand why visuals might enhance the learning process, a review of the literature on perception and memory provides insightful information. It has been claimed by Guilford (a research psychologist in the late 1940s) that there is a three-dimensional cube of intellectual abilities that can be assessed and trained (Guilford in Peterson, 1996). Guilford's factorial approach to intellectual abilities has the following components: semantic, symbolic, and figural. The semantic aspect includes word abilities, the symbolic dimension deals with the ability to construct relationships, and the main component of this schema is the figural dimension that primarily includes the visual abilities. According to Peterson, while the semantic and symbolic languages are used in learning, it is most often the figural that stimulate discovery and facilitates communication of the information in the learning process. Widely quoted statistics by Treichler (1967) that we generally remember 10% of what we read, 20% of what we hear, and 30% of what we see supports Peterson's claim.

Based on this information, we can assume that visual cognition is an important element that facilitates the learning process and helps to explain why we remember things better when visuals accompany words. Visual cognition is the process of how we perceive and remember visual information (Pinker in Rieber & Kini, 1991). As indicated, research has confirmed that we seem to be exceptionally good visual learners (Kobayashi, 1986) and that visuals may enhance the learning process (Adams and Hamm, 1989; Alesandrini, 1987; Benson, 1985; Considine and Haley, 1992; Dwyer, 1978; Duin, 1988; Soulier, 1988). There are currently two major conflicting theories about how information is stored in our memory: 1) propositions forms theory (Pylyshyn in Rieber and Kini, 1991) and 2) dual coding theory (Paivio, 1991). One of these theories provides an explanation of why we remember information better when it is presented with a visual image.

The propositions forms theory contends that information is stored in our memory based on its meaning in complete and logical statements. Specifically, Pylyshyn (in Rieber & Kini, 1991; see also Steinberg, 1991) claims that visual images are stored in memory in terms of their meanings, not as images. Specifically, according to this theory, when we process the meaning of pictures, we are converting the visual images to a series of statements in a manner somewhat analogous to how a computer converts analog data to digital format. This theory has not been widely adopted as it does not provide an explanation of why visual images enhance the learning process.

The dual coding theory, on the other hand, argues that we perceive and store words and visual images in two systems. One system is verbal and the other is perceptual (Paivio, 1967). According to Bagui, (1998), this theory contends that we process information from our environment by the use of our senses (eyes, ears, taste, smell, hearing and touch). This information is stored in our short-term memory and from here the information is processed in working memory and finally stored in long term memory. The information in our long-term memory becomes our knowledge base. When we are able to retrieve information from this knowledge base, we can assume that the information has been learned.

This theory argues that visual perceptions are not the same as verbal perception, processing, storage, and retrieval. That is, the process of selectively attending to and scanning a stimulus, interpreting important details, and perceiving meaning is perception (Levie, 1987; and Steinberg, 1991). The perceived stimulus is processed through one of two channels. One channel processes verbal information and the other processes images. According to the dual coding theory, learning is enhanced when information is processed through both channels rather than just one. This dual processing produces an additive effect because there are more cognitive paths to retrieve the information (Paivio, 1967; 199 1). The information retrieval, then, is greater due to the availability of two mental representations, rather than one. Specifically, when one memory representation is absent, the other representation remains accessible (Paivio and Caspo, 1973). Moreover, according to research cited by Reiber and Kini (1991), when the information is intensely imaginable, there is a greater likelihood of dual coding to occur.

Thus the dual coding theory provides us with an explanation of why the use of visuals enhances the learning process: "when learning from texts and pictures occurs, pictures can always be retrieved from both memory systems" (Molitor, Ballstaedt and Mandl in Mandl and Levin, 1989, p. 7). Dual coding enhances memory in terms of allowing us to absorb information from the environment using both the verbal and visual processes and helps in reducing the cognitive load in our working memory (Bagui, 1998). To test a prediction that information retrieval would be enhanced if both processing channels are tapped simultaneously, Szabo, DeMelo and Dwyer (1981) found that achievement scores were significantly higher when testing included the same visuals that were used during instruction. Research by Shih and Alessi (1996) also revealed that pictures facilitated learning on both recall and retention.

However, research in artificial intelligence shows that knowledge is stored in a unique memory system in a propositional format, irrespective of whether it was decoded as linguistic or visual information (Molitor, Ballstaedt and Mandl in Mandl and Levin, 1989). Specifically, according to studies by Baggett and Ehrenfeucht (cited in Mandl and Levin, 1989), that both verbal and visual cueing can be equally effective in recall learning, indicating that cueing is not medium dependent, as the dual coding theory proposes. This research is incongruent with the dual coding theory which means that, although the dual coding theory provides us with an explanation of why visuals enhance the learning process, it lacks strong support from empirical research.

Design Principles

Noticeably absent in the contribution to the instructional technology literature on screen design are the views and opinions by *artists and art critics*. Generally, most artists and art critics would accede that design principles (e.g., unity, focal point, balance and colour) and the elements of design-which are the tools a designer uses to express creative ideas (line, shape, form, texture, space, scale, proportion, and rhythm)-are necessary to create a good visual design (Graves, 1941). According to the seminal writings of Graves (194 1) design principles are the basics of any visual design. Readers who wish more information on basic design principles should consult Bates, 1960; Greenberg and Jordan, 199 1; Lauer, 1979; Poore, 1967; Riddell, 1984; Szabo & Kanuka, 1999; and Taylor, 1981.

Upon closer examination of the goals of the graphic designer and those of the instructional technologist, it becomes evident that both have much in common. In addition to creating visually pleasing layouts, goals of the graphic designers include (1) attracting and holding the viewer's attention, and, (2) communicating easily understood information that aims to have the viewer remember the information. To achieve these goals, most graphic designers use the principles of design. Is it possible for instructional technologists to apply these design principles to achieve similar goals? Do variations in visual design have an impact on learning as measured by objective performance outcomes?

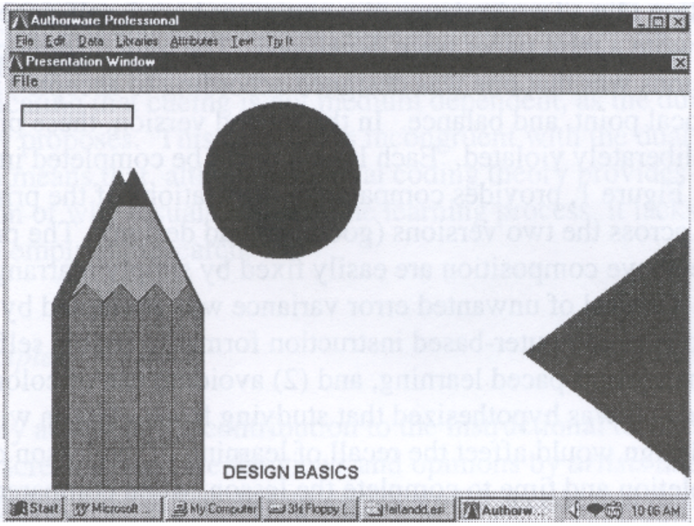
An Illustrative Research Study

In stark contract with the vast amounts of writing on visual design, there is a paucity of research that directly addresses the effects of visual design on the quantity or quality of learning or other measures of performance in the classroom. To address this gap in the research, an experimental study was conducted (Szabo & Kanuka, 1999) to test the hypotheses that visual (screen) design affects learning, study time and completion rate. Two versions of a computer-based, self-paced lesson on how to write a term paper were developed. The only difference between the versions was that one was designed according to accepted principles of unity, focal point, and balance. In the second version, these principles were deliberately violated. Each lesson could be completed in a single setting. Figure 1, provides comparative illustrations of the principle of balance across the two versions (good and bad design). The problems with the above composition are easily fixed by simply rearranging the objects. Control of unwanted error variance was attempted by (1) creating the lessons in computer-based instruction format to enable self-paced rather than group-paced learning, and (2) avoiding use of (gray scale was used). It was hypothesized that studying from a lesson with good screen design would affect the recall of learning of the lesson content, rate of completion and time to complete the lesson, when compared with a lesson using poor screen design. The findings of the study, using 87 adults revealed equivalent recall achievement test scores across the two treatments while the good design group's completion rate was higher (74% vs. 45%) and their time to complete the lesson was 21% lower than the bad design group's lesson.

Discussion

On the surface, the results of this study seem to reveal that following good screen design principles appears not to influence recall learning one way or the other. In addition, this study showed that poor use of design principles increases instructional time and reduced completion rate, or persistence. Screen design is a complex issue. Some questions that need to be discussed to attempt to understand these complex issues include: why would design principles not influence achievement? how do design principles influence time on task and completions rates? why does a pleasing design result in shorter time on task? how does poor visual design lower completion rates? what role does motivation play? There are a number of possible explanations that could be provided to explain these results.

The most probable explanation is that the participants, who were enrolled in a certificate program at a university, were already knowledgeable on the subject of the lesson (how to do a term paper). This prior knowledge likely nullified the differences in achievement scores. Upon a review of the post test scores, there is further evidence to support this explanation. The average for the good design lesson was 31 (out of a



This composition lacks balance because the pencil, circle and rectangle are placed on the left part of the screen, leaving only the triangle shape on the right. This composition also suffers from a lack of unity and an inappropriate focal point where the dark tip of the pencil leads the viewer's eye to the narrow rectangle and out of the composition.

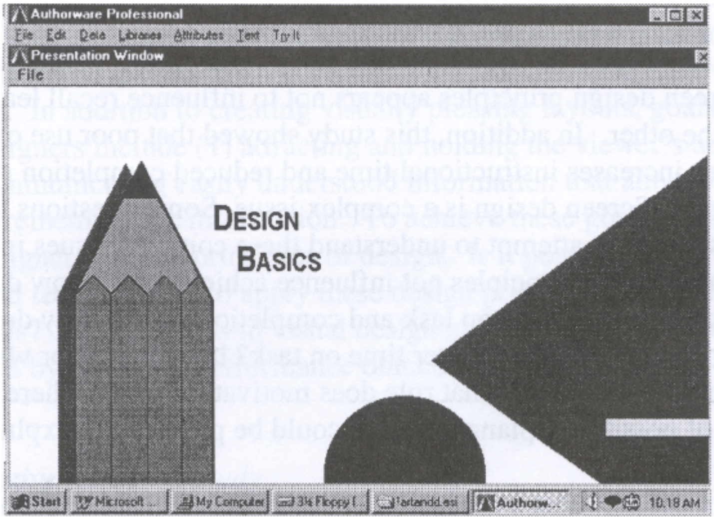


Figure 1. Example of poor versus good screen design.

possible 36) and the average for the poor design lesson was 29 (out of a possible 36). Conducting a pretest may have revealed that the sample had considerable prior knowledge on the topic; unfortunately, the absence of pre-treatment data makes it impossible to account for any initial group differences that may have been present. As a result, the researchers cannot conclude whether the differential mortality that occurred in the study on any of the dependent variables was due to a sampling error or to the treatment. As mentioned, a pretest was not conducted to avoid pretest sensitization. However, further research might shed light on this issue if a study was conducted using pre-treatment data such as general grade point averages or the results of previous writing assignments, This would give the researchers the ability to assess and account for group differences and prior knowledge without introducing pretest sensitization. In addition, further research should analyze the actual performance of writing a term paper of the participants, rather than a posttest, to determine the influence of design principles on achievement. Specifically, submission of a term paper and a description of the process followed to achieve it might be a more appropriate measure of achievement than recall learning.

Several questions also arise when reviewing the data that showed poor screen design results in increased instructional time and reduced persistence. An important question to ask here is: why would a pleasing design not result in longer time on task? Would learners not enjoy lingering in the aesthetically pleasing environment? Or does a pleasing design result in a shorter time on task because learners can move swiftly through the instruction when they are not obstructed by poor design? There are several plausible answers to these questions, Screen designs may vary in terms of complexity, which is in part of function of the learner's prior knowledge. Hegarty, Carpenter and Just (1991) concluded that learners execute more visual inspections when reading from illustrated text when the diagrams become more complex. Furthermore, coherent visuals increase the speed of detection of an object within a visual (Biederman, Glass and Stacy, 1973). If poor screen design increases the perception of complexity or incoherence, increased inspection time might be lead to longer overall study time without a concomitant gain in achievement.

Does quality affect task persistence, which is often used as an indicator of motivation to learn? Instructors are familiar with negative student reactions to spelling and typographical errors in the written materials. This may raise the question, if the writers can't get the spelling right, can the content be accurate; can the materials be of sufficient quality that they bear attention? A parallel in the airline industry is that if passengers see dirty coffee trays, they may question if the mechanics are also sloppy about maintenance and safety. If it is perceived that content or quality is suspect, the motivation to continue with the high level of effort may be diminished.

Students of science have learned to read science texts and attend to the visuals slowly and in depth. They experience a shift when reading texts from the humanities (and vice versa). One might say switching from science to humanities texts (or vice versa) interrupts a pattern which has become somewhat automatic, a topic studied by Shiffrin & Schneider (1977). This is but one example of automating our learning control processes for minimizing cognitive disruption, An example from the psychomotor world is the all too often realization that while driving a car, one suddenly realizes they have no recollection of the scenery just passed!

Suppose that students are used to well-designed instructional material in which the basic design principles have been carefully followed. Suddenly they encounter material that violates the design principles. Their automatic processing is now interrupted, not unlike the result of the driver on 'automatic pilot' who encounters traffic, a siren, or a stoplight. Could it be that good design principles promote automaticity in learning while poor design principles result in less automatic, less efficient learning?

We can also ask if an interruption to automated processing might have a measurable effect upon learning a topic that is new or unfamiliar to the learner. Presumably more than one person in the Szabo & Kanuka (1999) study has had experience in writing term papers, experience that overrode any other differences in achievement scores.

The Szabo & Kanuka study was delimited to the use of a subset of design principles; the instructional graphics served a representative function. To gain greater confidence in the findings from this study, it is necessary to replicate this study, with changes to correct for design and execution concerns. General suggestions for further research to extend our understanding include the following:

- Extending the study beyond recall achievement to include higher levels of achievement. For example, this study could be extended beyond recall achievement to include the ability to do a term paper (the quality of performance) and/or to include the time required to do a term paper. Effects on performance in writing a term paper might yield different results.
- Using an achievement instrument that reflects the design criteria used in the lessons.
- Extending the study to other learners who have limited term paper writing experience.

- Conducting the study in a controlled environment, rather than having participants complete the lessons on their own time.
- Replicating this study with a balanced number of genders in each group to determine if gender is an influencing factor.
- Conducting interviews with the participants on how they interacted with the material and how they saw the designs contributing to or inhibiting their learning experience.

One area in particular that needs to be examined further is the completion rates between participants using screen layouts with design principles and those that do not. In the Szabo & Kanuka study, 74% of the students completed the lesson using good design whereas only 45% completed the lesson using the poor design. As dropout rate in self-paced or distance education is a persistent problem, this is an area that should be explored further.

Issues Surrounding Screen Design Research

In addition to the general issues and difficulties noted above, which commonly arise in the course of research on learning, there are several unique challenges to be considered in the area of screen design. We present a sample of these for future research considerations.

Are screen design elements simply hypothetical constructs or is there in fact some basis to suggest they may have an observable effect on learning? Identification, classification and measurement in a reliable and valid way raise numerous issues. A good parallel is the hypothetical construct of intelligence and the numerous problems and issues surrounding its assessment and interpretation. Studies using different design principles and graphics with different functionality should be conducted to shed more light on this area of instruction. Attempts should be made to isolate and determine which, if any, of these design principles have a greater influence on time and completion rates.

Numbers of Screen Design Principles

Do the three principles of screen design identified in the literature and used in this study (unity, focal point and balance) comprise the complete and definitive set of principles? If there are, and without apriori theoretical guidance, the researcher may resort to simply evaluating them all, individually and in combination, The logistics become more complex if one allows the possibility of interactive effects; e.g., unity and balance may have no effects individually but in combination may influence the criteria chosen.

Theoretical Rationale

It is not clear what the various learning theories predict about how people learn with visuals; the depth and detail of our understanding are not sufficient to be prescriptive. There are myriad points of view or references which may be consulted in approaching this, such as behaviorism, information processing, constructivism, memory, perception, motivation, (visual) learning styles and length and quality of exposure, to name a few.

In the absence of a strong theoretical rationale, practical issues are often substituted. For example, as with research on color in learning, it is generally assumed that screen design has an effect, usually positive, on learning. Further research has shown these common assumptions to be questionable in the case of color and now for screen design.

Criteria

What outcomes can we expect to be sensitive to variations in screen design, and why? We have a bewildering array of cognitive and performance areas from which to choose. Furthermore, there is the issue of accurate (reliable and valid) assessment of those outcomes.

Individual Differences

Are there individual differences among learners that interact significantly with screen design elements to enhance or inhibit attainment of the criteria? For example, are visual learners or those with extensive training in graphic design more or less likely to be affected by variations in the treatment? What is the basis for predicting or hypothesizing such aptitude by treatment interactions as an exercise in designing research?

Sensitive Assessment Techniques

It can be argued that treatment effects may be lost when they are ignored in the assessment techniques. For example, Szabo et al (1981) showed that the same visuals, when incorporated into both the instruction and the assessment process resulted in greater learning than when assessment did not use the visuals. Similarly, one could argue that assessment used in research should include the variables of interest, e.g., good or poor screen design for optimal sensitivity.

Function of Screen Design

Levin, (Anglin, Towers & Levie, 1996) identified five different purposes or functionalities of instructional graphics in text learning; decoration, representation, organization, interpretation and transformation. Are the five functions of visuals identified by Levin real constructs which can be operationalized and examined for effects upon various cognitive or performance criteria of learning? Is there an interaction between these functions and screen design principles with respect to learning outcomes?

Conclusions

The research study discussed in this paper is a first attempt to show that good screen design influences learning when delivered with computer based instruction. It is the opinion of the researchers that understanding the principles of design and visual cognition are important theoretical foundations upon which the identification of appropriate design considerations would be practiced for computer based instruction. This is an important issue as more and more instructional materials are being delivered in highly visual, self-paced, individually directed study environments using computer-mediated communication and the World Wide Web. This places screen design in a paramount role to maintain interest and perseverance for the learners.

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