University of Alberta

SCREEN DESIGN: EFFECTS OF DESIGN PRINCIPLES ON RECALL LEARNING AND STUDY TIME

by

Heather Kanuka ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Masters of Education

IN

INSTRUCTIONAL TECHNOLOGY

Department of Adult, Career and Technology Education

Edmonton, Alberta

Spring, 1997

0-612-21240-8

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Degree:	Masters of Education
Year this degree was granted:	1997

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled SCREEN DESIGN: EFFECTS OF DESIGN PRINCIPLES ON RECALL LEARNING AND STUDY TIME submitted by HEATHER KANUKA in partial fulfillment of the requirements for the degree of MASTER OF EDUCATION in INSTRUCTIONAL TECHNOLOGY.

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ABSTRACT

The purpose of this study was to determine if artistic screen layouts (computer screens that used the principles of art and design) influence achievement, completion rates or time spent during the learning process. Two versions of the same computer based tutorial were developed, both consisting of identical content and sequence: both computer based tutorials had exactly the same text based information, graphics and design. Comparisons of the two groups showed that there was no statistically significant difference in post test achievement scores in the lessons that contained screen layouts that used good design principles compared with the lessons that contained screen layouts that used poor design principles. There was, however, a statistically significant difference in time spent completing the lessons that contained screen layouts using good design principles compared to the lessons that contained screen layouts that used poor design principles. Participants with lessons that used poor design principles had a significantly higher mean score in lesson completion time than group one (participants with lessons that used good design principles). A significant difference was also found between the number of subjects who completed the computer based lessons in group one compared to the number of subjects who completed the computer based lessons in group two.

ACKNOWLEDGEMENT

The successful completion of this study involved the consent of the many volunteers who agreed to participate in this study, the cooperation and support from Dianne Conrad at the Faculty of Extension and Dr. Paula Brook from the Department of Education Policy Studies who helped me recruit the volunteers required for this study.

To Dr. Szabo,

I express my sincerest gratitude for providing me with supervision, guidance, and support.

I would also like to thank Dr. Engel and Dr. Collett,

who provided many insightful contributions and assistance.

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CHAPTER ONE

The Problem

Introduction

Experts in the field of instructional technology claim that effective computer screens requires knowledge of: how to provide readers with road maps through a document, how to be consistent with visual formats, the special characteristics of computer-driven screens, the characteristics of the learners who will be viewing the screens, types of feedback, how to make the screens visually pleasing and create an artistic sense of layout, balance and creativity (Duin, 1988; Heines, 1984). Indeed, Heine's car has a license plate bearing the phrase "CBT IS ART" (personal correspondence, M. Szabo). Guidelines about road maps, visual formats, graphics, the special characteristics of computer-driven screens, learner characteristics and feedback are provided in the research literature. However, the empirical research literature on designing computer screens which have an artistic sense of layout, balance and creativity is almost non-existent. Perhaps a reason for a lack of empirical research on computer screens which have an artistic sense of layout stems from a particular notion about the purpose. There is, according to Thiel (1982), a "prevailing notion that it [an artistic sense of layout] is a kind of frosting, an aesthetic overlay that makes humdrum objects more appetizing" (p. 31). In other words, perhaps producing a screen that has an artistic sense of layout— although nice to look at —is not really functional. Is this true?

Statement of the Problem

This study addressed the following question: How do achievement, lesson time, and completion rate vary with screen layouts using good design principles, compared with screen layouts using poor design principles, in computer based instruction with part-time adult learners from a research university in Western Canada?

Hypotheses

The first hypothesis determined how **post test achievement scores** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles.**

> Null Hypothesis I: There will be no significant differences in information recall on achievement scores between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles.

The second hypothesis determined how **time spent on task** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles.**

> Null Hypothesis II: There will be no significant differences in time on task between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles.

The third hypothesis determined how **post test achievement scores** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles** on the basis of **gender.**

> Null Hypothesis III: There will be no significant differences in information recall on achievement scores between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles on the basis of gender.

The fourth hypothesis determined how **time on task** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles** on the basis of **gender**.

> Null Hypothesis IV: There will be no significant differences in time on task between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles on the basis of gender.

The fifth hypothesis determined how **completion rates** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles**.

> Null Hypothesis V: There will be no significant differences in completion rates between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles.

Limitations

The following limitations influenced the degree to which the results of this study can be generalized to adult learners enrolled in a research university in Western Canada.

1. The study was limited to students who volunteered. It was possible, then, that some bias existed because learners who participate in additional learning experiences are often the most dedicated learners.

2. Those subjects who volunteered had 2-6 years of postsecondary education, were predominately female and part-time learners.

3. A file was built into the program that recorded the time each participant started and finished the tutorial and was used to determine time spent on task. As the participants completed the computer based lessons on their own, out of class time, it was possible that some participants left the lesson running while attending to other activities resulting in an inaccurate record of time spent on task.

Delimitations

In an attempt to define the central focus of the problem, the specific parameters of this study were stated in the following delimitations:

1. subjects over the age of 21 who were volunteers and were currently enrolled at a research university in Western Canada,
2. one sitting with time ranging from about 30-45 minutes,
3. the examination of the influence of design principles on achievement. The study did not examine, nor was concerned with:

    the influence of computer based instruction on learning outcomes,

    the quality of computer based instruction,

    the influence of visuals on learning outcomes, or

    the use of design principles as feedback or as a content related memory tool,

4. assessment of cognitive achievement in terms of recall and time spent in the lesson. Interpretation, analysis and application was not studied, and
5. authoring programs; that is study did not examine, nor was concerned with online technologies such as the Internet.

Definition of Terms

Computer Terminology:

Computer Assisted Instruction (CAI): "The use of a computer system as a tutor. The computer presents instruction to students using text and graphics to illustrate important points and allows students to interact with the computer to practice the skills being taught" (Heines, 1984, p. 147).

Computer Based Instruction (CBI): The use of computers in the learning process whereby the computer delivers instruction.

Computer Managed Instruction (CMI): "Any system in which a computer is used to perform overall instructional management. It usually includes a testing and evaluation function, a planning function, and a record-keeping function. All CAI has elements of

CMI built in, but CMI usually refers to a more complete, stand-alone system" (Burke, 1982, p. 187).

Computer Graphics: Any visual illustration of an idea, thing or process and is presented on a computer screen.

General Terms:

Achievement: The main dependent variable for this study and was operationally defined as the participant's score on the post test that was designed to measure how achievement varied with a technically good computer screen layout compared to a technically poor computer screen layout.

Adult: Anyone over the age of 21.

Aesthetically Pleasing: an artistic sense of layout, balance and creativity

Composition: the organization of forms to make a visually satisfying whole. Also see *visual image.*

Visual Image: The organization of forms on a flat, two-dimensional surface. A visual image includes graphics but may also include numbers, text or a combination thereof.

Visual Literacy: Implies understanding, the means for seeing and sharing meaning with some level of predictable universality (Doris in University of Waterloo, 1996).

Artistic Screen Layouts: Screen layouts which use the principles of design (unity, focal point, balance and colour) resulting in an image that is visually pleasing.

Non-Artistic Screen Layouts: Screen layouts which do not use the principles of design (unity, focal point, balance and colour).

Assumptions

1. **It was assumed that all participants completed the post test to the best of their ability.**

2. **It was assumed that the post test used in this study measured recall learning.**

3. **It was assumed that all participants completed the post test approximately two hours after completion of the computer based tutorial.**

Significance of the Study

The worst thing that can happen to an artist is to create a visual image that does not interest the viewer. Should the same also hold true for the instructional technologist who creates computer screens? Heines (1984) claims a poorly designed computer screen can hinder communication. Can a visually pleasing computer screen enhance communication?

Much of the literature in computer based instruction offers guidelines based on the empirical research available regarding the use of text, colour and graphics (Aspillaga, 1991; Baek & Layne, 1988; Duin, 1988; Gullingham, 1988; Heines, 1984; Livingston, 1991; Rubens & Krull, 1985; Soulier, 1988; Steinberg, 1991; Szabo & Poohkay, 1994). This would include such areas as: text density, text size, line length, margins, columns, location of information, colour choices and the use of graphics (in motion or static). If a visually pleasing screen is important, as much of the research states (Misanchuk & Schwier, 1995; Yang & Moore, 1996), why are there not similar guidelines based on empirical research on how to design a computer screen that is visually pleasing? How do we know when a screen is visually pleasing? Are there certain characteristics that we can use to judge whether a computer screen is visually pleasing? Why should we be concerned about this?—does a visually pleasing screen influence learning in some way?

One possible reason for the lack of information on how to create a visually pleasing computer screen may originate from the assumption that a good visual design and a work of art are the same thing and, in turn, only an *artist* can produce a good visual design. Another possible reason as to why there is a lack of information about how to create a visually pleasing screen is that many of us believe this aspect of computer design falls into an area where we must use "judgment, common sense, and a refined connoisseurial sensitivity" (Misanchuk & Schwier, 1995, p. 20); or put another way, this area of computer screen design is *soft* information and cannot be empirically tested. In fact, neither of these assumptions are correct.

In regard to the first assumption, art and design are not interchangeable terms. The difference between a work of art and a good visual design has to do with *function* (Dickie, 1977). Specifically, a design serves a purpose. An artist's aim, on the other hand, is to create nothing more than a visual statement that expresses a feeling, mood, sentiment and emotional attitude (Ducasse, 1955). Thus, although the design of a visual image may be visually pleasing (to some) it is not, necessarily, a work of art. Moreover, one does not need to be an artist to create a technically good visual design. An example is a graphic designer. We know that a skilled graphic designer can create visually pleasing images which are not generally considered to be *works of art*. To create visually pleasing images, graphic artists use design principles. Most graphic designers would agree that if you unknowing are able to create visually pleasing compositions, then unknowledge is your way. But if you are unable to create visually pleasing compositions out of your unknowledge, then you ought to look for knowledge (Itten, 1970). As mentioned, this knowledge can be found through the study of the principles of design.

In regard to the second assumption, the principles of design (unity, focal point, balance and colour) are most often used to create visually pleasing images and can be empirically tested. Generally, when designing a visual image that is pleasing, the principles of design are used; not, as Misanchuk & Schwier (1995) claim, " ... judgment, common sense, and a refined connoisseurial sensitivity" (p. 20).

Upon a closer look at the goals of the graphic designer and the goals of the instructional technologist it becomes evident that both have much in common. In addition to creating visually pleasing layouts, the goals of graphic designers include: (1) attracting and holding the viewer's attention, and; (2) communicating easily understood information which aims to have the viewer remember the information. To achieve these goals, most graphic designers use the principles of design. Is it possible for instructional technologists to apply these same design principles to achieve the same goals? More importantly, if instructional technologists apply these design principles to computer screen layouts, how might this influence achievement, lesson time, and completion rates?

The general problem addressed in this study was: How do achievement and lesson time vary with screen layouts using good design principles, compared to screen layouts that use poor design principles, in computer based instruction with part-time adult learners from a research university in Western Canada? The problem was defined in terms of the null hypotheses to be tested. Limitations, delimitation's and assumptions were presented. Definitions of terms as well as the significance of the study were also included.

CHAPTER TWO

Literature Review

Introduction

This study examined the influence of screen design layout in computer based instruction on achievement with adult learners at a research university in Western Canada. Visual learning (literacy and cognition), screen design and layout (text and graphics), colour, and design principles are described in this chapter.

Visual Learning

Introduction

It has been claimed by J. P. Guilford (a research psychologist in the late 1940s) that there is a three dimensional cube of intellectual abilities which can be assessed and trained (Guilford in Peterson, 1996). This factorial approach developed by Guilford has the following components: semantic, symbolic and figural. The semantic aspect includes word abilities, the symbolic dimension deals with the ability to construct relationships and the main component of this schema is the figural dimension which primarily includes the visual abilities (Peterson, 1996). According to Peterson (1996) while the semantic and symbolic languages are used in learning, it is most often the figural that stimulates discovery and facilitates communication of the information in the learning process.

Visual Cognition

Visual cognition is the process of how we perceive and remember visual information (Pinker in Rieber & Kini, 1991). Research has confirmed that, as humans, we seem to be exceptionally good visual learners (Kobayashi, 1986) and that visuals enhance the leaning process (Adams & Hamm, 1989; Considine & Haley, 1992; Alesandrini, 1984; Duin, 1988; Soulier, 1988; Benson, 1989). A reasonable question to ask next is, why? Presently, according to Steinberg (1991), there are two conflicting theories about how information is stored in our memory. One of these theories provides an explanation of why we remember information better when it is presented with a visual image.

The first theory contends that information is stored in our memory, based on its meaning, in complete and logical statements. This is referred as *propositions* or *propositional forms* (Steinberg, 1991; Pylyshyn in Rieber & Kini, 1991). According to this view, "...pictures are stored in memory in terms of their meanings rather than as images" (Steinberg, 1991, p. 145). This view does not provide an explanation of why visual images enhance the learning process.

The second theory suggests that we store words and visual images in two systems: one verbal and the other perceptual (Steinberg, 1991). This is referred to as the *dual coding* theory (Paivio in Steinberg, 1991). In this theory, it is believed that visual perception is different from verbal perception. Perception, according to Levie (1987), is the process of selectively attending to and scanning a stimulus, interpreting important details and perceiving meaning (Steinberg, 1991):

> The imagery system (visual perception) is qualitatively different from the verbal. The imagery system organizes elementary units into higher order elements that are synchronous or spatial in character. For example, when we look at a face we see several features at one time and in certain spatial relationships to each other. The verbal system organizes linguistic units into higher order elements that are sequential structures. Thus, for instance, we organize sequences of letters into words and sequences of words into sentences.
>
> The verbal and imagery systems are similar in that both are dynamic ... The two systems are functionally independent but interconnected so that an activity in one system can initiate activity in the other. A picture (e.g., one's home) can initiate recall of verbal information (e.g., my home). Likewise a verbal phrase, such as "my home" can initiate recall of images of one's home. (p. 145).

The dual-coding theory suggests that we have separate encoding mechanisms, one visual and one verbal. This means that pictures and words activate independent visual and verbal codes and makes several assumptions (Rieber & Kini, 1991, p. 85):

1. separate coding mechanisms are additive, so that information coded in both picture and verbal forms is more likely to be remembered, and

2. the availability of these two coding mechanisms differ in that a visual is more likely to be coded verbally and visually than words.

According to this theory, visuals are remembered better than words because visuals are more likely to be encoded redundantly than words. Thus, the likelihood of recall is extended due to the accessibility of two mental representations instead of just one. If one memory trace is absent (whether a visual or words), the other remains accessible (Rieber & Kini, 1991).

In addition, when the content is highly imageable, dual-coding is more likely to occur (Paivio & Csapo in Rieber & Kini, 1991). Specifically, research shows that "words, sentences, and paragraphs that are highly imageable are recalled better than those which are not and that the learning of concrete concepts precedes the learning of abstract concepts—concrete concepts are stored as images whereas abstract concepts are stored as verbal representations" (Reiber & Kini, 1991, p. 85)

A number of studies (cited by Stanley in Moorhouse, 1974) provides some evidence which seems to confirm that we dual code information. Specifically, based on a review of the literature by Stanley (in Moorhouse, 1974), the following conclusions can be made:

1. The capacity for storage of information from visual inputs is large and most evidence suggests a greater capacity for pictures than words.

2. Information presented visually should be in such a form that distinctive features of the message are accentuated. A schematic drawing aids memory more than a literal pictorial representation.

3. Attention is limited and an unfamiliar or complex stimulus will produce a narrowed focus of attention.

4. People differ in important ways. Their motivational and emotional states as well as their basic value systems affect the fundamental pick-up and storage of information.

The dual coding theory, then, may explain why the use of visuals enhances the learning process. According to Molitor, Ballstaedt & Mandl in Mandl & Levin (1989), "when learning from texts and pictures occurs, pictures can always be retrieved from both memory systems" (p. 7).

However, the dual coding theory has been strongly criticized: "Above all, representatives of research in artificial intelligence maintain that all of our knowledge is stored in a unique memory system in a prepositional format independently of whether it was decoded as linguistic or visual information" (Molitor, Ballstaedt & Mandl in Mandl & Levin, 1989, p. 7). To support this proposition, studies cited in Mandl & Levin found that:

> ...in some situations visual stimuli as input can provide better cues than their equivalent verbal counterparts, for certain responses; but the study also shows that verbal cueing is also quite successful, demonstrating that cueing is not medium

> dependent. This finding bears on the question of single- versus dual-code memory. If one postulates that information from different media is stored separately, one would expect that cues to access the information be medium dependent. That has never been confirmed, however (p. 105-106).

Summary

There are two opposing theories of how we store information: single coding and dual coding. The dual coding theory maintains that we store visual information in a different system than verbal information; this theory offers an explanation of why the use of visuals enhance the learning process. The other theory asserts that all information is stored in terms of meaning. There is research to support both theories, however, no research presently exists which supports the view that stored information is medium dependent.

Visual Literacy

The phrase *visual literacy* has, in the past, not received much attention. Recently, however, visual literacy seems to be appearing in the literature relating to educational technology more frequently. The reason being, as Kirrane (1992) points out, is that we are on the threshold of displacing *print culture* (printed words) with *visual culture* "… an idea with implications as profound as the shift from oral culture to print [word] culture" (p. 58). Furthermore, also according to Kirrane (1992), this move from word media to visual media is altering how we think and learn. There is a deep concern from many in the field of education that, as we move toward a visual-based society, we are not creating and interpreting visual images accurately (Kirrane, 1992).

In general terms, visual literacy is an acquired competency in visual expression and communication that involves, according to Thiel (1981), "insights and skills no less disciplined than those required for proficiency in engineering and construction" (p. 12). According to Kirrane (1992), the International Visual Literacy Association has provided three explanations of what is meant by visual literacy:

1. *a*. a group of vision competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences; *b*. The learned ability to interpret the communication of visual symbols (images), and to create messages using visual symbols; *c*. The ability to translate visual images to verbal language and vice versa; *d*. The ability to search for and evaluate visual information in visual media.

2. visual thinking; visual aesthetics; creative exploration; visual linguistics; self-concept development; phototherapy; visual communication; visual symbology; visual expression; visual anthropology; visual learning; visual education; artistic expression; visual awareness; visual understanding; visual creativity; visual analysis; visual evaluation; visual message encoding; visual message decoding.

3. Refers to a group of vision competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences. The development of these competencies is fundamental to normal human learning. When developed, they enable a visually literate person to discriminate and interpret...visual actions, objects, and/or symbols, natural or [artificial]...Through the creative use of these competencies, [we are] able to communicate with others. Through the appreciative use of these competencies [we are] able to comprehend and enjoy the masterworks of visual communication (p. 60).

These explanations of visual literacy are useful in trying to develop a superficial conceptual framework about visual literacy. However, they are rather vague and open to a variety of interpretations. For example, in definition *1.a.*, visual literacy is defined as "a group of vision competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences." But what is meant by *competencies* that are developed which make one *visually literate* and how are they actually *developed*? And, what are the other *sensory experiences* that are integrated at the same time?

In definition *2.* visual literacy is defined through a provision of a variety of visual art jargon such as: "visual thinking; visual aesthetics; creative exploration; visual linguistics; self-concept development; phototherapy; . . ."etc. But what do these phrases *mean*? For example, the term "phototherapy" used in definition *2*, is defined by *Funk & Wagnalls Standard College Dictionary (1974)* as: "Treatment of diseases, especially skin diseases, by the application of light." The connection between skin disease and visual literacy is difficult to understand. Definition *3.*, as in *1.a.*, refers to visual literacy as " ... a group of vision competencies a human being can develop ... " but, as in *1.a.*, there is no definition of what the criteria are for *competency*.

A review of the literature on visual literacy reveals a widespread lack of accepted definitions. It would seem that those providing a definition of visual literacy do so from a viewpoint that reflects their related field of study. This has created, according to Baca and Braden (1990) " ... an apparent lack of agreement as to what the components of visual literacy are and how critical an element each construct is. The result has been the lack of a comprehensive description of the field of visual literacy and of the related elements and constructs which underlie it" (p. 99). In a proposed Delphi study by Baca & Braden (1990), the following were provided as some commonly applied definitions of visual literacy:

> The abilities required to learn, understand, think, communicate and store information in one's mind visually.
>
> The ability to understand and use images, including the ability to think, learn, and express oneself in terms of images.

Other definitions of visual literacy offered by experts in the field include:

> The active reconstruction of past visual experience with incoming visual messages to obtain meaning (Sinatra, 1986, p. 5).
>
> An integration of critical viewing with critical thinking such that a visually literate person is one who can identify, analyze, interpret, evaluate, and produce visual messages (Curtiss, 1990, p. 171).
>
> The ability to comprehend and create information that is carried and conveyed through imagery (Considine & Haley, 1992, p. 14).

Peterson (1996) contends that "As the instructional designer prepares courseware with a visual emphasis, it is best done with principles consistent with the constructivist definition given by Sinatra (1986) ... *the active reconstruction of past visual experience with incoming visual messages to obtain meaning*" (p. 3). Signs of multimedia learners and designers who demonstrate visual literacy are listed as follows (Peterson, 1996):

1. Grasp composition of images
2. Decode meaning of images
3. Infer from images
4. Disregard emotional interference during critical analysis
5. Manipulate image mentally
6. Translate visual data into verbal insight
7. Incorporate new visual information into existing core of knowledge
8. Communicate through showing, arranging and composing visual images (p. 4).

When the multimedia designers are visually literate, multimedia learners are capable of making better choices and are more capable at gathering information from environments which are verbo-visual rich (Peterson, 1996). A virbo-visual rich environment is where multimedia has been designed in a way that learners can infer information from both the visual and textual information.

As we move into this age of visual multimedia, then, there appears to be a need to make certain we are using visually literate design strategies. Specifically, there is a need for educators to practice more enlightened visual strategies using the principles of design (Kirrane, 1992). According to Branch & Moore (1990), "overhead transparencies, page layouts and bulletin boards usually present a flow of words down the page in straight text or outline form" (p. 16). With the use of visuals in the learning process, we also need (according to Branch & Moore, 1990) empirical support that "will enable the diagrams [visuals] to be effective as a medium on the basis of their instructional qualities rather than on their decorative qualities" (p. 16). In other words, individuals who are using visuals and words to facilitate the transfer of information need to be concerned about ensuring visually literate strategies are applied.

Noticeably absent in the contribution to the education technologies literature on visual literacy are the views and opinions by *artists and art critics*. However, their opinions can be found in other literature. Generally, most artists and art critics would accede that design principles (unity, focal point, balance and colour) are necessary to create a good visual image (Graves, 1941; Lauer, 1979; Greenberg & Jordan, 1991; Riddell, 1984). According to Graves (1941), the design principles are the building blocks of any visual design: "When an artist organizes these elements he [she] creates Form, which is Design or Composition ... [If we are to create such a visual image] we must understand the elements and principles of design" (pp. 3-4). This is not to say, however, that every good visual design needs every design principle; but when the designer is striving for a technically good design, the use of design principles produces a visual image which is that much better.

Summary

As we move away from a text based society and toward a more visual society we need to be concerned about whether we are creating and interpreting visual images accurately. Educators who are providing visuals as a means of communication in the learning process need to be able to produce visual designs that are *visually literate*. There is much disagreement in the literature about how visual literacy should be defined. In general terms, however, visual literacy can be defined as "the ability to comprehend and create information that is carried and conveyed through imagery" (Considine & Haley, 1992, p. 14).

Design Principles

Introduction

There is much literature which indicates that effective programs use both words and visuals to communicate and support the organization of materials (Benson, 1985). Yet, while the vast majority of studies indicate that the use of visuals as an instructional aid facilitates learning, other studies indicate that not all visuals are equally effective in all instructional environments (Dwyer, 1978; Kirrane, 1992). Could it be that failure to use design principles are what make some visuals less effective than others in the learning process? And not, as Dwyer (1978) and others (Kirrane, 1992) claim: too much detail? The principles of design (unity/harmony, focal point/emphasis/dominance, and balance) are described in this next section.

Unity/Harmony

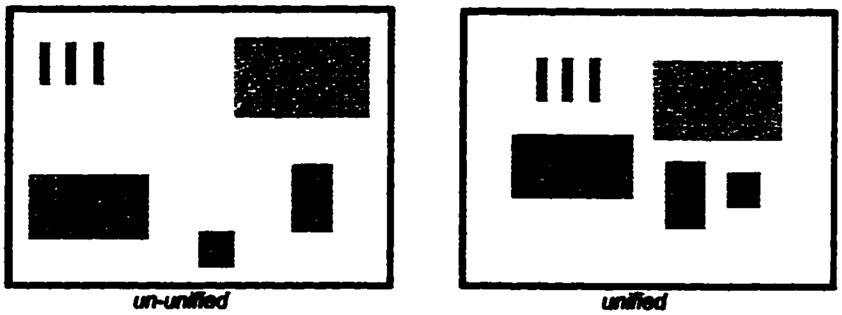
> Unity implies that a congruity or agreement exits among the elements in a design; they look as though they belong together, as though there is some visual connection beyond mere chance that has caused them to come together. Another term for the same idea is harmony. If they appear separate and/or unrelated, your pattern falls apart and lacks unity (Lauer, 1979, p. 2).

According to Graves (1941), unity can be defined as a cohesion, consistency or oneness. It is also, according to Graves (1941), the fundamental design element of a visual composition: "Composition implies unity; the words are synonymous. To say that a composition lacks unity is a contradiction of terms. If it does, it is not a composition" (Graves, 1941, p. 52). According to Lauer (1979), the purpose of unity is to make a visual image coherent and readable.

Creating unity is, according to Lauer (1979), a relatively easy task; it is already in our nature to seek organization—or to *make sense of things*. Specifically, the observer is already searching for some coherent unity; all the designer must do is provide some clues (Lauer, 1979). Every visual image is a collection of units or items; the challenge is more in the *organizing* of the elements (Taylor, 1981). In other words, it is the skill of organization (or *design*) that produces a unified pattern.

A critical consideration of visual unity is that the whole must dominate over the parts; the viewer must first perceive the entire design prior to observing the individual elements (Lauer, 1979; Taylor, 1981; Graves, 1941; Greenberg & Jordan, 1991). It is also important not to confuse *visual unity* with *intellectual unity*: "Visual unity denotes some harmony or agreement between the items that is apparent to the eye ... A conceptual unity is not observable by the eye. A unifying idea will not necessarily produce a unified pattern" (Lauer, 1979, p. 4). There are several ways to achieve unity, such as: proximity, repetition and continuation (Graves, 1941; Lauer, 1979).

Proximity: A relatively simple approach to make separate elements look as if they belong together is by placing the elements close together. Figure 1 is an example of a unified and un-unified composition.



If the units are to be viewed as a group, the space between each object should be less than the width of each object (Scott, 1951).

Figure 1

Repetition: According to Graves (1941), repetition is probably the oldest and simplest way of creating unity. Figure 2 provides an example of a unified composition that has been achieved through repetition.

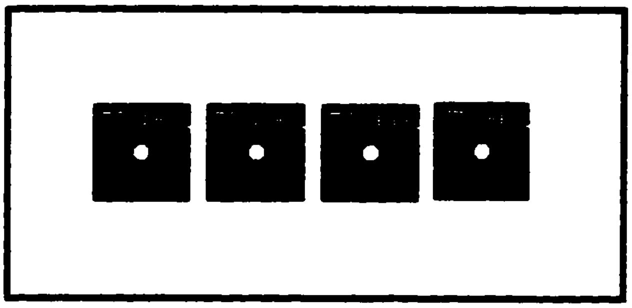
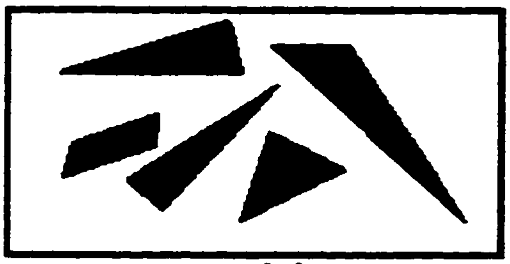
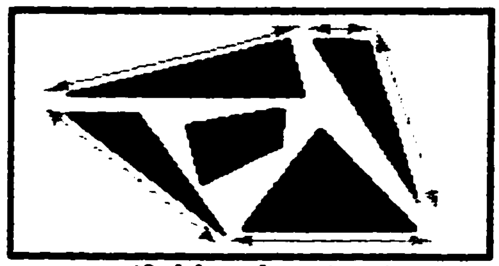


Figure 2

Continuation: This technique is more subtle and difficult to achieve (Lauer, 1979). It involves something (such as a line or an edge) that moves the viewer's eye from one object to another. The designer must carefully place the objects so they are just touching or almost touching one another. Figure 3 provides an example of a unified composition that has been achieved through continuation.



un-unified



unified through continuation

Figure 3

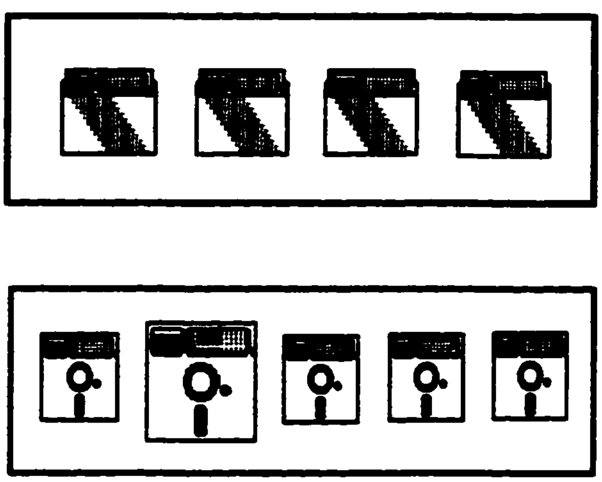
Appendix A provides an example of an un-unified and unified screen used for this study.

Focal Point (Dominance or Emphasis)

> The designer's main enemy is boredom. It is almost better for viewers to stand and revile your image, rather than to pass it quickly with a bored "ho-hum." [The designer's] job is to catch attention and provide a pattern that stimulates the viewer by offering some visual satisfaction. Nothing will guarantee success, but one device that can help is a point of emphasis, a "focal point." This attracts attention and encourages the viewer to look further . (Lauer, 1979, p. 22)

When creating a visual image a designer will want to lead the viewer's eye into the visual image; to achieve this, designers use a *focal point* also referred to as the centre of interest, dominance or point of emphasis (Riddell, 1984). The purpose of a focal point is to draw attention and encourage the viewer to continue looking (Lauer, 1979, Graves, 1941; Greenberg & Jordan, 1991). A focal point alone will not make a design; rather, it is a tool designers use to 'grab' the viewer's attention (Lauer, 1979). The ways to achieve focal points are endless. The following are two common techniques.

Contrast: When one element differs from the others, a focal point occurs. This can be achieved in a variety of ways but, generally, when the overall feeling or pattern is interrupted, the eye is attracted to the difference—no matter how subtle (Lauer, 1979, Bates, 1960). Figure 4 provides an example of a focal point achieved through contrast. Even when there is just a slight change on the object third from the left, the eye is attracted to it. A point of caution: according to Lauer (1979), any contrast must be done with moderation. The focal point, for example, must remain a component of the overall design, not a strange object out of place. If a focal point is too prominent, it may overpower the rest of the design; when this happens, the viewer's eye never leaves the focal point to see the rest of the visual image (Lauer, 1979).

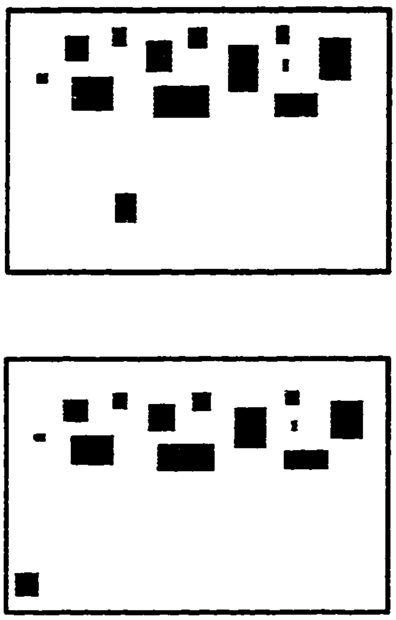


a. When the overall feeling or pattern is interrupted, the eye is attracted to the difference—no matter how subtle.

b. If a focal point is too prominent, it may dominate the rest of the design; when this happens, the viewer's eyes never leaves the focal point to see the rest of the visual image.

Figure 4

<u>Isolation</u>: When one object is positioned apart from other objects it becomes a focal point (Lauer, 1979). That is, by separation, an object takes on a visual importance. The object does not need to be any different from the other elements; it becomes different by its placement, not its form. Figure 5 is an example.



a. The object does not need to be any different from the other elements; it becomes different by its placement, not its form.

b. There is also a point of caution here: if a focal point is positioned too close to an edge, it will tend to draw the viewer's eye out of the picture.

Figure 5

Appendix B provides an example of a composition with an inappropriate focal point and and an appropriate focal point used for this study.

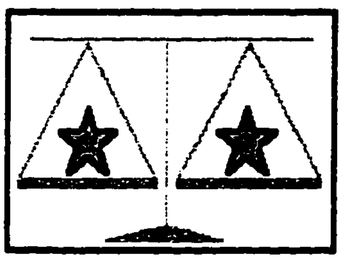
<u>Balance</u>

> A sense of balance is innate; as children we develop a sense of balance in our bodies and observe balance in the world around us. Lack of balance or imbalance disturbs us. Dangerously leaning trees, rocks, furniture, ladders, and so forth are avoided carefully. But even when no physical danger is present, as in a design or painting, we still feel more comfortable with a balanced pattern (Lauer, 1979, p. 36).

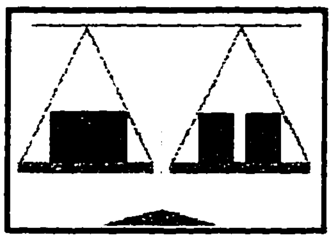
Once a designer selects the images for a composition, a decision must be made on how these images are to be balanced within the page (Riddell, 1984). This requires, according to Riddell (1984) "some thought, experimentation and experience" (p. 42).

When looking at a visual image we envision a vertical axis and usually expect to see some sort of *visual weight* grouping on either side (Lauer, 1979; Greenberg & Jordan, 1991; Poore, 1967). This functions as the fulcrum on a scale and should provide a sense of balance. When this balance is not present a "certain vague uneasiness or dissatisfaction results. We feel a need to rearrange the elements, in the same way that we automatically straighten a picture on the wall" (Lauer, 1979, p. 36). There are two ways to achieve balance: symmetry and asymmetry (Scott, 1951; Bates, 1960; Lauer, 1979; Beitler, 1969).

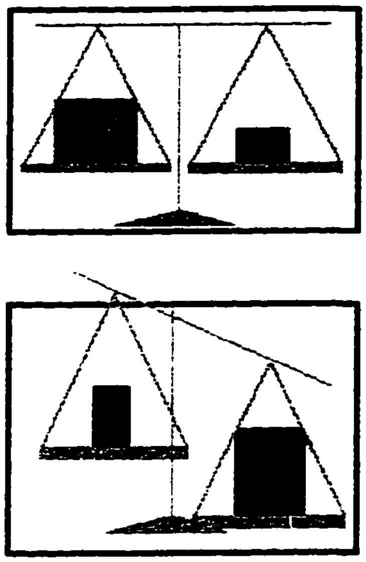
Symmetry: Symmetrical balance involves objects that are repeated in the same positions on either side of a central axis. This type of balance is the easiest to develop and the most natural way to attain balance for beginning designers (Lauer, 1979). Figure 6 a, b, c and d are a few examples of compositions with symmetrical balance.



a. Identical objects from the center create formal, bisymmetrical balance.



b. Two small objects balance one large object when placed equal distances from the center. This is obvious formal balance.

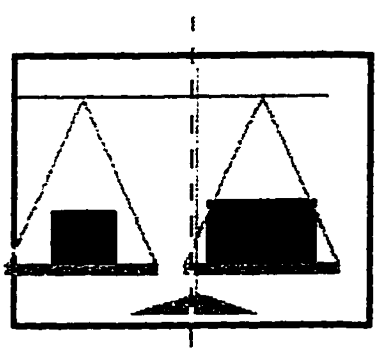


c. A small dark element balances a large light element when placed equal distances from the center.

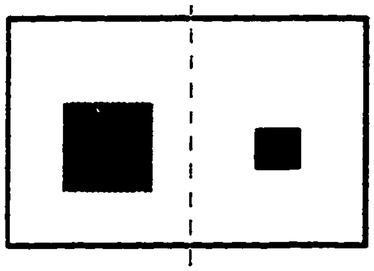
d. When a larger, dark object is placed lower, it becomes a balanced composition.

Figure 6

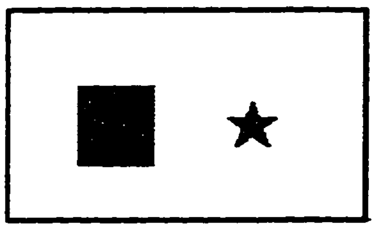
Asymmetry: Balance can also be achieved with dissimilar objects that have equal visual weight or equal eye attraction (Lauer, 1979). Asymmetrical balance is more complicated to accomplish as it requires a 'causal' relationship. Asymmetrical balance can be achieved through colour, value, shape, texture or position (Lauer, 1979). **Figure 7** a, b, c, d and e are a few examples of compositions with asymmetrical balance.



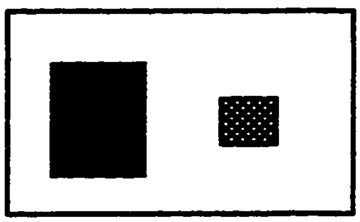
a. A large dark object placed closer to the center balances the smaller dark object placed further from the center.



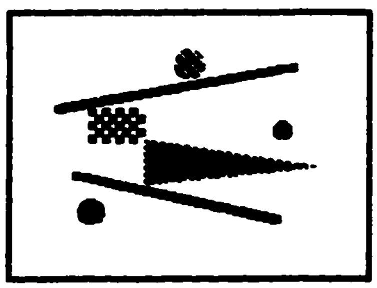
b. A darker, smaller element is usually equal to a lighter, larger one.



c. A small complicated shape is balanced with a larger more stable shape.



d. A small textured shape can balance a larger, untextured shape.



e. A variety of sizes and values of objects can be arranged to give the effect of equal weights in informal balance.

Figure 7

Appendix C provides an example of a balanced and unbalanced screen used for this study.

<u>Summary</u>

The principles of design include: unity/harmony (continuation, proximity and repetition), focal point/emphasis/dominance (contrast and isolation), balance (symetry and asymmetry), and colour. The principles of design under investigation for this study were: unity, focal point and balance; colour was not a variable under investigation for the study. The reason colour was not a variable under investigation was due to the fact that there is a lack of understanding about our colour genes as well as the science of colour (colour physics). This lack of information would make it impossible for the researcher to determine how colour influences the learning process. Another factor contributing to the decision not to include colour was that the use of colour could create a number of uncontrolable variables. Examples would include:

- the possibility of participants having colour blindness;
- it would be very likely that the participants would have different colour monitors and/or different monitor contrast and brightness settings; and,
- as colour is a property of light, any change of lighting would change the colour used.

To avoid these problems, the computer based lessons were developed without colour.

A review of the literature on colour and information on colour as a design principle is located in **Appendix D**.

Screen Design and Layout

Introduction

Expert writers and designers of computer based instruction recognize that effective programs are those that use both words and visuals to communicate and support the organization of material (Benson, 1985). The design of effective computer screens using both words and visuals, according to Heines (1984), requires knowledge of "the special characteristics of computer-driven screens, an artistic sense of layout and balance, creativity and sensitivity to the characteristics of the people who will be viewing the screens" (p. ix). Following is a review of the literature on screen design for text and graphics.

Screen Design for Text

There is considerable information on the use of text in computer based instruction. This section provides an overview of the research on text density/readability factors, text layout and text style.

Text Density/Readability Factors

A common printing standard is to fill about 50% of a page; however, studies of online information find 80% of the screen filled (Jackson in Duin, 1988). A somewhat more recent review of the empirical research by Tullis (cited in Duin), discovered that "after examining studies recommends overall text densities of 25% to 60%, with preference closer to 25%" (p. 48-49). Yang & Moore (1996) are also of the opinion that "a lean language uses not only concise syntax, but also simple expressions. It allows only one theme in each paragraph or on one screen. A lengthy and complex paragraph will overload memory, cause confusion, and decrease interest" (p. 10). Research cited by Rimar (1996) provides some support for this assumption: "Text densities for screen-based programs are optimal at around 25 percent of screen area. Segregating information into discrete locations increases readability, and makes it clear what information is available in which location on the screen (Gropper, 1991). Reducing screen density holds many advantages for the learner" (p. 248). Heines (1984) notes that many screens pack too much information on each screen. According to Grabinger & Albers (cited in Rimar, 1996) designers should "present only one main (but complete) idea per screen. This provides two benefits: the first is limiting the amount of content that goes on a screen; the second focusing the message designer on the amount of available screen area" (p. 247). Duin (1988) also notes that "many inexperienced people design a screen on the computer as they would a page in a class handout" (p. 48). This results, according to Rimar, in screens "that are too full, poorly conceptualized, and hard to use. Rivlin *et al.* (1990, p. 5) note that it is better to use computers to display what they show best and that large volumes of text are better delivered in print form" (p. 247).

A final point, relating to the above information, includes a number of research studies which have found that "... reading screen text is 24-29 percent slower than reading regular text, in part due to character legibility, and that single-spaced text on screens is read eleven percent slower than double spaced text (Kruk & Mater, 1984; Merril, 1982). All of this, as Rubens & Krull (1985) point out, allow for ample room for screen text and for spreading information across several screens instead of squeezing it into one" (cited in Duin, 1988, p. 49).

Text Style

When developing learning materials on a paper-based platform, according to Rimar (1996), text resolution is generally not an issue: "Even common magazines are printed at 1,200 dots per inch (DPI), which is quite sufficient for most purposes" (p. 250). However, as Rimar also notes, screen-based technologies lack this resolution: "A typical computer display has a resolution of 640 x 480 pixels (picture elements), and a display area of approximately 10.5" x 7.5" (for a typical 14" diagonal screen). This yields a total resolution of approximately 64 pixels per inch ... [that] results in compromised legibility of delicate graphics and typefaces" (p. 250). As was noted in the text density section, reading off the computer screen is 24-29% slower than reading off a paper platform; this is due, in part, to the character legibility on computer screens (Duin, 1988).

According to Rimar (1996), to combat the problem of character legibility on the computer screen, designers should use a sans serif font. Yang & Moore (1996), on the other hand, suggest that the use of fonts with serif are preferable to non-serif fonts. And Lynch (cited in Rimar) states "that typefaces used in electronic documents should be judged solely by their appearance on screen (rather than their printed appearance)" (cited in Rimar, p. 250). A serif font has tags that hang from the lines which form the letters whereas a non-serif font is uses straight and smooth lines to form the letters, without any tags. Figure 8 is an example of a serif font and a sans-serif font.

This font is SERIF

This font is SANS-SERIF

Figure 8

Whatever the typeface chosen, it has also been suggested that proper kerning should be applied to the typeface chosen (Rimar, 1996): "Although this technique can be abused by making the variations in width too great, a font with variable letter widths is generally pleasing to the eye and promotes readability (Heines, 1984; Lynch, 1994b)" (p. 250). Kerning text means to adjust the spacing between pairs of letters. Text with certain letter pairs, such as AV, often looks better when the letters are moved closer together. Figure 9 is an example of a kerned font and a non-kerned font.

AV

AV

Figure 9

It has also been suggested that uppercase and lowercase characters be used (rather than solely uppercase). Research cited in Rimar (1996) concludes that "using capital letters as a cueing device lowers comprehension when compared to the standard typeface, and using bold print as a cueing device raises comprehension when compared to the standard typeface" (p. 249). Dumas (1988) also notes that when we read, we do not look at the individual letters in a word but we see the word in its entirety as a pattern. Thus, when upper case is used solely, this pattern is lost. Additional research cited by Rimar notes that people read lower case text at a faster rate (p. 251). Based on this evidence, then, designers should use sentence case — except, possibly, in single line headings.

In regard to the text size, Heines (1984) suggests that it should be consistent throughout the main body of the text. This opinion is also supported by Gropper (cited in Rimar, 1996). The reason being, is that when the main text is one size it is then possible to "set up a hierarchy by using other sizes for titles, emphasis and special effects, without confusing the learner" (Rimar, p. 250). According to Duin (1988) students also rely on on-line cues in order to move through computer based instruction:

> "The use of headings, underlining, boldface print, changes in typeface or style, or a change in placement, can all act as reader cues. Since the left placement of material has been found to speed retrieval and improve readability (Hartley & Brunhill, 1976), headings or cues placed in this area should be in boldface or underlined. Another means of aiding students to find specific instructions is to put this text in highlighted blocks (Simpson, 1982). Rubens & Krull (1985) also recommend placing blank lines between paragraphs and indenting paragraphs if the text is not already somewhat broken up" (p. 49).

These kinds of text layouts, according to Yang & Moore (1996) facilitate the cognitive process. However, Heines (1984) cautions that these kinds of character attributes should not be overused as their main purpose is to emphasize titles and key words in the body text. Heines also suggests using size to emphasize titles as he considers it more visually pleasing than underlining words. Gropper (cited in Rimar) on the other hand, states a preference for underlining as a visual cue for titles, but also acknowledges that underlining in the body text can decrease readability of the line below — especially in single-spaced text. And yet another opinion offered by Dumas (1988) prefers uppercase letters for single words identifying titles — but also acknowledges that it is less effective for other uses.

Finally, a study by Aspillaga (1991) demonstrated "that information placed in a consistent location within the monitor screen facilitated the transfer of information and enhancement of learning" (p. 91). Both Rimar (1996) and Dumas (1988) also support this notion by stating that consistency should be sustained across all applications: "A factor that is significantly more important in screen-based programs than in paper-based materials is consistency of location ... this helps the learner locate whatever information is being sought, and makes use of the interface easier" (p. 247). Lynch (cited in Rimar, 1996) also confers that "since reading on screen is much more difficult than reading from text from the printed page, it is appropriate to establish a clear and consistent graphic layout for text blocks in designs that incorporate large amounts of text" (p. 247). Graber & Albers (cited in Rimar) are also of the opinion that "choosing one section of the screen for particular use is appropriate ... it is a good practice to have the learner input responses at one screen location consistently, preferring the bottom of the screen for this task" (p. 247).

Consistency of location can also provide a benefit for the developer as well as the learner. As Rimar (1996) and Lynch (cited in Rimar) point out consistency of location of information provides an ability for the developer to reuse these elements from screen to screen: "this permits the developer to create each new screen without having to stop and re-invent the layout approach to handle each new design problem" (p. 247).

Text Layout

As was pointed out in the section on text density, reading text on a computer screen is slower than on a paper platform. It is possible, according to some experts, to use certain layouts that can help increase computer screen readability (Duin, 1988; Rimar, 1996). Advice offered often includes information on the placement and form of text.

Well developed computer screens, according to Lynch (cited in Rimar, 1996), make important information immediately obvious: "if done correctly in screen-based programs, the medium is transparent" (p. 246). Unfortunately, according to Rimar, many designers try to design the computer screen as they would on paper: "This does not work well, because most learners expect to see a whole page on the screen at once. Emulating a typical printed page is possible in a computer application, but it forces the learner to constantly scroll back and forth to see all of the information, which is quite cumbersome" (p. 246). It has been suggested that using paging sequences, rather than scroll bars, is more suitable to display large amounts of text (Rivlin *et al.* in Rimar, 1996).

According to Duin (1988) online text should be centered on the page; research also indicates, according to Duin "that the left half of the page has a strong influence on reader attention (Niekamp, 1981); therefore, Simpson (1982) suggests that on-line text be centered and only cued information be placed on the far left" (Duin, 1988, p. 49).

Line length should be short: "acceptable line lengths for printed documents range from 3 1/2 to 5 1/2 inches. While no standard has yet been set for the screen, guidelines do call for short lines" (Bork, Franklin, Blum, Katz & Kurtz cited in Duin, 1988, p. 49). Yang & Moore also support this assumption: "Say only what needs to be said; use short words and short sentences" (p. 10). Heines (1984) asserts that type size and line length have a direct relationship and advises a maximum line length of 8 to 10 words per screen. However, according to Rimar (1996), this advice seems archaic today as computer screens are capable of displaying text with better clarity (greater pixel density). Yet, Rimar also acknowledges that it is best to error on the side of caution, "making type larger and lines shorter than necessary ... Whatever the line length and text size, filling a screen with one big block of text will result in decreased readability" (p. 252).

Column layout should be in a single-column format, according to Rimar (1996). This opinion is supported in a study cited in Duin (1988) which found two-column formats reduced the reading rate by 200 wpm. As a result, it has been recommended that single-column formats should be used for on-line information. The reason cited for the results of this study is, in part, due to the extra movement that the learner's eye must do to read a two-column format.

According to research cited by Duin (1988), the right margin should be ragged; studies investigating the use of right justification have found that a larger percentage of technical reports use ragged right-hand margins. The reason being, according to research cited by Duin, is that researchers found that ragged right margins provide visual reference points that guide the eye smoothly down the page.

Dumas (1988) states that most conventional print-based conventions should still be applied to screen design. Some of these rules include avoiding, whenever possible, the use of abbreviations and acronyms, dates and codes should be aligned by their delimiters, alphabetic data is best left justified and numeric data should be aligned at the decimal point, or right justified when no decimal point exists. Duin (1988) adds to this list of conventions by stating that text should still be broken up and suggests breaking lines at the end of words rather than hyphenating. Duin also cites research that found readability increases with double-spaced text. Rimar (1996) cites research by Lynch (1994b) which found "increased line spacing, especially when used in 10-12 point sizes, can greatly improve reader speed and comprehension" (p. 251). These researchers also suggest that computer-screen designers should use enhanced leading (3-4 points more than the size of font selected) if double spacing is not used. Blocks of text should also be broken up by using bulleted lists, numbered steps and specific examples where appropriate. In addition, when developing lists, it is better to have the lists vertical so the viewer can scan down, rather than across columns (Rimar, 1996). Dumas also suggests that single spacing should be used for lists but a blank line should be inserted every fifth entry for ease of readability.

Summary

Many experts in the field of computer-based learning offer advice on the use of text claiming that it is a crucial part of screen design. Guidelines have been provided on the text style, text layout and text density; according to these experts following these guidelines can enhance readability and comprehension. However, very little of the advice provided is supported with empirical studies. Furthermore, the empirical studies that do support some of these guidelines were conducted prior to the 1990s. Generalizing research done prior to the '90s should be done with circumspection as computer screen technologies today are considerably superior at displaying text than in the 1980s.

Overall, based on these guidelines, on-line text should be centered, large, kept below 50% of characters available on the screen, short line length, single-column format, ragged right margin and information cueing should be on the left part of the screen with a consistent location.

Graphics

We have all heard the saying: "A picture is worth a thousand words." Is this true? According to the literature on this topic, it would seem that sometimes this statement is true and sometimes it is not true. Adams & Hamm (1989) state: "studies confirm that the power and permanency of what we learn is greater when visually based mental models are used in conjunction with the printed word. Inferences drawn from visual models can lead to more profound thinking" (p. 7). Yang & Moore (1996) suggest that "to discover the meaning of abstract concepts, learners should have basic and concrete knowledge first ... Graphics provide more cues, such as spatial and transitional relationships, to help learners decode and remember the knowledge content" (p. 9). Considine & Haley (1992) corroborate these statements; their studies show that "visualization often facilitates comprehension of verbal or printed language" (p. 28). Research by Teng-Mei Chao, Cennamo & Bruanlich (1996) show that graphics, when combined with text, "exert a positive effect, encourage deep processing, and improve fact retention. These findings are particularly true for poor readers. Recall is generally enhanced when graphics depict information central to the text, when they represent new important content, or when they represent structural relationships mentioned in the text" (p. 41). Alesandrini (1987) found that the use of visuals in the learning process increases the amount learned by adults; Pressley (1977) found this to also be true in children. Rieber & Kini (1991) cite research which indicate that adults are more likely to spontaneously form internal images than children. Duin (1988) cites research which indicates that graphics should be used as a *road map* to guide the readers through exercises. Soulier (1988) states that learners are more likely to read text that is associated with a visual image and that the use of visuals is one of the most important ways to attract and hold a learner's attention. Reiber & Kini (1991) confirm that computer graphics, when designed appropriately, enhance learning in computer-based instruction. They (1991) also cite the following advantages: "they aid visualization of spatial relationships between concepts and rules in short-term memory (Cooper & Shepherd, 1973). They can act as powerful mnemonics for remembering verbal information and concrete concepts (Paivio & Csapo, 1973; Pressley, 1976). Additionally, graphics are commonly believed to be effective attention-gaining devices and help increase the affective appeal of learning facts and materials" (p. 83).

There is sufficient evidence which indicates that the use of visuals facilitates the learning process. According to Steinberg (1991):

> Nonverbal visual materials can increase learner motivation and concentration. Visual materials can prepare students for learning by grabbing their attention with pictures or animation related to the subject matter, such as a map of a country to be studied. In CAI, visuals can display inaccessible processes such as changes in the shape of sound waves that accompany changes in pitch, or changes that evolve over long periods of time, such as genetic changes in fruit flies. Visuals can illustrate, clarify, or supplement verbal information (Dwyer, 1985, Steinberg, 1984). Graphic displays can supplement understanding even when verbal text is straightforward. (p. 142)

Many of the guidelines for using graphics in computer based instruction are similar to the guidelines for text. For example, according to Rimar (1996), a visual image with delicate lines and poor layout will not convey information well. On the other hand, also according to Rimar, "designing graphics as if they were text elements (bold clear lines, simple designs, and proper spacing) will produce usable graphics" (p. 254-255).

Problems with the Research

An attempt in this chapter was made to collect recent research articles. However, it was observed that many of the authors used in this section of the literature review cite previous authors' works; unfortunately, much of that research is paper platform (not used on computer screens) and/or the computer equipment used in the research is outdated. At best, any research done prior to the 1990s may only be marginally related and should be generalized with much caution. The reason is that technologies available today are considerably better at displaying visuals than in the 1980s when most computer monitors were either CGA or MGA with low pixel densities. On this topic Misanchuk & Schwier (1995) state: "Age alone does not necessarily invalidate generalizations, but one has to wonder whether the results of investigations conducted on the hardware available in the 1960s or 1970s or even the 1980s really has currency in today's rapidly shifting technological world. For example, the rapid emergence and widespread dissemination of high resolution, many-bits-deep colour monitors throws into question generalizations derived from studies conducted on relatively coarse-grained monitors capable of displaying only six or eight colours" (p. 14). Confounding this problem is that many of the research articles did not even state the type of hardware used for their research or the research cited.

Another problem with determining the effectiveness of visuals in the learning process, based on the research literature cited in this section, relates to the *instructional* *situation*. Specifically, as Misanchuk & Schwier (1995) point out: "it is difficult to talk about using [a visual] out of the context it serves. What may be an effective use of [a visual] for title screens may be wholly inappropriate in information screens, visual data bases, or testing contexts" (p. 8). Moreover, many articles cited in this research review cite other research articles that are not sufficiently similar in tasks. There is a general consensus that "a high degree of similarity between a research task and real life is essential. That fact seems to have been glossed over in some of the recent research in screen design" (Misanchuk & Schwier, 1995, p. 17).

There is also some evidence in the research literature to indicate that the mere presence of visuals does not automatically guarantee better instruction (Steinberg, 1991): "Appropriately designed displays enhance learning. Designed without an understanding of how people gain meaning from them, displays can have no effect or can even interfere with learning" (p. 144). A study by Ruthkosky & Dwyer (1996) which investigated the combination of an illustration with a verbal organizer provides support for Steinberg's claim: the results of their study indicated that adding a visual to a verbal organizer "does not significantly increase the students' achievement of different educational objectives" (p. 38). Other studies indicate that not all visuals are equally effective in all instructional environments. For example, studies by Dwyer (1978) indicate that the effectiveness of visuals is primarily dependent upon:

> (a) the amount of realistic detail contained in the visualization used; (b) the method by which the visualized instruction is presented to students (externally paced vs. self-paced); (c) student characteristics, i.e., intelligence, prior knowledge in the content area, reading and/or oral comprehension level, etc.; (d) the type or level of educational objective to be achieved by the students; (e) the technique used to focus student attention on the essential learning characteristics in the visualized materials, e.g., cues such as questions, arrows, motion,

> verbal/visual feedback, overt/covert responses, etc.; and (f) the type of test format employed to assess student information acquisition, e.g., for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction (pp. xiiv-xiv).

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

However, these studies are in direct conflict with what graphic designer Tufte (1990) maintains are essential attributes resulting in effective visuals for envisioning information. For example, it is Tufte's (1990) opinion that when designers need to clarify a visual design, they should add detail. Specifically, Tufte (1990) states (in direct contradiction with Dwyer's research studies and the research cited by Kirrane, 1992):

> What about confusing clutter? Information overload? Doesn't data have to be "boiled down" and "simplified"? These common questions miss the point, for the quality of detail is an issue completely separate from difficulty of reading. *Clutter and confusion are failures of design, not attributes of design.* Often the less complex and less subtle the line, the more ambiguous and less interesting the reading .... Confusion and clutter are failures of design, not attributes of information. And so the point is to find design strategies that reveal detail and complexity—rather than to fault the data for an excess of complication. Or, worse, to fault viewers for a lack of understanding (p. 50-53).

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

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

With the increasing availability of computer clip art software and associated graphic tools, the application of visuals in computer based instruction has increased enormously over the past few years. As computer clip art software expands and the capabilities of new computer hardware to display these visuals gets better this trend is likely to increase. This fact can already be seen in commercial software packages. It should be no surprise, then, to see that many computer based instructional designers have followed the lead of the commercial producers and indiscriminately incorporated visuals into their programs. In agreement with Rieber & Kini (1991) having the capability to use graphics does not automatically grant the designer the wisdom to use them appropriately. "Perception and memory are at least two of the important theoretical bases upon which the identification of appropriate instructional design considerations should be derived" (Reiber & Kini, 1996, p. 86).

Summary

While there is a plethora of research available on the use of visuals in computer based instruction, there is, in fact, very little valid guidance. Research has provided us with the following information on the use of visuals in the learning process with computer based instruction:

- Sometimes visuals facilitate the learning process.
- Sometimes visuals impede the learning process.
- Sometimes visuals do not have an influence in the learning process.

CHAPTER THREE

Design And Methodology

Introduction

This study addressed the following question: How do achievement, study time and completion rate vary with screen layouts using design principles, compared with screen layouts that use poor design principles, in computer based instruction with part-time adult learners from a research university in Western Canada? The hypothesis examined, setting, subjects, instrumentation and methodology (including data collection and analysis procedures) are described in this chapter.

Hypotheses Examined

The first hypothesis determined how **post test achievement scores** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles.**

Null Hypothesis I: There will be no significant differences in information recall on achievement scores between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles.

The second hypothesis determined how **time spent on task** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles.**

Null Hypothesis II: There will be no significant differences in time on task between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles.

The third hypothesis determined how **post test achievement scores** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles** on the basis of **gender**.

Null Hypothesis III: There will be no significant differences in information recall on achievement scores between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles on the basis of gender.

The fourth hypothesis determined how **time on task** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles** on the basis of **gender**.

Null Hypothesis IV: There will be no significant differences in time on task between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles on the basis of gender.

The fifth hypothesis determined how **completion rates** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles**.

Null Hypothesis V: There will be no significant differences in completion rates between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles.

Design

The research design used was a randomized, single factor, two-level posttest-only experimental design.

Setting

Data collection took place at a research university in Western Canada whose Faculty of Extension provides a number of certificate and diploma programs as well as non-certificate courses and serves the northern area of a province in Western Canada.

Subjects

One hundred and thirteen subjects who were enrolled in a research university in Western Canada were asked to participate in this study; 87 agreed to participate; fifty two of the eighty seven who agreed to participate completed the computer based tutorial and post test required for this study.

Demographic studies have been conducted on the student population for this kind of education service. Based on the results of these studies it was anticipated that the sample would consist of 70-80% female (20-30% male) who have two to six years post secondary education. As a convenience sample was utilized in this study (rather than a random sample of students), it was possible that a bias was introduced. Demographic data was collected to determine the nature and extent of the bias. There was, as anticipated, an uneven distribution of males and females in this study: twelve males and forty females participated in this study all of whom had two to six years post secondary education.

Four classes from the Certificate in Adult and Continuing Education (CACE) and one adult education class from the undergraduate program in the Department of Education Policy Studies, participated in this study. The students who were enrolled in the CACE program were part-time learners; the classes were held during the day Fridays and Saturdays once a month. Students from the undergraduate class were part-time evening students; evening classes were held weekly.

All students were asked to participate in this research project by the researcher; the researcher was not the instructor for any of these classes. To participate in this study, students had to have access to a computer with Windows 3.1 or Windows 95, 25 Mhz 386, preferably 33 Mhz 486 with 8 MB RAM, 256 colour-SVGA monitor with 1 MB video RAM, mouse and a 3.5 inch high density floppy disk drive. One hundred and thirteen subjects were asked to participate; 87 agreed to participate. The initial assignment of students was 43 for the computer based tutorial with good design principles (group one) and 44 (group two) for the computer based tutorial with poor design principles. Of the 43 participants in group one, 32 completed the computer based tutorial and post test (74%); of the 44 in group two, 20 completed the computer based tutorial and post test (45%).

The students were informed that they were volunteers and free to withdraw at any time without penalty (a copy of the consent form is in **Appendix E**). They were also informed that those choosing to participate in this study would be asked, upon completion of the computer based tutorial, to complete a pen and paper post test. The content (which was *How to Write a Term Paper*) was not required content or relevant to any of the course objectives. The post test was a 36 item multiple choice questionnaire that took approximately 15 to 20 minutes to complete. The post test and key used for this study are in **Appendix F**.

In order to optimize participation rate, it was explained by the researcher to the participants that this study would provide them with three benefits:

- as volunteers they will help to contribute to the research in education;
- they will have an opportunity to experience a non-traditional instructional technique; and,
- they will acquire information on how to write a term paper.

Methods

Computer Based Instruction Development

The computer based tutorial was designed and developed by the researcher using Authorware Professional (version 2.2) on a Macintosh computer and converted to the Windows Operating Systems. To participate in this study the participants had to have access to a computer which had the following system requirements: Windows 3.1 or Windows 95; 25 Mhz 386, or better with 8 MB RAM; 256 colour-SVGA monitor with 1 MB video RAM; mouse; and a 3.5 inch high density floppy disk drive. These system requirements were listed on the information form and the label on the diskette.

There were two versions of the same computer based tutorial, both consisting of identical content: both computer based tutorials had exactly the same text based information, graphics and design (such as title pages, help menus, content menus and paging sequencing). To ensure that colour did not act as a confounding variable, the lessons were developed in black, white and various shades of gray. Table 1 identifies the style features that were used on each of the screen displays.

Table 1

Style Features

Feature	Description
Typeface	Times New Roman
Case	Mixed case characters for all text were used with the exclusion of some titles
Size of fonts	Varied from 12 pt. to 18 pt.
Subject Matter	How to do a term paper
Graphics	A variety of graphics were used from MS Word, Word Perfect, Corel Draw, Authorware and the Public Domain
Directions	Directions were provided both on-line and orally from the researcher

Design principles studied included: unity, focal point and balance. Colour was not used as a design element. Appendices A, B and C provide examples of display screens for each design element used in this study.

Group one was provided with a computer based tutorial that had screen layouts which used good design principles; group two was provided with a computer based tutorial that had screen layouts which used poor design principles. A graphic artist was used to judge whether the screen layouts used design principles in one version of the computer based instruction and whether the screen layouts did not use design principles in the other version of the computer based tutorial. Both lessons are included in the pocket of this thesis.

A sub-routine was also developed in the computer based instruction program that tracked the time spent doing the computer based lessons; this time was displayed on the last screen. Instructions were given to the participants by the researcher to state this time on the bottom portion of the information form (located in Appendix G and H) and return it to the researcher.

Achievement Instrument

Achievement testing in this study was used to serve as an assessment tool to measure learning outcomes. This study used a pen and paper criterion-referenced multiple choice exam based on the objectives for the computer based instruction program. The multiple choice questions were designed to measure cognitive achievement in terms of recall. Interpretation, analysis, and application were not studied. The measurement of achievement was defined as the score that subjects attained on the post test; the post test assessed the influence of the design principles on achievement in a specific content area.

The achievement instrument (post test) consisted of a 36 question, pen and paper, multiple choice exam. Each test question was scored and entered on Excel for Windows 95 for data analysis by the researcher. These calculations were double checked as correct using the SPSS software for Windows 3.11 (release 6.1). A copy of the post test is in **Appendix F**. **Appendix I** is an illustration of how the post test scores were entered.

Content validity of the exam was evaluated by an objective comparison of the test items with the computer based instruction content and objectives. A systematic evaluation of the terms specific to the content, specification of objectives and a description of how the content was sampled to develop the test items was completed by the researcher. It should be noted that the achievement instrument did not cover *all* the content which was covered in the computer based tutorial; it was a *representative sample* of the content. Because content validity is concerned with the match between the content of the researcher's course and the test the researcher developed, the researcher did the content-validity analysis. A reliability analysis-scale (Cronbach's Alpha) was also conducted to determine if the items on the post test were standardized (standard deviation of 1). The reliability coefficient is based on the average correlation of items within a test. If the items are not standardized, it is based on the average covariance among items. Negative values for alpha occur when the average interitem correlation is negative, which violates the reliability model. Using SPSS for Windows (release 6.1), the Cronbach's Alpha for the post test used in this study = .99.

Procedures

The two versions of the computer based instruction program were copied to 3.5 inch diskettes for use with Windows Operating System or Windows 95. One version of the computer based tutorial was marked with an orange dot on the label, one other version was marked with a purple dot. Each student who agreed to volunteer was randomly assigned to one of the two versions of the computer based tutorial on *How to do a Term Paper*. The content of the computer based tutorial was not required content relevant to the course objectives. Students were randomly assigned to one of the two groups using a class list and a table of random numbers (located in the Appendix of Borg & Gall, 1989).

It was explained to the participants by the researcher that they were to do the lessons on their own time (at home, work or elsewhere). The next class (one day later) those who completed the computer based tutorial were asked to do a post test exam based on the information in the computer based tutorial. Those who could not complete the computer based tutorial by the following day, but could within a few weeks, were provided with the post test and a self addressed, stamped envelop and asked to mail it to the researcher upon completion. An example of the hand out provided to those who mailed in the achievement instrument is located in Appendix H. Participants mailing in the results were asked to wait at least two hours before completing the post test.

An explanation of how to load the program was provided orally as well as a written hand out and on the label of the diskette. Appendix G is an example. An explanation of how to use the computer based tutorial was provided in the introduction of the lessons. This introductory information included how to move from one screen to another, how to select a menu option and how to exit at any point during the lesson. A copy of the lessons used in this study are on 3.5 inch diskettes and placed in a thesis pocket.

A title page indicated the introduction to the program. Following the title page was information on how to use the computer based tutorial, next was a menu indicating the course content which was *How to do a Term Paper*. The entire tutorial should not have exceeded 30-45 minutes—although the completion times ranged from 21 minutes to 61 minutes. A table of completion times for this study is located in **Appendix J**. The post test was a pen and paper multiple choice exam consisting of 36 questions. The post test did not exceed 20 minutes. The data from the post test was entered for analysis on an Excel spreadsheet for Windows 95. A table of the scores for this study is located in **Appendix I**. The consent forms and post tests will be kept by the researcher for a period of five years and then destroyed. Consent forms were supplied and returned by the subjects prior to their participation in this study. **Appendix E** is a sample consent form.

Pilot Test

A pilot test was conducted prior to data collection and data analysis. It was carried out with four subjects, similar to those of the sample, to determine if problems existed with the data collection and data analysis procedures. It was hoped that any problems with data-collecting routines, scoring techniques, statistical and analytical procedures as well as terms, clarity of instructions and ease of completion would be discovered in the pilot test. Based on the feedback provided, revisions were made.

Ethics

An explanation of the purpose of this study was provided orally by the researcher to the subjects prior to participation as well as in a written hand out provided to the subjects by the researcher. A sample of the handout is in **Appendix G**. The purpose of this study was explained to the subjects as an interest in determining whether different screen designs have an influence on learning. The subjects were also given the following information:

- the expected duration of the computer based tutorial (approximately 30 minutes),
- a description of how confidentiality will be maintained,
- who to contact regarding any questions or problems resulting from this study,
- a statement that participation is voluntary and refusal to participate will not involve a penalty or loss of benefits to which the subject is otherwise entitled, and
- withdrawal at any time will not result in any penalty or loss of benefits to which the subject is otherwise entitled.

A consent form was developed which indicated that the test results on each subject will be kept confidential. The bottom portion of the information form was developed indicating that the results of this study would be provided upon request (a sample of the information form is included in **Appendix G and H**). At no point during the study were subjects required to state their name (with the exception of the consent form) or personal identification number.

Computer Based Instruction Development

Group one (*n=32*) was provided with the computer based tutorial that had screen layouts which used design principles. Group two (*n=20*) was provided with the computer based tutorial that had screen layouts which did not use design principles. Examples of screen layouts which used design principles and screen layouts which did not use design principles are in **Appendices A, B and C**. A graphic artist was used to judge whether or not the screen layouts used design principles in one version of the tutorial and screen layouts which did not use design principles in the other version of the tutorial.

Data Collection

Each participant was given a pen and paper multiple choice retention post test with questions based on the information on the screens which did and did not use design principles. The post test scores for both groups were entered on an Excel spreadsheet for Windows 95 in tabular form. **Appendix I** is an example of the spreadsheet.

Summary

Fifty one subjects participated in this study. Four classes from the Certificate in Adult and Continuing Education program (CACE) participated in this study and one undergraduate adult and higher education class from the department of Education Policy Studies. The researcher was not the instructor for any of these classes and the computer based tutorial content (which was *How to do a Term Paper*) was not required content or relevant to any of the course objectives. Data for this study were collected using a pen and paper multiple choice retention test. The data were then analyzed on Excel (version 7.0) for Windows 95 to determine if there was a significant influence on achievement with screen layouts using design principles compared to screen layouts that do not use design principles with adult learners from a research university in Western Canada. The results from the data collected and analyzed are presented in the following chapter.

CHAPTER FOUR

Data Analysis and Results

Introduction

This study addressed the following question: How do achievement and lesson time vary with screen layouts using good design principles, compared with screen layouts using poor design principles, in computer based instruction with part-time adult learners from a research university in Western Canada?

Hypotheses Examined

The first hypothesis determined how **post test achievement scores** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles.**

> Null Hypothesis I: There will be no significant differences in information recall on achievement scores between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles.

A *t*-test was used to determine equality of means. Null Hypothesis I (of no difference between group one and group two) was not rejected. As is shown in Table 2 there was no significant difference in post test achievement scores in the lessons that contained screen layouts that used design principles compared to the lessons that contained screen layouts that did not use design principles.

Table 2

***t* Distribution - Scores on Achievement Instrument**

Design Principles	Group One (*n=32*) *M*	Group Two (*n=20*) *M*	*t* Value
Group Mean	30.61	29.15	1.54
	STD = 3.2	*STD= 3.4*	

The second hypothesis determined how **time spent on task** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles.**

> Null Hypothesis II: There will be no significant differences in time on task between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles.

Null Hypothesis II identified the difference in time spent completing the computer based tutorial between group one and group two. A *t*-test was used to determine equality of means. As is shown in Table 3 there was a significant difference in post test time spent completing the lessons that contained screen layouts that used good design principles compared to the lessons that that used poor design principles. Hypothesis II (of no significant difference between group one and group two) was, therefore, rejected.

Table 3

***t* Distribution - Time to Complete Computer Based Tutorial (minutes)**

Design Principles	Group One (*n=32*) *M*	Group Two (*n=20*) *M*	*t* Value
Group Mean	34.23	41.30	-2.59
	STD = 8.2	*STD = 10.3*	

The third hypothesis determined how **post test achievement scores** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles** on the basis of **gender**.

> Null Hypothesis III: There will be no significant differences in information recall on achievement scores between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles on the basis of gender.

Null Hypothesis III was conducted to determine the difference in group one on the basis of gender for scores on the achievement instrument; it was not rejected. As is shown in Table 4 there was no significant difference in mean achievement scores on the basis of gender for group one. A *t*-test was used to determine equality of means. An analysis of group two was not conducted as the numbers were insufficient to assess an equality of means (there were two males and eighteen females for group two; group one had ten males and twenty one females).

Table 4

***t* Distribution - Scores on Achievement Instrument based on Gender**

Design Principles	Group One (n=10) *Male*	Group One (n=21) *Female*	*t* Value
Group Mean	30.60	30.62	.01

p<.05

The fourth hypothesis determined how **time on task** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles** on the basis of **gender**.

Null Hypothesis IV: There will be no significant differences in time on task between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles on the basis of gender.

Hypothesis IV was conducted to determine the difference in group one on the basis of gender for time on task and was not rejected for group one. As is shown in Table 5 there was no significant difference in time spent on task on the basis of gender for group one. A *t*-test was used to determine equality of means. An analysis of group two was not conducted as the numbers were insufficient to assess an equality of means.

Table 5

***t* Distribution - Time Required to Complete the Computer Based Lessons based on Gender (minutes)**

Design Principles	Group One (n=10) *Male*	Group One (n=21) *Female*	*t* Value
Group Mean	34.70	34.00	-.22

p<.05

The fifth hypothesis determined how **completion rates** varied with screen layouts that **used good design principles** compared to screen layouts that **used poor design principles.**

Null Hypothesis V: There will be no significant differences in completion rates between lessons containing screen layouts using good design principles and lessons containing screen layouts using poor design principles.

Null Hypothesis V identified the difference in completion rates for the computer based tutorial between group one and group two. A *t*-test was used to determine equality of means. As is shown in Table 6 there was a significant difference in completion rates between the lessons that used good design principles compared to the lessons that used poor design principles. Hypothesis V (of no significant difference between group one and group two) was, therefore, rejected.

Table 6

t Distribution - Completion Rates

Design Principles	Group One	Group Two	t Value
Group Mean	32	20	2.76

$p<.05$

One hundred and thirteen subjects who were enrolled in a research university in Western Canada were asked to participate in this study; 87 agreed to participate. Each student who agreed to participate was randomly assigned to one of the two versions of the computer based tutorial using a class list and a table of random numbers (located in the Appendix of Borg & Gall, 1989). The initial assignment of students was 43 for the computer based tutorial with design principles (group one) and 44 (group two) for the computer based tutorial without design principles. Of the 43 participants in group one, 32 completed the computer based tutorial and post test; of the 44 in group two, 20 completed the computer based tutorial and post test.

There was no significant difference in post test achievement scores in the lessons that contained screen layouts that used design principles compared to the lessons that contained screen layouts that did not use design principles. There was no significant difference in mean scores on the achievement instrument or time required to complete the computer based lessons for gender in group one.

However, there was a significant difference in time spent completing the lessons that contained screen layouts using design principles compared to the lessons that contained screen layouts that did not use design principles. Thus, to achieve the same score the learners with the screen design that did not use design principles had to spend significantly more time to achieve the same score as the learners with the screen design that used design principles.

Finally, there was a significant difference in completion rates between group one (screen layouts using good design principles) compared to group two (screen layouts using poor design principles).

CHAPTER FIVE

Summary, Discussion, Recommendations and Generalizability

Summary

This study addressed the following question: How do achievement, lesson time and completion rate vary with screen layouts using good design principles, compared with screen layouts using poor design principles, in computer based instruction with part-time adult learners from a research university in Western Canada?

Four classes from the Certificate and Adult and Continuing education and one adult education class from the undergraduate program in the department of Education Policy Studies, participated in this study. Two versions of the same computer based tutorial were developed by the researcher, both consisting of identical content: both computer based tutorials had exactly the same text based information, graphics and design (such as title pages, help menus, content menus and paging sequencing). The lessons were developed in black, white and gray-scale. Design principles which varied were: unity, focal point and balance. One randomly assigned group was provided with the computer based tutorial that had screen layouts which used design principles; the other group was provided with the computer based tutorial that had screen layouts which did not use design principles.

Achievement testing in this study was used to serve as an assessment tool to measure learning outcomes. This study used a pen and paper criterion referenced multiple choice posttest designed to measure achievement in terms of recall. Time spent doing the computer based lessons was tracked and recorded through a sub-routine in the program.

The *t* distribution was used to determine the level of statistical significance at the 0.05 level of the difference between the sample means. There was no significant difference in achievement scores between the two groups. Participants with the screen design that used poor design principles spent significantly more time (21%) than the participants with the screen design that used good design principles. It was also found that there was no difference in either achievement or time spent on task in group one on the basis of gender. Finally, it was also found that there was a significant difference in completion rate between the participants in group one (74% completion rate) and group two (45% completion rate).

Discussion of the Hypotheses Tested

In regard to achievement, following good screen design principles as used in this study appears not to affect achievement one way or the other. What this indicates, then, is that the design principles chosen in the study (unity, focal point and balance) do not appear to affect recall learning. A number of possible explanations could be provided to explain these results. First, the voluntary nature used in this study may have caused a self-selection that eliminated those whose learning would be affected by design. Second, as indicated in Chapter One, this study was limited to students who volunteer; it was also possible, then, that some bias existed because learners who participate in additional learning experiences are often the most dedicated learners. Third, all participants had from two to six years postsecondary education. Based on this fact, then, it was likely that all participants had some prior knowledge of the content of the lessons (*How to do a Term Paper)*. Finally, it was possible that the testing method did not reflect differences in design principles used in the study. Specifically, the task (computer based lesson) was textual and visual; however, the outcome (posttest) was entirely textual. The results of the achievement instrument (posttest), then, may have been different if it included both text and visuals.

However, the results of this study indicate that if we are concerned with minimizing learning time and maximizing learner completion rates, as we design screens for computer based instruction we should consider applying the principles of design used in this study. An explanation for the results that occurred in this study could be that the use of good design principles in computer based learning requires less unrelated processing of information as well as easier concentration on the content in terms of recall. This study does not support Dwyer's (1978) research and Kirrane's (1992) summary of the research that too much detail interferes with the learning process. Specifically, Dwyer and Kirrane state that some pictures and graphics may be counterproductive for learning when they are excessively elaborate or too realistic. This study does, however, provide support for the opinions of artists and art critics (such as Ducasse, 1955; Graves, 1941; Lauer, 1979) and graphic designer Tufte's (1990) claim that "it is not how much empty space there is, but how it is used. It is not how much information there is, but how effectively it is arranged" (p. 50). These experts in the field of art and design look for the following principles of design: unity (harmony), focal pint (dominance, emphasis). balance, and colour. These principles of design are achieved through the use of the following design elements (or *tools*) that a designer uses to express creative ideas: line, shape (form), texture, space, scale (proportion) and rhythm. The results of this study also partially support the opinions of those who advocate the need for computer screen designers to become visually literate. According to Peterson (1996), for example, when computer based designers are visually literate, learners are capable of gathering information more efficiently.

Another explanation of the results could be that, as the participants did the computer based lessons on their own (not in a controlled environment by the researcher), it was possible that some participants may have left the lesson running while attending to other activities resulting in an inaccurate record of time spent on task.

With respect to gender, the results of this study indicate that following good screen design principles appears to have no gender-based affect on achievement. The results of this study also indicate that following good screen design principles appears not to affect time on task between genders. An explanation for these results could be that the screen design principles chosen in the study do not result in learning differences between genders (time on task or recall learning). However, any possible explanation in respect to gender differences based on this study should be regarded with caution as the sample size for males was small.

Recommendations for Further research

To gain greater reliability of the findings from this study, it is necessary to replicate this study. Beyond the need to replicate this study as is, other suggestions for further research include:

- Extending the study beyond recall achievement to include higher levels of achievement. For example, this study could be extended beyond recall achievement to include the *ability* to do a term paper (the quality of performance) and/or to include the *time* required to do a term paper.
- The use of an achievement instrument that reflects the design criteria used in the lessons.
- Extending the study to other learners who have limited term paper writing experience.
- Conducting the study in a controlled environment, rather than having participants complete the lessons on their own time.
- Replicating this study with a balanced number of gender in each group.
- Isolate and attempt to determine which, if any, of the design principles used in the present study have a greater influence on time and completion.

Screen design is a complex issue and this study only investigated one variable of the many variables in screen design that influences the learning process. One variable that needs to be examined further is the completion rates between participants using screen layouts with design principles and those that do not. As the data were being collected it was noticed that of the 43 participants with the lessons using design principles (group one), 32 completed the computer based lessons and post test. However, of the 44 participants with the lessons not using design principles (group two), only 20 completed the computer based lessons and post test. In other words, almost three-fourths from group one (the computer based lessons with design principles) completed the study whereas less than one-half from group two (without design principles) completed the study. Appendices I and J are hard copies of the data collected on Excel for Windows 95 which illustrate this point. As drop-out rates in distant education (which can be defined as any form of learning that is not face-to-face) is a persistent problem, this is an area that should be explored further.

Generalizability of the Findings

One issue that must be addressed is the generalizability of the findings in this study to populations other than the subject group. In this study the subject population was a group of relatively well educated (all participants had two to six years post secondary education) students in an urban city who were enrolled at a research university in Western Canada. The results of this study, then, could be generalizable to a wide cross-section of Western Canadian post secondary students who are relatively well educated. Due to the small number of male students in group two (those participants that received the computer based tutorial with poor design principles), and small total sample size for males (twelve), the findings for male students should be not generalized.

Finally, much of the current research in computer based tutorials — such as the one used in this study that was developed using an authoring software package — is generalized to other computer platforms, such as the Internet. There are considerable differences between presentation of the information, programmed page layouts, page sequencing, speed of information retrieval and interaction capabilities with these two platforms. Thus, the findings in this study should be generalized to other computer platforms, such as the Internet, with caution.

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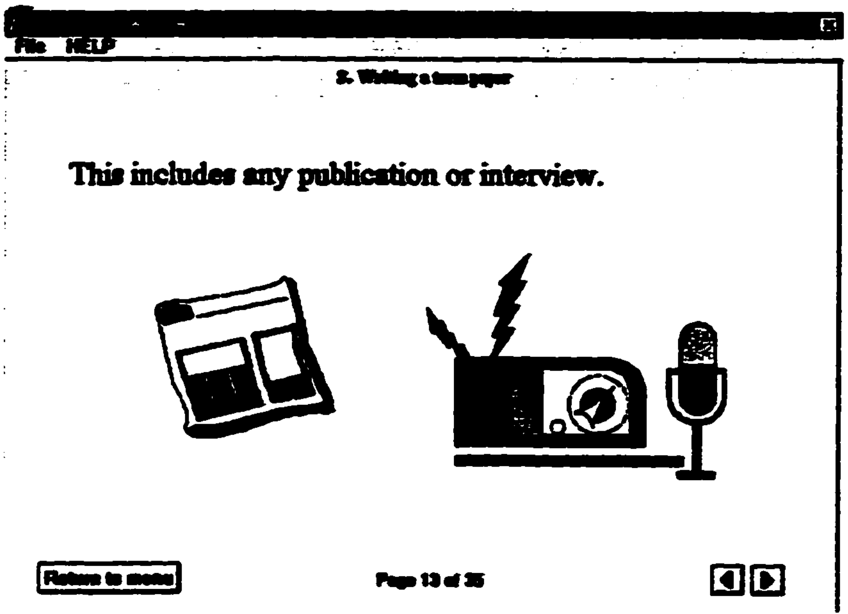
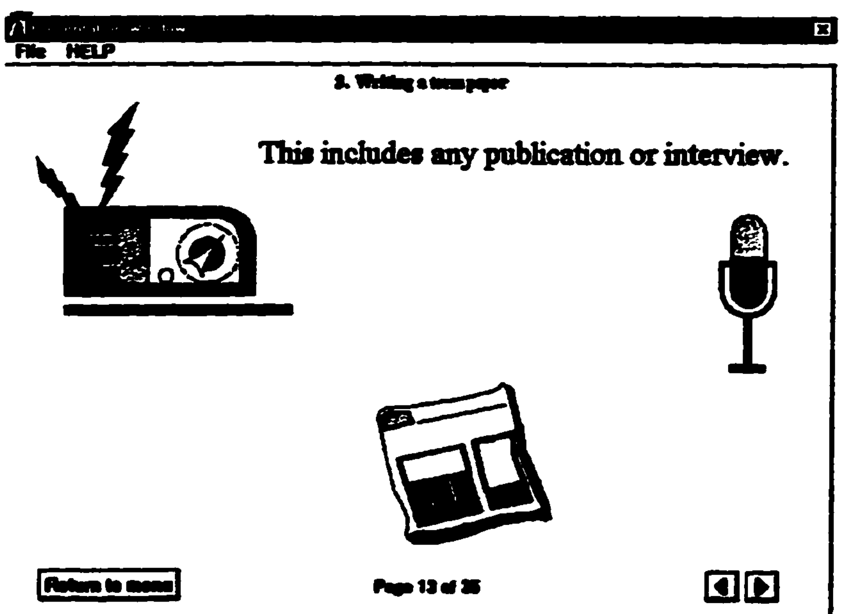
APPENDIX A. DESIGN PRINCIPLES: UNITY



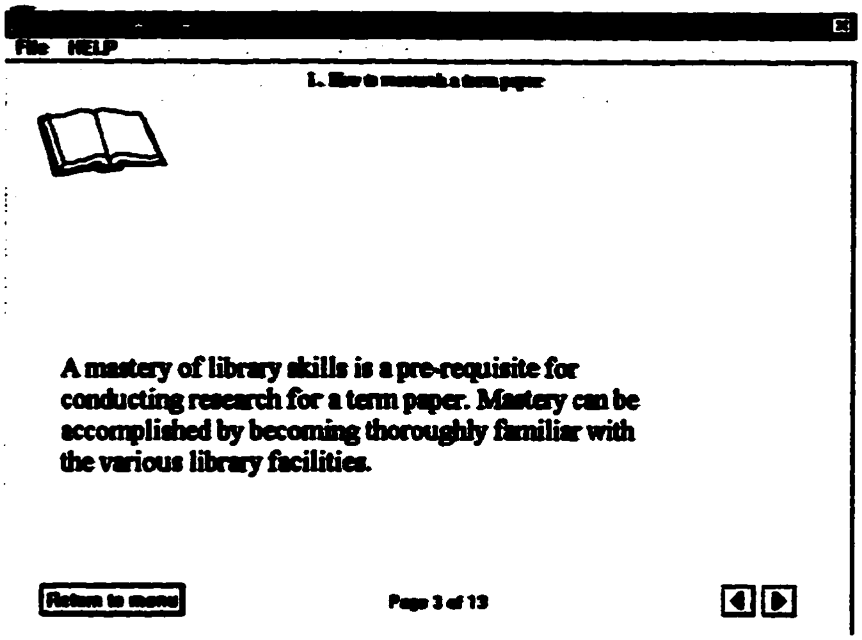
A.



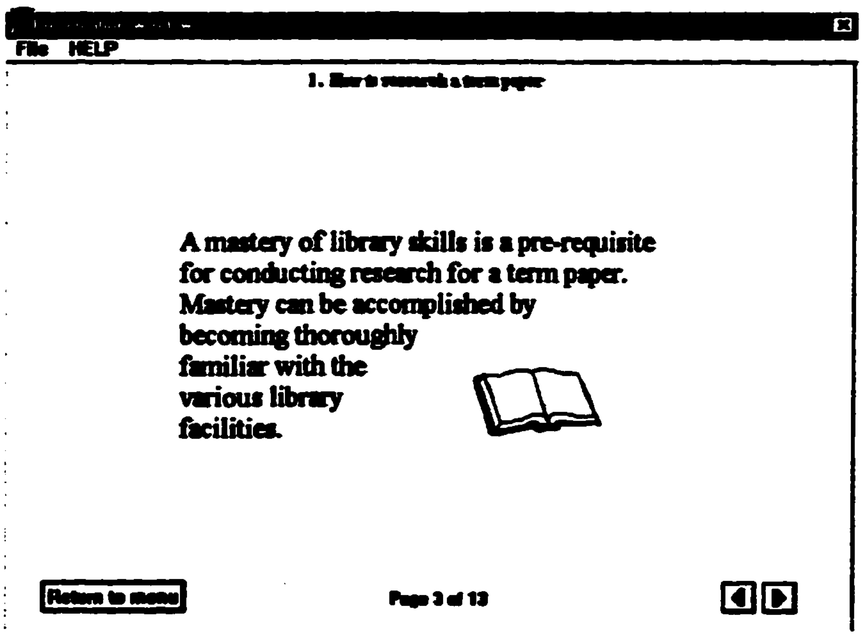
B.

B. lacks unity because: (1) the sum total of the square inches between the objects is greater than the total of the square inches around the objects as a group; and, (2) the objects are closer to the edge than they are to each other. A. holds together better as a unit.

APPENDIX B. DESIGN PRINCIPLES: FOCAL POINT



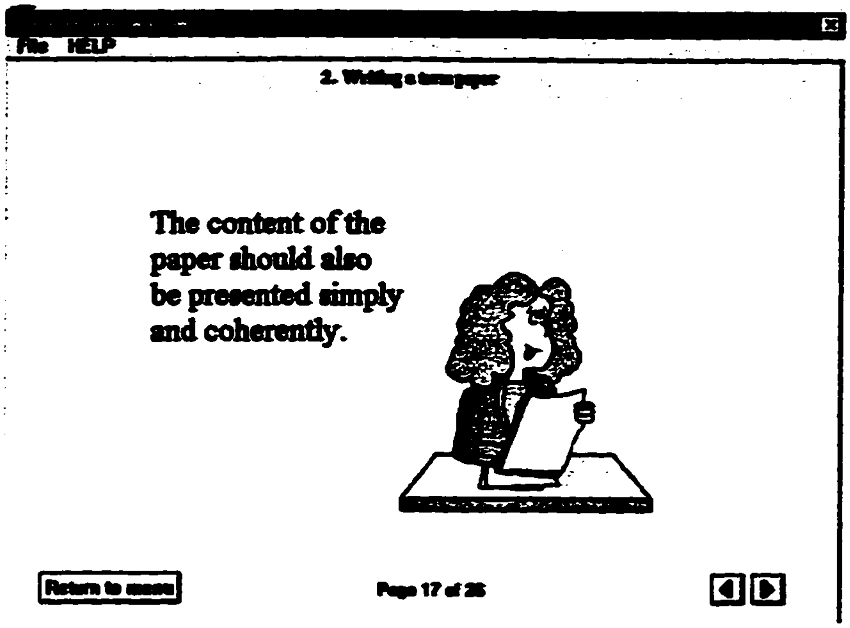
A.



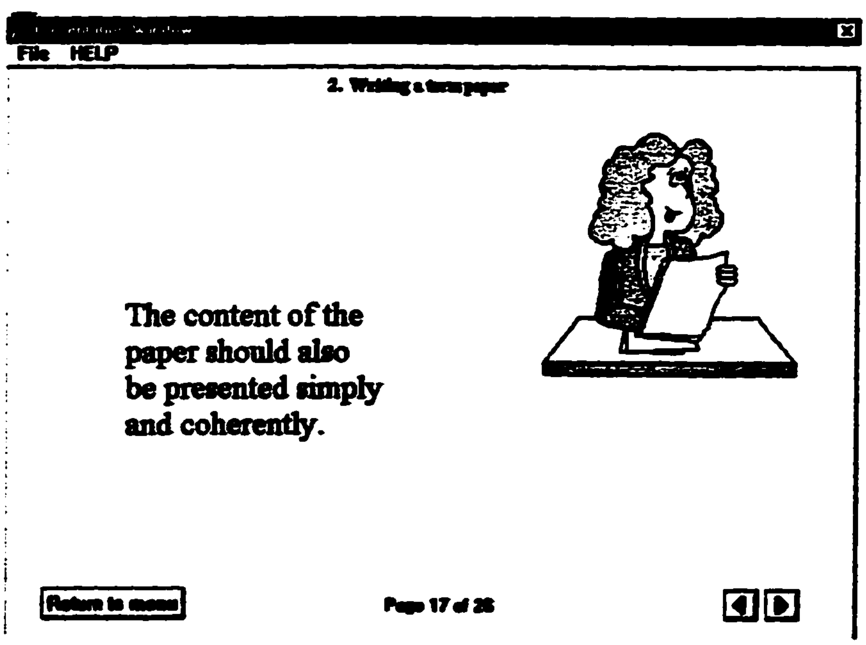
B.

When one object is positioned apart from other objects it becomes a focal point. An object can also become a focal point through contrast. In both **A.** and **B.** the graphic (book) is used to draw the viewer's eye into the screen. However, if a focal point is positioned too close to an edge, it will tend to draw the viewer's eye out of the picture, such as example **A.** In **B.** the dark edge of the book leads the viewer's eye into the text.

APPENDIX C. DESIGN PRINCIPLES: BALANCE



A.



B.

In example **A.** the large dark graphic placed closer to the center and slightly lower balances the smaller and lighter text placed further from the center. This is *informal* balance. **B.**, on the other hand, fails to achieve balance as the large dark graphic is placed too far away from the centre and higher than the lighter text.

APPENDIX D. COLOUR

Colour

Introduction

Colour theory is a very complex science—most of which goes beyond what the researcher needs to know. However, if a critical evaluation of the research is to be done on colour, some basic knowledge of colour theory is essential.

The most important aspect of colour is that it is a property of *light*. In 1676, Sir Isaac Newton discovered that when sunlight entered a prism the light dispersed into spectral colours: red, orange, yellow green, blue, dark blue, and violet (Itten, 1970). When a spectrum of colours was collected by means of a converging lens, the sum of the colours yielded white light again. In addition, if the spectrum of colours was divided into two parts (red-orange-yellow and green-blue-violet) and then collected with a converging lens, the result was two mixed colours—whose mixture with each other yielded white again.

It was also discovered that if one hue (the pigment of a colour) from the prismatic spectrum, such as green, was isolated and the remaining colours collected (red, orange, yellow, blue, violet) using a lens, the mixed colour obtained was red. These kinds of coloured light (whose mixture with each other is white) are referred to as *complementary*. These kinds of colour, discovered by Sir Isaac Newton, were produced by *refraction*. Other ways of generating colour include: interference, diffraction, polarization and fluorescence (Itten, 1970).

The importance of this discovery is that light waves are not themselves in colour. The human eye can perceive light wave lengths between 400 and 700 millimicrons and each hue (the pigment of a colour) can be accurately defined by specifying its wave length or frequency (Itten, 1970). Exactly how the human eye discriminates these wave lengths is not yet well understood (Kirrane, 1992).

Although we do not yet fully understand how our eyes discriminate wave lengths, we do know that some colours result from absorption and are known as *subtractive* colours. Specifically, if we hold a red and a green filter in front of an arc lamp, the two together will result in black (or darkness). A red filter, for example, absorbs all the rays in the spectrum except for the red interval, and the green filter absorbs all but the green. No colour is left over, and the effect is black. What this means, then, is that when we say that an object is red, what we are really saying is that the molecular composition of its surface absorbs all the light rays except red. The red object does not have colour itself; light generates colour (Itten, 1970).

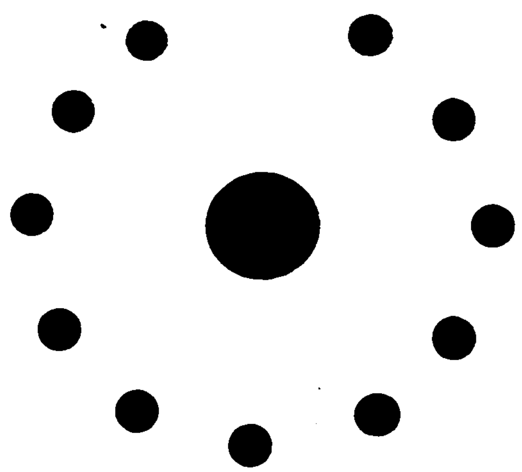
The Science of Colour

Colour (according to Itten, 1970) may be approached from three directions: (1) visually (hue, value and intensity; contrast), (2) expression (emotionally) and (3) construction (symbolically). Following is an overview of each.

Visually (Hue, Value, and Intensity)

According to Itten (1970), there are three ways colours are said to differ: hue, value and intensity.

Hue refers to the name of a colour (such as red, green, yellow) There are twelve hues in total according to the *Prang* colour wheel and are classified by primary, secondary and tertiary colours (Bates, 1960). An important aspect in understanding hue is that it pertains to the *pigment* of a colour. **Figure 2** is an reproduction of the Prang colour wheel:



Reading clockwise around the circle, the colours are:
Yellow, yellow-green, green, blue-green, blue, blue-violet, violet, red-violet, red, red-orange, orange, and yellow orange.

Figure 2

Value refers to the *lightness* or *darkness* of the hue. That is, the value of a pigment can be altered by adding white or black to the colour. When white is added to a pigment, the *tint* is adjusted. When black is added to a pigment, the *shade* is adjusted. Most people can discriminate between at least forty tints and shades of any colour. **Figure 2** is an example of a change of a colour's value:

Figure 3

Intensity refers to the intensity of the hue and is sometimes referred to as *chroma* or *saturation*. A colour is at its full intensity when it is unmixed. There are two ways to lower the intensity of a colour: mix a *neutral* grey to a colour, or, mix a colour with its complement (the colour directly across from it on the colour wheel). When a colour's brightness is lowered (or neutralized) it is often referred to as changing the colour's *tone*. **Figure 4** is an example of a change of tone in a colour with a green hue:

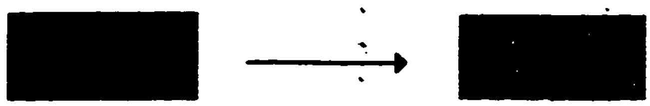


Figure 4

When complements are mixed in equal amounts, they produce a *neutral* tone (gray). As mentioned, a colour is at its full intensity (brightest) when it is unmixed. However, a colour's brightness can be intensified by placing its complementary colour right next to it. When blue and orange, for example, are side by side each colour will appear more intense than in any other condition (Itten, 1970). This effect is called *simultaneous contrast*. **Figure 5** is an example of colours which have been intensified.

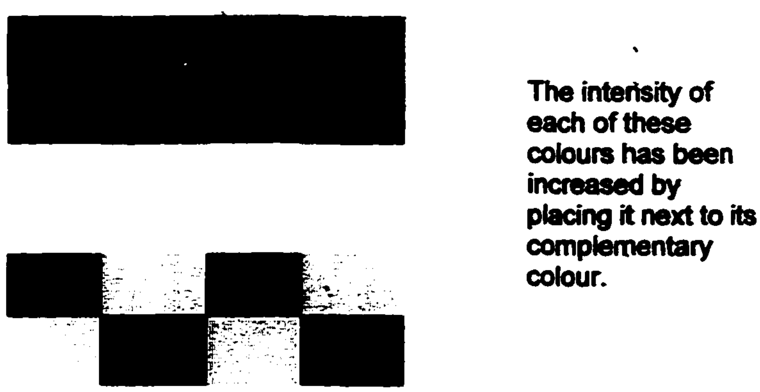


Figure 5

<u>Colour Contrast</u>

Colour can also be approached from the kinds of colour contrast. There are seven kinds of colour contrasts: contrast of hue, light-dark contrast, cold-warm contrast, complementary contrast, simultaneous contrast, contrast of saturation and contrast of extension Itten, 1979). Following are visual examples of the above kinds of contrasts.

Figure 6

1. The strongest expression of ***contrast of hue*** is yellow/red/blue.

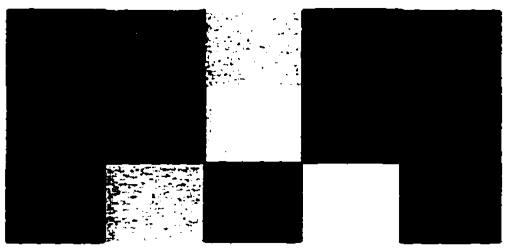


Figure 7

2. A ***light-dark contrast*** is easily recognized with black, white and grays.

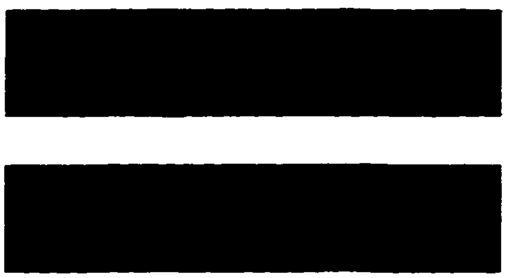


Figure 8

3. The strongest ***cold-warm contrast*** is red-orange/blue-green.

Figure 9

4. ***Complementary contrast*** of a mixture band of complementary pairs.

Figure 10

5. (a) This ***simultaneous contrast*** effect becomes more intense the longer the principle colour of a square is viewed. Although all three grays are the same colour, each square seems to be tinged with the complementary of the background.

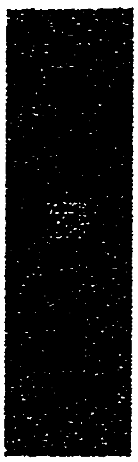


Figure 11

5. (b) The three small gray squares, surrounded by yellow-orange are barely distinct from each other, have been used for this example. The first gray intensifies the simultaneous effect; the second is neutral and suffers simultaneous modification; the third fails to be modified.

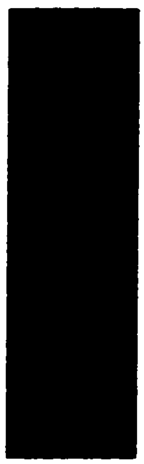
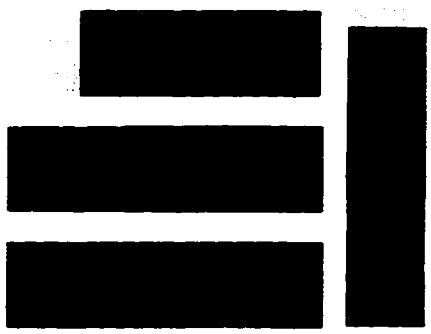


Figure 12

5. (c) The green squares have been intensified by placing them on a red background.

6. This is an example of ***contrast of saturation*** with a checkered pattern.

Figure 13



7. These are examples of ***contrast of extension*** for complementary colours.

Harmonious proportions of area for complementary colours:
Yellow : Violet = 1/4 : 3/4
Orange : Blue = 1/3 : 2/3
Red : Green = 1/2 : 1/2

Figure 14

<u>Emotional</u>

Have you ever felt *blue*? Have you ever been *green* with envy? Have you ever been so mad you saw *red*? Or been in a *black* mood? Using a colour reference can often clarify an emotional expression; there is no question that colour can stimulate certain emotions and feelings (Itten, 1970). It is well known that "even before we *read* the subject matter or identify the forms, the colour has already created an atmosphere to which we have responded." (Laurer, 1979, p. 231). For designers who do not understand the emotional effects of certain colour combinations, the result could be an unintentional arousal of an emotion in the viewer; on the other hand, colour is probably the most effective element for designers who *do* wish to arouse a certain emotional response (Lauer, 1979). For example, most of us recognize *cold* and *warm* colours. Colours, such as red, orange and yellow usually elicit a warm and happy feeling whereas pale blue and green draw a quieter, more melancholy emotion (Lauer, 1979).

Symbolism

Have you ever caught someone *red* handed? Have you ever told a *white* lie and was to *yellow* to admit it? Have you ever had a true *blue* friend?

Colour can also be symbolic, such as sin, innocence, cowardice and fidelity (Lauer, 1979). A main point to remember with the use of colour to represent symbolism is that it is cultural. For example, North Americans usually associate mourning with the colour black. However, in India it is white, in Turkey it is violet, in Ethiopia is it brown and in Burma it is yellow (Lauer, 1979). If you are European by decent, you would probably think of royalty in terms of the colour purple but in China it is yellow and in Rome it is red. And in marriage, we usually connect the colour white with a bride; yet in India and Rome it is yellow (Lauer, 1979).

Care in the use of colour for symbolism should be taken to ensure that the audience understands the cultural reference. In Canada with our *vertical mosaic* this may be difficult.

Summary

Colour physics is a science that is not yet well understood. Based on what we know, when using colour we should consider the following:

- Try to avoid using, on the same screen, the following colour combinations: purple-blue, green-brown, red-green (or consult a reference book on colour blindness). If the audience is older, avoid yellows or any colours with yellow combinations.
- Avoid the use of colour for symbolism unless you are sure that your audience understands the cultural reference.
- Try to be sensitive to any colour combinations that may arouse an unwanted emotional response (for example, pale blue and green combinations may prompt a melancholy mood.
- Select shapes for the colours that accurately communicate the colour's present emotional qualities. That is, "all elements of design should work together unless a deliberate incongruity (and visual confusion) is the desired effect ... A jagged angular, dynamic shape in a soft grayish blue can seem like a design contradiction. Feeling and shape are related to colour" (Lauer, 1979, p. 231).
- Avoid the use of *colour discord.* Colour discord is the combination of a primary and tertiary colour (for example, red and blue-purple), secondary and tertiary colour (orange and yellow-green) and two tertiary colours on either side of a primary colour (blue-green and blue-purple). These colour combinations are usually visually disturbing. *Moderate* discord, on the other hand, can cause exciting, eye-catching colour combinations (this can be achieved by altering the *value*) of the colours.
- Make good use of monochromatic, analogous, complementary and triadic colour harmonies: "knowing these harmonies can be helpful to designers in consciously planning the visual effects they wish a finished pattern (design) to have" (Lauer, 1979, p. 224).
- If colour is the primary vehicle of expression, do not draw lines on the screen and then add the colour. Composition must begin with the colour: "He who draws lines and then adds colour will never succeed in producing a clear, intense colour effect. Colours have dimensions and directionality of their own, and delineate areas in their own way" (Itten, 1970, p. 18).

Colour and Computer Based Instruction

The use of colour in computer based instruction has become a standard in the industry. Many different studies provide guidelines on the use of colour in screen design; much of the research is conflicting.

A study by Livingston (1991) found that the use of colour interferes with learning. Two other studies by England (1984b) and Reilly & Roach (1986) indicate that the use of too many colours will reduce the legibility of a presentation. Madge, Meyer & Sweezie (in Livingston, 1991) suggest the use of four colours in screen display. Yang & Moore (1996) cite research that advises the use of not more than four colours on a single screen. Rambally & Rambally (1987) state the use of up to eleven colours is acceptable in designing screen displays.

There appears to be somewhat better agreement within the literature as to the influence of colour versus non-colour on learning outcomes. A study by Hathaway (1984) found that most subjects will perform equally well under conditions of colour and non-colour (black and white). These results are in agreement with a study by Katzman & Nyenhuis (1972). However, these studies do not agree with a study by Durrett & Trezona (in Misanchuk & Schwier, 1995) which found that "material presented in colour is generally processed faster than the same material presented in black-and-white." (p. 10).

Colours most recommended (according research cited by Dolsky, 1993) include "green, cyan, white and yellow. Green, cyan and white are described as the most usable colors" (p. 2). Research by Dolsky (1993) concluded that combinations of vivid colours (such as red, purple, black, blue and magenta) were preferred by adults than less vivid colours (such as green, yellow and orange). Yang & Moore cite research that suggest that "red and blue text are difficult to read. Colours in the middle of the light spectrum are preferred for text" (p. 12). Other studies go so far at to state that "colour stirs the heart ... and other visual organs by influencing everything from blood pressure and endocrine functions to brain was patterns and strength (Horton in Misanchuk & Schwier, 1996, p. 8).

Misanchuk & Schwier (1996) conducted an in-depth investigation of the literature on the use of colour with computers. Following are the results of their findings (Misanchuk & Schwier, 1996, p. 10-13):

Amount of colour

- Use colour conservatively; limit the number and amount of colours used.
- Limit the palette per screen to what the eye can actually keep track of at one glance (usually about six colours, depending on the complexity of the screen design).
- Design first for monochrome displays, and then add colour.
- Long term users are capable of perceiving and responding to a broader range of colour and coding relationships, so the number of colours used can increase with experience.
- Use colours selectively to manipulate attention. Colour can be used to highlight text or graphics to make them conspicuous.
- Material presented in colour is generally processed faster than the same material presented in black-and-white.
- Use colour to help formatting.
- Use colour in graphic displays for greater information density.
- Electronically generated colours take on different properties in relation to each other.
- Wavelength affects colour differentiation: luminance affects legibility.
- Changes in brightness seem to cause changes in hue for all colours except blue, green and yellow. These should be used where colour shifting due to luminance changes could be detrimental.
- As viewers age, higher levels of brightness are needed to distinguish colours.

Consistency

- Be consistent in colour choices.
- Carefully select colours for all visual devices such as touch screens, buttons, menus, and titles.
- If colour coding is used in an information system, use it consistently.
- As with all uses of colour, consistency is crucial when using colour for coding information.

Choice of colour

- In selecting colour combinations, make sure they are compatible (avoid saturated complementary colours such as blue/orange, red/green, violet/yellow).
- Gray is a versatile colour. Use gray in inactive screen areas and backgrounds to enhance two or three other colours.
- Avoid background colours too high in brightness and saturation.
- Against gray backgrounds use light, highly saturated borders for active windows. One suggestion is that yellow is the only colour satisfying this requirement, while others argue that one should always use red, white, or yellow text on black. Regardless, attend more closely to brightness than hue for building contrast for legibility.
- Use high colour contrast for character/background. Incorporate shape as well as colour to make the system usable for those with colour-deficient vision.
- Dark text on a bright background is more legible than the reverse.
- Avoid using red and green at the edges of screens if you want people to notice those elements. People are less sensitive to red/green at the periphery of vision. If you must use them, make items blink before resorting to continuous display, to attract attention.
- Do not use blue for text, limit blue to large nonfoveal areas, but use it as a background colour to enhance depth perception.
- Avoid using pure blue for text, thin lines and small shapes. Individuals have difficulty focusing on blue.
- Strong colours should not be used over large adjacent areas. Use strong colours sparingly between dull background tones.
- When a quick response is necessary, use colours with higher degrees of saturation.
- Use colours found in nature, particularly toward the lighter side: grays, blues, yellows. These colours are widely considered harmonious.

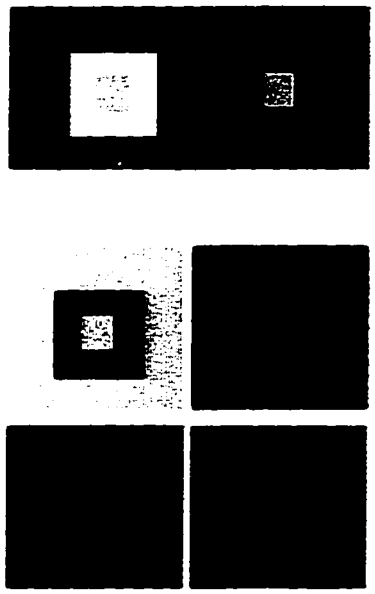
- For users with colour-deficient vision, use dramatic changes in colour to discriminate among elements by making changes in at least two of the three main colours. For example, displays in which only the red pigment is changed, while blue and green remain constant, will cause problems for these users.

Coding/Cueing with Colour

- Colour can assist learning if used as a redundant cue.
- Colour coding can link logically related data; differentiate between required and optional data; highlight errors; and separate prompts, commands, and other elements in the interface.
- Use commonplace denotations (red = danger, yellow = yeild). Care must be taken to ensure that denotations are indeed shared, as some are culturally determined, such as the colours of political parties. Similarly, resultant cultural connotations may emerge, such as red denoting socialism, in turn connotating revolution. These denotations and connotations may not be shared by different cultures.
- Choose distinctive hues, brightness and saturation differences for discrimination among major items. Poor colour memory may be overcome by carefully using colour to enhance discrimination.
- Ensure colour coding supports the task; have colour coding under user control; be alert to common expectations about colour codes.
- Use colour changes to indicate status changes.

How valid any of these studies on the use of colour with computer screens are, is questionable. An important aspect to consider when critically evaluating the research on colour is to understand that colour is a property of light. The main consideration in this fact is that as light changes the colour will also change. Hence, there is no one objective colour for any thing or object. This is important to remember because if any part of the lighting changes, it will change the colour the researcher has chosen. For example, the colour in a room with a forty watt bulb will appear differently than in a room with florescent lighting. With the exception of one research study (Dolsky, 1993) none of the researchers stated what the lighting was when conducting the study or whether the lighting was held constant.

In addition, colours will also change according to their surrounding. Even in the same light, a colour will appear different depending on the colour adjacent to it. When colours are viewed in combination with others, the visual differences are often dramatic. The result is a change in value (dark and light). Figure 15 is an example.



a. The yellow squares of equal size look bigger on white than on black.

b. These combinations show how the same blue is altered in expression by different juxtaposed colours. This example illustrates that colours change as their values and intensities change, even when the pigment (hue) remains the same.

Figure 15

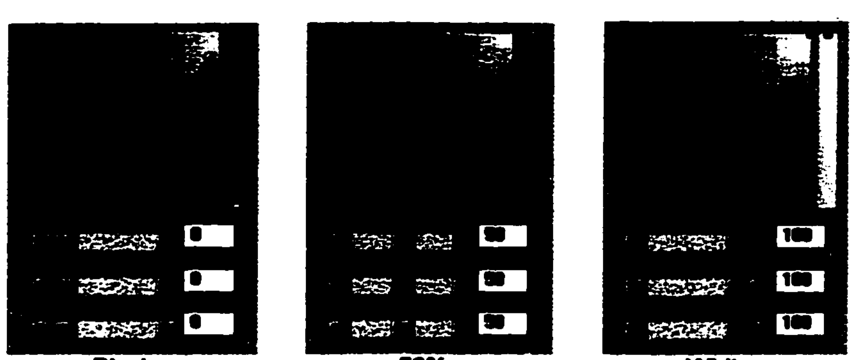
Colours are comprised of the three elements: hue (the name or pigment of a colour), value (lightness or darkness of a colour) and intensity (brightness or dullness of a colour). Again, very few researchers tested for one property of colour while holding the other two constant. It is difficult to know, therefore, what aspect of colour was actually being tested in much of the research.

In addition to the above problems, computer screen colour research suffers from many of the same problems as computer screen graphic research. Specifically, many research articles used in this section of the literature review cite other literature many decades old. Moreover, much of the research is paper platform. This problem, however, is a bit more complex with colour as colour computer monitors display colours differently than paper based platform. Specifically, there are three main colour selection systems used on computer systems which should be understood when discussing colour and computer based instruction (University of Waterloo, 1996).

1. Hue-Saturation-Brightness (HSB): This presents the classic attributes of colour. On computer screens, the user can select a base colour (hue), a level of saturation and a desired luminance.

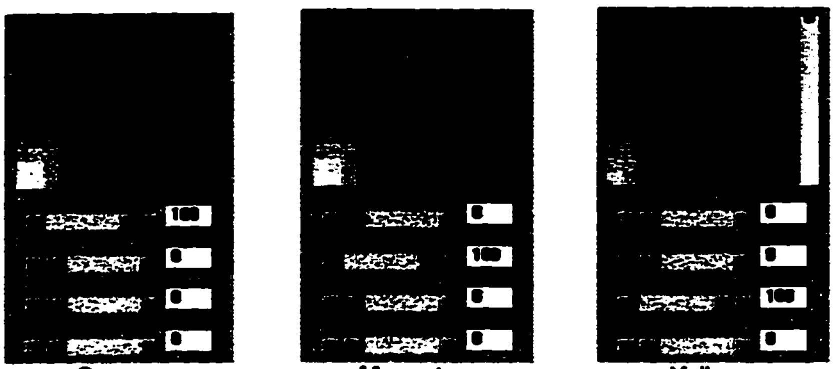
Saturation = 50 Brightness = 50 | Saturation = 100 Brightness = 50 | Saturation = 50 Brightness = 100 | Saturation = 100 Brightness = 100

2. Red-Green-Blue (RBG): The red, blue and green colours are used extensively in computer applications (vs. red, blue and yellow for paper based platforms). These colours are the base upon which other colours are added to create additional hues.



Black | 50% | White

<u>3. Cyan-Magenta-BlacK-Yellow (CMKY):</u> The cyan, magenta, black and yellow colours are used almost exclusively for printing. CMKY uses the subtractive properties of dyes on a page to create colour. It is similar to the RBG system except that the black component allows the printing of true blacks on colour printers which are not capable of mixing pigments to create a true black.



Cyan Magenta Yellow

A final and critical problem in the colour research is a lack of understanding about our colour genes. A study reported by the *Washington Post* (April 6, 1992 cited by Kirrane, 1992) indicates that we all see colours somewhat differently. Specifically, when study participants turned knobs to come up with a coloured light that matched a red control light, they dialed up different wavelengths. A similar study was cited in The Edmonton Journal (February, 1995):

> ... eye experts theorized that there were three genes for color vision. If one gene was missing or flawed, the consequence would be some degree of colorblindness.
>
> But research described this month in The Journal *Sciences* shows there are at least 10 pigment genes—and maybe many more.
>
> Neitz & Neitz ... found that people have many more genes controlling color vision than previously thought and the number varies widely from one person to another ...

Their discovery suggests that even people with normal color vision actually have a unique range of pigment genes.

This could make some people more sensitive to reds, for instance, while others would not see quite so many nuances in burgundies, scarlets and crimsons.

This explains why two people can look at the same color and perceive it so differently. One person's pure blue is another's blue-green. The bright bold yellow seen by one, might be faintly tinged with green to a second beholder.

Those fights about the color television aren't just semantics after all," Jay Neitz said. "There are blips in our own perception of the world."

Summary

A lack of understanding about colour theory is evident in most of the research on the use of colour in the learning process with computer based instruction. Most research, for example, has investigated *colour* but failed to identify which area of colour was studied. This lack of knowledge about the elements of colour results in studies that fail to control for brightness and saturation. This makes it impossible to determine whether the participants were reacting to value, hue or intensity.

To gain a more reliable understanding of the influence of colour with computer based instruction there needs to be sound empirical research based on a good understanding of the theory of colour.

APPENDIX E. CONSENT FORM

CONSENT FORM

I ____________________________________(Name of Subject) agree to participate in the study of the influence of screen layout with adult learners intended for use within the instructional computing and consent to the following:

1. To provide the researcher, Heather Kanuka, with information required for the study.
2. To authorize the release of this information for the purposes related to the study.

I understand that my identity shall remain confidential and shall be present only in the master records of the researcher.

I understand that my participation in this study is voluntary and that I may withdraw my participation at any time during the course of the study upon written notice being delivered to the researcher.

Dated this _____ day of _________(month), A.D. 1996, in the City of Edmonton in the Province of Alberta.

____
Signature of Subject

____
Printed name of Subject

____
Signature of Witness/Researcher
Heather Kanuka

APPENDIX F. POST TEST AND KEY

Date: ________________

COMPUTER BASED INSTRUCTION - ACHIEVEMENT INSTRUMENT

1. A pre-requisite for conducting research for a term paper includes
   a) a mastery of library skills
   b) substantial prior knowledge of the topic
   c) related work experience on the topic
   d) knowing the people who work at the library

2. While conducting your preliminary research for a term paper, you should record
   a) the time you started
   b) the time you finished
   c) both a and b
   d) all the bibliographic information

3. Paraphrasing or summarizing an author's ideas will force you to
   a) analyze
   b) evaluate
   c) get the full meaning out of the material you read
   d) all of the above

4. A term paper consists of four sections. They are
   a) content, position, style and documentation
   b) title page, table of contents, body of the term paper and a reference list
   c) introduction, personal thoughts, reflection and conclusions
   d) title page, position, conclusion and reference list

5. Writing a term paper involves two interrelated phases:
   a) writing the content of the paper following the rules of grammar and writing the paper following a prescribed style found in a manual
   b) conducting a thorough library investigation and recording all the bibliographic information
   c) narrowing down the topic and conducting a thorough library investigation.
   d) Both a and b

6. A conscientious effort to use language that is accurate and grammatically correct must be made if
   a) you are to receive full marks
   b) you wish to enter graduate studies
   c) you want to publish your term paper
   d) the thrust and meaning are to be transmitted to the reader in your paper

7. Before you begin to write your paper you should prepare an outline of the body of the paper. This will consist of
   a) an introduction (purpose), review of related literature, position, limitations and discussion (conclusion).
   b) A title page, table of contents, body and reference list
   c) a review of related literature, discussion, a title page and reference list
   d) none of the above.

8. Each point of the outline
   a) must be typed as a sub-title in the paper
   b) does not necessarily have to be in the paper
   c) must be elaborated on as you write the paper
   d) must be included in the table of contents

9. The intent of the term paper is to
   a) get a good mark
   b) frustrate students
   c) weed out the students who are not capable of writing academic verbosity
   d) inform the reader of the results of your library research

10. In writing the term paper, you should try to write what you have to say with
   a) unusual felicity
   b) much academic verbosity
   c) clarity and precision
   d) with very few spelling and grammatical errors

11. The content of the paper should also be presented
   a) simply and coherently
   b) with many complexities but coherently
   c) with less than 10 spelling and grammatical errors
   d) in a duo-tang

12. A term paper should be written with
   a) clarity and precision
   b) unity
   c) accuracy that is forcefully expressed
   d) all of the above

13. When writing the term paper, you need to cover the topic as thoroughly as you can
   a) even if it means exceeding the number of required pages
   b) in less than the number of required pages
   c) in the number of required pages or less
   d) in whatever number of pages you feel is adequate

14. A term paper must be accurate
   a) therefore the language used in the paper must be accurate
   b) and a professional typist should be hired to type it
   c) but it really does not matter if ideas are not expressed in exactly the way you intended
   d) all of the above

15. Because a term paper is, most times, not of a personal or conversational nature
   a) first person is generally used
   b) third person is generally used
   c) second person is generally used
   d) fifth person is generally used

16. There are many words in the English language which mean almost the same thing. You should try to make every effort to ensure
   a) the appropriate word will convey the intended meaning
   b) you use a thesaurus to look for words that are unusual as it will make you look smarter
   c) you use a thesaurus to find different words when paraphrasing, even if the word does not have exactly the same meaning
   d) both b and c

17. Simplified spelling is inappropriate and should be avoided except
   a) when using APA format
   b) in a scholarly paper
   c) in a direct quotation from another source
   d) in spring and summer sessions

18. The number of hyphenated words in a paper
   a) is 40 according the APA format
   b) does not matter
   c) should be kept to a minimum
   d) is really up to the discretion of the writer

19. Words that are improperly divided
   a) are acceptable if it makes the right margin justified
   b) are acceptable according to APA format but not EPA format
   c) may cause the reader to assume that the writer of the paper was careless in preparing the content
   d) both a and b

20. Excessive use of abbreviations
  a) should be avoided as it hinders reading comprehension
  b) should be avoided according to EPA format
  c) is acceptable if the writer defines the abbreviations in the introduction
  d) is acceptable if the writer knows the reader is knowledgeable about the topic

21. The basic difference(s) between term papers and theses are
  a) the nature of the problem solved
  b) the research procedure followed
  c) the form of reporting the results
  d) all of the above

22. Because of the limited scope of a term paper, the investigation is normally
  a) conduced at home
  b) conducted in the library and seldom involves research in a laboratory or in the field
  c) conducted in a laboratory
  d) not done at all

23. The standards of scholarly writing require that all source material
  a) whether quoted or paraphrased, be acknowledged by the writer
  b) be acknowledged by the writer only when from a direct quote
  c) be acknowledged by the writer only when paraphrased
  d) be referenced in the reference list only when from a direct quote

24. Source material from a publication or interview
  a) does not need to be acknowledged by the writer
  b) only needs to be acknowledged by the writer when the interview or publication is of a formal nature
  c) needs to be acknowledged by the writer, whether informal or formal
  d) should not be used in a term paper

25. Source material should be acknowledged by the writer not only as a matter of professional courtesy, but also
  a) to validate the work done by other authorities
  b) because it is the law in Alberta
  c) because it impresses most instructors
  d) both b and c

26. Direct quotations should be used only when
  a) giving words of law, official rulings and important edicts
  b) citing mathematical, scientific and other formulas
  c) the exact words of the writer are absolutely essential or a significant thought has been expressed with unusual felicity
  d) all of the above

27. Page numbers should be placed
  a) on the upper right hand corner of the page, 1.2 cm from the top and side edge of the paper
  b) on the lower right hand corner of the page, 1.2 cm from the lower and side edge of the paper
  c) on the upper centre part of the page, 1.2 cm from the top of the paper
  d) on the lower centre part of the page, 1.2 cm from the bottom of the paper

28. Prefatory page numbers are placed at the
  a) centre of the guide sheet, 1.2 cm from the bottom of the page
  b) centre of the guide sheet, 1.2 cm from the top of the page
  c) upper right and corner of the page, 1.2 cm from the top of the side edge of the paper
  d) lower right hand corner of the page, 1.2 cm from the bottom of the side edge of the paper

29. A formal listing of all source materials that were used in preparing the term paper is placed
  a) at the front of the paper
  b) at the back of the paper
  c) after the table of contents
  d) it does not matter where it appears

30. The formal listing of source materials is referred to as
   a) a table of contents
   b) a bibliography or reference list
   c) end notes
   d) annotations

31. The bibliography (or reference list) will contain
   a) the page number where the source was cited in the paper
   b) the address of the source cited
   c) both a and b
   d) descriptive details for the authorities quoted that appear in the citations in the text

32. The function of the bibliography (or reference list) is to
   a) complement the citation by providing the reader with a full description of the work
   b) impress the instructor
   c) acknowledge an idea used in the paper which is not the author's
   d) none of the above

33. The writer of the paper is responsible for ensuring that
   a) each source cited appears in the reference list in ascending alphabetical order by surname
   b) each source cited appears in the reference list in order of date in descending order
   c) each source cited appears in the reference list in order of date in ascending order
   d) each source cited appears in the reference list in descending alphabetical order by surname

34. The term paper must be typed according to
   a) the same standards used in any high school
   b) faculty or department requirements
   c) Education Policy Standards
   d) body b and c

35. When typing the paper, the following guideline(s) should be used:
   a) there should be 25 lines to the page and all typing must be on one side of the paper
   b) the text should be double spaced (except for block quotes which are single spaced and titles which are triple spaced).
   c) Line indentations of five spaces to the right of the left margin
   d) all of the above

36. Before submitting a term paper, the writer should have someone proofread it for
   a) accuracy of grammar and spelling
   b) content and page number sequence
   c) a cross-check of titles in the bibliography with references cited in the paper
   d) all of the above

KEY

1. A
2. D
3. D
4. A
5. A
6. D
7. A
8. C
9. D
10. C
11. A
12. D
13. C
14. A
15. B
16. A
17. C
18. C
19. C
20. A
21. D
22. B
23. A
24. C
25. A
26. D
27. A
28. D
29. B
30. B
31. D
32. A
33. A
34. B
35. D
36. D

APPENDIX G. INFORMATION HAND-OUT

Research Purpose:

The purpose of this research project is to investigate whether or not screen layout influences achievement. The content of the computer based tutorial is: How To Do A Term Paper. The content is exactly the same in both versions of the tutorial. One version of the tutorial will not use design basics and one tutorial will use design basics. Participants of this research project will be randomly assigned to one of the two tutorials.

System Requirements:

1. Windows 3.1 or Windows 95
2. 25 Mhz 386, preferably 33 Mhz 486 with 8 MB RAM or better
3. 256 colour-SVGA monitor with 1 MB video RAM or better
4. Mouse
5. 3.5" high density floppy disk drive.

To Load:

1. Insert diskette in Drive A (or 3.5" high density floppy disk drive)
2. In **program manager** select **file run** and type: **A:term-ppr.exe** and click on **OK**.

Upon completion of the tutorial:

At the end of the tutorial you will notice that there is a screen which will have the time and date you began, the time you finished and the total time you spent on the tutorial. Please record this information on the bottom portion of this sheet and return it to the researcher.

Thank you for participating in this project.

Please fill in the information below that is located on the last screen of the tutorial

✂--

You have reached the end of this tutorial.

It is now ________ on ________. You started working on this tutorial at ________. You have spent ________ minutes working on this tutorial.

If you are interested obtaining in the results of this research, please complete the section below and the results will be mailed to you.

Name: ______________________________

Address: ______________________________

City and Postal Code: ______________________________

APPENDIX H. MAILED INFORMATION HAND-OUT

General Information:

1. Complete the enclosed **consent form.**
2. Complete the computer based tutorial **"How To Do A Term Paper."** This should take approximately 30 minutes.
3. At the end of the computer based tutorial, **before to exiting**, fill out the bottom portion of this form. Wait two hours before completing step 4 (post test).
4. Without using the computer based tutorial for help (or any other reference sources), complete the **Computer Based Instruction - Achievement Instrument**, also enclosed. This should take approximately 15-20 minutes.
5. Mail the **Computer Based Instruction - Achievement Instrument**, the **consent form** and the **bottom portion of this form** in the enclosed envelop.

System Requirements:

1. Windows 3.1 or Windows 95
2. 25 MHz 386, preferably 33 MHz 486 with 8 MB RAM
3. 256 colour-SVGA monitor with 1 MB video RAM
4. Mouse
5. 3.5" high density floppy disk drive.

To Load:

1. Insert diskette in Drive A (or 3.5" high density floppy disk drive)
2. In **program manager** select **file run** and type: **A:term-ppr.exe** and click on **OK**.

Upon completion of the tutorial:

At the end of the tutorial you will notice that there is a screen which will have the time and date you began, the time you finished and the total time you spent on the tutorial. Please record this information on the following portion of this sheet and return it to the researcher.

Please fill in the information below that is located on the last screen of the tutorial

✂---

You have reached the end of this tutorial.

It is now ________ on ________. You started working on this tutorial at ________. You have spent _______ minutes working on this tutorial.

If you are interested obtaining in the results of this research, please complete the section below and the results will be mailed to you.

Name: ________________________________

Address: ________________________________

City and Postal Code: ________________________________

Thank you for participating in this project.

APPENDIX I. POST TEST SCORES

ACHIEVEMENT INSTRUMENT

good design principles				poor design principles		
#	gender	score		#	gender	score
1	f	32		1	f	29
2	f	36		2	f	33
3	f	32		3	f	22
4	m	29		4	m	34
5	f	34		5	f	29
6	m	22		6	m	27
7	m	34		7	f	25
8	m	32		8	f	25
9	f	29		9	f	32
10	f	32		10	f	35
11	m	33		11	f	30
12	f	32		12	f	29
13	m	31		13	f	32
14	f	30		14	f	25
15	f	32		15	f	28
16	f	25		16	f	31
17	f	28		17	f	28
18	f	27		18	f	27
19	m	34		19	f	30
20	f	32		20	f	32
21	m	27				
22	m	30				
23	f	25				
24	f	32				
25	f	33				
26	f	32				
27	f	27				
28	m	34				
29	f	34				
30	f	29				
31	f	33				
32	f	27				
	Average:	30.6			Average:	29.2
	Median:	32.0			Median:	29.0
	Count:	32			Count:	20
	Minimum:	22			Minimum:	22
	Maximum:	36			Maximum:	35
	SDV:	3.2			SDV:	3.4
	Males:	10			Males:	2
	Avg. Males:	30.6			Avg. Males:	30.5
	Females:	21			Females:	18
	Avg. Females:	30.6			Avg. Females:	29.0

APPENDIX J. TIMES REQUIRED TO COMPLETE COMPUTER BASED LESSONS

Working Time

	Minutes			Minutes
good design principles	37		poor design principles	28
	26			40
	27			39
	52			45
	30			46
	47			35
	30			41
	34			43
	35			48
	39			55
	28			21
	40			43
	35			51
	25			33
	30			37
	24			24
	35			61
	48			40
	30			40
	37			56
	26			
	29			
	33			
	27			
	45			
	50			
	46			
	36			
	31			
	29			
	20			
	30			
Average:	34.2		Average:	41.3
Median	32.0		Median	40.5
Count:	32		Count:	20
Minimum:	20		Minimum:	21
Maximum	52		Maximum	61
Standard Deviation:	8.2		Standard Deviation:	10.3