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ABSTRACT

This article focuses on the effectiveness of computer-based instruction (CBI) screen designs, including their benefits and limitations, as well as human constraints in designing effective CBI. The paper begins with an overview of what comprises an effective CBI screen design, including characteristics of human factors, how information must be visually presented to stimulate and enhance human comprehension, how physical actions must flow to minimize the potential for fatigue and injury, and consideration of the capabilities and limitations of the hardware and software at the human computer interface. Benefits of a well-designed CBI screen are summarized, including effects on general academic performance and cognitive outcomes, as well as the advantages of graphic presentation of information. The following problems that may impact the usability and effectiveness of a CBI medium are discussed: constraints in design guidelines; human constraints; hardware constraints; application considerations; and design complexity and inconsistent terminology/techniques. It is concluded that different CBI screen design interfaces have different strengths and weaknesses. Some concepts and tasks are very difficult to convey symbolically and are not suited for a CBI screen design; other concepts and tasks may be well suited. Which tasks are best suited for which styles and systems still needs much study. (Contains 29 references.) (AEF)

Effects of Screen Designs in CBI Environments

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Background and Introduction

As the twentieth century draws to a close and the computer industry matures, awareness that the human computer interface is a key element in computer-based instruction (CBI) designs is finally occurring. This awakening has been caused by a variety of factors predicated upon the effects of screen design in CBI environments. The combined voices of frustrated users, fed up with complicated procedures and incomprehensive screens, have finally become overwhelming. Examples of "good" screen designs, when and if they did occur, have been presented as vivid proof that good design is possible (Brown, 1988; Mathews & Mertins, 1987, 1988). Technology, as it leaps forward into the twenty-first century, has eliminated many of the barriers to good screen design and unleashed a variety of new graphic displays and interaction techniques (Galitz, 1992; Kearsley, 1988; Shneidermann, 1982; Shneidermann & Margona, 1987).

The focus of this article is on the effectiveness of CBI screen designs, including their benefits and limitations as well as human constraints in designing effective computer-based instruction. Graphics have revolutionized screen design and the user interface. A graphical screen bears scant resemblance to its text-based colleagues. Whereas a traditional screen maintains a one-dimensional, text-oriented, form-like quality, graphic screens can assume a three-dimensional look (Brown, 1988; Kearsley, 1988). Information can "float" in windows (small rectangular boxes seeming to rise above the background plane (Galitz, 1992). Windows can also float above other windows. Information can appear and disappear, as needed, and in some cases texts can be replaced by symbols representing objects or actions. These symbols are commonly referred to as "icons" (Engel & Granda, 1975; Brown, 1988; Galitz, 1992). Graphics and human characteristics are some of the effective features of screen design.

What Comprises an Effective CBI Screen Design?

To be truly effective, a good CBI screen design requires many things. Included are the characteristics of human factors (that is, how we see, understand, and think). It also includes how information must be visually presented to stimulate and enhance human comprehension, and how physical actions must flow to minimize the potential for fatigue and injury (Blaschke, 1986; Mathews &Mertins, 1987, 1988). Good CBI designs must also consider the capabilities and limitations of the hardware and software at the human computer interface (Tullis, 1981, 1985).

Screen design specifications must be such that they permit interaction between the user and the computer. Walker (1989) pointed out that most of the benefits of one interaction style over another are anecdotal. This has made the debate between advocates of graphical and other styles of interaction more religious than scientific. Whiteside, Jones, Levy, and Wixon (1985) compared the usability characteristics of seven systems, including direct-manipulation, menu, and command language styles of interaction. They found that user performance was independent of type of system. There were large differences in learnability and usability among all treatment combinations. How well the system was designed was the best indicator, not the interaction style. Shneidermann (1982) compared learning and performance for direct-manipulation and command-based word processing systems. While no differences existed after the first experimental session, the direct-manipulation system user's performance became increasingly superior as the study progressed (and task complexity increased). It appeared that the direct-manipulation system facilitated the learning process as task complexity increased. Brems and Whitten (1987) evaluated a family of seven commands for user preferences. The alternative design styles were commands described by icons only, icons with textual captions, and textual captions only. While the meanings of the icons were learned, textual captions were preferred to uncaptioned icons. Learning, they concluded, was not a good indicator of preference. The same results were recorded by McGrath (1992) in her comparison of hypertext-based CAI and non-CAI learners.

Benefits of a CBI Screen Design

At best, a poorly designed CBI screen can exact a toll in human productivity and learning potentials. At its worst, a poorly designed CBI graphics can create an impression that understanding it will require more time than one can afford to commit, or that it is too complex to understand at all. Those who have the luxury of doing so (e.g., professionals or experts) may refuse to use it, and the purpose for which it was designed will never be met (Liao, 1992; Singer, 1992).

The benefits of a well-designed CBI screen have been under experimental scrutiny. There are very few studies on the effectiveness of CBI designs. However, there are some positive findings in the few that have been published. Becker (1987), Blaschke (1986), Kulik and Kulik (1987), McGrath (1992), and Singer (1992) found positive correlations between computer access and design effect with general academic performance. Lioa's (1992) meta-analytic study indicated that cognitive outcomes of using CAI extended beyond the content of the specific software being used and the subject being taught. Improvements in these cognitive outcomes are possible through improved system design, and access to better hardware and software to run the system.

Dunsmore (1982) attempted to improve screen clarity and readability by making screens less crowded. Separate items, which have been combined on the same display line to conserve space, were placed on separate lines instead. The result: Screen users were about 20 percent more productive with the less-crowded version. Keister and Gallaway (1983) reformatted a series of screens following the guidelines as outlined in Engel and Granda (1975). There result indicated that users of the modified screens completed their tasks in 25 percent less time and with about 20 percent fewer errors than those who used the original screens. Tullis (1981) reported how reformatting inquiry screens using good design specifications reduced decision-making time by about 40 percent, resulting in a saving of 80 percent person-years in the affected system. In a second study that compared 500 screens (Tullis, 1983), it was found that the time to extract information from displays of airline or loading information was 128 percent faster for the best format than for the worst. Other studies (e.g., Brown, 1988; Mann & Shnetzler, 1986; Pulat & Nwankwo, 1987) have also shown that proper formatting of information on screens does have a significant positive effect on performance .

Screen navigation, commands, and file management can be executed through menu bars and pull-downs. Menus may "pop-up." In the screen body, selection fields (such as radio buttons, check and list boxes, and palletes) coexist with the reliable old entry field. More sophisticated entry fields with attached or drop-down menus of alternatives are also available. Screen objects and actions may be selected through use of pointing mechanisms such as the mouse or joystick instead of the traditional keyboard. Shneidermann and Margona (1987) compared some simple file manipulation using a graphical system (Macintosh) and a command language system (DOS). The graphical system was found best in learnability, performance time, and subjective ratings.

Increased computer power and the vast improvement in the display enable the user's actions to be reacted to quickly, dynamically, and meaningfully. This new interface is often characterized as representing one's "desktop" with scattered notes, papers, and objects such as files, trays, and trash cans arrayed around the screen (Kearsley, 1988; Liao, 1992).

In CBI environments, graphic presentation of information utilizes a person's information processing capabilities much more effectively than other presentation methods. Properly used, a graphic presentation minimizes the necessity for perceptual and mental recoding and reduces short-term memory loads. Graphic presentation also permits faster information transfer between the computer and the user by permitting more visual comparisons of amounts, trends, or relations; more compact representation of information; and simplification of structural perception (Brown, 1988; Galitz, 1992). Graphics can also add appeal or charm to the screen interface and permit greater customization to create a unique style in CBI environments that are user friendly (Galitz, 1992; Shneidermann, 1977, 1982, 1982a).

Limitations of a CBI Screen Design

Screen design may also be contributing to the visual fatigue reported by some users. Dainoff, Happ, and Crane (1986) estimated that as many as 45 percent of all users may be victims of CRT-induced visual fatigue. In a study that required extended CRT viewing, Mathews and Mertins (1987, 1988) indicated that about 60 percent of the study participants reported eyefocusing problem and 40 percent reported pain in the eye area.

The benefits of a mediated graphical system may be tempered by several possible problems. One or all may impact the usability and effectiveness of a particular CBI medium. These include the following:

Constraints in Design Guidelines

The graphical interface is burdened today by the lack of experientially derived design guidelines. More designer interest has existed in solving technical rather than usability issues, so few studies that might aid decision-making designs exist. It is also difficult to develop studies evaluating design alternatives because of increased CBI screen design complexities. Too many variables that must be controlled make meaningful causal inference difficult to substantiate. Consequently, there is little understanding of how most design aspects relate to productivity, knowledge gains and transfer, and satisfaction.

Human Constraints

Human limitations exist in terms of one's capability of dealing with the increased complexity of the graphical interface. The variety of visual displays and motor skills required are likely to challenge all but the sophisticated users. Correctly double-clicking a mouse, for example, is difficult for some novice users (Galitz, 1992; Shneidermann & Margona, 1987).

Hardware Constraints

Good screen designs also require hardware of adequate power, processing speed, screen resolution, and graphic capability. Any insufficiencies in these areas will prevent a mediated screen design's full potentials from being realized.

Application Considerations

Graphics may not be the best alternative in all situations. Studies have found textual presentation of information (Brown, 1988; Shneidermann, 1977, 1982a; Shneidermann & Margona, 1987; Stern, 1984) or tabular display of information (Tufte, 1983) superior to graphics. So, it is the content of the graphic that is critical to the usefulness of the CBI medium. The wrong or a cluttered presentation may actually lead to greater confusion and frustration, not less.

Design Complexity and Inconsistent Terminology/Techniques The elements and techniques available to CBI screen designers far outnumber those that have been at the disposal of the text-based screen designer. This "more' may not necessarily be better, unless it is thoughtfully, simply, and consistently applied to the CBI environment. Since graphics are most often applied with color, the advantages and problems of color must be considered. In addition, many techniques and terminologies exist between various graphical system providers. These inconsistencies occur because of both copyright and legal implications as well as product differentiation considerations. The result, however, is that learning for both designers and users is much more difficult than it should be (Brems & Whitten, 1987).

Conclusion

A graphical system possesses a set of defining concepts. Included are sophisticated visual presentation, pick and click interaction, a restricted set of interface options, object-orientation, visualization, extensive utilization of a person's recognition memory, and concurrent performance of functions. The conclusions based on research studies indicated that different CBI screen design interfaces have different strengths and weaknesses. Some concepts and tasks are very difficult to convey symbolically and do not seem to be suited for a CBI screen design. Other concepts and tasks, however, may be well suited. Which tasks are best suited for which styles and systems still needs much study.

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