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AUTHOR	Bradshaw, Amy C.
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ABSTRACT

The purpose of this study was to determine the effects of presentation interference on students' ability to learn from, and their beliefs regarding, computer-generated presentations. Informed by single-element screen design studies and professional practice, this combined-element study compared a contextually based, intentionally interference free presentation against two presentations containing multiple, typical design flaws. Undergraduate students (n=118) were randomly assigned to three groups, and subjects individually viewed one of the three treatments. Following the presentation, subjects completed a post test and a belief questionnaire. Three hypotheses were tested: (1) subjects receiving presentations with no intentional presentation interference would perform better on the post test; (2) subjects receiving presentations with less interference would perform better than those receiving presentations with more interference; and (3) subjects in the interference-free presentation group would report more positive beliefs regarding computer generated presentations than would subjects receiving presentations with interference. Results indicated significantly higher posttest scores for the interference free presentation group. It was concluded that, although the well designed presentation and a presentation containing intentional interference both resulted in strong beliefs regarding the beneficial nature of computer generated presentations, treatments containing presentation interference significantly reduced learning. (Contains 65 references.) (Author/DLS)

Measuring the Learning Cost of Presentation Interference

Amy C. Bradshaw
Arizona State University

Abstract

The purpose of this study was to determine the effects of presentation interference on students' ability to learn from, and their beliefs regarding, computer-generated presentations. Informed by single-element screen design studies and professional practice, this combined-element study compared a contextually based, intentionally interference free presentation against two presentations containing multiple, typical design flaws. One hundred and eighteen undergraduate students were randomly assigned to three groups and subjects individually viewed one of the three treatments. Following the presentation, subjects completed a posttest and a belief questionnaire.

Three hypotheses were tested: subjects receiving presentations with no intentional presentation interference would perform better on the posttest; subjects receiving presentations with less interference would perform better than those receiving presentations with more interference; and subjects in the interference-free presentation group would report more positive beliefs regarding computer generated presentations than would subjects receiving presentations with interference.

Results indicated significantly higher posttest scores for the interference free presentation group than for either of the two groups receiving presentations containing interference. Results also suggest that increasing intentional interference does not always lead to increased learning cost. In some contexts, elements that can be reasonably expected to hinder learning may have positive or neutral effects. Subjects in all three groups agreed that computer generated presentations are generally beneficial, however responses from the group with no interference and the group with four intentionally introduced types of interference were both significantly higher than responses from the group with two intentionally introduced types of interference. Although the well designed presentation and a presentation containing intentional interference both resulted in strong beliefs regarding the beneficial nature of computer generated presentations, treatments containing presentation interference significantly reduced learning.

Introduction

The advances in presentation media have been so exciting that many people have focused on the media and have forgotten to examine critically the purpose, the content, and the overall visual appearance of products. Particularly in cases where there is no instructor to clarify meanings and relationships, it is vital that the message(s) of a presentation be easily accessible. Poorly designed screens have the potential to turn learners' attention away from the message and onto the delivery system itself. Although many design guidelines have been produced, the limitations of most standards are that (a) assertions are not fully supported by research , (b) context is ignored, and (c) prescriptive guidelines are not conducive to formative and summative evaluation processes. Research is needed that combines design elements in realistic ways to determine factors or combinations of factors that hinder learning while acknowledging the context-driven nature of successful design decisions. Further, developers need a method of evaluation and feedback that can be used to improve existing presentations.

Purpose of the Study

A review of screen design research shows that most studies focus on the effects of a single element (as opposed to multiple element) change on subjects' ability to learn from presented material. Although studies indicate that single element changes can affect learning, most existing research does not address the difference between what was learned from a realistic presentation and what could have been learned from a rigorously critiqued and revised presentation.

The present study used a different approach. First, an "error free" visual arrangement for a specific content area was developed. This was accomplished by adapting screen design prescriptives from research and professional practice to a specific presentation topic. Individual screen elements (e.g., color, text, etc.) were handled according to established guidelines from professional practice and single element research, insofar as results from such prescriptives were appropriate to the context. Next, the presentation was critiqued by three professional presentation developers, revised, and approved as "error free," that is, no distracting flaws were detected. Finally, the study

compared the error free version against two additional presentations to which presentation interference had been intentionally added.

Researchers (e.g., Seels, 1994) have called for more specific, operationally defined constructs that can be used in multiple element research. The term "presentation interference" is used in this study to refer to distracting flaws in presentations that may result from poorly combined, or inappropriate uses of, individual screen design elements. Identifying and labeling presentation interference is one step toward the development of both better screens and a contextual approach to multiple element screen design research. The purpose of this study was to determine the negative effects of presentation interference and to lay the groundwork for future research. In addition, the results of this study will contribute to research-based guidelines and a presentation evaluation method that can be used during and after presentation development to help designers identify and eliminate interference.

Justification

Existing research-based prescriptions tend not to go beyond studies of single elements (e.g., text size). Screen design researchers have avoided examining the effects of more than a single element for two primary reasons: (a) when individual elements are combined, effects cannot be clearly attributed to one factor or another; and (b) because effective screen design is not context neutral, screen design from an effective presentation cannot automatically be imposed on another topic. However, these typical generalization methods, albeit ostensibly tidy, are not very realistic. Actual presentations contain more one element and generally more than one type of presentation design flaw (referred to here as presentation interference). Further, the combination of elements may produce an effect greater than the sum of effects from elements examined individually (Mukherjee & Edmonds, 1994). Existing single-element studies have tried to attribute learning gains to a specific manipulation of an element being studied (e.g., 18 point bold text versus 14 point plain text), often with recommendations that the element be handled by other developers in exactly the same way as produced the better result in the particular study. Some studies are misleading because even the treatments with the best results were not designed according to professional layout standards. Further, most guidelines encourage novice designers to follow positive statements (e.g., "use complimentary fonts"). Such statements create problems because designers may think they have followed the directions, yet still produce poor designs. With typical prescriptive guidelines, designers have no external source of feedback or evaluation.

The present study has taken the reverse approach to the problem. Rather than comparing two "realistic practice" treatments and prescribing the one that produces the higher gain, the present study measured the results from an interference-free presentation design against results from versions representing "realistic practice." The difference between what was learned from flawed versions and what could have been learned from the error free version is referred to in this study as "learning cost." By identifying and measuring the lost opportunity for learning that results from screen design flaws, evaluation guidelines can be produced that help presentation developers identify and eliminate errors in presentations that may distract learners from the messages. Such guides (e.g., Bradshaw 1997b)would fit naturally into formative and summative evaluation processes.

Relevant Issues

Visual Literacy

Any research on screen design must be informed by the field of visual literacy. Conversely, findings from screen design should add to and support this relatively young field. After only 25 years of research and exploration, the field of visual literacy and its constructs and vocabulary are not yet fully explored. Dwyer (1972) developed a program of research to identify, classify, and measure "essential stimuli characteristics" of media. Braden and Hortin (1982, cited in Hortin, 1994) attempted to categorize and define the subsets of visual literacy. Baca (1990, cited in Braden, 1994) surveyed 52 visual literacy experts in an attempt to identify constructs of visual literacy. From this study, Baca provided one of the simplest and most recent definitions of visual literacy to refer to the use of visuals for six purposes: communication, thinking, learning, constructing meaning, creative expression, and aesthetic enjoyment (p. 3). The first four of these purposes are immediately relevant to screen design and to the educational purposes for which screen design is employed. Baca's definition reflects the pervasive nature of visuals, both in and beyond education.

Braden and Baca (1991) presented a conceptual map of the visual constructs identified in Baca's survey. In a graphic representation, the six elements of Baca's definition radiate from "purpose." Each of the six elements can then be further elaborated in separate diagrams. For example, "visual literacy" used to describe visuals for the purpose of learning, can be expanded in a separate diagram. The secondary diagram can illustrate the goals of

learning including, among other goals, developing the ability to create visuals and the ability to acquire information from visuals (p. 158). Both of these particular goals have strong links to another of the six basic purposes of Baca's definition, aesthetic enjoyment.

Aesthetics serve a greater purpose than simple enjoyment. Aesthetic principles applied to screen design may make learning more accessible by structuring and organizing information. Visual literacy not only allows both students and teachers the ability to understand visual information, but also the ability to develop and present information that is more accessible to other viewers. Fredette (1993) stated, "Aesthetic ways of knowing must become part of the basic education of all students" (p. 66). Visual literacy is vital in a time when most teachers have access to, and encouragement to use, programs such as *PowerPoint* to aid in the presentation of information. Art and aesthetics may be as important to educating and learning as are reading, writing and arithmetic. Several researchers (e.g., Bertoline, Burton, & Wiley, 1992) have recommended that visual literacy be incorporated into curricula or specific courses, including mainstream communication courses. For at least two decades, educators such as Broudy (1977), who asked, "Is 'Rt [art] the 4th R?" have called for a more central role of visual literacy in education.

Although neither visual literacy broadly nor screen design specifically have an overt, widespread presence in education, screen design and presentation issues may well be covertly operating and affecting learners' abilities to understand and learn from material presented in classrooms. In all subject areas, educators are feeling pressure from administration and peers to include technology in their classrooms. Electronic presentations offer one of the most visible and accessible ways to meet this demand. Instructor-controlled, computer-based presentations are an intermediary step between the traditional lecture and more broad incorporation of technology, such as using computers as the main delivery method for instruction, tutoring, and practice. If the visual arrangement of information on computer screens affects learning, aesthetics must be acknowledged and incorporated into screen design.

Identifying Appropriate Vocabulary

Can poorly-designed presentation screens produce negative learning effects? If so, what are those effects on learners' comprehension and retention of message content? In asking the question, it becomes clear that one of the factors that may be hindering the movement into research on the overall effects of the combined elements of screen design is vocabulary. How does one refer to the negative phenomena resulting from poorly combined individual elements of screen design? The terms studyability, comprehensibility, noise, and interference are discussed below.

<u>Studyability</u>

The term *studyability* was introduced by Grabinger (1993) to describe "the ease with which a user can examine and learn from a screen of information" (p. 37). The term has not been widely adopted by other researchers and is somewhat limited in that a concentration of effort on the part of the learner is implied that is not always present.

<u>Comprehensibility</u>

The term *comprehensibility* has been used to describe the overall effectiveness of a screen to transmit information to viewers (Grabinger, 1989; Pettersson, 1994). The term measures the positive effects of the arrangement of screen elements. A high degree of comprehensibility would mean that the message of a particular screen is easy to access.

<u>Noise</u>

The term *noise* is sometimes used to describe visual phenomena that interfere with delivery of a message. In their review of the literature, Mukherjee and Edmonds noted that "one does not have to look far to find computer interfaces and screens that generate 'noise' and hinder instruction and the communication of messages" (1994, p. 112). Shannon and Weaver used this term in their model of communication to describe phenomena that alter messages so that what is received is different from what was sent. For lack of a widely accepted term, *noise* is useful but can become less so when applied to audiovisual or multimedia applications because discussion of metaphorical noise can be confused with literal audio noise.

Interference

The word *interference* is significant in several fields. In cognitive science, the term refers to prior knowledge that interferes with the acquisition of new knowledge. Cognitive science studies show that interference turns attention away from the message. The term is also used in communication. In broadcasting, for example, it is used to refer to the noise resulting from poor signal transmission that interferes with clear reception. Whereas *noise* implies a change in the message, *interference* suggests the possibility that the message may not even be received. Interference is not without precedent in visual communication. Bertoline, Burton, and Wiley (1992) state,

> Interference is the undesired outside influence that tends to prevent the completion of effective communication. It can occur at any level or stage in the process. The goal of any communication is to eliminate or minimize the influence of interference and thus maximize effective communication. (p. 252)

Pettersson (1993) uses the term in discussing the need to avoid unnecessary elements in visual design: "Too many details and too much complexity give rise to distracting 'interference' and reduce the interest for the content and the impact of the important part of the content of the visual" (p. 227).

Interference is a particularly useful term that is not limited exclusively to one medium. The term works equally well in describing print-based or computer-mediated instruction, two areas often seen as unable to apply identical solutions. *Interference* can be applied easily to projected presentations or multimedia applications to describe any element of the program, visual or audio, that hinders message reception. Where *comprehensibility* can be used to describe the overall positive effect of visual arrangement, *interference* describes the individual or combined elements that negatively affect visual or audiovisual designs.

Several types of flaws (i.e., inappropriate color choice, unreadable text, design flaws in charts and graphs, etc.), or combinations of flaws, contribute to poor overall design. These types of design errors, referred to here as *presentation interference*, have a potentially negative effect on learning from visually supported presentations, for two primary reasons. First, screens that are well designed provide for easier cognitive organization (e.g., Hannafin & Peck, 1988); the learning process itself is easier. Second, gaining and maintaining learner attention is a vital component of instruction (e.g., Fleming & Levie, 1978). When learners form negative attitudes toward presentations or attention is misdirected toward irrelevant components, learners may become less engaged in the learning.

Presentation interference includes any delivery- or presentation-related factor that distracts the learner from the message content (Bradshaw, 1996a). Inappropriate uses of specific elements can lead to presentation interference, some examples of which include

- meaningless or inconsistent sound effects or screen transitions
- inappropriate colors (e.g., color coding, fit to subject, fit with other colors)
- inappropriate typography choices (e.g., size, font, style)
- inappropriate graphic choices (e.g., size, style, format)
- inappropriate placement of elements
- inappropriate or inconsistent alignment of elements

The term "presentation interference" is also applicable to portability-related distractions. Elements such as color or graphical characters that are appropriate for one cultural audience, for example, may be extremely distracting for another (Bradshaw, 1996b). Necessarily, presentation interference is context driven. A more thorough guide to suggested categories of presentation interference, including examples and a rubric for use in screen design critiques has been developed and used by the author (Bradshaw, 1997b).

Poorly Designed Visuals

Some educational researchers view the lack of visual or instructional training as just two more problems in a long list of unprofessional uses of instructional tools that will have little effect on the legitimate work of those trained in educational technology (e.g., G. Morrison, personal communication, February 13, 1995). Others, particularly those with interests in visual literacy, are concerned that the "slick feel" of modern media lulls users (both teachers and developers) into accepting many presentations and software programs as instructionally "valid" and "good," regardless of their actual educational worth. When computer presentations are delivered via projection systems, such as LCD (liquid crystal display) projectors and panels, the problem is exacerbated. This investigator's experience has been that the use of this equipment may exaggerate the effectiveness the presentation in the mind of the presenter without necessarily improving learning.

Much remains to be explored regarding the learning costs of poorly designed visuals in instruction. If visual design *can* affect learning, instructional designers must consider both the delivery method and appearance of instruction in addition to the content and strategy. Haag and Snetsigner (1994) agree that, "as form and function go hand in hand so, too, must instructional design and aesthetic design. They are inextricably connected" (p. 94).

Hardin (1994) has suggested the problem of poorly designed visuals could be solved if teachers would simply practice developing materials. Regarding the production of charts and diagrams, Hardin said, "we should encourage non-designers to produce frequently on the theory that practice will increase skill" (p. 24). But practice does little good without credible, empirically based guidelines. Practicing visual design with neither attention to visual design principles nor expert feedback is just as likely to reinforce bad habits and poor techniques as it is to develop expertise. The argument is somewhat moot, since few teachers have the luxury of spending time practicing designs that they have no intention of actually using.

Screen Design

In their review of the literature on screen design, Mukherjee and Edmonds (1994, p. 115) noted that the general functions of screen design are to

- focus learners' attention
- develop and maintain learners' interest
- promote deep processing
- promote engagement between learners and lesson content
- help learners find and organize information

Instructional design journal articles, chapters, and books focus on the above screen design functions and occasionally focus on the role of specific screen design elements in achieving these goals. Hannafin and Peck (1988), for example, link screen design to purpose and screen type: transitional, instructional, and question. In many instructional design books (e.g., Criswell, 1989), specific purpose screens (e.g., title, menu, instruction, practice, feedback) are emphasized more than the particular visual design elements within these screens. Emphasis is given in general terms, such as to the need for standard screen components (e.g., navigation controls), functional areas, (i.e., where titles should appear and what portion of the screen should be reserved for graphics), and types of visuals (e.g., charts, graphs, etc.). Guides of the type described are not generally accessed by most "nonprofessional" screen developers and are intended for "front-end" use. However, presentation media developers, many of whom are teachers who develop their own materials by necessity, also need a system that can be used in a follow-up evaluation process, one that is specific enough to catch design flaws while being flexible enough to accommodate specific contexts.

Lack of Research-based Guidelines

Although much screen design literature provides strategies for screen design, Mukherjee and Edmonds (1994) found that most design strategies are not supported by research evidence or experience (p. 113). Some design texts are supported in small part by research, yet even in these cases there are often unattributed statements such as "black and yellow are the most readable combination." While statements such as these may well be backed by research, citations are not provided. There is a conspicuous lack of research to support the intuitive sense that instruction that *looks good* should make learning easier. Even within the research community, not all of the overall guidelines (that address more than a single element) are entirely based on research and, where guidelines are research based, specific guidelines are not always linked to specific studies (e.g., Fleming & Levie, 1978). Examples of non-research-based or partially research-based prescriptive guidelines include those by Keyes (1993), Lenze (1992), Pettersson (1993), and Milheim and Lavix (1992). Kosslyn's (1989) thorough article "Understanding Charts and Graphs," which points out design flaws and provides cognitive rationales for design choices, is an excellent guide for the development of charts and graphs but does not provide research evidence to support prescribed design choices. Misanchuk (cited in Grabinger, 1993) states that while aesthetic guidelines exist to help designers create attractive displays "aside from Hartley's (1978) work, there are few, if any, empirically based guidelines to help instructional designers combine text elements in ways that facilitate learning" (p. 35).

Practical Guidelines

Achieving screen design goals using specific visual design elements has been the focus of several textbooks, such as Rabb's (1990) Presentation Design Book, although most visual design texts have been written

primarily for print media (Hartley, 1978). Typical examples of guides to visual design include desktop publishing and basic design books, such as Text, Typography and Layout for Desktop Publishing (Silver & Silver, 1991). Desktop publishing software producers often develop their own layout and design guides. Aldus published a basic design book (Kerlow, 1991) that included tutorials for *PageMaker 4.0*. A wide variety of magazine and journal articles have also been written to aid the growing population of novice software producers, such as Olson and Wilson's (1985) simple checklist for designing computer screen displays and, more recently, guides such as those by McFarland (1995), Wilhelm (1996), and Strasser (1996), and guidelines available via the internet (e.g., Radel, 1995)

As electronic media become more accessible, more prescriptive articles appear in a wider variety of journals and magazines. The majority of these works rely on common practice and "common sense," as opposed to findings from research. One of the problems with approaching the concept of "good screen design" is that there is no possibility of an ultimate solution. "Good design" is not context neutral – specific arrangements that work well for one content area and audience do not automatically work well for all other content areas and audiences. Still, this has not stopped the production of prescriptive guidelines calling for specific text sizes and color combinations that should be used in any case.

General Screen Design Prescriptives

Categorizing specific screen design elements and then manipulating elements within each category has been referred to by Mayer (1984) as a "behavioral" approach. This has been one of the most common ways to approach an initial understanding of screen design and is the method used in most existing screen design research. Although a useful place to start, the method is limited because general prescriptives are not equally relevant to all settings. Much of the existing prescriptives focus on the following elements: text, graphics, color, line, animation, and consistency. The prescriptives that follow, although not exhaustive, are typical of those found in the literature. They are based on professional practice, general heuristic, and research.

Text

Several researchers (e.g., Hathaway 1984; Mourant, Lakshmanan , & Chantadisai, 1981) report that large amounts of text cause eye fatigue. Researchers (Hartley, 1987; Hathaway, 1984; Morrison, Ross, & Dell, 1988, cited in Knupfer, 1994) also report that large amounts of text are more likely to be forgotten. Soulier (1988) suggests that when a great deal of text is called for, it is better to print the text out.

Text displayed in all capital letters is difficult to read (Pettersson, 1993), therefore, in most cases, text should contain a mixture of upper and lower case characters. Ross and Morrison (1988) also suggest using low-density text, reducing ideas to one idea, and using outline format. In many cases, minimal drop shadows can make text more legible.

Regarding the use of serif or san serif fonts, suggestions from the literature are mixed. It is generally accepted that what readers are used to reading or personally prefer will be easier for them to read (Dreyfus, 1985). Some researchers suggest that small serifs should be used for printed material and sans serifs be used for computer and projected material (because thin serifs do not generally project well).

Gibson and Mayta (1992, cited in Knupfer, 1994) suggest that for computer-displayed text, text size should not be smaller than 26 points. This prescriptive creates a problem, however, because not all 26-point fonts are visually the same size. For computer-displayed text, Gibson and Mayta also suggest using bold text throughout, or at least for headings and key words. Again, this must depend on the specific typeface used because some fonts are already "heavy" and bolding may actually make them less readable.

Graphics

Soulier (1988) describes graphics as visual metaphors. Graphics aid in motivation and maintaining attention by adding variety, thereby making the screen more interesting (Kemp & Dayton, 1985). Aspillaga's (1991) research suggests that placing graphics close to corresponding text results in significantly higher achievement than placing them elsewhere on the same screen. In cases where information must be split to two screens, Soulier (1988) suggests placing the graphics after the text. This contradicts Pettersson's (1993) suggestion that developers achieve priming by placing graphics before related text.

Researchers (e.g., Pettersson, 1993; Fleming & Levie, 1978; and Soulier, 1988) report that simple line drawings are generally more effective than complex drawings or photographs because they contain only relevant information; less information requires less time to interpret.

Color

In general, the most highly preferred surface colors for adults are blue, red, and green (Pettersson, 1993). Generally ranked lowest are violet, orange, and yellow (Fleming & Levie, 1978). The most visible colors are white, yellow, and green (Pettersson, 1993). The least visible, assuming equal intensity, are red and blue (Fleming & Levie, 1978). Researchers (e.g., Pettersson, 1993; Fleming & Levie, 1978) agree that the most readable color combination is black and yellow. A good general guideline is to start with a fairly light or fairly dark background color that is appropriate to the content, and then choose an opposite (fairly dark or fairly light) color for text (Bradshaw, 1997a). This general strategy allows for color combinations that are appropriate to the specific topic and allows for more creativity while still ensuring readability. Rather than focusing on specific colors as always best, developers should work to ensure contrast between background and text.

Dwyer (e.g., 1972, 1978) has conducted many studies on color and reports that color coding and cueing increase learning. Hannafin and Peck (1988) suggest bright colors, such as red, for cueing viewers to new information; however, developers should focus more on "bright color" in this statement than on "such as red," because red is one of the most difficult colors to see (Fleming & Levie, 1978; Pettersson, 1993). "Bright color" could also include yellow, one of the most visible colors. Again, context must be considered. A light, bright color used for highlighting would not be successful on a light background for instance.

Line

Lines carry information by way of location of point of origin, curvature, direction, length, point of change, or terminus (Fleming & Levie, 1978). Straight lines are very quickly perceived, compared to less regular and predictable lines (Fleming & Levie, 1978). Horizontal and vertical lines are perceptually "special." They are more intense (i.e., they evoke more activity in the visual cortex of the brain), are more easily compared, and are more accurately judged for spatial orientation (Fleming & Levie, 1978).

Animation

Soulier (1988) recommends using animation only when appropriate and keeping it short. In a study of the effects of visual grouping strategies with animated and static graphic presentations, Reiber (1991) found that "animation was a significant aid to learning as compared to static graphics, but only when presented as part of a series of verbal and visual chunks" (p. 12). The literature does not provide evidence that animation for its own sake increases learning. By extension of the simplicity principle that applies to graphics, simple animations are often more effective than video, although they do not have the same emotive potential as video.

Consistency

Thurling, Hanneman, and Haake (1995) discuss issues relating to consistency and use the term "cognitive overhead" to describe the process and effort required to make sense of each new screen when elements are not arranged and placed consistently throughout a program. They suggest cognitive overhead can be reduced and attention to the message increased through careful attention to consistency within all categories of screen design. Consistency of navigation and help procedures, as well as consistent location of certain classes of elements (e.g., diagrams or text blocks) is recognized to simplify the learning task (Hannafin & Peck, 1988).

Pertinent Studies

Research on the visual elements of screen design is generally divided into single-element or multiple-element studies.

Single-element Studies

The vast majority of research in the area of screen design has focused on the effects of *individual* design factors (e.g., text size). Many of the single-element studies include examples of presentation interference, although the researchers viewed their studies in terms of positive results from specific prescribed practices rather than in terms of negative effects resulting from interference. Dwyer (e.g., 1978) has extensively studied visualization and the effects of color, color coding, and realism. Several of his studies have centered on the relative effectiveness of different types of illustrations in facilitating learning. For example, in one study subject groups were shown different presentations that included the same instructional content but with different visual representations of a heart. Visuals ranged from simple black and white line drawings to realistic color photographs. Dwyer provides samples of the heart visuals used (1978, p. 56). These visuals provide an example of how interference may be unintentionally

included in visual research. One of the visuals used was a color photograph of a heart, which was very clear and realistic. Another visual, a lower-quality black and white photograph of the same heart, is not realistic or even recognizable, yet the two were used to compare the differences in learning from color or black and white visuals. This example is less a comparison between color and black and white than it is an example of a poor visual interfering with delivery of a visual message. Despite the visual bias of this particular study and others like it, research on the actual benefits of color to learning remains inconclusive (Dwyer, 1978, pp. 147-150).

Knupfer and McIsaac (1990, 1991) tested retention of subject matter when text was interrupted with a graphic and varying degrees of white space. A central question of the initial study was "at what point does the amount of white space surrounding a graphic enhance or inhibit reading of the text?" The authors point out that because materials used in the studies were not professionally produced, the arrangement of text and graphics could be assumed to reflect common practice. This is quite credible and, in fact, the layout used was not unlike many arrangements found by this investigator. Specifically, a graphic was inserted within a single column of text, which made reading more challenging because the reader had to search for the next word following a break in text. As the studies showed, the more white space surrounding the graphic, the lower the gain between pretest and posttest on the material read. White space used in this way interferes with the message content (one way to remedy this type of interference is to break the single wrap-around column into two, with the text from each column wrapping around only one side of the graphic). These studies are quite useful because they illustrate how white space, generally thought of as desirable, can easily contribute to interference.

Knupfer and McIsaac (1992) conducted a similar study to examine the effects of graphics with varying degrees of shading superimposed on a text field. Subjects, divided into four groups, read displayed text and were then tested on the material they read. Subjects reading text with no graphic scored higher than those reading text with an overlaid line drawing. A third group, who read text with an overlaid graphic with 10% gray shading, scored even lower. Although the performance of these first three groups suggests support for the belief that interference negatively affects learning, a fourth group, who read text with an overlaid graphic with 40% shading, scored higher than the group presented with only 10% shading. It may be that where certain types of interference are very high and where certain motivations (e.g., immediate testing or grades) exist, subjects exert greater effort to perceive the message.

Studies of individual screen elements are important and necessary because they provide a starting point for research into screen design as a whole. Understanding the effects of individual elements enables a designer to combine them in ways that are *theoretically* effective. However, the benefit of these studies is limited because in actual practice, usually more than a single element of the overall design is flawed. Examining only one factor at a time does not represent what Grabinger (1989) refers to as the visual "gestalt." The problem is stated well by Mukherjee and Edmonds (1994): "even when it is known which elements have been combined, the overall effect of the combination is not equal to the sum of the effects of each individual element" (p. 115). Neuman (1991) further comments on a fundamental limitation of single-element research.

> Reality . . . is indivisible as well as multiple. Residing wholly in an individual's mind, reality cannot be fragmented into variables to be studied in isolation. Separating any part from the whole invariably alters both the part and the whole; studying only discrete parts therefore distorts the reality we seek to understand. (p. 41)

Necessarily, screen design works synergistically for each viewer.

<u>Multiple-element Studies</u>

Multiple-element screen design studies are almost nonexistent. This type of research is difficult because when individual elements are combined, effects cannot be clearly attributed to one factor or another. Grabinger (1989) found that

> Despite research into individual screen design factors, there is a dearth of research into effects of combinations of these factors. Multiple-element research tends to be more complex than single-element research. Examination of single text elements usually stops with that element and its effects on narrowly defined tasks. (p. 178)

Grabinger (1993) attempted to move beyond single-element studies by presenting many arrangements and asking viewers to select the ones they found most readable. The visuals used in the study consisted of rectangles to represent the location of graphics and "X"s to represent text. This study was neither generalizable nor realistic because the visuals had no context. "Effective" screen design is not context neutral – a screen design from an "effective" presentation cannot automatically be imposed on another topic. Results from studies by Morrison, et al (1989, cited in Morrison et al, 1991, p. 189) suggest that subjects "may apply different perspectives when evaluating screens with realistic content because of the need to process the information so that it can be recalled or applied at a later time."

An earlier study on the effects of multiple elements of screen design was conducted by Grabinger and Albers (1988, cited in Grabinger 1989) in which fourth graders were presented with CAI programs with two different screen designs. One used plain text and the other incorporated indentation, highlighting, command bars, and boxes to make the screens appear more organized and structured. The researchers found no difference in recall or retention between the two groups, but they did note a difference in the average time spent on each screen.

Time is a vital element in learning. It make sense that learning from complex or unorganized screens requires greater amounts of time. In user-controlled CAI, students are able to accommodate for different presentation styles by spending more time reading or reviewing screens that are difficult to comprehend. This extra time is not available in content-centered instruction, such as in teacher-controlled or prerecorded presentations to groups of learners. In these cases, students do not have the extra time to make up for lack of clarity, nor can they return to specific screens for review. It follows, then, that where the purpose of a study is to measure the negative effects of various screen designs on learning and retention, time must be controlled. This condition would also reflect much of the actual practice of classroom presentations. If learners do not have control over time, will they learn and retain even less of the instructional content from poor or even average screen designs than they would from interference-free screens?

Recommendations From the Literature

A clear need for comprehensive studies exists. Researchers are beginning to call for more research on the effects of combinations of individual elements. Grabinger (1989), suggests the need for researching recommendations about the best ways to combine several elements (p. 178). Haag and Snetsigner (1994) believe

> Implementing artistic principles to improve the aesthetic appeal of screens may offer a more holistic and comprehensive method of testing the impact of screen design on learners. This approach may prove a better method of investigation in this area than prior studies examining individual variables (p. 96).

Dwyer (1994) predicted that, at the college level, future research will be multifocused and will continue to explore the instructional effect of intervening variables (used singly and in combination). Research will be more comprehensive. Dwyer hopes prescriptive guidelines will be produced to help identify generic conditions necessary to maximize learning. He also suggests that different types of visuals and different types of cueing need to be comprehensively explored.

Grabinger (1993), Mukherjee and Edmonds (1994), and Haag and Snetsigner (1994) believe screen design research should move beyond single element studies. All have called for research recommendations regarding combining several elements and believe the time has come for multiple-element studies. Seels (1994) believes that, for research in visual literacy to proceed, the constructs of visual thinking, learning, and communication need to be associated with more specific operationally defined constructs.

Realistically, actual presentations will contain more than one type of flaw. Therefore, finding creative approaches toward accomplishing multiple-element research is worth the effort. The benefits of well-designed screens and the costs of poorly designed screens can only be fully understood through research that combines design elements in realistic ways. Realistic practice, including multiple design elements, should be measured against a contextually "ideal" arrangement of elements as hypothesized by combining findings from individual element studies and from professional practice. Studies on individual elements have been and continue to be important. Without them, we would not now be ready to embark on the next stage of research on screen design. With the knowledge gained from past research, we can attempt to develop interference-free screens and hypothesize about the effects of combined, flawed elements. A review of the literature suggests that research into the area of screen design should

- acknowledge the "visual gestalt"

- acknowledge the importance of context
- measure the effects of combined screen elements on learning
- have a way of determining whether some combinations of elements are more (or less) effective in aiding learning than others
- be based on treatments of visual elements previous research and practice have suggested are most effective
- lead to research-based prescriptive guidelines
- lead to operationally defined constructs that invite further research

Method

The present study incorporates the above recommendations. In addition, this study (a) includes materials designed according to professional standards that have been critiqued by experts, (b) measures subjects' beliefs regarding the content and method of delivery, and (c) contributes to a process of context-based screen design feedback to be used during and after presentation development.

Research Hypotheses

Three hypotheses were investigated during this study:
Hypothesis 1: A presentation that is intentionally presentation interference free will result in higher posttest scores than will presentations with interference. *Hypothesis 2:* As the amount of presentation interference in a presentation increases, corresponding posttest scores will decrease. *Hypothesis 3:* Subjects viewing the interference free presentation will report more positive beliefs regarding (a) the presentation, (b) computer generated presentations in general, and (c) instructors who use computer generated presentations, than will those viewing presentations containing presentation interference.

Subjects

Subjects were 118 students enrolled in undergraduate Computers in Education courses at a large Southwestern university during the fall 1996 semester. Of these, 74 (63%) are female, (86%) were within the age range of 17-29; 9 subjects were aged 30 - 39; 5 subjects were aged 40 - 49; and 2 subjects were over 50 years old. Ninety eight of the subjects (80%) were enrolled in one of three sections of Computer Literacy, an undergraduate course with some emphasis on computers in education. Twenty five subjects were enrolled in one of four sections of Computer Applications, a recommended course for students in the College of Education. Although not required of all students, both classes meet a university numeracy requirement, so they are viewed by many students as required. Subjects received extra credit from their instructors for participating in the study and were randomly assigned to one of three groups.

Treatments and Instruments

A computer generated presentation, such as an instructor could create and present using *PowerPoint* to support a speaker's presentation, was developed via *Authorware* to teach learners the various types of skin cancer and how to prevent them. The presentation included recorded narration, was designed according to known research findings and prescriptive guidelines, and was 12 minutes in length. The "control" version was free of intentional interference and passed a screen design critique by three professional presentation designers employed at a major electronic technology corporation in the Southwest.

In the second version of the presentation, two elements were intentionally manipulated in order to produce presentation interference. Treatment 2 began with the control version, with two changes: (a) background color (changed from medium blue to pink); and (b) font (changed from a basic san serif font to "Copacabana," a more ornate, display font).

In the third version, four changes were made. Treatment 3 began with the control version, to which the following changes were made: (a) background color (same as version 2), (b) font (same as version 2), (c) the addition of transition sounds, and (d) slightly off-center but consistent text and bullet placement. Although the point size for text remained constant for all three treatments, the x-height of the font used in Treatments 2 and 3 is smaller than the x-height of the font used in Treatment 1. The result is text that is technically the same size but that appears to be smaller. Thus, the net result is three types of interference present in Treatment 2 and five types of presentation interference in Treatment 3.

All the presentations were presented via Power Macintoshes with 17-inch monitors and were programmed to control the amount of time spent viewing each screen. The timing for the three presentations was identical except for the additional time required in version three by the length of the sound effects used. (The sound effects ranged in length from one to two seconds.)

A two-part instrument was used to collect data. The first part was a 25-item "short answer" and "fill in the blank" achievement test regarding the information presented. The second portion was a series of 12 seven-point, bipolar probability items. Questions 1 through 5 of the belief questionnaire referred to students' beliefs regarding the credibility and pacing of the program and how much they learned from it. Questions 7 through 9 referred to subjects' beliefs regarding computer generated presentations and the instructors who use them. Question 10 referred to the subjects' own experiences with screen design and multimedia, and questions 6, 11, and 12 referred to subjects' beliefs about their behavior before and after viewing the presentation.

Content validity was assured in the following manner: Content for both tests and instruments was based on information and photographs distributed by the American Cancer Society and the Mayo Clinic. Posttest items are parallel to the presentation. Both test and treatments were developed by a university-level presentation design instructor. Upon completion, the presentation was evaluated by three professional presentation developers in a blind critique. Both the test and the presentation were evaluated for content by the researcher, two software development teachers, and one corporate trainer.

Most internal consistency measures require multiple administrations of a test or multiple forms of the same test. A split half internal consistency procedure, which can be calculated after a single administration of a single form, was used for this study. Using the split half procedure, the reliability coefficient for the posttest was 0.82.

Procedures

Three versions of a prerecorded instructional presentation were delivered via *Authorware*. The lesson centered on the topic of skin cancer prevention. The presentation was prerecorded in order to control the amount of time spent on each screen. The control version was free of intentional interference and the treatment versions contained typical, limited combinations of interference. Data were collected during a two-week period. Subjects chose their own participation times from a variety of times offered and were randomly assigned to one of three presentation treatments. Treatments were presented via Power Macintoshes with 17-inch monitors. Subjects viewed the presentations individually, wearing headphones, under the same physical conditions, in the same laboratory, with the same lighting conditions, and received extra credit for participating in the study. The duration of the presentation was 12 minutes. All subjects completed the questionnaires immediately following the presentation and were allowed as much time to complete the posttest and questionnaire as they desired. Completing the questionnaire required between 10 and 20 minutes. All posttests were scored by the same grader and rechecked for accuracy by another instructor. The number of points correctly answered on the posttest was converted to a proportion of the items possible.

Design

In order to determine the effect of presentation interference, an experimental posttest only control group design was used (Figure 4). The posttest only control group design with random group assignment controls for all sources of internal invalidity except for mortality (Gay, 1992). Mortality was not a serious threat to this study because of the short data collection period. Variables such as age, computer anxiety, grade point average, etc., were controlled for by random assignment to treatment groups. An interference free presentation was used as the control treatment with results being compared to those of two additional treatments containing presentation interference. The independent variable was treatment (presentation version). The dependent variables were (a) the proportion of correct responses to the follow-up test and (b) responses to the belief questionnaire. Data were analyzed using analysis of variance (ANOVA), Fisher's Least Significant Difference (LSD) post hoc analysis, and calculation of effect size.

Results

Hypothesis 1

A presentation that is intentionally presentation interference free will result in higher posttest scores than will presentations with interference. Treatment 1 did result in a higher mean score on the follow-up test than Treatments 2 and 3. An analysis of variance (Table 1) shows that a significant difference in posttest scores exists by treatment, $F(2, 117) = 4.575$, $p = .012$.

Table 1. Analysis of Variance of Posttest Scores by Treatment

SOURCE	SS	DF	MS	F
TREATMENT	0.145	2	0.072	4.575 *
ERROR	1.822	115 0.016		

* p = .01

Fisher's Least Significant Difference reveals that the difference between that the posttest means of Treatments 1 and 2 (.083) is significant (p = .004), with a moderate effect size of .55. The difference in posttest means between treatments 1 and 3 (.064) is also significant (p = .027) with a moderate effect size of .43.

Hypothesis 2

As the amount of presentation interference in a presentation increases, corresponding posttest scores will decrease. Group means by treatment are displayed in Table 2. As expected, Treatment 2, with two types of interference, resulted in lower posttest scores than did Treatment 1, with no intentional interference. However, contrary to the hypothesis, Treatment 3, with the most presentation interference, did not result in a significantly lower posttest scores than Treatment 2.

Table 2. Posttest Means by Treatment Group: Percent Correct

	Treatment		
	1	2	3
Learning Cost	.86	.80	.82
N	37	41	40

Hypothesis 3

Subjects viewing the interference free presentation will report more positive beliefs regarding message content and delivery method than will those viewing presentations containing presentation interference. All subjects completed a 12-item belief questionnaire. Responses were collected via a seven-point bipolar probability scale. For items 1 - 10, 7 = "Strongly Agree" and 1 = "Strongly Disagree;" for item 11, 7 = "Extremely Concerned" and 1 = "Not at all Concerned;" and for item 12, 7 = "Extremely Often" and 1 = "Not at All." It was hypothesized that subjects in the control group (Treatment 1) would respond more positively to the items on the questionnaire than would subjects in groups two or three. Table 4 presents the questionnaire items and mean responses.

Table 3. Mean Responses to Belief Questionnaire

#	Item	T1	T2	T3	F
1.	I thought the presentation was believable and authoritative.	6.76	6.46	6.60	1.76
2.	I learned a lot from this presentation.	5.70	5.49	5.68	.47
3.	I thought the presentation was too fast.	2.27	2.34	2.23	.07
4.	I thought the presentation was too slow.	2.87	3.07	3.20	.41
5.	I thought the presentation was paced just about right.	5.46	5.42	5.38	.02
6.	I expect some of my behaviors to change as a result of viewing this presentation.	4.60	4.27	4.75	.79
7.	In general, computer-generated presentations are very beneficial.	6.16	5.66	6.40	4.92 *
8.	Instructors who use computer presentations are usually better than those who do not.	4.25	3.98	4.65	1.57
9.	I trust and respect teachers who use computer presentations in the classroom more than I trust and respect those who do not.	3.16	2.61	3.50	2.86
10.	I have had lots of experience with screen design and multi-media production.	2.54	2.22	2.68	.73
11a.	Before viewing the presentation, I was concerned about my getting skin cancer.	3.38	3.60	3.46	.18
11b.	Now, after viewing the presentation, I am concerned about my getting skin cancer.	4.97	5.24	5.13	.31
12a.	Before I viewed the presentation, I applied sunscreen this often:	3.08	3.17	3.10	.03
12b.	After viewing the presentation, I expect to apply sunscreen this often:	5.00	4.78	5.05	.32

Subjects in all groups thought the presentation was believable and authoritative, with mean responses for item 1 ranging from 6.46 to 6.76 of 7.00 possible. Responses across all groups were also positive for item 2, "I learned a lot from this presentation," with mean responses ranging from 5.49 to 5.7 of 7.00, and for item 5, "I thought the presentation was paced just about right," with mean responses ranging from 5.38 to 5.46 of 7.00.

For items 6, "I expect some of my behaviors to change as a result of viewing this presentation," and 8, "Instructors who use computer presentations are usually better than those who do not," responses were uniformly neutral across treatment groups. For item 9: "I trust and respect teachers who use computer presentations in the classroom more than I trust and respect those who do not," responses were slightly negative and the difference between treatment groups was not significant ($p = .06$). Responses to item 10, "I have had lots of experience with screen design and multimedia production," were uniformly low across treatment groups (2.57, 2.22, and 2.68, respectively, on a scale of one through seven with one being "strongly disagree").

Analysis of variance revealed that the difference in mean treatment group responses to item 7: "In general, computer-generated presentations are very beneficial" was significant ($p < .01$), as shown in Table 4. This item directly addresses one of the primary questions of this study. Means by treatment for item 7 are shown in Table 5. Group 3, which received the treatment with the most types of interference, had the highest mean response to this item (6.4), followed by groups 1 and 2 (6.2 and 5.7, respectively).

Because significance was found using ANOVA, LSD post hoc tests were performed amongst all treatment means. The difference between treatment groups 1 and 2 regarding item 7 was significant ($p = .043$) with a low effect size of .35. The difference between treatment groups 2 and 3 was also significant ($p = .003$), with a moderate effect size of .52. There was no significant difference in mean response between Treatments 1 and 3 ($p = .339$).

Table 4. Analysis of Variance of Item 7, Computer Presentations Beneficial

SOURCE	SS	DF	MS	F
TREATMENT	11.611	2	5.806	4.915 *
ERROR	135.847	115	1.181	

* $p < .01$

Table 5. Treatment Means for Item 7, "Computer-generated presentations are beneficial"

	Treatment 1	Treatment 2	Treatment 3
Agreement	6.2	5.7	6.4
N	37	41	40

Responses to items 11 and 12 did not vary significantly by treatment, nor was there any significant difference between treatments regarding the gain from item 11a to 11b or from item 12a to 12b. Note that items 11 and 12 did not deal directly with presentation-related issues, rather they focused on individuals' concerns and habits regarding their own health and skin care habits.

Three hypotheses were investigated in this study. The first, whether Treatment 1 (no intentional interference) would result in a higher mean posttest score than either Treatment 2 or Treatment 3, is supported by the results. The difference between Treatments 1 and 2 was significant ($p < .01$). The difference between Treatments 1 and 3 was also significant ($p = .02$). The second hypothesis, that increases in the amount of interference would result in lower posttest scores, was not supported; There was no significant difference in learning cost between Treatments 2 and 3.

The third hypothesis, that the presentation with no intentional interference would result in more positive responses to the belief questionnaire are supported in part. Treatment 1 did result in a significantly more positive mean response to item 7 ("In general, computer generated presentations are very beneficial") than did Treatment 2, as expected. However, Treatment 3, with the most intentional interference and which was expected to result in less positive responses than either Treatments 1 or 2, also resulted in a significantly more positive mean response than Treatment 2. There was no significant difference between Treatments 1 and 3 regarding item 7.

Discussion

Presentation Interference

Interference Versus No Interference

Hypothesis 1 predicted that a presentation without intentional interference would result in higher posttest scores than would those containing presentation interference. Comparing group means for the interference free presentation with each of the two interference presentations revealed that the posttest scores for the interference free presentation group were significantly higher than those of either of the two groups receiving presentations containing interference. This is not surprising in light of existing single element research and studies that unintentionally included interference (e.g., Dwyer, 1978). Unlike Grabinger and Albers' (1988, cited in Grabinger 1989) study, subjects in this study did not have control over the amount of time allowed for each screen, a pacing condition closer to that in which an instructor lectures with a *PowerPoint* presentation, and controls the pace. Subjects' responses to pace-related questionnaire items indicate that the pacing in the present study was adequate for all three treatment groups.

Interference Versus More Interference

Hypothesis 2 predicted that increasing the amounts of presentation interference would result in lower posttest scores. This hypothesis is partially supported. Between groups 1 and 2, the significant difference ($p = .004$) in posttest scores is attributed to the presence of presentation interference. Treatment 2 contained two intentional changes from Treatment 1. The background color changed from blue to pink, and the font changed from a basic san serif font to a more ornate display font that appeared to be smaller. Two types of interference were intentionally introduced, yet the net result was at least three types of interference because the visual size of, for example, "48 points," is not identical from font to font. The apparent size difference from identical point sizes supports Mukherjee and Edmonds (1994) point that the whole is greater than the sum of the parts, and illustrates why a prescriptive that computer delivered text should be "at least 26 points" (Gibson & Mayta, 1992, cited in Knupfer, 1994) can be meaningless or misleading. Past single element research attributed differences in learning to the change of a single element. While manipulation of only one element makes cause and effect easier to ascribe, the value to actual practice is limited because screen designs are made up of multiple elements that often have more than a single flaw. As the present multiple element study demonstrated (e.g., point size versus apparent size), single intentional element changes can have multiple apparent effects. The difference between treatment groups in the present study is not

entirely attributable to any single element (e.g., background color) because the purpose and design of the study required multiple element manipulations. The focus of this study was not to determine which kinds of interference are worse than others, but to determine whether the presence of interference in realistic combinations had a significant effect on learning from a computer generated presentation. The study also sought to determine whether increasing the interference present in a presentation would increase the difficulty in learning.

There was no significant difference between Treatment 2 with three types (including the apparent text size) of interference and Treatment 3, with five types (including the apparent text size) of interference. This may be partially explained in terms of Thuring, Hanneman, and Haake's (1995) concept of "Cognitive Overhead." Cognitive Overhead increases when learners must become reoriented with inconsistent design elements in a presentation. For example, the first intentional change in Treatment 3 from Treatment 2, the minor misalignment of bullets and text, would not be considered to add to a learner's cognitive overhead after the first occurrence because their misplacement remained consistent throughout the presentation. According to the concept, a presentation in which the bullets and text on alternating screens was aligned and misaligned would increase the cognitive overhead to a greater extent than would consistent misalignment throughout an entire presentation. If the misalignment in this study was noticed, it may have become less noticeable or important to learners as the presentation progressed. Reducing inconsistencies should reduce cognitive overhead. In this regard, cognitive overhead and presentation interference are similar in that they both refer to negative effects within specific contexts (as opposed to supposed context-free universal prescriptives).

The second intentional difference in Treatment 3 from Treatment 2 was the screen transition sound effects. The sound effects had no topical relevance to the material being presented and were expected to distract learners from the message content. However, results showed no significant difference between Treatment 2 and Treatment 3. Participants, wearing headsets, viewed the presentations via Power Macintoshes in a busy, open-use computer laboratory. During data collection the lab was in nearly normal use. Although the computers not being utilized for the study had messages taped to the monitors requesting that users work quietly, there were consistent, typical noises and distractions. All three treatments included audio narration for each screen but Treatments 1 and 2 were silent during screen transitions, allowing ambient noises and distractions to be available to participants. Only Treatment 3 had sound effects and, although they were intended as a distraction, they may have minimized the distractions from others working in the crowded computer laboratory and kept learners' attention on the presentation. There is no evidence from this study that the sound effects either aided or hindered learning.

Results suggest that intentionally increasing interference does not necessarily lead to lower posttest scores. Further, elements that can be reasonably expected to result in interference may, in some contexts and settings, have positive or neutral effects. In a particular setting and context, there may be a threshold at which additional interference results in compensation by learners. The phenomena of higher achievement from what could be reasonably expected to be more difficult screens is evidenced in the literature (e.g., Knupfer and McIsaac, 1992). Cermak and Craik (1979, cited in Pettersson, 1993) found that when learners perceive a task as more demanding, they process the materials more deeply and better remember both details and main ideas. This is also suggested by research conducted by Grabinger (1989). However, busier or more elaborate displays do not necessarily improve learning. According to Hannafin and Hooper (1989),

> Although the student may be more aroused by visually stimulating displays, and important details may be illuminated by improving legibility, such displays may also increase the processing burden on the learner and cause shallow processing of important lesson content. (p. 156)

Beliefs Regarding Computer Generated Presentations

Hypothesis 3 stated that subjects viewing the interference free presentation would respond more positively to belief statements regarding message content and delivery method than would those viewing presentations containing presentation interference.

Overall, subjects responded positively to all three versions of the presentation. The only significant differences in subject responses to the belief questionnaire were to item 7, "In general, computer generated presentations are very beneficial." Subjects from all three groups agreed with this statement, however the responses from group 1 (with no intentional interference) and group 3 (with the most intentional interference) were significantly higher ($p = .043$, $p = .003$, respectively) than those from group 2. The significant difference between Treatments 1 and 2 was expected but the fact that Treatment 3 resulted in a higher mean response than Treatment 2 was not.

This may be explained in light of findings from a survey reported by Sammons (1995) of 500 students in 15 university classes in which computer generated presentations were used. Results from that survey indicated that although students generally liked the use of computer aided presentations in classrooms, according to Sammons, many students thought that the computer was not being used to its advantage and that "using a computer as a glorified overhead projector is a waste" (p. 68). Common comments regarding the screen designs of instructor developed presentations were the following:

1. Letters are often not large enough or legible.
2. There is not enough color contrast.
3. Too much information appears on each screen. Students suggest including only key points.
4. Students prefer an outline format with a hierarchy of points and subpoints rather than bullets all at one level. (p. 68)

Considering Sammons' study in which subjects believed that classroom presentations did not use the computer to its advantage, one might infer that subjects in group 3 (with transitional sound effects) may have perceived that the presentation took advantage of the computer's options. The difference between treatment groups 1 (no interference) and 3 (the most interference) regarding item 7 was not significant. Subjects in group 1 felt strongly that presentations are beneficial. That belief was supported by their performance on the posttest. Subjects in group 3 believed as strongly as those in group 1 that presentations are beneficial, but they performed significantly worse on the posttest than did subjects in group 1. Treatment 3 did result in positive beliefs about the medium but did not result in improved learning. Results indicate that although subjects who view well designed presentations and those who view presentations containing interference may both report strong beliefs regarding the beneficial nature of computer generated presentations, presentations containing interference significantly reduce learning.

Subjects generally agreed with item 8, "Instructors who use computer presentations are usually better than those who do not," with neutral means (3.98–4.65 out of 7) across groups and no significant difference between treatment groups. Responses to item 9, "I trust and respect teachers who use computer presentations in the classroom more than I trust and respect those who do not," were slightly negative for all groups (2.61–3.5 out of 7).

Implications of the Study

Presentation Interference is a viable construct for use in screen design development and research. Previous research on screen design was driven by the search for identifiable individual element prescriptives to be used in an additive process. Research has shown that manipulating single elements can affect learning (e.g., Aspillaga, 1991, Winn & Solomon, 1993). However, presentations do not consist of only a single element and the combination of single elements results in a new whole. Moreover, a set of specific universal visual design formulas cannot possibly be appropriate to every context. Design prescriptives derived from single-element research are a useful and logical starting point but several researchers (e.g., Grabinger, 1989; Hannafin & Hooper, 1989: Haag & Snetsigner, 1994; Mukherjee & Edmonds, 1994) agree that they are not enough. In addition, presentation development should include cognitive strategies (e.g., Hannafin and Hooper, 1989), and a followup evaluation process to eliminate presentation interference. Looking for and eliminating interference is always context-based.

This study supports the assertion that screen design flaws, in this case, relatively conservative ones, can negatively affect learning. The purpose of this research was not to quantify or categorize interference in order to devise universal rules regarding the "right" way to use elements. Quantifying design choices is of limited value.

In practice, no designer would knowingly leave one poorly executed element in because another was "worse" according to research. A label such as "inappropriate design choice" is only meaningful in relation to the particular context in which the choice is inappropriate. The goal is not to choose one type of interference over another, but to eliminate interference altogether.

The concept of presentation interference is not intended as a replacement for any of the existing screen design constructs. The process of identifying and eliminating presentation interference is intended to augment the design process as a context relevant way to evaluate and improve existing presentations and to evaluate whether or not constructs such as comprehensibility and readability have been achieved.

Continued emphasis on single element research will not allow for practical exploration of the visual gestalt. Researchers are not likely to get beyond two or three elements if they must measure every single element and every multiple element combination by degrees to get to the point of realistic combinations. The present study looked at interference created by inappropriate use of four (or arguably, five) elements. In order to look at the combination of only four types of interference and be able to quantify and attribute the effects to individual elements or specific

combinations, 15 treatments would have to be developed (1 control + 4 single + 4 + 3 + 2 + 1 = 15). Using the generally accepted guideline of a minimum size of 30 subjects for each experimental treatment group (e.g., Gay, 1992), at least 450 subjects would be required. Conducting or replicating such a study is extremely impractical and, even if it were not, the use of such quantifiably categorized single elements would be of strictly limited use.

Strengths and Limitations

This study began with a contextually appropriate arrangement of elements to present realistic content. Presentation design decisions were context based. Expert development and feedback regarding the design of the presentation were used to establish the interference free control treatment. The interference free control treatment was measured against treatments with realistic combinations of interference. This allowed a more meaningful result than would comparing two treatments that both reflected realistic practice. The study used a holistic approach and acknowledged the visual gestalt by including multiple flawed elements, in realistic combinations, in a presentation with real content. Replication could be expected to find similar, general kinds of results but not identical findings because exact contexts will not be duplicated.

Limitations of this study that may affect validity or include the age of subjects and their voluntary participation, although the effects of the latter factor were reduced by randomization. Students in this study participated individually with headsets. In a crowded lecture hall, sitting with friends and fellow students, sound effects may have an entirely different effect.

Recommendations for Future Research

Several suggestions from this study are deserving of further research:

Replicate this study with these and other types of interference in presentations based on different content and contexts but with similarly rigorously prepared interference free control versions. The importance of beginning with a contextually based ideal, which can then be measured against realistic practice cannot be overstated. The context based interference free control treatment can be measured against presentations based on the control version to which combinations of presentation interference have been cumulatively increased (e.g., three, five, and seven intentionally added examples of interference).

Conduct research to investigate whether at some point, the addition of more interference does not increase learning cost. This should be investigated, not in an effort to quantify or categorize types of interference, but to see if learners can compensate for extra interference with extra effort. If such a point exists in replication, context dictates that point will necessarily be different for every study.

Revise the belief questionnaire to include items such as "Learning from this presentation was easy" or "This presentation required concentration."

Conduct research with similar treatments but expose each entire treatment group to the corresponding presentation at one time in a lecture hall. While this may be difficult practically, the method may reveal different responses to transitional sound effects than resulted from individual participation with headphones.

Consider adding a later followup test to measure whether there is a difference in recall over time.

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