EFFECTS OF INTERFACE WINDOWING MODES AND INDIVIDUAL DIFFERENCES ON DISORIENTATION AND COGNITIVE LOAD IN A HYPERMEDIA LEARNING ENVIRONMENT

By

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This dissertation is dedicated to my devoted father, Abdullah, the most honorable person in my life. Unfortunately, he passed away and walked to his beloved God on August 19, 2002, while his son was away from home to complete his Ph.D. studies.

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The purpose of our study was to investigate the effects of different interface windowing modes (tiled and overlapping windows) and individual differences (computer experience) on users' disorientation and cognitive overload in a hypermedia learning environment. The second aim of our study was to make suggestions for designing more effective interface and hypermedia systems that minimize user disorientation, and cognitive overload. Literature on hypermedia systems, disorientation, cognitive overload, web-based navigation, interface design, and individual differences helped to frame the study and clarify research questions.

A quantitative study was conducted to reveal the answers to research question. The study involves three dependent variables, and one independent variable with two levels. Dependent variables were user disorientation, cognitive overload, and computer understanding and experience. Data were collected from surveys, Active Script Pages and Java Script coded web pages and the Internet Explorer History file. Participants were

randomly assigned to one of the two interface windowing (tiled and overlapping) modes. The information on the two treatments was identical. Results were drawn from a statistical analysis of the data.

Much of the recent research disorientation and cognitive overload in hypermedia systems discusses measurement of disorientation and cognitive overload. Our study, however, particularly investigated user disorientation and cognitive overload in a structured and non structured hypermedia learning environment. For the first time in the literature, user disorientation and cognitive overload were separately measured in hypermedia learning environments using different instruments.

Results showed that subjects in the tiled windows-interface mode become less disoriented and cognitively overloaded than subjects in an overlapping windows-interface mode. Also, results from our study indicate that there is a positive significant correlation between ease of use and orientation ratio. Furthermore, our study found negative significant correlation between ease of use and perceived disorientation, and between orientation ratio and disorientation.

CHAPTER 1
INTRODUCTION

The purpose of our study was to investigate the effects of different interface windowing modes (tiled and overlapping) on user's disorientation and cognitive overload in a hypermedia environment. In this chapter we first discuss the research problem. Next, we explain the need for the study. Then we define the purpose of the study. Finally, we describe research questions, hypotheses, and limitations of the study.

Statement of the Problem

The nature of hypermedia systems are complex, based on nonlinear organization of information. Hypermedia systems have the ability to contain a huge amount of complex multimedia information that is interconnected and cross-referenced through links (Head, Archer, & Yuan 2000). The flexible structure of hypermedia systems gives users the freedom to browse and interact with information in the hypermedia environment. However, many hypermedia systems do not achieve their full potential, because of poor design and structure (Otter & Johnson, 2000). Disorientation (feeling lost) and cognitive overload are two of the fundamental challenges that users experience when trying to navigate a hypermedia system (Conklin, 1987). Cognitive overload is defined as being overwhelmed or confused by the options available to users in multi-path, multi-tool environments such as hypermedia documents (Murray, 2001).

Even small hypermedia systems create frustrating cognitive problems for users (Smith, 1996). Therefore, disorientation and cognitive overload in a hypermedia system are the focus of our study.

Need for the Study

The use of hypermedia systems to deliver learning and teaching material has become increasingly common (Chen & Macredie, 2002). Hypermedia learning environments provide a way of accessing, organizing, presenting, and interacting with information (Klett, 2002). The general term, hypermedia learning environment, is used to describe electronic based learning environments that include multimedia (graphics, video, audio, and photos) and text. Before the Internet, only programmers controlled the interface and structure of electronic learning environments. In recent years, access and use of the Internet for teaching and learning is growing rapidly because of the ease of use, design, and accessibility of the World Wide Web (Grabowski & Small, 1997). Hence, both individuals and companies have rushed to create hypermedia-based learning environments. Therefore, many electronic learning environments have been created without consideration of the efficiency of use, interface issues, or structure (Theng, Jones, & Thimbleby, 1995a).

Individuals have different learning styles (i.e. different ways of absorbing, connecting, storing, and using new information) and respond to different ways of perceiving information (White, 1983). Therefore, presenting information in a linear way, one page after another, may not be suitable for every learner. The flexible environment of hypermedia gives users freedom to navigate unfamiliar and complex information structures within hypermedia systems. Users can follow a particular line of interest, and may skip from one part of a document to another. While hypermedia has many potential advantages, some potential problems have been considered. Klett (2002, p.2) said that "with insufficient concepts, consistency, screen layout, interface design, navigation strategies, low-level of interactions can result in inadequate learning environments" for

users. In addition, the freedom offered by hypermedia learning environments may come at a price, because flexibility increases complexity (Ellis & Kurniawan, 2000). The large amount of information provided to a learner in a nonlinear fashion may cause the learner to become lost and to experience cognitive overload in the hypermedia system. Chen (2002, p.450) states that "learners who are uncertain of how to deal with nonlinear learning programs may meet disorientation problems, so their learning achievements may be disrupted."

Designing meaningful, clear, and usable screen layouts and interface is necessary because of the limited capabilities of the human information-processing system (Franzwa, 1973). The interface windowing modes are important aspects of human-computer interface design. Windows refer to certain independent areas of the screen that can be resized and moved. Overlapping-window refers to an interface windowing system that windows can be stacked on the screen like pieces of paper (Bly & Rosenberg, 1986). Tiled-window refers to keeping windows content always visible and nonoverlapped (Bly & Rosenberg, 1986). Web-based learning environments allow users to open independent overlapping windows, where windows are allowed to overlap each other. This often makes it difficult for users to locate information that they need and to coordinate several sources of information and to perform tasks on time. Minimizing overlapping of the multiple windows operations may yield faster performance than independent overlapping-windows in hypermedia learning environments for task environment, switching between tasks, and task execution while engaged in the hypermedia medium. Performing tasks in one window, while simultaneously accessing and using multiple sources of information or multiple representations, is often difficult. Providing multiple-

window access to the user at a given time for a given task is likely to help users (Kandogan & Shneiderman, 1997). Kandogan & Shneiderman (1997, p.252) stated that "multi-window operations on groups of windows can decrease cognitive overload on users by decreasing the number of window operations." Overlapping windows may hide basic information needed to perform a task. Borälv, Göransson, Olsson, and Sandblad (1994, p.73) state that "the user's effort to decrease the size of the overlapping window or move it might destroy the intended gestalt of the interface."

The flexibility and complexity of hypermedia systems come with a price. Disorientation is one of the major limiting factors of hypermedia (McDonald & Stevenson, 1996). Many existing hypermedia learning environments are poorly designed and produced, in terms of structure, interface, and linking (Theng, Jones, & Thimbleby, 1995a). Poorly designed hypermedia learning environments may lead users to become lost in the hypermedia system. Beasley & Waugh (1995) and Tripp & Robby (1990) stated that learning is likely to suffer as disorientation increases. Structural-knowledge acquisition and retention decrease when disorientation increases, in an electronic learning environment (Beasley & Waugh, 1996, p.277). These findings indicate that disorientation and cognitive overload may affect, reduce and interrupt the cognitive activities and mental resources of the learner. Mayer, Moreno, Boire, and Vagge (1999) showed that tasks high in cognitive overload can restrain learning. While the use of hypermedia information systems has become more popular, some limitations and problems of hypermedia have become more apparent. Usability problems (Bly & Rosenberg, 1986), disorientation (Elm & Woods, 1985; Conklin 1987), cognitive overload (Conklin, 1987), and ineffective navigation (Hedberg, Harper & Brown, 1993)

are limits and drawbacks of hypermedia information systems. Many hypermedia information systems are poorly designed and built in terms of how information is structured and displayed (Theng et al., 1995a). Navigation and being lost in hyperspace is one of the main issues in hypermedia research (Theng, 1997). Therefore, more research is needed for efficacy and effectiveness of hypermedia information systems (Harmon 1993; Harmon & Dinsmore, 1994).

Although disorientation and navigation problems in the hypermedia system are well documented, researches have not yet provided answers to the effects of tiled and overlapping-windows structure on disorientation and cognitive overload in hypermedia learning environment. Much of the research on disorientation and cognitive overload related learner navigational efficiency in electronic learning environments has focused on navigational links, aids, strategies, and hypermedia topology. However, researchers have not addressed whether there is a relationship between interface windowing modes, disorientation, and cognitive overload in a hypermedia system.

Purpose of the Study

Our study was designed to investigate the effects of different interface windowing modes (tiled and overlapping) and individual differences (computer experience) on users' disorientation and cognitive overload in a hypermedia system. Our study also makes suggestions for the designing more effective interfaces and hypermedia systems that minimize disorientation and cognitive overload.

Research Questions and Hypotheses

Our study was conducted to answer several research questions associated with hypermedia-based interface windowing modes, tiled and overlapping-windows, and their

effects on user disorientation and cognitive overload in terms of users' information-retrieval task performance. The research questions and related hypotheses are as follows.

- Is there any significant difference on users' disorientation between using tiled-windows interface mode and using overlapping-windows interface mode?
- There is no significant difference in user disorientation in overlapping-windows interface mode versus tiled-windows interface mode, in the hypermedia learning environment.
- Is there any significant difference in users' cognitive overload between using tiled-windows interface mode and using overlapping-windows interface mode?
- There is no significant difference in user's cognitive overload in overlapping-windows interface mode versus tiled-windows interface mode in the hypermedia learning environment.
- Is there any relationship between two different measures of disorientation?
- There is no significant relationship between two different measures of disorientation.
- Is there any relationship between cognitive overload and two different measures of disorientation?
- There is no significant relationship between cognitive overload and two different measures of disorientation
- Are there any relationship among user's computer experience, and disorientation and cognitive overload.
- There are no statistically significant interface windowing effects on the vector of three dependent variables when effects of subjects' computer experience are controlled.

Assumptions

In attempting to find the answers to the research questions, several assumptions were made before and during our study. Results of our study are based on these assumptions:

- The subjects on both treatments have the same prior content knowledge about the content of the tutorial.

- Participants in this study accurately completed instruments and tasks in a serious manner and to the best of their ability.

Limitations of the Study

In attempting to find answers to these research questions, certain limitations and assumptions may limit generalizability of this research:

- Subjects' attention and perception toward the designed hypermedia learning environment might influence performance.
- Prior experience in using web browsers and mouse might influence the speed of information access.
- Subjects' reading abilities
- Interface windowing modes were not designed for color impaired users. Cognitive overload measure requires user's reaction to a visual color change (Brunken, Plass, & Leutner, 2003). Therefore, possibility of colorblind users may affect the results of this study.
- Subjects' purposes, needs, and motivation for participating in this experiment might influence performance
- Subjects' experience of the computer operating system
- Subjects' prior knowledge of content information
- Comfort level of treatment environment (e.g., external noise)

Definition of Terms

The following terms have been defined to precipitate a better understanding of their use in the study.

Active server pages (ASP): a specification for a dynamically created Web page with an .ASP extension.

Browser: specific software that allows the user to navigate or browse through a hypermedia system.

Browsing: open and exploratory information-seeking activity that involves scanning and tracking ideas from one node to another (McAleese, 1989).

Cognitive Overload: refers to users being overwhelmed or confused by the options available to them in multi-path, multi-tool environments such as hypermedia documents (Murray, 2001).

Cognitive style: an individual's preferred and habitual approach to organizing, processing, and representing information (Riding & Rayner, 1998).

Computer experience: extent and type of prior computer interaction and software and hypermedia use.

Disorientation: the tendency to lose one's sense of location and direction in a nonlinear document (Ahuja & Webster, 2001).

Expert: a person with particular skills and knowledge obtained through experience rather than inherent talent (Ericsson & Charness, 1994).

Field dependence: the "degree to which a learner's perception or comprehension of information is affected by the surrounding perceptual or contextual filed" (Jonassen & Grabowski, 1993, p.87).

Field Independence: the degree to which an individual who is internally directed, serialistic, and analytical in terms of their approaching to learning, problem solving, and organizing information (Chen & Macredia, 2002).

GEFT (Group Embedded Figures Test): a test that can be administered to several persons at once (Witkin et al. 1971).

Hypermedia: a combination of networks of nodes (can be called documents, files, cards, pages, frames, screens) and information (text, graphics, video, sound etc.).

Hypertext: a collection of text that can be linked to other text in an unlimited nonlinear fashion.

Links: electronic connections between nodes.

Navigation: seeking specific information nodes through links and associations with existing nodes.

Node: an individual unit of text within a hypertext document. Nodes contain text information sometimes enriched with media.

Nonlinear: not organized in a linear fashion.

Novice: the computer user who has no or little prior knowledge about the hypermedia system (Nielsen, 1995).

Overlapping-windows: an interface windowing system that windows can be stacked on the screen like pieces of paper (Bly & Rosenberg, 1986).

Tiled-windows: keeping windows content always visible and nonoverlapped (Bly & Rosenberg, 1986).

Usability: how easy it is for the user in the hypermedia environment to have a pleasant experience (Neilsen, 1995).

Windows: the independent areas of the screen that contain text, graphic, audio, and video, and can be resized and moved (Dix, Finlay, Abowd, & Beale, 1998)

World Wide Web: the part of the Internet that allows for the displaying and publishing hypertext documents written in Hypertext Markup Language (HTML).

CHAPTER 2
REVIEW OF LITERATURE

This literature review examines the research involving hypermedia information systems in terms of usability, navigation, disorientation, cognitive overload, and user's level of computer understanding and expertise. First, we discuss the history of hypermedia and theory of hypermedia information systems. Next, we review usability and navigation in hypermedia. Then, we review disorientation and cognitive overload problems in hypermedia learning environments. The chapter closes with level of user expertise in hypermedia, and an update on current hypermedia information systems issues. Finally, this review explores individual differences in hypermedia systems.

Introduction to Hypermedia Systems

Hypermedia is a system for organizing, structuring, and accessing information using multimedia nodes connected together by links (Conklin, 1987). Hypermedia information systems are increasingly used to deliver instructions, or represent information, because of the dramatic advances in computer technology in the last decade (Zacharia, 2000). Hypermedia systems allow users to browse nodes and links to find information for specific purposes. Hypertext has the ability to both represent core information in a nonlinear network and give users access to relationships within a core of information. Hypertext functionality includes sophisticated navigation, annotation and information presentation. The term hypermedia includes hypertext within multimedia environments. Multimedia concerns the development, use, management and integration of various media forms, including text, graphics, audio, video and animation. Incorporating

multiple media offers the opportunity to convey information more effectively than a single medium may provide. The hypermedia information system uses the World Wide Web browsers to display nodes on a computer screen. There is a close similarity among the World Wide Web, hypertext, and hypermedia. The concept of hypertext and hypermedia is the basis for the World Wide Web. The World Wide Web is a very large version of hypertext that may include text, graphics, video, and audio. The term hypermedia learning environment was described as a self-directed, information-flowing environment with high interaction between instructor and learner (Marchionini, 1988).

Brief History of Hypermedia

The history of hypermedia has roots traced back to 1945. Vannevar Bush proposed a machine called "Memex" in his article in "Atlantic Monthly" titled "As We May Think" (Dix, Finlay, Abowd & Beale, 1998). Bush's aim was to store, retrieve, and manage the increasing quantity of information by connecting pieces of information (Dix et al., 1998). The Memex machine could help one to acquire appropriate information from an increasing amount of information (Louka, 1994). The Memex idea was only an idea at the time, because of technological impediments. After 50 years, Bush's vision turned into effective models. Todays technology allows reading, browsing, and linking in a nonlinear electronic environment.

The term "Hypertext" was coined by one of the pioneers of the technology, Theodor Holm Nelson, in the 1960s. Nelson's Xanadu system created a storehouse based on the link-node relationship (Dix et al., 1998). The first distributed, shared-screen, collaborative hypertext system, NLS (oNLine System)/Augment, was demonstrated at the 1968 Fall Joint Computer Conference by Douglas Engelbart (Beiber, 2000). After 3 decades, Nelson's idea was developed into commercial use, in the 1990s.

Hypermedia Systems

Hypermedia is a combination of networks of nodes (also called documents, files, cards, pages, frames, or screens) including information (text, graphics, video, sound, etc.). While hypertext is a text-only electronic environment, hypermedia encompasses other media such as graphics, video, and sound. The World Wide Web is version of hypermedia extended to a huge network of computers connecting millions of users from all around the world. Hypermedia is different from traditional paper. While information on traditional paper is limited to a linear, and in a sequential format, hypermedia has the ability that is free from a linear format (Eveland & Dunwoody, 2001).

Hypertext is a collection of text that can be linked to other text in an unlimited nonlinear fashion (Lyskawa, 1998). Hypertext is known as nonsequential text (Neilsen, 1995). The hypertext system has a link element. The text on the screen is associated with objects or text in the link. Hypermedia learning environments contains nodes of information connected by links. A node may be a text, a graphics, an audio clip, a video clip, a photo or a combination of these components. A link is an electronic connection between two nodes.

One of the major characteristics of hypermedia is nonlinearity (Foltz, 1996). Nonlinearity allows the user more flexibility in navigating throughout the text. It is nonsequential. Users may (at least to some extent) choose their path through the information nodes presented. The major difference between hypertext and traditional text is the restriction of text and reading in a linear order.

Hypermedia is a more general concept than hypertext. Hypermedia is a combination of multimedia components using computers' interactivity characteristics, dynamic display, and user interface. Hypermedia is an extension of hypertext including

visual information; and sound video, animation, and other forms of data. Basically hypermedia refers to the nonlinear format of all forms of electronic media and text (Dix et al., 1998). The World Wide Web (www) is a multimedia-based (nonlinear) hypermedia system. Web browsers are the tools used to access information across the World Wide Web. A node is an individual unit of text within a hypertext document. Nodes contain text information sometimes enriched with media. Links refers to electronic connections among nodes.

Some features of hypermedia systems are nonlinearity (Foltz, 1996), flexibility (Conklin, 1987; Kim, 2000), learner control (Marchionini, 1988), variety of media (Marchionini, 1988), navigation, backtracking, annotation, and structure (Beiber, 2000).

Nonlinearity allows the user to control what path to take when searching for information (Foltz, 1996). Hypermedia is flexible in terms of representing information, navigating the structure, and storing the data. Media can be represented in a variety forms. Hypermedia gives flexibility and freedom to the user for learning and information retrieval (Conklin, 1987). The user has flexibility in choosing the sequence in which to access information (Kim, 2000). Hypermedia learning environments let the learner control navigation, media, and content selection. Hypermedia offers such a high level of learner control that users are required to apply higher-order thinking (Marchionini, 1988). Hypermedia has the capability to associate links with other links, graphics, and audio and video files. Hypermedia may contain a variety of media such as graphics, pictures, video, and audio. Marchionini (1988) suggests that "hypermedia systems allow huge collections of information in a variety of media to be stored in an extremely compact form that can be accessed easily and rapidly" (p.9). Navigation allows users to explore links,

backtracking allows users to return to the previously visited nodes, annotation allows users to bookmark, and comment. Structural features enable uses to navigate through local and global paths (Beiber, 2000).

Hypermedia and Human Memory

There are similarities between hypermedia systems and current theories of human memory and learning (Rose, 1992). The proposed memory models are based on information-processing theory. Jonassen (1989) stated that learning occurs when new information is linked to existing knowledge, structured by associative networks. Semantic network structure and nonlinearity features of hypermedia systems resemble theories of memory and cognition may be a fruitful educational tool. It has been claimed that the idea of the structure of human memory and the process of learning is consistent with the process of using a hypermedia systems (Jonassen, 1989; Marchionini, 1988). Both hypermedia and human memory are created by nodes of information connected by links (Eveland & Dunwoody, 2001). The similarity between memory and hypermedia may allow the designer and the learner to establish the essential relationships between them. On the contrary, physical textbooks and media can only allow the learner to represent information in a linear way.

The principle of the semantic-network model suggests that a key to learning new information is associating it to existing knowledge, by semantically related links (Daniels, 1996). Norman (1996) stated that the more complex the connections among existing knowledge stored in memory and new information, the more additional new information will be learned. Research on learning shows that meaningful learning is accomplished when new information is associated to existing knowledge or node structures (Caudhill & Butler, 1990; Jonassen, 1989).

Potential of Hypermedia Systems

In addition to the advantage of delivering instruction, hypermedia holds promise for learning (Conklin, 1987). Hypermedia has been used by researchers studying cognitive flexibility theory. Basic characteristics of Spiro's Cognitive Flexibility Theory are random access, nonlinear exploration of the learning environment, and multiple representations of the content (Spiro, Feltovich, Jacobson, & Coulson, 1991). Hypermedia learning environments may support Cognitive Flexibility Theory. Jonassen (1989) noted that the structure of hypermedia is similar to the structure of the user's semantic network. The associative networks that humans use to store and retrieve information resemble associative links. Therefore it is also believed that hypermedia can improve comprehension (Beasley, 1994). The educational capabilities of hypermedia system are supported by theories such as multiple-channel learning, multimedia capability of technology, and how people organize information in long-term memory, (i.e., semantic-network theory) (Quillian, 1968). Quillian (1968) proposed a model of long-term memory composed of interrelated concepts (nodes) connected by a number of semantic relationships (links) to form a network. The links are unique to each individual, based on different experiences, and social and cultural backgrounds (Daniels, 1996).

Usability Issues with Hypermedia

Usability in hypermedia means easy to learn, efficient to use, easy to remember, scarcity of errors and pleasant to use (Neilsen, 1995). A hypermedia system has an interface element where the user interacts with. Windows are used extensively in hypermedia systems as a part of user interface to present graphics, images, text, audio, and video. Windows includes node and nodes linked with other nodes. User interface is the key to hypermedia systems, in terms of usability, efficiency, and user's comfort and

orientation. Navigation disorientation and cognitive overload are major problems that limit the usefulness of hypermedia (Conklin, 1987; Neilsen, 1995; Dix et al., 1998; McDonald & Stevenson 1996; McDonald & Stevenson 1998). Researchers have looked for solutions to the problems in hypermedia systems.

Developing well-structured and well-designed effective hypermedia learning environments is not an easy process, because of the number of associative links that exist among nodes, nonlinearity, and the number of design possibilities. Providing screen displays to construct a performing environment for the user, configuring a clear visual image, and creating a working context for the user's action are the goals of graphic user interface design (Lynch, 1994). The complex structure of hypermedia may lead to user disorientation and cognitive overload. Designers have had to deal with these problems.

Multiple overlapping windows and window repositioning may lead to anxiety, disorientation, and cognitive overload. If the links are connected by overlapping windows to the information, the learner must constantly maintain the train of overlapping windows. Within the structured hypermedia learning environment, the user may navigate and seek information without any unnecessary interruptions. Tasks in tiled windows interface mode may be completed without switching among windows. A disorganized form of hypermedia with overlapping windows may hide basic information needed to perform a task. To simplify the user's task, additional navigation features must be provided. A table of contents and an index are the two typical navigational features in linear text (Foltz, 1996). However, the structure in a hypertext is more complicated than in a linear text. Clark (2003) states that poor interface design leads to cognitive overload

that users become overwhelmed or confused by the options available to them in multi-path, multi-tool environments.

Interface Windowing Modes

The interface windowing modes are important aspects of human-computer interface design. Designing meaningful, clear, and usable screen layouts and interface is necessary because of the limited capabilities of the human information-processing system (Franzwa, 1973). Learners easily exhibit cognitive overload in the hypermedia learning environment, resulting in low performance (Case, 1985). Windows refer to certain independent areas of the screen that can be resized and moved. They may contain text, graphic, audio, and video in a hypermedia system (Dix et al. 1998). Computer interfaces allow users to open multiple windows on a screen at once.

A tiled-window interface keeps window content visible and non-overlapped (Bly & Rosenberg, 1986). Overlapping-window refers to an interface windowing system that windows can be stacked on the screen like pieces of paper (Bly & Rosenberg, 1986). Tiled-windows allow control of the size and location of each window. Tiled-windows are visible and do not overlap other windows. Users need to cognitively absorb into their minds the information represented in a hypermedia environment, to help them process information and make decisions. A tiled-window interface may provide concurrent access to different views of information. This enhances users' ability to effectively assimilate the information presented. Overlapping windows can be stacked like piles of papers. Advantages of tiled-windows are as follows:

- Tiled-windows are always visible
- In a tiled-window interfaces, location of information is always the same and familiar for the users

- Users are not required to make repositioning decisions
- Little window manipulation is needed for tiled-windows, but they allow a limited amount of room on the screen to display more information than can fit on the screen at once
- The user may navigate and seek information without any unnecessary interruptions.

Overlapping windows have some disadvantages:

- Windows may be placed on top of one another
- Windows may get lost.
- Freedom to maintain many windows at once may lead to crowding and confusion
- Greater amount of window manipulation needed for the user
- Overlapping windows can provide flexibility in arrangement, but may to lead to disorganized and crowded display
- Displayed contents are nonpredictable.
- Overlapping windows and windows repositioning may lead to trouble, anxiety, disorientation, and cognitive overload
- Overlapping windows may hide basic information needed to perform a task

Once it was "believed that overlapping windows are preferable to tiled ones" (Bly & Rosenberg, 1986, p. 101). However, little research shows whether tiled or overlapping-windows are more beneficial to users in terms of disorientation and cognitive overload. Dix et al. (1998) stated that overlapping windows can cause problems by obscuring vital information. To avoid this problem, they suggested tiled (nonoverlapping windows). Tiled-window learning environments may alleviate cognitive overload of the user (Benshoof & Hooper 1993).

Bly and Rosenberg (1986) studied effects of tiled and overlapping-windows on user efficiency. Users were required to answer a series of questions, and to finish tasks on a computer screen that could present either tiled-windows or overlapping-windows. The

study showed that tiled-windows system users completed their tasks faster than the overlapping windows users. Results were not unexpected, because tiled-windows users had fewer window operations than did overlapping windows users. Bly and Rosenberg (1986) also found that overlapping windows are better for inexperienced users. But, for experienced users, tiled-windows may be easier to use. It is clear that overlapping windows are more efficient for tasks little requiring window operation. For inquiry tasks more window operation, tiled-windows would be a good choice. Additionally, screen layout or the location of information are important for system functioning. Aspillaga (1991) investigated the effects of information location on learning foreign language. The purpose of the study was to compare the effects of displaying text overlapping a related part of a graphic image with displaying text at a consistent location. In the experiment, written material overlapping a relevant characteristic of a picture. In the second part, text was located on the upper middle section of the screen. In the third, text was randomly assigned to the upper middle section of the screen, the bottom middle of screen, or overlapping a relevant characteristic of the picture. Aspillaga (1991) found that information that overlaps a suitable part of a graphic successively helps transfer of learning when compared to information located in random locations. In addition, information located consistently on the screen significantly facilitates learning compared to information that is randomly located.

Multiple-window environments are increasingly used as the way of interacting with the computer. Computer screen provides spatial and locational cues that help the user find and relocate information (Tombaugh, Lickorish & Wright, 1987). Tombaugh et al.

(1987) found that with practice, users efficiently used multiple windows environments and searched better in single window environments.

Benshoof & Hooper (1993) investigated the effects of using single and multiple window presentation on achievement and window use learning math. The study compared the presented information on single and multiple windows with the achievement of high and low ability students. In the single windows treatment, the identical content was presented on the main window which included the problem and answer spaces. A help window demonstrated the symbols and their meanings. In this treatment the multiple windows were tiled and the information and help windows were not overlapping. Results indicated that high-ability students in the overlapping and help window achieved significantly better on verbal information and rule-use questions when compared to other students. In addition, high-mathematics-ability students performed better than low-mathematics-ability students in the multiple window treatment. Surprisingly, contrary to the previous studies (Aspilliga, 1991; Bly & Rosenberg 1986), Benshoof and Hooper (1993) found that the use of tiled-windows did not improve performance.

Furthermore, Benshoof, Graves, and Hooper (1995) investigated the effects of single and multiple window presentation on student achievement, instructional time, window use, and attitudes of elementary school students during computer-based instruction. Three types of learning environments were used: Single window, multiple windows, and a single and multiple windows combination. While the single window treatment could present only one source of information, multiple window treatments could contain symbols, their meanings, problem, and answer space. The content of each

learning environment was identical. Subjects were required to learn abut symbols and solve the problem on the assigned learning environment. The results indicated that subjects performed better in the combination treatment than subjects in the single window treatment. The single window treatment could only display one part of information to the user. This lead the single user treatment more memory loads than the multiple windows (tiled window) treatment. Apparently multiple window learning environments allowed learner to see several sources of information and alleviate memory load.

Navigation Issues in Hypermedia System

Navigation is necessary to find the relevant information in the learning environment. Navigation can be accomplished over many spaces (e.g. sea, land air etc.). Specifically, navigation in this study is a meaningful exploration in hypermedia system and arriving at a destination (e.g., a node, graphic, text, page, video, audio etc.) that will be satisfactory. Navigation is the basic characteristic of hypermedia system. Hypermedia systems allow the learner a new way to access and organize information. Most of hypermedia activities are based on navigation, browsing, and searching. Hypermedia systems offer users freedom and flexibility on exploring hyperspace. However, the success of browsing in the hypermedia system depends on the usability of the hypermedia and the ability of users to navigate the system (Lawless & Brown, 1997). Dillon, McKnight, & Richardson (1990) defined navigation as meaningful user action as movement through a hypermedia system. When navigating, the user moves through the hypermedia system by following links from node to node in a linear or nonlinear fashion. Navigation is the means for accessing information in the hypermedia space. The navigation aspect makes hypermedia an effective tool for organizing, presenting information, and delivering instruction. Learners can explore presented information in

any order they want by choosing the subject they wish to look at next (Shneiderman & Kearlesly, 1989). However, the dramatic growth of hypermedia based systems (e.g., Internet), users' freedom and the nonlinear structured environment of hypermedia causes problems such as disorientation and cognitive overload (Neilsen, 1990; Conklin, 1987) on the users (particularly learners that navigate them). In educational settings of hypermedia systems, disorientation and cognitive overload is a challenge for an efficient learning process and transforming information. Studies have showed that tasks high in cognitive overload may impede learning (Mayer, Moreno, Boire, & Vagge, 1999).

Hypermedia has the ability to produce complex and highly interconnected information spaces allowing users to access huge amounts of information. People have a lot of experience navigating through physical spaces but very little experience exploring multidimensional and highly interconnected web spaces. Hypermedia tasks are more complex because they are abstract presentations of a multidimensional space. Browsing is a cognitive activity for reading and searching in hypermedia without having a definite goal or idea to accomplish (Theng, Rigny, Thimbleby, & Jones, 1996).

Navigational tools help the learner organize the structure of hypermedia learning environments and connection of various components. Navigation gives the learner the freedom to interact with the learning environment and gives autonomy back to the learner. In the hypermedia learning environment (HLE), the learner is potentially a navigator, an explorer, and a pathfinder.

Poor interface design may cause the user frustration (Chen & Macredie, 2002) when they are navigating in the hypermedia system. During navigation, a user can easily become confused about where they are, and may frequently be unable to determine how

to get somewhere they want to be (Hooper, 1988). "Most people are poor navigators" (Brickell, 1993, p. 107).

Navigation is becoming one of the most important design issues in hypermedia learning environments because a user may lose his/her way to accessing and interacting within the medium without effectively navigating. Design and implementation of efficient user interfaces is essential for successful hypermedia learning environments. A bad user interface may result in inefficiency and low user acceptance. Progressive disclosure (Jones, 1989) reduces the apparent complexity of a system by presenting only the information relevant and available to the user at any point in time. Providing media integration and showing all of the information available for exploration (Laurel, Oren & Don, 1992) may reduce the complexity of hypermedia learning environments.

Disorientation in Hypermedia Systems

Hypermedia environments contain an overwhelming amount of information that is hard to navigate and make decisions. Disorientation is one of the most cited problems with hypermedia system. Studies by Nielsen (1990) showed that 56 percent of readers of a hypermedia systems agreed that they were often confused about where they were. Many researchers also observed that users may become confused, lost or disoriented in hypermedia system (Elm & Woods; 1985, Conklin 1987; Neilsen 1990; Gupta & Gramopadhye; 1995; McDonald & Stevenson 1996; McDonald & Stevenson 1998; Theng, 1997; Dias & Sousa, 1997; Ahuja & Webster, 2001; Baylor, 2001; and Chen 2002). Disorientation or getting lost in hypermedia may be caused by both poor design of the learning environment and the inexperience of the user with their environment or content (Evelend & Dunwoody, 2001). The Graphic, Visualization and Usability Center at Georgia Tech Research Corporation conducted a survey called the 4th WWW User

Survey from 10 October through November 1995 from a sample size of more than 23, 000 responses (Pitkow and KeHoe, 1995). The problems with using the web reported from the survey are: not being able to find a page that user knows is out there (34.5%), not being able to organize the pages & information users gather (25.8%), and not being able to find a page once visited (23.7%). In addition, 14.3% of the users reported that not being able to visualize where they have been and where they can go was a problem. 6.5% of users reported that being lost in hypermedia was a problem (Pitkow & KeHoe, 1995). 6.5% is not a small number considering the millions of web users. Results from the survey give an idea about the problems experienced by users. The experience of being lost in hypermedia may lead users to feel that they are wasting time, overlooking important information, and influence the way they interact with hypermedia (Theng, 1997). The disorientation problem has the potential of interrupting navigation and browsing in hypermedia systems (McDonald & Stevenson 1998). The hypermedia learning environment offers more freedom and more dimensions in which the user can move and therefore greater potential for users in the hypermedia learning environment to become lost. In the hypermedia environment, learners may face the problem of having to keep track of where they are. Hypermedia is a relatively new learning environment for learners. Learners' disorientation is a commonly reported problem in hypermedia research (Daniels & Moore 2000; Neilsen, 1995). Furthermore, Trip and Roby (1990) stated that disorientation will cause amplified cognitive overload that may reduce the mental resources available. Elm and Woods (1985) outlined three different forms of disorientation in a hypertext system.

- Not knowing where to go next.

- Knowing where to go, but not knowing how to get there.
- Not knowing where they are in the overall structure of document.

Gupta and Gramopadhye (1995) mentioned two categories of hypermedia related problems: implementation dependent and endemic. The implementation dependent category contains display restrictions and browser limitations. The endemic category includes disorientation and cognitive overload that impact usability of hypermedia systems. Authors stated that the endemic problems are more challenging than the implementation dependent problems in terms of limiting the usefulness of hypermedia system. Disorientation refers to an experience by users not knowing where they are within hypermedia and not knowing how to move to a desired location (Theng, Jones, & Thimbley, 1996). Disorientation is a user's perception of his/her uncertainty in location (Baylor, 2001). It may limit the usefulness of a hypermedia learning environment. Stanton, Taylor, & Tweedie (1992) describe disorientation in hypermedia learning environment as not knowing where one wishes to go.

Foss (1989) characterized the disorientation problem and the undesirable results of navigating noticed in users the use of hypermedia system into two categories.

- The Embedded Digression / Choice Multiplicity Problem
- The Art Museum Phenomena

The first problem refers to the user feeling distracted, lost, and forgetful of his/her paths and goals when he/she pursues multiple ways and movements that take the user away from the main topic. The Embedded Digression problem is associated with difficulties occurring from the abundance of path choices that hypermedia causes. The Art Museum Phenomenon refers to problems related to the act of browsing and information seeking activity. The second problem involves the user not being able to

recognize which nodes have been visited or which parts remain to be visited. The Art Museum Phenomenon is a metaphor of what occurs in a similar way when spending a whole day visiting an art museum without giving special attention to a particular drawing or a model. The next day the visitor probably would not be able to describe any painting that he/she saw in the museum (Dias & Sousa, 1997). Foss (1989) defined the following problems that disoriented users may also suffer in a hypertext system. Limitations on short term memory of humans may lead to the following problems:

- Arriving at a specific point in a hypertext document then forgetting what was done there
- Forgetting to return to a departure point
- Forgetting to pursue departures that were planned earlier
- Not knowing if there are any other relevant frames in the document
- Not remembering which sections have been visited or altered.

How does disorientation occur? Neilsen (1990) stated that disorientation happens when the user loses his/her way while navigating or browsing through a hypermedia system. As a result of this, the user may not able to formulate appropriate actions for the screen that the user seeing or find information that they know somewhere in the hypermedia system. Schoon and Cafolla (2002) identified different forms of disorientation. First, disorientation occurs when the links lead the user to irrelevant, unrelated information, and to a myriad of links toward no clear end. Second, inexperienced users may be vulnerable to the disorientation when they are navigating in the hypermedia system. Third, lack of high quality design and unstructured hypermedia systems could lead the user to become disoriented (Schoon & Cafolla 2002).

McDonald and Stevenson (1996) investigated the disorientation effects of two topologies of hypertext on navigation performance in comparison to a standard, linear version of the same document. The users were presented with three versions of the same document: linear (normal text), hypertext with a hierarchical topology, and hypertext with a nonlinear topology. Subjects who had the same experience of using computers used the document to answer 10 questions after a distraction period to retrieve related information. Subjects' performance was measured in terms of speed and accuracy. The results indicated that users performed much better (in terms of being lost) with the linear version of the document than any other structures of hypertext. The results of the study yielded that an appropriate physical structure of hypermedia may alleviate disorientation and improve user confidence. In addition, navigational aid plays an important role in terms of disorientation. Gupta and Gramopadhye (1995) investigated usefulness of the navigational aid (map, index, combination map and index), hypertext size (small stuck and large stuck), and trials (before, after) in alleviating the problems associated with using hypermedia system. In addition, researchers explored the effects of navigational map interfaces on learners' disorientation in hypermedia systems. The users were required to find specific information in hypermedia systems fill in the missing blanks, and locate specific information. To evaluate subjects' performance, speed and accuracy measurements were taken. The results showed that navigational maps and indexes helps users reduce time on task in hypermedia systems.

Beasley and Waugh (1995) conducted a study to asses the effects of text with hotwords, and two mapping techniques spider concept map and hierarchical map, on learner disorientation in a hypermedia environment that was hierarchical in nature. The

subjects were randomly assigned to browse one of three particular browsing environments. The perceived disorientation of subjects was measured. The result of the study indicated that the subjects in the hierarchical maps treatment reported feeling significantly less disoriented that the subjects in the hotwords treatment. In addition, no significant differences were found between learners in hotwords and spider maps treatment.

Furthermore, Beasley and Waugh (1996) conducted a study to investigate the effects of content-structure in terms of structural knowledge acquisition, retention, and disorientation. A lesson was developed and organized in a hierarchical fashion using hypermedia system. The most general concepts appeared in highest hierarchy and the most detailed concepts appeared in lowest hierarchy. The subjects were required to set up a paper- and - pencil representation of the organization of the main concepts in the lesson and asked to complete the nonlinear media disorientation assessment. The subjects who were aware of the post-treatment lesson-structure diagramming activity performed better on the activity. The result of the study showed that there was a significant negative correlation between feelings of disorientation, structural knowledge acquisition, and structural knowledge retention. When learners' attention is partially focused on the objective, determining the structure of the hypermedia environment, the learners' disorientation will decrease and their retention will increase. Therefore, alleviated disorientation has been thought an important issue for learners using hypermedia learning environment.

Dias and Sousa (1997) investigated the role of navigational maps as a helping tool during navigation in terms of student performance. The researchers provided a

navigational map that contained the index with a path traced by the user and stages remaining. The researchers provided a general overview of the hypermedia system by the map. The users were required to search requested information and then write down what they found. To evaluate the performance of the users, researchers measured time spent on each page visited, frequency of visits for each node and the map, time spent on the navigational map, and tasks test. Results of the study showed that using the map lead the user to lower performance, less use of systems, and lower perceived control.

McDonald and Stevenson (1998) investigated the effects of three hypertext topologies (hierarchical, nonlinear, and mixed) in terms of hierarchical structure with cross referential links on the navigation performance of users with high and low prior knowledge on the subject. Participants were required to read text and find answers of questions that were asked. The result of the study showed that users who were unfamiliar with the hypermedia environments and the subject matter of the text were disoriented during the treatment. Researchers found that mixed and hierarchical topology produced the best performance in both browsing and navigation. Knowledgeable users also performed better than non-knowledgeable users. Furthermore, researchers found that the mixed topology of hypertext may allow the freedom to jump into new parts of document and the hierarchical structure may serve to constrain movements of user preventing disorientation. In addition, researchers suggested that mixed text is an appropriate structure for novices. It may help to compensate for a user's lack of conceptual structure of the domain.

Chiu and Wang (2000) studied the effects of the scope of navigation map on disorientation in hypermedia courseware. Five different versions of hypermedia

courseware were designed. Four different link maps were used in the hypermedia system. The number of browsed pages, the number of searching steps, and the nonlinear media disorientation assessment were measured. The results indicated no significant difference among the link maps that were used in hypermedia system.

Baylor (2001) investigated the effects of navigation mode (linear, nonlinear) distracting links (presence, absent), sensation-seeking tendency (high, low), and spatial-synthetic ability (high, low), in terms of disorientation and incidental learning in a hypermedia system. In the experiment, subjects were randomly assigned to navigate and search four different web-sites (linear-distracted and non-distracted, nonlinear distracted and non-distracted) designed for the experiment. Disorientation, spatial-synthetic ability, and sensation-seeking tendency of the users were measured. The results showed that users in a linear mode were more disoriented than those in a nonlinear mode of navigation. There is also a negative relationship between learning and perceived disorientation in the hypermedia system.

Brinkerhoff, Klein, and Koroghlanian (2001) investigated the influence of overview mode (structured, unstructured and no overview) and computer experience (high and low) on achievement, attitude, and instructional time in hypermedia learning environments. The result of the study showed that overview mode may affect the attitudes of the user by reducing disorientation related to navigating through the hypermedia system.

Schoon and Cafolla (2002) investigated World Wide Web hypertext linkage patterns in terms of navigational efficiency and disorientation. Four different linkage patterns (linear, star, hierarchy, and arbitrary) were used in the experiment. The subjects

were assigned the task of finding the location of answers of asked questions. Outcome measures were the final path, the total number of restarts, the total number of revisits, and the navigational action efficiency. The results of the study showed that the star type of linkage was more efficient than the other linkage patterns. Arbitrary linkage patterns may lead users to disorientation because of non-efficient navigation.

Lin (2003) investigated the effect of different text topologies on older users' performance in hypertext. Subjects were twelve older adults who had at least one year computer experience. The browsing and navigation efficiency performance of subjects in hypertext were measured. The browsing measures were the number of hypertext nodes opened and the number of nodes opened more than once. Navigation measures were the mean time taken by the subject to answer queries and the mean number of additional links revisited beyond the minimum links required. The results of the study suggested that an organized hierarchy in hypertext is more effective than hypertext with nonlinear referential networks in terms of browsing and navigation for the aged users.

Cognitive Overload in Hypermedia Systems

Cognitive Overload can be defined as being confused or overwhelmed by the options available to users in a hypermedia environment (Murray, 2001). Multiple and flexible choices within a hypermedia system may lead to cognitive overload. Cognitive overload can effect orientation of users within hypermedia learning environments. Cognitive overload refers to users being overwhelmed or confused by the options available to them in multi-path, multi-tool environments such as hypermedia (Murray, 2001). Thuring, Hannemann, and Haake (1995) stated that increased cognitive overload results in an inability to orient within hypermedia or navigate through hypermedia. Cognitive overload is one of the main obstacles to learning (Clark, 2003). Cognitive

Load Theory broadly was elaborated by John Sweller in 1988. The theory shed some light on the limitations of working memory capacity (Sweller, 1988; Sweller, 1994; Sweller & Chandler, 1994). There are three types of cognitive load: intrinsic, extraneous and germane load. "Intrinsic load refers to the complexity of learning material" (Renkl & Atkinson, 2003, p. 17). Extraneous load refers to the complexity of mental activities during the learning and germane load refers to the capacity of working memory (Renkl & Atkinson, 2003). Brunken, Plass, & Leuther (2003) stated that learner experience, prior domain specific knowledge, and individual differences influence cognitive load that results in more effort, more errors, and less knowledge acquisition.

In hypermedia learning environments, cognitive overload is another essential problem, which exploits users as they navigate through the hypermedia system (Conklin, 1987). Cognitive overload happens when the learner is "bombarded with too much information at once" (Clark, 2003, p. 3). Additionally, Daniels and Moore (2000) stated that cognitive overload is one of the main barriers for hypermedia users. Furthermore, researchers noted that nonlinearity aspect of hypermedia system often results in learner disorientation and cognitive overload (Beasley & Waugh 1995; Conklin, 1987; Tripp & Roby, 1990, & Zhu, 1999).

Hypermedia learning environments are more appropriate for exploration type learning. However, exploration requires cognitive efforts (Kashihara, Kinshuk, Oppermann, Rashev, & Simm, 2000), which may cause cognitive overload.

Learner performance is an aspect of cognitive overload and can measure time on task, number of errors, and correct test items (Pass, Tuovinen, Tabbers, & Gerven, 2003). Mayer and Moreno (2003) proposed three assumptions about how the human mind works

based on research. These assumptions are “dual channel”, “limited capacity”, and “active processing” assumptions. Dual channel refers to the human information processing system as two separate channels verbal and visual. Limited capacity means that verbal and visual channels have limited capacity to process information at any one time. Active processing refers to a limited amount of cognitive process in the verbal and visual channels for learning (Mayer & Moreno, 2003).

Mayer & Moreno (1998) and Mousavi, Low & Sweller (1995) investigated ways to reduce cognitive overload. They found that physical integration of visual and verbal information (split-attention effect), representing information both visual and auditory (modality effect), abandoning verbal information (redundancy effect) are the ways to decrease cognitive overload.

Individual Differences and Hypermedia

Compute Expertise

Computer users have different characteristics. These characteristics can be categorized into different categories such as level of expertise, users’ prior knowledge, and gender. An expert can be defined as a person with particular skills and knowledge obtained through experience rather than inherent talent (Ericsson & Charness, 1994). A novice is a user who has little or no prior knowledge about the hypermedia system. Nielsen (1995) stated that the level of users’ expertise has a great effect on how users use the hypermedia system. In the hypermedia research, an expert was used to define the more experienced users among the participants available for the researcher in terms of computer experience. A novice was used to describe less experienced users among the subjects in terms of computer usage. Potosky and Bobko (1998, p. 338) defined computer experience as “the degree to which a person understands how to use a computer.” The

user's experience has been studied by many researchers in the hypermedia learning environment.

McDonald and Stevenson (1998) examined the interaction between users' domain knowledge (high and low prior knowledge of the topic) and their navigation behaviors as they searched a text adapted to hierarchical, nonlinear, and mixed structure of hypertext system. The subjects were divided into knowledgeable and non-knowledgeable participants according to their knowledge of a particular subject. The total number of nodes opened, number of repeated nodes, completion time, and additional nodes opened were measured. Subjects answered questions by searching through the hypertext. From the result of the study, researchers found that knowledgeable users opened more nodes than non-knowledgeable users in the hierarchical and nonlinear hypertext system, but not in the mixed hypertext. Furthermore knowledgeable subjects opened fewer reopened nodes across all hypertext structures. Researcher found that overall knowledgeable subjects completed tasks faster that the non-knowledgeable subjects, when they look at the completion times in the first task and after the distracting task. The researchers concluded that knowledgeable participants performed better than non-knowledgeable subjects.

Mohageg (1992) examined whether linking configurations and combinations of hierarchical and network linking was best suited for expert user or novice users' performance. The researcher found that users of the hierarchical linking structure performed significantly better than subjects who used network linking. The researcher also claimed that expert users navigating in a nonlinear hypertext may avoid disorientation and cognitive overload because of having poses of mental representation.

In addition, the computer expertise level may influence navigating and learning from hypertext. Brinkerhoff et al (2001) claimed that users who were familiar with hypertext may use fewer mental resources on navigation and orientation with hypermedia system than those less familiar with hypertext.

Reed and Giessler (1995) investigated the relationship different type of prior-computer experiences and linear or nonlinear steps participants choose while they were working with hypermedia learning environments. The results showed that subjects with more experience had more nonlinear steps than participants with low experience.

Ayersman and Reed (1998) examined the relationships among the learners' use of hypermedia-based mental models, and their knowledge of hypermedia and two task types. The study showed that subjects with higher levels of computer experience demonstrated more convenience for identifying hypermedia structure than less experienced users.

Reed et al. (2000) investigated the effects of prior computer experience on navigation in a hypermedia learning environment. The study showed that participants with high hypermedia experience spent less time than subjects with less hypermedia experience, while navigating in the hypermedia system. Also participants with more years' experience at working with computers took more linear steps; on the other hand participants with more hypermedia experience took less linear steps when using a hypermedia learning environment.

Brinkerhoff, Klein, and Koroghlanian (2001) examined overview mode and computer experience in a hypermedia system. Researchers found that subjects who had

high computer experience learned more than subjects who had low computer experience in the hypermedia learning environment.

In summary, experts, or more experience computer users might be able to facilitate nonlinear hypermedia learning environments in a more efficient and flexible way. Although, most of studies investigated the relationship between computer experience and navigation, little attention has been given to the effect of user's computer experience level and different interface windowing mode (structured-tiled and unstructured-overlapping-windows mode) on disorientation and cognitive overload in a hypermedia learning environment.

The problem of disorientation in the hypermedia system lessens the cognitive overload of the learner and reduces the instructional capabilities of hypermedia. Jonassen (1988) stressed that disorientation might increase cognitive overload. Beasley and Waugh (1996) studied the effects of cognitive mapping structures and its effect on hypermedia disorientation and cognitive overload. The results indicated that when disorientation increased, the cognitive overload of the learner increased. Increased cognitive overload will likely reduce the mental resource of learning (Beasley & Waugh, 1996). When designing hypermedia based learning environments, designers face challenges controlling cognitive overload. Zhu (1999) investigated the relationship among the size of a node, the number of links, node-by-link interaction and students' performance in learning, information searching, and attitude. Subjects were assessed by general and specific information searching, multiple-choice, tests, and written essay measures. A likert-scale questionnaire was used to measure attitude of the learners. Results showed that there was a significant relationship between the number of links and

cognitive overload. Kashihara et al. (2000) described a methodology for hypermedia learning environments. The aim of the methodology is to limit learning space (exploration space control-ESC) in order to control cognitive overload. In order to limit the information space, three factors were recommended by Exploration Space Control:

- Limiting information resources
- Limiting exploration path
- Limiting information to be presented

The nonlinear linking capabilities of hypermedia learning environments allow the user to navigate the learning environment by his/her own choice. Niederhauser et al. (2000) investigated the effects of cognitive overload associated with using hypertext linking capabilities to "criss-cross the conceptual landscape" on student learning in terms of cognitive load theory. Subjects were assessed reading hypertext and completed multiple choice and essay posttests. Participants were allowed the freedom to read the hypertext in whatever way they thought best assisted their learning. Researchers only represented text to avoid problems related to multimedia features (e.g. graphics, audio, and video). The navigation and screen reading time were measured. The results indicated that successful learners preferred to read the hypertext in a linear manner. These subjects may have reduced cognitive overload by using their default reading strategy based on their past experience. On the other hand, students who took nonlinear steps reading in hypertext exposed additional extraneous load because of the decisions required for selecting and continuing information. Gerjets and Scheiter (2003) noted that neglecting most of the additional information provided in hypermedia learning environment may reduce extraneous cognitive overload.

Plass et al. (2003) investigated the role of cognitive load in multimedia learning and how cognitive load affects the way learners with different cognitive styles function visual and verbal information. Researcher used a second-language multimedia program for the study. Participants were assigned three different instruction modes: the visual mode, the verbal mode, and both the visual and verbal modes. Subjects were defined in terms of high and low spatial ability. Vocabulary test was chosen to measure verbal ability. The results indicated that low-ability students recalled fewer translations of foreign language words than high-ability students when they were required to choose and function visual explanations while reading.

Cognitive Style

Cognitive style and individual differences have been recognized by educators since the late 1940s (Daniels, 1996). Paolucci (1998) noted that cognitive styles interact with cognitive activities such as thinking, perceiving, and problem solving not its content. Cognitive styles can be defined as an individual's preferred and habitual approach to organizing, processing, and representing information (Riding & Rayner, 1998). In the 1970s, Witkin and his colleagues developed a test called the Group Embedded Figures Test (GEFT) to measure individual's cognitive style. Among the different types of cognitive styles, field dependence and independence (Witkin, Oltman, & Raskin, 1977) are one of the most frequently utilized measures of cognitive styles in the research on hypermedia systems (Ford & Chen 2002; Kim 2000), because cognitive style indicates how well a learner can restructure an illustration of knowledge based on the use of salient cues and field arrangement (Weller, Repman, Lan, & Rooze, 1995). Field dependence refers to the "degree to which a learner's perception or comprehension of information is affected by the surrounding perceptual or contextual filed" (Jonassen & Grabowski,

1993, p.87). Field independence refers to the degree to which an individual is internally directed, serialistic, and analytic in terms of their approach to learning, problem solving, and organizing information (Chen & Macredia, 2002).

Flexibility and multimodal aspects of hypermedia learning environments can accommodate individual differences. There are several studies about individual differences and hypermedia learning environments. Kim (2000) investigated how users with different cognitive styles locate information on a hypermedia based system. In addition, the researcher examined the effects of user's cognitive style on searching behavior in relation to the user's online search experience. Participants were required to take The Group Embedded Figures Test (GEFT) and fill out a questionnaire to determine their cognitive style and search experience. The average time spent, the number of search, and the average number of nodes visited was measured. The results of the study indicated that there was a significant relationship between online search experience and cognitive style. While field dependent users with no experience or little experience had difficulties on information search tasks, field independent users spent less time and visited fewer nodes than the field dependent users.

Ford and Chen (2000) investigated the interactions among individual cognitive style, learning outcome, and learning behavior in terms of students' learning in a hypermedia system. A hypermedia learning environment was developed to teach web design with HTML. Researchers found no significant difference between field dependent and field independent students and their learning outcomes; although field dependent and field independent learners preferred to use different type of topics. While field dependent students preferred to learn HTML with examples, field independent students preferred to

look at the detailed descriptions of each HTML code. Furthermore, the study showed that students with different cognitive styles displayed different learning strategies and required different navigational support in hypermedia learning environments.

Liu and Reed (1995) investigated the effects of learners' cognitive style on learning strategies. To measure participants' cognitive style, Witkin's Group Embedded Figure Test (GEFT) was employed. A hypermedia learning environment was used to teach English to students learning English as a second language. Subjects choose different presentation modes to support information about vocabulary words they were instructed to learn. The results indicated that field independent students preferred to use the index tool in a nonlinear fashion. On the other hand field dependent students preferred to follow the index tool in a linear fashion from beginning to end. In addition, field independent students tended to use more relationship options of words while, on the contrary, field dependent students tended to use more video context options.

Reed et al. (2000) examined the effect of learning style as measured by the GEFT on the number of linear steps in a hypermedia learning environment. The HyperCard program was used to develop a hypermedia learning environment for the treatment. Time on task and percentage of nonlinear steps were measured. The results of the study showed that field dependent learners took more nonlinear steps than field independent or field mixed learners. In addition, field dependents took more time than field independents.

Weller et al. (1995) examined the effects of cognitive style measured by the GEFT on the use of structural organizers, learner navigation, and gender in the hypermedia learning environment in terms of student learning. Participants were randomly assigned

to one of four different versions of computer ethics software. After subjects completed the lesson, they were required to take a 20-item paper-pencil post test. The results showed that field independent subjects learned more efficiently than field dependent subjects regardless of whether organizational components were included in the hypermedia based instruction. In the second experiment of the study, researchers investigated the effects of cognitive styles (field dependent and field independent) in achievement on hypermedia based instruction. The results indicated that field independent participants learned more efficiently from hypermedia based instruction than field dependent participants.

Daniels and Moore (2000) investigated the effects of cognitive style field dependence/independence and learner control of presentation mode within an educational hypermedia environment. Subjects were randomly assigned to one of two versions of the program, a control group which utilized the commercially designed multimedia presentations and a treatment group that provided the choice of single-channel presentation in addition to the multiple-channel presentation. A ten-item post test and five recall questions were assessed. The results of the study showed that there was no relationship between GEFT scores and the frequency of selecting multiple-channel or single channel presentation in hypermedia learning environment.

Studies indicated that field dependent and filed independent users will accomplish differently when they experience hypermedia system through different interface and information presentation modes. However, in different hypermedia interface windowing modes and the effects of users' cognitive styles (field dependent and field independent) have been ignored. In the present proposed study, the effects of different interface

windowing modes (tiled and overlapping) on user's disorientation and cognitive overload in a hypermedia environment was investigated.

CHAPTER 3
METHODOLOGY

Introduction

The following objectives were established to guide our study:

- To examine the effects of different interface window modes (tiled and overlapping) on cognitive overload of users with different levels of computer understanding and experience
- To examine the effects of different interface window modes on disorientation
- To explore the relationship among disorientation and cognitive overload
- To explore the relationship between interface modes and disorientation and cognitive overload.

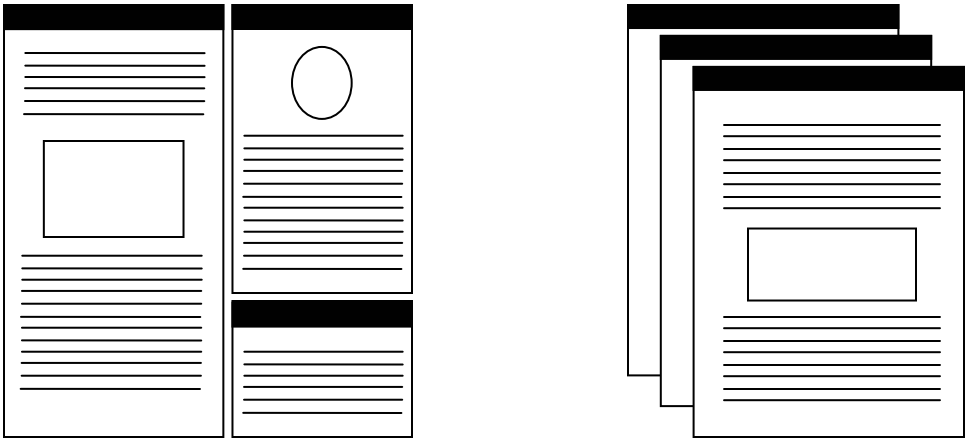
In our study we attempted to elicit information about how different interface windowing modes (tiled and overlapping) might affect users' disorientation and cognitive overload in a hypermedia learning environment.

Chapter 3 covers information about experimental design, research hypotheses, participants, and data analysis methods.

Description of Setting

The research took place at the College of Education's computer lab (Machintosh, iMacs-G4) at the University of Florida. The size of the computer monitors was 17-inch widescreen. All desktop item colors were identical. The CPU speed of the computers was the same. Mouse tracking, double-clicking speed, and keyboard key repeat rate were the same in all computers. Internet Explorer, version 5.2, was used by participants in order to browse and navigate through the hypermedia learning environment.

To serve the purpose of the study, two interface presentation modes (tiled-windows interface mode and overlapping-windows interface mode) were designed and developed using Macromedia Dreamweaver (Macromedia Inc.) in a hypermedia learning environment which included a HyperStudio (Sunburst Technology Inc.) tutorial. The tiled-windows interface mode contained three different tiled-windows, the graphic window, the text window, and the navigation window. The second mode was the overlapping-windows interface mode. The overlapping-windows interface mode's index page contained the tutorial directions, objective, and navigation links. The information provided within the hypermedia learning environments were identical. A small pop-up window was located on the upper-left corner of the hypermedia learning environment in order to measure participants' secondary task: simply visual reaction time.



Tiled-windows Overlapping-windows

Figure 3-1. Tiled-windows interface mode and overlapping-windows interface mode

Navigation on both tiled and overlapping windows interface modes included navigation links for text and navigation for graphic. Figure 3-1 presents a sample layout of two interface modes.

Sample

The study's participants were randomly drawn from undergraduate and graduate students at a large south eastern public university. A total of 146 participant participated in the study. The number of females were 111, while the number of males were 35. The participants ranged in age from 18 to 47, with a mode age of 21.

Table 3-1. Demographic information.

		N	%
Gender	Male	35	23.97
	Female	111	76.03
Age	18	3	2.05
	19	27	18.49
	20	38	26.03
	21	39	26.71
	22	17	11.64
	23	5	3.42
	24	3	2.05
	25 or higher	13	8.90
	Missing	1	0.68
Year in school	Freshman	5	3.42
	Sophomore	38	26.03
	Junior	36	24.66
	Senior	53	36.30
	Graduate	14	9.59

Materials

The experimental system was on the desktop of each computer for the participants and the speed of launching and opening files was the same for all machines used in the study. Macromedia Dreamweaver html editing and web designing software was used to design the interface modes and hypermedia learning environment. The hypermedia learning environments were located online on an Active Server Pages (ASP) supported web server (Appendix E and F). The Internet Explorer history file was used to monitor user's movements (the name of visited pages and the number of visited pages) through

the hypermedia learning environment on each computer (Appendix H). The entire process was online. A HyperStudio tutorial was replaced in each interface mode. The information in both environments were identical.

Self-Report Computer Experience

Participants' computer experiences were measured using the Self-Report Computer Experience survey (see Appendix B) developed by Potosky & Bobko (1998). This instrument consists of 12 items presented with a five-point Likert-type scale rating from 1 (strongly disagree) to 5 (strongly agree). There were two factors in the instrument. The first factor measures participant's technical competency, the other factor measures participants' general competence subscale. The internal reliability estimate for the overall Self-Report Computer Experience (SCE) measure was 0.79. The Self-Report Computer Experience was used to obtain participants' general computer knowledge and experience. In the questionnaire, items 1 – 6 comprise the technical competence subscale. Items 7 – 12 comprise the general competence subscale. (Potosky & Bobko, 1998). The pearson correlation between the two subscales was .70. The authors' permission had been obtained by e-mail communication.

Participant Disorientation and Ease of Use Questionnaire

The level of participant disorientation was determined with the Nonlinear Media Disorientation Assessment Instrument (Ahuja & Webster 2001) (see Appendix D). The questionnaire was assigned to measure users' perception of disorientation and ease of use. This measure was developed by Ahuja and Webster (2001). The authors' permission was obtained to use the instrument by e-mail communication. The disorientation measure consists of seven items presented with a seven-point, Likert-type scale ranging from 1 (never) to 7 (always). Internal-consistency reliability (Cronbach's

alpha) for ease of use was 0.87. Disorientation measure was constructed from seven items loading on factor 1 with a Cronbach's alpha of 0.89 (Ahuja & Webster 2001). The ease of use section of the questionnaire consists of a three item measure that authors adopted from Davis (1989). The ease of use part of the questionnaire consists on three items presented with a seven-point scales ranging from "strongly disagree" to "strongly agree". Internal-consistency reliability (Cronbach's alpha) for ease of use was 0.87.

Direct Measurement of Disorientation

The data analysis for disorientation was based on the score obtained from the history file in Internet Explorer. Before starting the experiment, the Internet Explorer history was cleared. After the experiment, the Internet Explorer's the history file was collected from the computers and the total number of visited nodes was counted and recorded on the user's task paper.

D: Orientation ratio;

R: The number of information nodes of the pre-defined path to complete required information retrieval task;

N: The total number of nodes accessed;

Orientation ratio (D) = the number of information nodes of the pre-defined path to complete required information retrieval task (R) / the total number of nodes accessed (N) (Dias & Sousa, 1997). This ratio measures the degree of disorientation because it determines the precision of information retrieval (Dias & Sousa, 1997). If D equals to 1, the user oriented. If D equals to 0 the user was completely lost in the hypermedia system.

$D=R/N$

If D equals to 1, the user oriented

If D equals to 0, the user was completely lost in the hypermedia system.

Direct Measurement of Cognitive Load

While the user was engaging in primary tasks on the hypermedia learning environment, the secondary task is attended to at the same time making it possible to measure the cognitive load of the user (Brunken, Plass, & Leutner, 2003). This method is called "Dual-Task Measurement of Cognitive Load" in multimedia learning. The secondary task was presented to the participants as a simple "visual-monitoring task" (Brunken et. al., 2003). Once the user opens the learning environment, a small pop-up window opened on the upper-left corner of the screen. The default background color of a small pop-up window was white with black text. The size of the pop-up window was 120 pixel width by 85 pixel height. The pop-up window was coded as nonresizable. A java script code was written to prevent the user from closing the pop-up window. When the user closed the pop-up window it reopens again in the same location with the same size.

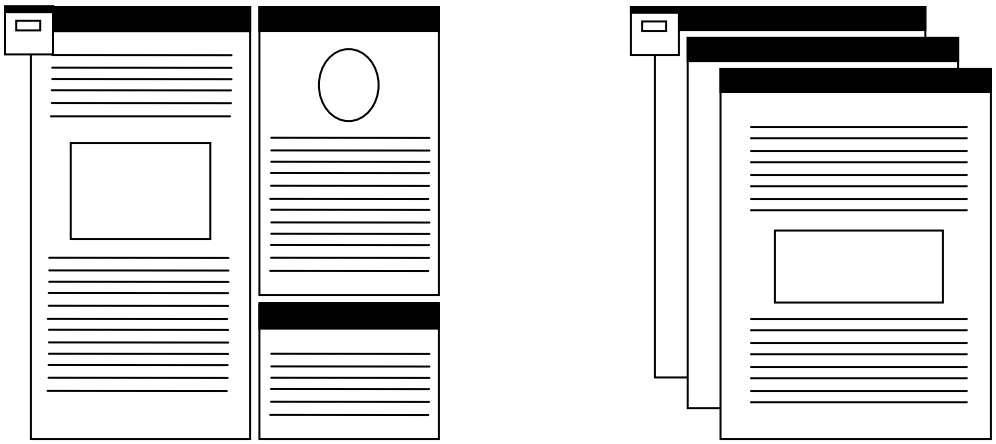


Figure 3-2. Developed screen layout of the dual tasks condition

While the user worked on tasks in the learning environment, the user monitored the pop-up window for color changed. The background color of the pop-up window changed at random time intervals. As soon as the user notices the background color change, the user clicked on the button in the pop-up window. Users' reaction time was displayed in

an alert message. The user was asked to record the time that was displayed in an alert message.

The secondary task required users to react as soon as possible to a background color change in a small pop up window that was replaced to the learning environment. When the background color changed, it indicated to the user that response was required. When the user responded by clicking the button, the alert window showed response time at the same time as the user's IP address and response time was written on the server. The continuous visual monitoring task as a second task proceeds to measure cognitive load in hypermedia learning environments (Brunken et al. 2003). Figure 3-2 demonstrates a screen layout of the dual task condition.

Dual-Task Measurement of Cognitive Load:

- Primary task: Information retrieval task
- Secondary task: Simple visual color change reaction task

The small pop-up window frame's color occasionally changes in random time intervals. The following data were sent to a server when the user clicked on the button as a reaction to background color change of the pop-up window.

- IP address of the participant's computer
- Users' simple visual color change reaction time (t).

The data were saved on a server (see Appendix G). Upon conclusion of this data collection, the data were imported into a spreadsheet program for data organization and storage.

Method

Participants were randomly assigned to the tiled-windows interface mode or the overlapping-windows mode interface. Information retrieval tasks were administered on

the hypermedia learning environment. The information retrieval task requires the user to traverse different depths and paths in the hypermedia structure (see Appendix C). The hypermedia learning environment web site includes links to other nodes, graphics, and text. Both interface modes included a "simple navigation system" which presented local links to other pages in the hypermedia learning environment (Park & Kim, 2000). The number of pages visited during task completion was measured.

Procedures

The experiment was conducted in sessions at the computer lab. The tutorial files were located on the eliteracy.org server. A short orientation session was provided to the participants to assist them in utilizing the features, becoming comfortable, and familiar with the hypermedia system environment. All participants were informed about the study and the learning environment to reduce novelty effects of the environment. A schedule was arranged to participate in the study. Each participant was provided with an informed consent form to read and sign. Participants were randomly assigned to one of two treatment conditions of interface windowing: tiled or overlapping. First, information was collected regarding the participants' demographics. Demographic information inventory questionnaire consists of four questions soliciting age, gender, class standing and major (see Appendix A). Participants completed The Self-Report Computer Experience (SCE) questionnaire. The user task worksheet (see Appendix C) was provided to participants. Participants were allowed to read the directions on the user task worksheet. The particular URL address of interface treatment was provided. A number was given to each computer in order to collect data. Participants were asked to write their computer numbers on the worksheet and 20 minutes were given to participants to complete information retrieval tasks. Participants were asked to start finding answers as

quick as possible and were told to take the most direct route possible to locate each answer. Participants wrote their answers on a task work sheet. The task worksheet included five basic information retrieval questions directing participants to search information and navigate within the learning environment. Efficient browsing, finding of information, and executing a certain task in a hypermedia learning environment were the indicators of performance of users. Therefore, a fixed amount of time was chosen for browsing during the experiment. This was consistent with previous researches, such as Ahuja & Webster (2001), and Head, Archer, & Yuan (2000). The final data collection of this study occurred at the end of treatment. The disorientation and Ease of Use instrument were administered. This study was approved by University of Florida Institutional Review Board (approval #2003-U-762).

Dependent and Independent Variables

The following dependent variables were used in the study.

Disorientation: This variable is defined as the tendency to lose one's sense of location and direction in a nonlinear document (Ahuja & Webster, 2001). Two instruments were used to measure the participants' disorientation: Disorientation and Ease of Use and Orientation Ration (D=R/N).

Cognitive Overload: This variable refers to users being overwhelmed or confused by the options available to them in multi-path, multi-tool environments such as hypermedia documents (Murray, 2001). An ASP and java script coded a pop-up window was designed to measure participants' cognitive overload.

Computer Experience was covariate. It is defined as the degree of a person's understanding about how to use computers (Potosky & Bobko, 1998).

One independent variable with two levels was used in the study. Interface windowing modes: The tiled-windows and the overlapping-windows (see Appendix). The interfaces for the study was designed and developed by the researcher.

Research Design

This study involves three dependent variables and one independent variable with two levels. Independent sample t-test was used to examine whether two groups are significantly different from each other. Independent samples t-tests were appropriate because the answer of whether the mean of the overlapping-windows interface mode differs from the mean of the tiled-windows interface mode. An independent-samples t-test determines the probability of obtaining difference between mean scores. There are three basic assumptions for using t-test. The results of t-test are dependent upon how well the present study meets these assumptions (Shavelson, 1996).

- Are the observations independent?
- Groups are normally distributed.
- Variances of two groups are the same.

A Pearson's r Correlation Coefficient was used to test correlation between the dependent variables.

A Multivariate Analysis of Covariance (MANCOVA) was employed for this study. MANCOVA is a procedure that is used to compare differences in groups with multiple dependent variables while statistically controlling for covariates (Stevens, 2002).

Basic assumptions for MANCOVA are as follows (Stevens, 2002).

- Linear relationship between covariate and dependent variables
- The observations on the dependent variables follow a multivariate normal distribution in each group.

- The population covariance matrices for the p dependent variables are equal.

Data Collection

Data were collected during a thirty-minute experiment session held at the computer lab. Participants were provided with a computer already opened to either tiled-windows mode or overlapping-windows mode in a web browser live on the Internet. The data were collected from surveys, ASP and Java Script coded web page and the Internet Explorer History file. An online data collection script was also included to collect secondary task reaction time of users. Second task reaction time data were collected as a log file on the server. The log file included respectively the computer's internet protocol (IP) address number and user reaction time.

Table 3-2. Data-collection time table.

Session	Procedure	Data collected	Time needed
First Session	IRB inform consent Participant demographic information	Background information	1 min
	SCE survey	Self-report computer experience	2 min
	Instructions, orientation	No data	5 min
Second Session	Disorientation measure: Information Searching and retrieval	Information retrieval task the total number of nodes visited d for information retrieval task	20 min
	Cognitive over load	Secondary task reaction time	
Last Session	Disorientation Questionnaire	Sense of getting lost data	2 min

Research Hypotheses

The following are the research hypotheses of the research.

Hypothesis 1: There is no significant difference in user disorientation between overlapping-windows interface mode and tiled-windows interface mode in the hypermedia learning environment.

Hypothesis 2: There is no significant difference in user cognitive overload between overlapping-windows interface mode and tiled-windows interface mode in the hypermedia learning environment.

Hypothesis 3: There is no significant relationship between two different measures of disorientation.

Hypothesis 4: There is no significant relationship between cognitive overload and two different measures of disorientation

Hypothesis 5: There are no significant relationship among user's computer experience, disorientation and cognitive overload.

Hypothesis 6: There are no statistically significant interface windowing effects on the vector of three dependent variables when effects of participants' computer experience are controlled.

Data Analysis

Data Analysis was based on the participantion of 146 students randomly assigned to the two interface windowing treatment groups. Dependent measures included computer understanding and experience survey, disorientation and ease of use survey, orientation ratio, and second task reaction time (cognitive overload).

Data were analyzed using the SPSS® Version 10.0 for Windows™ software package. The sample was described using descriptive statistics. First t-test was employed to examine relationship between variables. T-test was performed for each dependent variable. The level of significance for all statistical analysis was set at .05.

CHAPTER 4
RESULTS

Introduction

Chapter 1 outlined the basis for conducting this study. A historical perspective of problems associated with hypermedia was presented and current picture was established. The purpose of our study was to investigate the effects of different interface windowing modes (tiled and overlapping-windows presentations) and individual differences (computer expertise) on user disorientation and cognitive overload, in a hypermedia learning environment. Chapter 2 provided a theoretical and conceptual framework for the topic. The research questions, hypotheses, and methodology were outlined in the chapter 3. 146 students were randomly assigned to two interface windowing mode groups. Dependent measures included disorientation and ease of use survey, orientation ratio, computer experience survey, and cognitive overload measurement (reaction time). The data were analyzed using Independent t- tests, the Pearson's *r* Correlation Coefficient, and Multivariate Analysis of Covariance (MANCOVA). The level of significance for all statistical analyses was set at .05.

This chapter presents the descriptive statistics of the sample, hypotheses testing, and results of the t-tests, the Pearson's *r* Correlation Coefficient, and MANCOVA used to test hypotheses.

Descriptive Statistics of the Sample

The sample used in this study consisted of students enrolled in EME 2040 Introduction to Educational Technology and EME 4406 Integrating Technology into the

Curriculum, from the 2004 spring semester. The total number students in these classes were 269. The study was conducted at the beginning of the spring semester. Students were asked to enroll in the experiment voluntarily. 146 participants completed the 30 minute session for this study. The enrollment rate for the study was %54.3 (n=146). Subjects were drawn from students who had taken classes from the Education Technology program. A majority of the students were not from the Educational Technology program.

Female subjects numbered 111, while male subjects numbered 35. Participants ranged in age from 18 to 47; with a mode age of 21 and median of age 30.5 (see Figure 4-1 and Table 4-1).

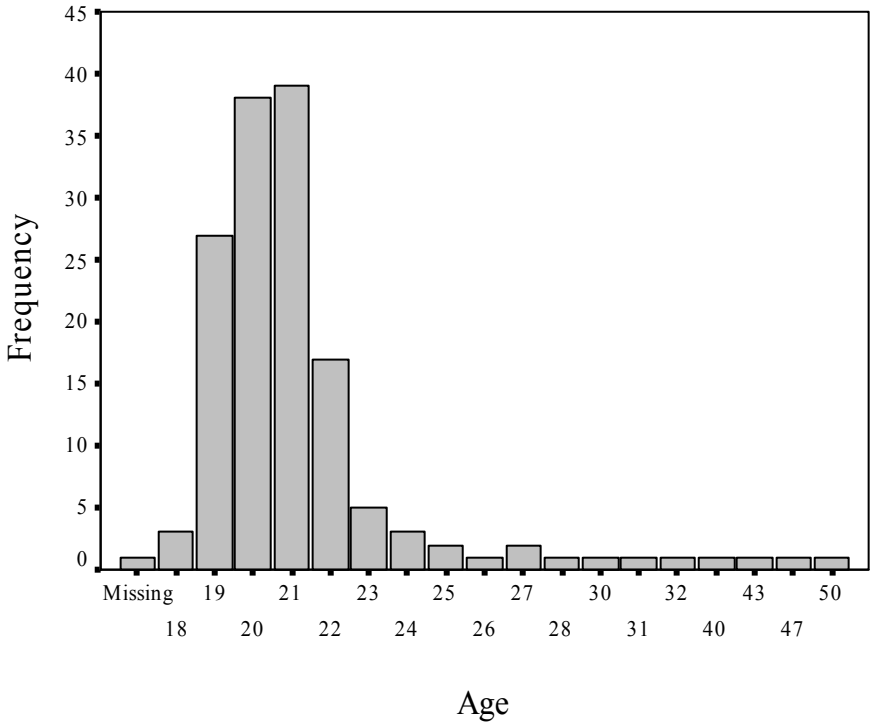


Figure 4-1. Distribution of participant age

Figure 4-1 shows the distribution of participants' age. Table 4-1 displays the demographic data information for participants.

Table 4-1. Demographic data information of the samples

		N	%
Gender	Male	35	23.97
	Female	111	76.03
Age	18	3	2.05
	19	27	18.49
	20	38	26.03
	21	39	26.71
	22	17	11.64
	23	5	3.42
	24	3	2.05
	25 or higher	13	8.90
	Not Defined	1	0.68
Year in School	Freshman	5	3.42
	Sophomore	38	26.03
	Junior	36	24.66
	Senior	53	36.30
	Graduate	14	9.59

Participants were randomly assigned to the interface windowing modes. Table 4-2 displays participants' distribution for treatment groups.

Table 4-2. Participants' distribution for treatment groups

Interface mode	Frequency	Percent
Tiled-windows	73	50
Overlapping-windows	73	50

The independent t-test was used to assess whether the means of two groups statistically differ from each other on interface windowing modes.

Hypotheses Testing

Hypothesis 1: There is no significant difference in user disorientation between overlapping-windows interface mode and tiled-windows interface mode in the hypermedia learning environment. Independent sample t-test was used to determine if significant differences existed between tiled and overlapping-windows on user disorientation. Table 4-3 shows descriptive statistics for the two groups separately.

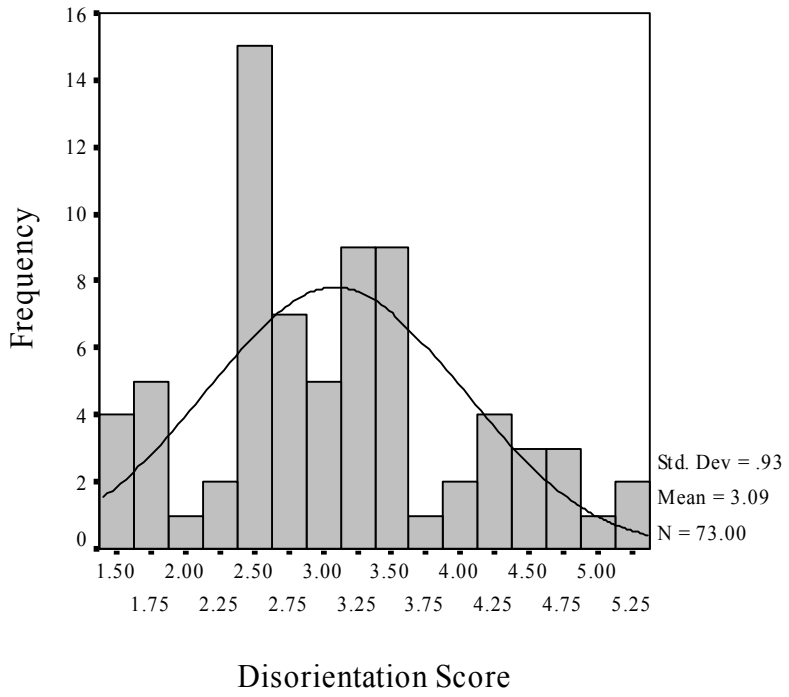


Figure 4-2. Distribution of user disorientation scores on tiled-windows interface mode

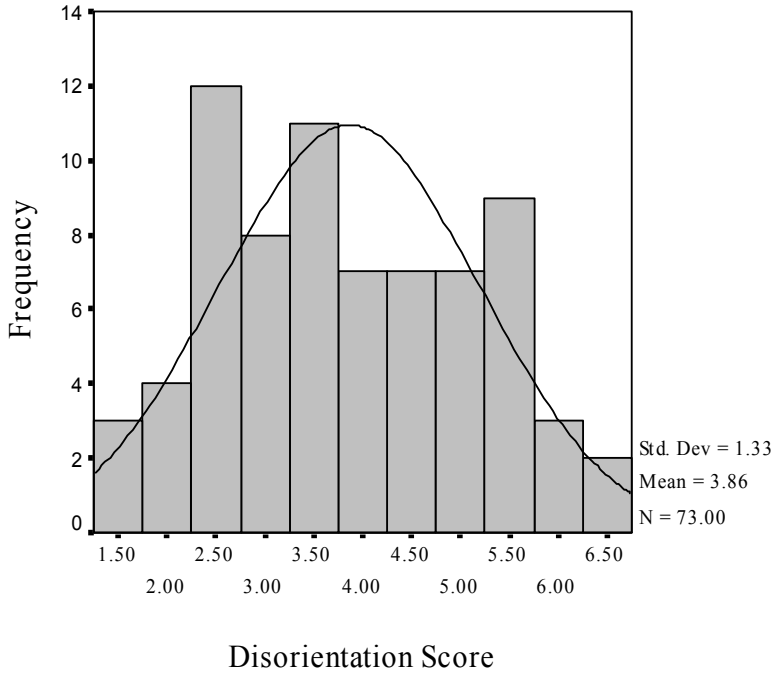


Figure 4-3. Distribution of user disorientation scores on overlapping-windows interface mode

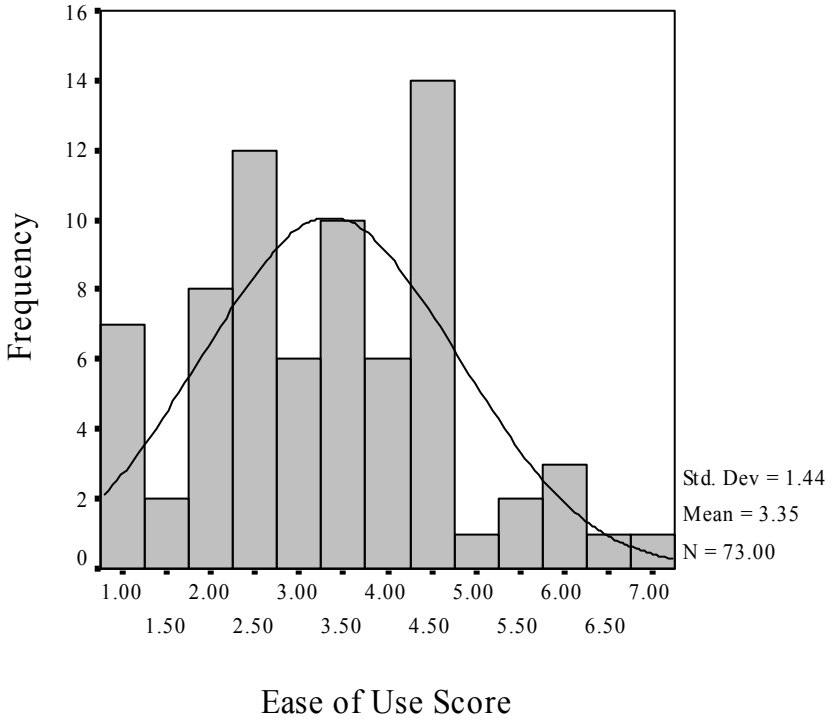


Figure 4-4. Distribution of ease of use on overlapping-windows interface mode

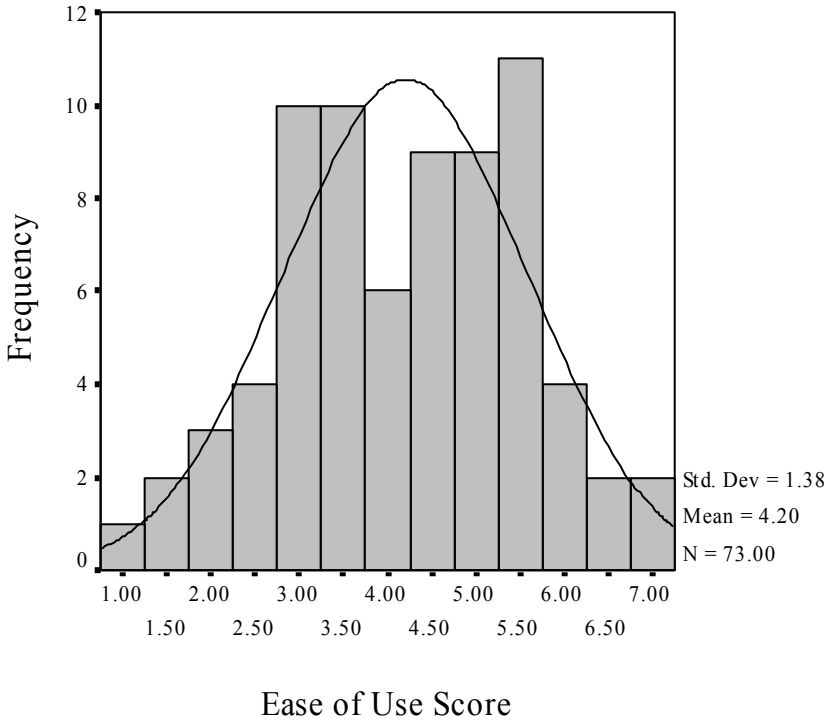


Figure 4-5. Distribution of ease of use on tiled-windows interface mode

Table 4-3. Disorientation means and standard deviations for the treatment groups

Interface mode	Mean	SD
Tiled-windows	3.0881	.9315
Overlapping-windows	3.8630	1.3281

Figure 4-2, Figure 4-3, Figure 4-4, and Figure 4-5 show distribution of user's disorientation and ease of use scores on the tiled and overlapping-windows condition.

An inspection of the two group means indicate that the disorientation of users on overlapping-windows interface mode was significantly higher (M=3.8630) than did the tiled-windows interface mode users (M=3.0881), t(144)=-4.082, p=.000.

An inspection of the two group means indicates that the average user disorientation for tiled-windows interface mode (3.0881) is significantly lower than the average user disorientation for overlapping-windows interface mode (3.8630). As seen in Figure 4-6, the mean of disorientation in the overlapping-windows (3.8630) is higher than the mean of disorientation in the tiled-windows. It is likely obtain significant difference between two different interface windowing modes. Figure 4-7 shows estimated marginal means for the ease of use. Figure 4-7 and figure 4-8 show Boxplots for disorientation and ease of use.

Table 4-4. Independent samples t-test for disorientation

Variable	df	t-value	p
Disorientation score	144	-4.082	.000

The analysis indicated that subjects on the tiled-windows interface mode were less disoriented (M=3.0881, SD=.9315) than did those in the overlapping-windows interface mode (M=3.8630, SD=1.3281), t(144)=-4.082, p=.000.

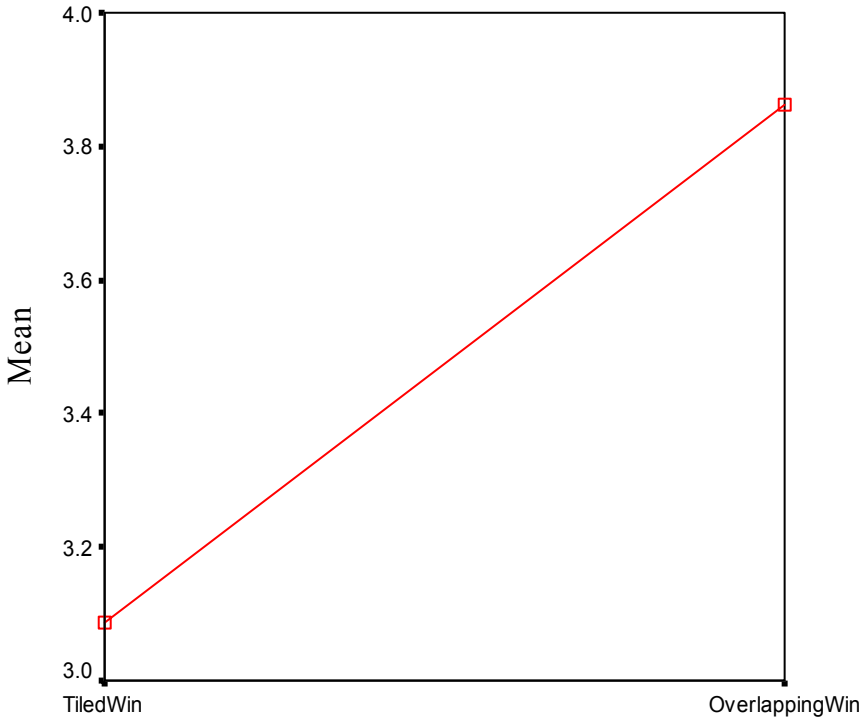


Figure 4-6. Estimated marginal means of disorientation

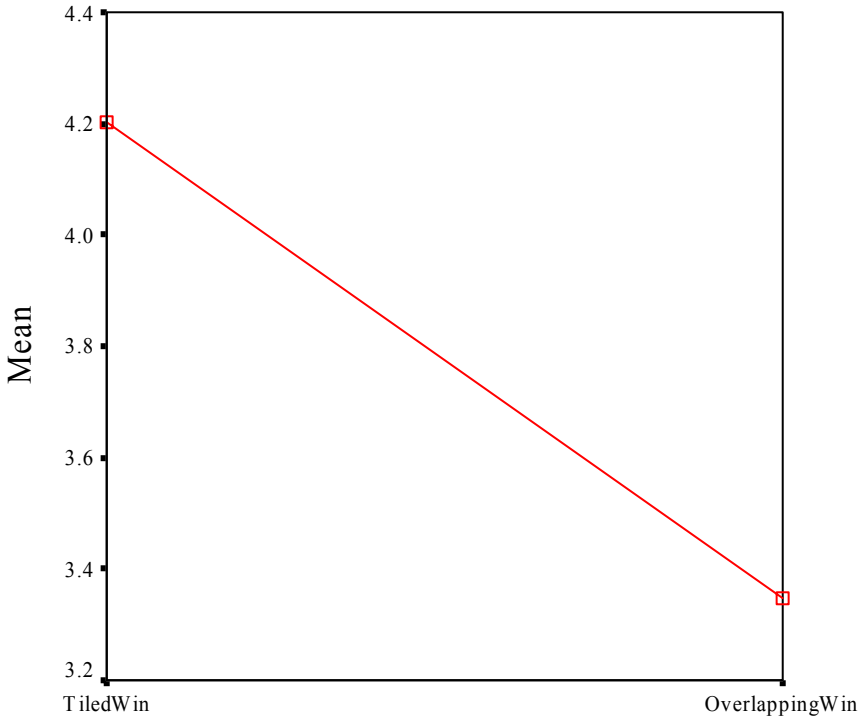


Figure 4-7. Estimated marginal means of ease of use

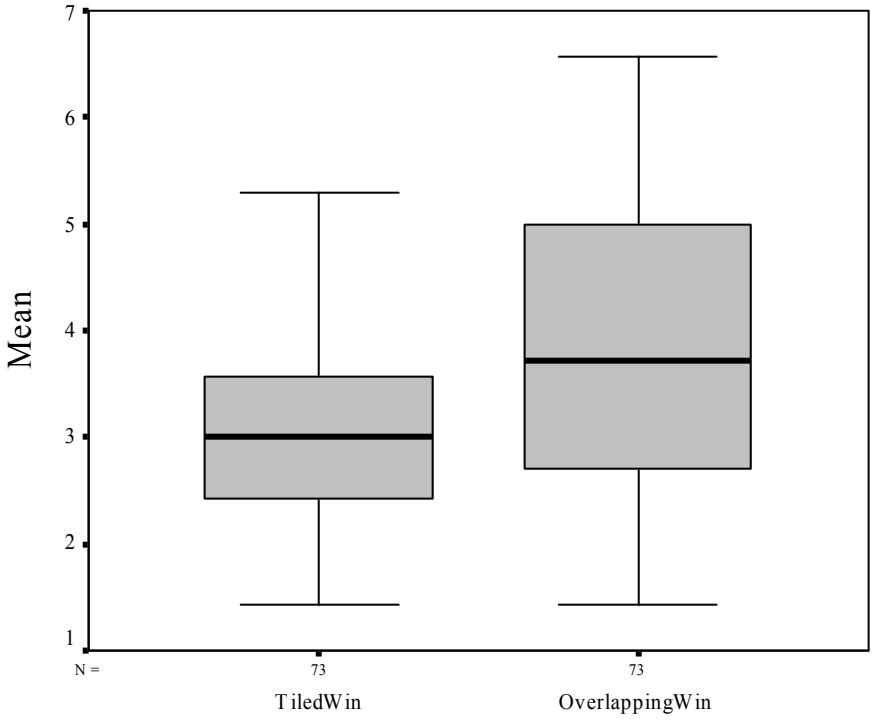


Figure 4-8. Boxplot for disorientation means

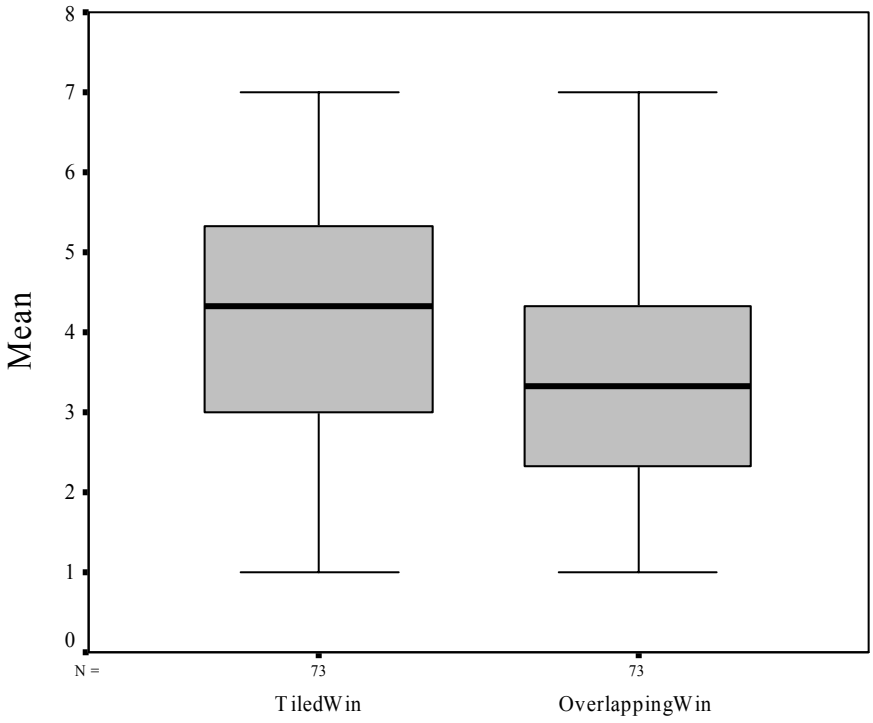


Figure 4-9. Boxplot for ease of use means

The user disorientation:

D=R/N

D: Orientation ratio;

R: The number of information nodes of the pre-defined path to complete required information retrieval task;

N: The total number of nodes accessed;

Orientation ratio (D) = the number of information nodes of the pre-defined path to complete required information retrieval task (R) / the total number of nodes accessed (N) (Dias & Sousa, 1997). This ratio measures the degree of disorientation because it determines the precision of information retrieval (Dias & Sousa, 1997). If D equals to 1, the user is oriented. If D equals to 0 the user was completely lost in the hypermedia system.

An independent t-test was conducted to analyze the Orientation Ration between two interface windowing modes.

Table 4-5. Orientation ratio means and standard deviations for the treatment groups

Interface mode	Mean	SD
Tiled-windows	.84987	.17135
Overlapping-windows	.62898	.20893

The analysis shows that the average orientation ratio for tiled-windows interface mode (M=.84987) is significantly higher than the average orientation ratio for overlapping-windows interface mode (M=.62898).

Table 4-6. Independent samples t-test for orientation ratio

Variable	df	t-value	p
Orientation ratio score	144	6.985	.000

The analysis indicates that subjects on the tiled-windows interface mode are more oriented (M=.84987, SD=.17135) than did those on the overlapping-windows interface mode (M=.62898, SD=.20893), t(144)=6.985, p=.000. Figure 4-10 shows Boxplot for the orientation ratio.

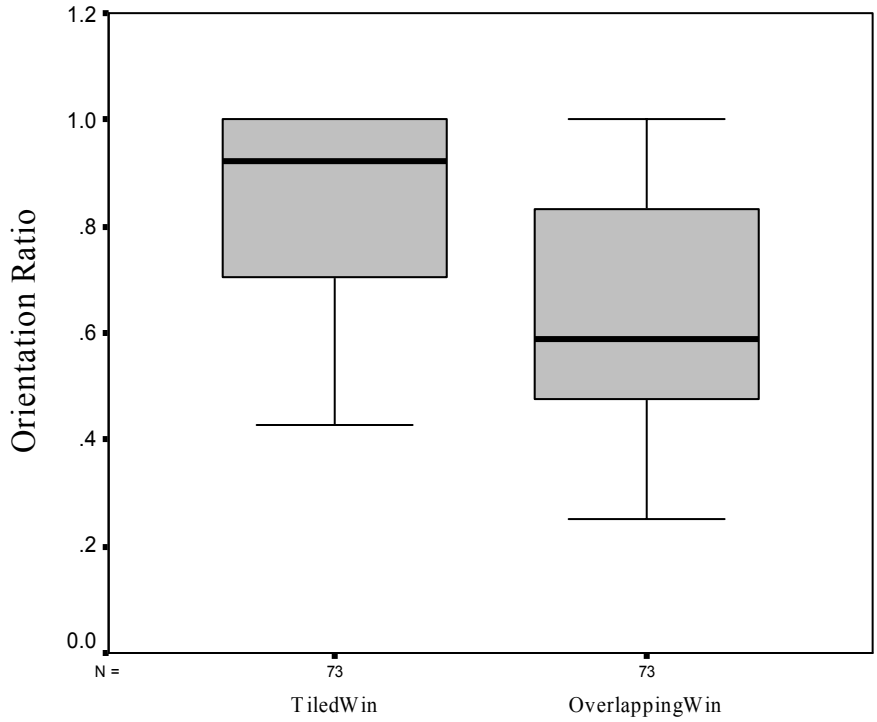


Figure 4-10. Boxplot for orientation ratio means

Table 4-7. Ease of use means and standard deviations for treatment groups

Interface mode	Mean	SD
Tiled-windows	4.2009	1.3774
Overlapping-windows	3.3470	1.4438

In the ease of use (reverse rated) analysis of the treatments, an independent t-test was used in order to determine if significant differences existed between tiled and overlapping-windows on user's rating about ease of use. Table 4-7 shows descriptive statistics for the two groups separately.

The analysis indicates that subjects who are on the tiled-windows treatment rated the ease of use significantly higher than (M=4.2009) did users on the overlapping-windows treatment (M=33470), t(144)=3.656, p=.000.

Table 4-8. Independent samples t-test for ease of use

Variable	df	t-value	p
Ease of use score	144	3.656	.000

In the tiled-windows interface mode users were less disoriented (M=3.0881, SD=1.11) than those in the overlapping-windows interface mode (M=3.8630, SD=1.3281), t(144)=-4.082, p=.000.

Hypothesis 2:

There is no significant difference in user cognitive overload between overlapping-windows interface mode and tiled-windows interface mode in the hypermedia learning environment.

A t-test was used to test the null hypothesis. The independent samples t-test was used to determine the differences in the means of the two groups on one dependent variable (cognitive overload). Table 4-9 shows descriptive statistics for the two groups separately. Figure 4-11 shows estimated marginal means of orientation ratio.

Table 4-9. Cognitive overload means and standard deviations for treatment groups

Interface mode	Mean	SD
Tiled-windows	27.7671	40.6724
Overlapping-windows	57.02802	78.2846

Table 4-10. Independent samples t-test for cognitive overload

Variables	df	t-value	p
Cognitive overload score	144	-2.834	.005

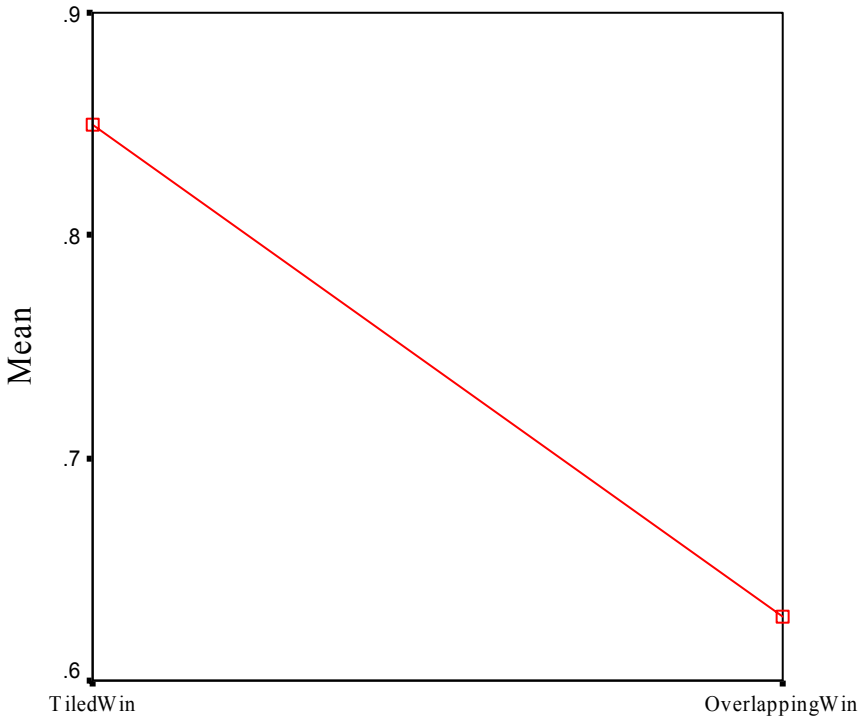


Figure 4-11. Estimated marginal means of orientation ratio

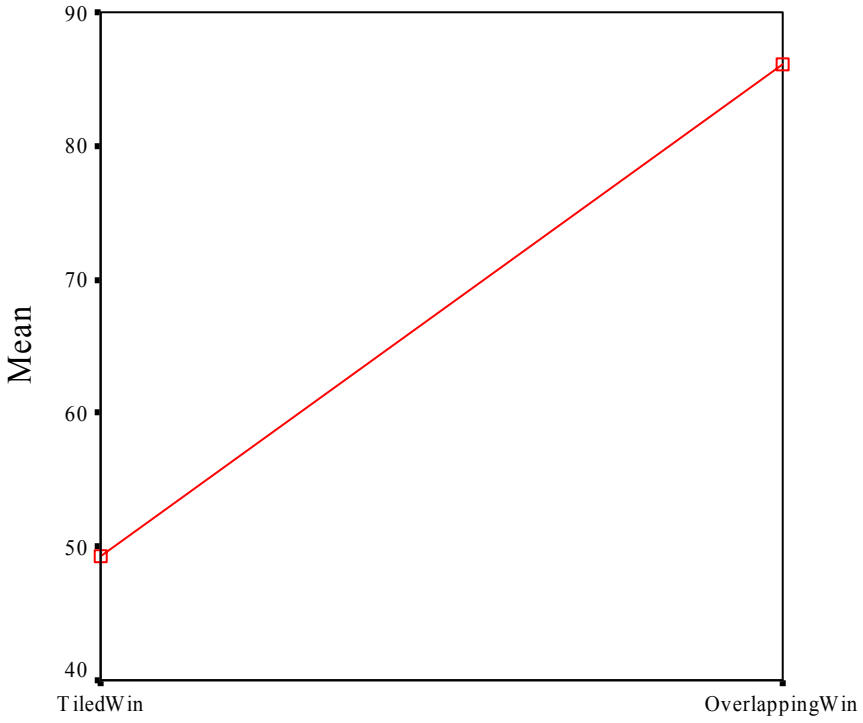


Figure 4-12. Estimated marginal means of cognitive overload

The analysis indicates that subjects who are on the tiled-windows treatment react to the second task significantly faster than (M=27.7671) did users who are on the overlapping-windows treatment (M=57.0280), t(144)=-2.834, p=.005.

Results shows that users in the tiled-windows interface mode are less cognitively overloaded than those in the overlapping-windows interface mode.

A t-test was used to test whether user computer experience has an effect on disorientation and cognitive overload. The independent groups t-test was used to determine the differences in the means of the two groups on one dependent variable (computer experience). Table 4-11 shows descriptive statistics for the two groups separately.

Figure 4-13 and Figure 4-14 show distribution of computer understanding and experience on the tiled and the overlapping interface condition.

Table 4-11. Self-report computer experience means and standard deviations for treatment groups

Interface mode	Mean	SD
Tiled-windows	2.8034	.5779
Overlapping-windows	2.8609	.6636

Table 4-12. Independent samples t-test for self-report computer experience and the interface modes

Variable	df	t-value	p
SCE score	144	-.558	.578

The analysis indicates that subjects' computer experiences in two treatment conditions are not different (M=2.8034), t(144)=-.558, p=.578. Figure 4-15 shows estimated marginal means for self-report computer experience.

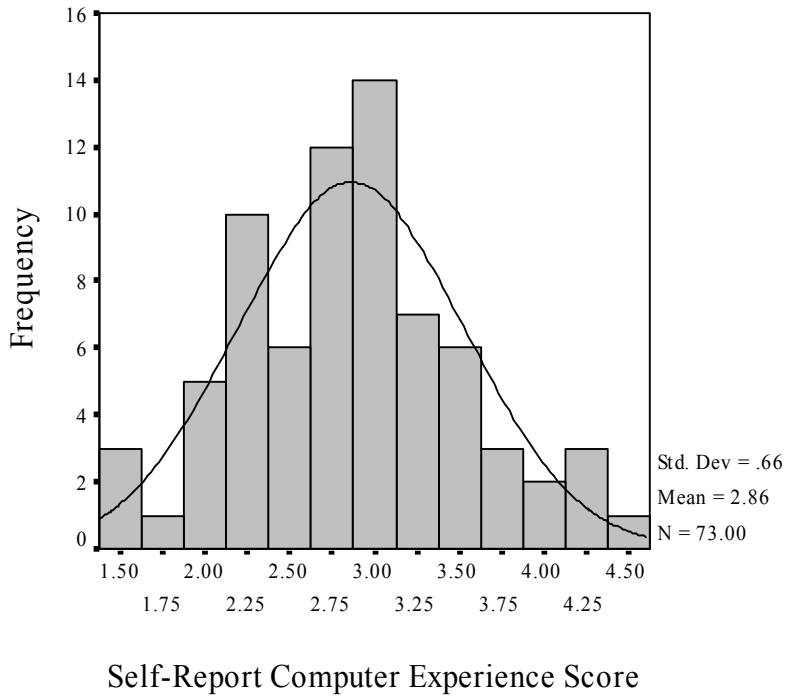


Figure 4-13. Distribution of self-report computer experience on overlapping-windows interface mode

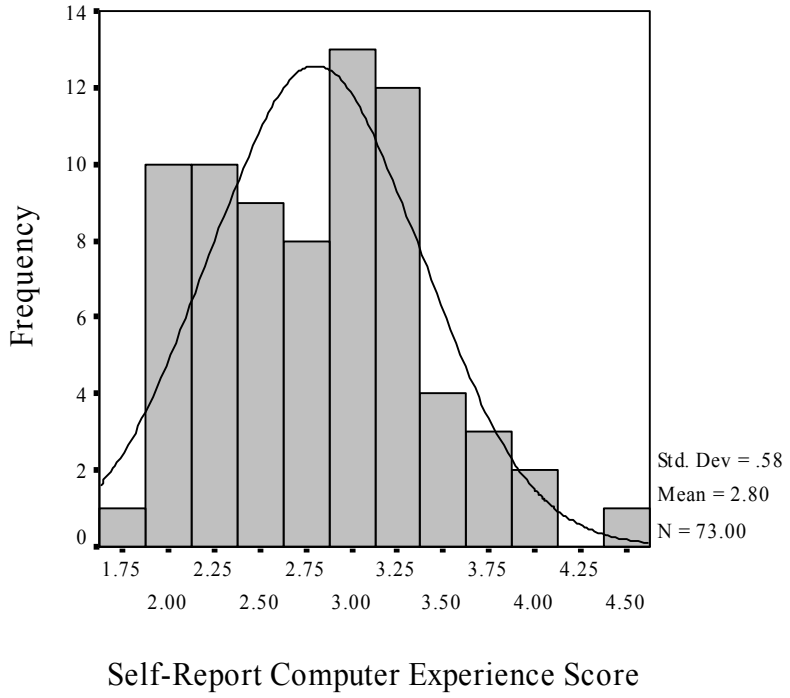


Figure 4-14. Distribution of self-report computer experience on tiled-windows interface mode

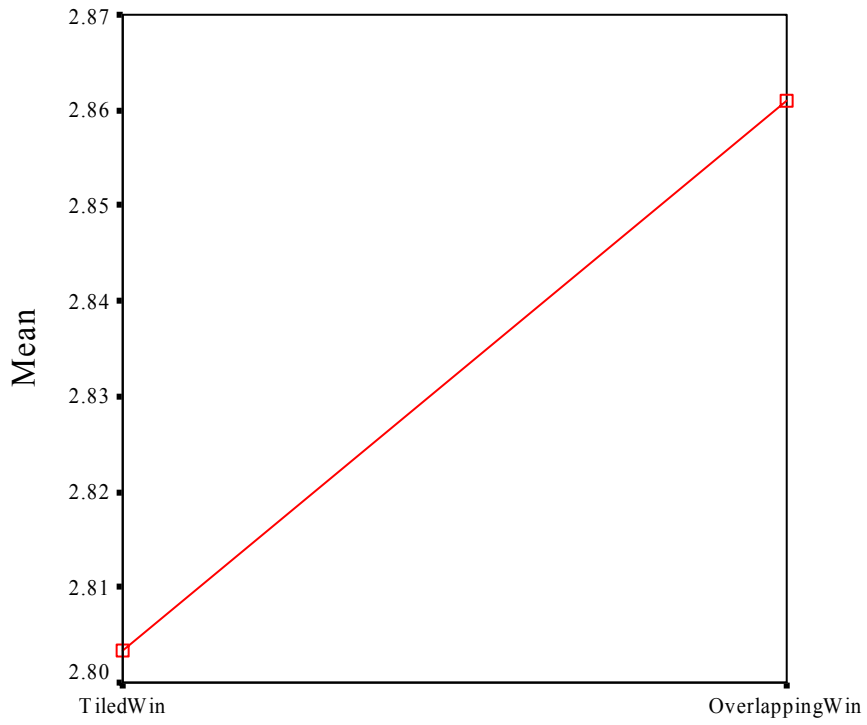


Figure 4-15. Estimated marginal means of self-report computer experience

Hypothesis 3: There is no significant relationship between two different measures of disorientation.

Hypothesis 4: There is no significant relationship between cognitive overload and two different measures of disorientation.

Hypothesis 5: There are no relationship among user's computer experience and disorientation and cognitive overload.

Hypotheses three to five were tested to evaluate the relationship among disorientation, orientation ratio, cognitive overload, computer experience, and ease of use. A Pearson's *r* Correlation Coefficient was used to test the correlation among the dependent variables. Correlational procedures were used to determine the linear relationship among the dependent variables. Correlation coefficients range from -1 to +1

with strength of association indicated by higher absolute values. The sign of correlations describes the type of relationship.

A correlation analysis between data variables was done using the Pearson's *r* Correlation Coefficient between data variables (computer experience, disorientation, ease of use, orientation ratio, and cognitive overload). The following results were founded.

Table 4-13. Intercorrelations (*r*) among variables

Variable	Y_1	Y_2	Y_3	Y_4	Y_5
SCE (Y_1)	1	.018	.058	-.077	.073
Ease of use (Y_2)		1	-.659*	.266*	-.033
Disorientation (Y_3)			1	-.313*	.120
Orientation ratio(Y_4)				1	-.021
Cognitive overload (Y_5)					1

(*p<.01)

Results demonstrates that a significant negative correlation between ease of use and user disorientation (r=-.659, p=.01).

Correlations show that greater orientation ratio is significantly associated with ease of use (r=.266, p.01).

Results from correlation matrix indicate that a significant negative correlation between orientation ratio and user disorientation (r=-.659, p=.01).

Hypothesis 6: There are no statistically significant interface windowing mode effects on the vector of three dependent variables when effects of subjects' computer experience are controlled.

The null hypothesis of no significant effects on interface windowing modes on the vector of three dependent variables (disorientation, orientation ratio, and cognitive

overload) when effects of subjects' computer experience are controlled was tested using a Multivariate Analysis of Covariance (MANCOVA) procedure. MANCOVA performs analysis of variance on multiple dependent variables and takes into account their correlations and the effect of the covariate (self-report computer experience) on the dependent variables. This procedure was appropriate when determining differences between independent variables on multiple interval dependent variables while statistically controlling other variables (Stevenson, 2002). MANCOVA is used to compare differences in groups with multiple dependent variables while statistically controlling covariate (user self-report computer experience).

Research hypothesis 6 was tested using MANCOVA. The self-report computer experience (SCE) was chosen as a covariate. The test statistic used in this procedure was Wilk's λ. Cognitive overload, orientation ratio, and user disorientation scores were dependent variables and SCE was covariate. The computer experience covariate was not significant with Wilk's $\lambda = .704$, $F(3,141)= .470$ ($p>.01$). MANCOVA results revealed significant multivariate effects for interface modes in the user disorientation, orientation ratio, cognitive overload, and ease of use, Wilks' $\lambda = .000$, $F(3, 141) = .470$.

Summary

This study was conducted to investigate the effects of tiled and overlapping-windows interface mode and computer experience on users' disorientation and cognitive overload in a hypermedia learning environment. Participants were randomly assigned to one of the two treatment groups. Participants were assigned to complete demographic computer experience surveys before the treatment. During a thirty minute study session with the tutorial titled the HyperStudio tutorial participants executed a task worksheet, second task (color change reaction), as well as user disorientation and ease of use survey.

The results of the study indicate that there are significant differences in user disorientation, orientation ratio, ease of use, and cognitive overload between two different interface windowing modes. The correlation analysis between dependent variables reveals that there is a positive significant correlation between ease of use and orientation ratio.

There are also negative significant correlations between ease of use, user disorientation, and orientation ratio. However, no significant correlation was found between user disorientation, cognitive overload, and orientation ratio, and cognitive overload.

The results of our study may help to provide guidelines for user interface designers in hypermedia learning environments. In chapter 5, the results are discussed and related to the literature. Furthermore, conclusions, and implications of the study and recommendations for further research are presented.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study was conducted to investigate the effects of tiled and overlapped-windows interface modes and computer understanding and experience on users' disorientation and cognitive overload in a hypermedia learning environment. Six research questions were raised for this study.

Question 1: Is there any significant difference on users' disorientation between using tiled-windows interface mode and using overlapped-windows interface mode?

Question 2: Is there any significant difference on users' cognitive overload between using tiled-windows interface mode and using overlapped-windows interface mode?

Question 3: Is there any relationship between two different measures of disorientation?

Question 4: Is there any relationship between cognitive overload and two different measures of disorientation?

Question 5: Are there any relationships among user's computer experience and disorientation and cognitive overload.

Question 6: Are there any significant interface windowing effects on the vector of three dependent variables when effects of subject's computer experience are controlled?

The experiment was designed and conducted to answer these research questions. Cognitive overload, disorientation, ease of use, and user's computer experience were the

dependent variables. The interface windowing mode was the independent variable with two levels (tiled-windows and overlapped-windows). The data was analyzed using an independent t-test, Pearson's *r* Correlation Coefficient, and Multivariate Analysis of Covariance (MANCOVA). Findings are reported below:

Hypothesis 1: There is no significant difference in user disorientation between overlapped-windows interface mode and tiled-windows interface mode in the hypermedia learning environment.

A significant difference was found to exist between the type of interface modes and user disorientation. The null hypothesis was rejected at the .05 level of significance.

Hypothesis 2: There is no significant difference in user cognitive overload between overlapped-windows interface mode and tiled-windows interface mode in the hypermedia learning environment.

A significant difference was found to exist between the type of interfaces modes and user cognitive overload. The null hypothesis was rejected at the .05 level of significance.

Independent sample t-test was conducted to investigate the effect of computer experience on disorientation and cognitive overload. A significant difference was not found to exist between the type of interfaces modes and user computer experience.

Hypothesis 3: There is no significant relationship between two different measures of disorientation.

A significant correlation was found to exist between disorientation and orientation ratio. The null hypothesis was rejected at the .01 level of significance.

Hypothesis 4: There is no significant relationship between cognitive overload and two different measures of disorientation

There is no significant relationship between two different measures of disorientation and cognitive overload.

No significant correlation was found to exist between disorientation and orientation ratio. The null hypothesis was not rejected at the .01 level of significance.

Hypothesis 5: There are no relationship among user's computer experience and disorientation and cognitive overload.

No significant correlation was found to exist between disorientation and computer experience. The null hypothesis was not rejected at the .01 level of significance.

Hypothesis 6: No statistically significant interface windowing effect was found on the vector of three dependent variables when effects of subjects' computer experience are controlled.

Subject Computer Experience covariate was not significant with Wilk's $\lambda = .990$, $F(3,141) = .470$ ($p > .01$). Therefore, the null hypothesis that there are no statistically significant interface windowing modes effects on the vector of three dependent variables when effects of subjects' computer experience are controlled was failed to reject.

Discussions

The following discussion addresses the results with regard to user disorientation, cognitive overload, and computer understanding and experience in the interface windowing modes. The results of this study may lead to improvements in the design of web based interface features.

The findings of the study contribute to the experimental literature investigating the effects of interface windowing modes on disorientation and cognitive overload in the

hypermedia learning environment. Hypermedia has become more widely used as a delivery medium for instruction. Characteristics of hypermedia are particularly appropriate for exploratory environments where a numbers of links and cross-references are provided, so that the learner can explore and navigate his/her own interests according to learner's experience, background and perspective (Nunes & Fowell, 1996). Furthermore, unlimited random access and linking characteristics of hypermedia has great potential for effective case-based instruction. Hypermedia learning environments are best suited for ill-structured intellectual and cognitive domains, taking advantage of Spiro's random access instruction. Cognitive Flexibility Theory (CFT) stresses multiple perspectives and knowledge criss-crossing. Spiro, Feltovich, Jacobson, and Coulson (1991, 67) describe CFT as "… the need for rearranged instructional sequences, for multiple dimensions of knowledge representation, for multiple interconnections across knowledge components, and so on. Features like these correspond nicely to well known properties of hypertext systems, which facilitate multiple linkages among content elements." Hypermedia provides elements such as the criss-crossed landscape, nonlinear and multidimensional traversal of a complex subject matter including presenting content from various perspectives.

Learner disorientation and cognitive overload are well known problems of hypermedia learning environments. Nunes and Fowell (1996) describe that these problems result in the learning process being interrupted. Learners may end up studying less meaningful topics and omit to study crucial ones (Nunes & Fowell, 1996). There are the consequences of being disoriented and cognitively overloaded in hypermedia learning environments. Nunes & Fowel (1996) stated that disorientated learners have trouble

finding specific information, even if they know that it is present. Therefore, learners may fail to see how parts of the knowledge base are related and even omit large relevant sections of information (Hammon, 1993). As a result of cognitive overload, learners may become unclear of their learning objectives or how to accomplish them. Thus, learners may fail to become involved in the learning process (Nunes & Fowel, 1996).

Much of the recent research on disorientation and cognitive overload in hypermedia systems discusses measurement of disorientation and cognitive load. This research, however, particularly investigated user disorientation and cognitive load in a structured and non structured hypermedia learning environment. For the first time in the literature, user disorientation and cognitive overload were separately measured in hypermedia learning environments using different instruments.

Interface is an important component in hypermedia design. Appropriate and structured interface design helps to minimize problems in hypermedia learning environments. Therefore, lack of or poor interface design will not help learners in the choice of navigational paths and orientation.

In our study, user disorientation, orientation ratio, ease of use of the electronic learning environments, and cognitive overload were found to be significantly related on interface design of the hypermedia learning environments. Users benefited from tiled-windows which provide cues from locations on the interface. These findings are consistent with the previous suggestions of Kandemir and Shneiderman (1997), Borälv, Göransson, Olsson, and Sandblad (1994), and Theng, Jones, & Thimbleby (1995a).

Beasley & Waugh (1995) and Tripp & Roby (1990) stated that learning is likely to suffer as disorientation increases. Structural knowledge acquisition and retention

decreases when disorientation increases in an electronic learning environment (Beasley & Waugh, 1996, p.297). These findings indicate that disorientation and cognitive overload may affect, reduce and interrupt the cognitive activities and the mental resources of learners. In their research, Mayer, Moreno, Boire, and Vagge (1999) demonstrates that tasks high in cognitive overload can impede learning. The study indicates that the problem of disorientation and cognitive overload in the hypermedia system negatively affect the ease of use of the hypermedia learning environment.

Aspillaga (1991) stated that learning and recall was likely enhanced by the availability of the whole picture and the consistent location of information that was not blocked on the electronic learning environment screen. Findings of this study indicate that users on the tiled-windows treatment reported less disorientation and cognitive overload. The results from the ease of use survey demonstrated that users found the tiled-windows easy to use. These findings show that structured hypermedia learning environment may help to improve learning.

Waterworth and Chingell (1989) stated that the interface design may affect learning from hypermedia. Therefore, the results of this study may have implications interface design of hypermedia learning environments.

Surprisingly, findings in this study reported that no significant correlations were discovered between cognitive overload and two different measures of disorientation. It was expected that disorientation would have an influence on cognitive overload, however, no relationship was found. Previous research that examined the relationship between perceived user disorientation and dual task measurement method of cognitive overload in multimedia was not found, so a comparison of the current results was not

possible. The dual task method of measuring cognitive overload represented as an alternative direct measurement of cognitive load (Brunken et. al., 2003). However, some deficiencies associated with the dual-task cognitive load measure may lead unexpected results. Brunken et al. (2003) reported the shortcomings associated with duals-task cognitive load measurement. First, the dual-task cognitive load measurement method only requires the use of the users visual sensory. It was expected that the reaction time for auditor second task would be shorter than the visual-only condition because of the higher amount of cognitive load in visual working memory. Second, individual differences may affect the user's second task reaction time. Third, the treatment environment may also affect the second task reaction time (e.g., visual distractions and auditory noise).

The finding that subjects under the overlapped-windows condition were more disoriented and cognitively loaded than those under the tiled-windows condition was not surprising. The finding of the current study, which are consistent with the results of the Kandogan & Shneiderman (1997), Kandogan & Shneiderman (1998), and Benshoof & Hooper (1993) study, suggested that tiled-windows can decrease the cognitive overload on users by decreasing the number of windows operations. Since the amount of cognitive resources the user needs under the overlapped-windows condition seemed to be greater than under the tiled-windows condition. Tiled-windows interface mode allows learners to see several sources of information at the same time and alleviate disorientation and cognitive overload due to the limitation of short term memory of humans. On the other hand, the overlapped-windows treatment could only display one part of information to the user or the information could be overlapped by other windows.

These conclusions suggest that interface design of hypermedia learning environments has significant effects on user disorientation and cognitive overload.

Implications

The following implications were identified and reported from the study's findings. The tiled-windows interface mode keeps the format of windows and windows content always visible. Since the introduction of the Internet, many interface windowing modes have been presented and implemented for user's browsing and navigation in the hypermedia system. Findings of this research have the same applications for hypermedia-based instruction. It suggests that designers and instructors pay special attention to interface windowing modes and structures in hypermedia-based instructional systems. Sources of disorientation and cognitive overload experienced by users when working on information retrieval task with hypermedia systems have been reported by researchers as disruptions to mental resources of cognitive process, reducing and interrupting the cognitive activities and the mental resources of learners (Mayer et. al.1999; Beasley & Waugh, 1995; Tripp & Roby,1990; Aspillaga, 1991).

The results of this study suggest that the tiled-windows interface treatment provided help to users, enabling them to efficiently communicate with the hypermedia learning environment. The findings from this study may have implications for designing and presenting distance education via the Internet.

The results of this study may assist interface designers in their decisions regarding what windowing form their hypermedia systems should have in order to most benefit the user. It may also assist in providing empirical evidence for justifying how interface windowing modes can be used to alleviate disorientation and cognitive overload.

One particularly important finding in this study is that there is no relationship between the user disorientation measure and cognitive overload measure.

Recommendations

This study provides empirical evidence that the interface windowing modes should take into account users' disorientation and cognitive overload in terms of navigation, browsing, and information retrieval.

The results from the Disorientation and Ease of Use survey clearly indicate that users preferred the tiled-windows to the overlapped-windows interface mode. The tiled-windows interface mode may be easier to navigate for users.

The results also indicated that users who have more computer understanding and experience were less disoriented than users who have less computer understanding and experience.

Future Research

The results of this study have raised some interesting questions about interface windowing modes in hypermedia systems. Several recommendations for the future research have emerged from this study.

1. The sampling population of this study was college students. College students are more educated that the general population. This study should be replicated with more general populations who have little or no computer experience.

2. Each individual has different learning and cognitive style. One could look into the relationship between interface mode and cognitive styles.

3. This study focused on the effects of two different interface modes on disorientation and cognitive overload. This study could be replicated to examine the effects of interface windowing modes and individual differences on users' performance on the information access performance.

4. One could investigate the effects of interface windowing modes on learner satisfaction and performance.

5. A more in-depth analysis of task completion time needs to be addressed in order to use the interface design efficiently in hypermedia learning environments.

6. It would be interesting to know the effects of navigational aids on user disorientation and cognitive overload on the interface windowing modes.

7. The effects of graphic and text location could be investigated on disorientation and cognitive overload.

8. One could investigate the effects of background color of the content on user disorientation and cognitive overload.

9. The effect of attention, perception, and motivation on disorientation and cognitive overload in hypermedia learning environments could be investigated.

APPENDIX A
SUBJECT BACKGROUND INFORMATION

Computer Number:…….

Date:……/……/……

Time:……

Computer Lab:……

Directions: Please the following information about yourself.

NOTE: Names will only be used to keep track of the information you provide. This information will never be released publicly.

Last Name:……First Name:……

Age:……..

Gender: Male……Female……

Year:

Freshman……Sophomore……Junior…….Senior…….Graduate…

Major:

…….

APPENDIX B
SELF-REPORT COMPUTER EXPERIENCE SURVEY

Computer Number:……...

Date:……/……/……..

Time:……

Computer Lab.:……

Direction: The following items pertain to your experience with computers. There are not right or wrong answers, and you need not to be an "expert" to complete these items. Describe yourself honestly and state your opinions as accurately as possible. Fill in the circle (below the number) the position that best describes your computer experience, as shown scale below, where 1 = "Very minimal" and 5 = "Extensive".

1. I frequently read computer magazines or other sources of information that describe new computer technology.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

2. I know how to recover deleted or "lost data" on a computer or PC.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

3. I know what a LAN is.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

4. I know what an operating system is.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

5. I know how to write computer programs

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

6. I know how to install software on a personal computer.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

7. I know what e-mail is.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

8. I know what a database is.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

9. I am computer literate.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

10. I regularly use a PC for word processing.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

11. I often use a mainframe computer system.

	1	2	3	4	5

Very minimal	O	O	O	O	O	Extensive

12. I am good at using computers.

	1	2	3	4	5	
Very minimal	O	O	O	O	O	Extensive

APPENDIX C
USER TASKS WORKSHEET

Computer Number:……

Second Task: Color Change Reaction Time:

1……

2……

3……

Directions (Please read carefully):

You are going to navigate through a learning environment that contains a HyperStudio tutorial.

While navigating throughout the tutorial, you will be asked to complete five tasks. Each task is timed. You will write down the beginning and ending time for each task on your work sheet. You need to refer to the time on your computer. Each task will take you approximately 3 to 4 minutes. You will browse, search, and navigate the learning environment to complete each task. For each task, you will be looking for a number on each graphic that will be circled and in red.

While you are working on the tasks, you need to pay attention to the small pop-up window that will appear on the upper-left corner of your screen. Make sure that you monitor the pop-up window for color changes. Your second task is to react to the background color change of the little pop-up window located in upper-left hand corner of the screen. The background color of this pop-up window will change at random time intervals. As soon as you notice the background color change, click on labeled button in

the pop-up window. A reaction time will pop up in a new window. Please record your reaction time on the work sheet. After recording the reaction time click on "*OK*". Once you click on *OK* "*a security notice window*" may pop up. When you see the security window click on "*send*" and return your task.

- Use the Internet Explore for navigating and browsing.
- Do not close the pop-up window located upper left corner.
- When you are done, please do not logout your computer.

Task 1:

Task beginning time:

Task completing time:

Find the graphic number matches the text describing step 10 the "Linking to web".

Graphic number for step 10:…….

Task 2:

Task beginning time:

Task completing time:

Find the graphic number matches the text describing step 4 "Adding text object."

Graphic number for step 4:……

Task 3:

Task beginning time:

Task completion time:

Find the graphic number that matches the text describing "How to save a stack."

Write the Graphic Number for saving a stack:…….

Task 4:

Task beginning time:

Task completion time:

Find the graphic number that matches the text describing “How to delete a card.”

Graphic Numbers for deleting a card:…….and……..

Task 5:

Task beginning time:

Task completion time:

Find the definition of “Transition between cards” and write it down.

Transition……...

……..……...

……

APPENDIX D
DISORIENTATION AND EASE OF USE QUESTIONNAIRE

Computer Number:……

Date:……/……/…….

Time:……...

Computer Lab:…….

Direction: Encircle the number that best reflect your impression about the interface of the learning environment.

Disorientation

1. I felt lost

Never						Always
1	2	3	4	5	6	7

2. I felt like I was going around in circles

Never						Always
1	2	3	4	5	6	7

3. It was difficult to find a page that I had previously viewed

Never						Always
1	2	3	4	5	6	7

4. Navigating between pages was a problem

Never						Always
1	2	3	4	5	6	7

5. I didn't know how to get my desired location

Never Always

1 2 3 4 5 6 7

6. I felt disoriented

Never Always

1 2 3 4 5 6 7

7. After browsing for a while I had no idea where to go next

Never Always

1 2 3 4 5 6 7

Ease of Use

8. Learning to use the site was easy

Strongly disagree Strongly agree

1 2 3 4 5 6 7

9. Becoming skillful at using the site was easy

Strongly disagree Strongly agree

1 2 3 4 5 6 7

10. This site easy to navigate

Strongly disagree Strongly agree

1 2 3 4 5 6 7

APPENDIX E
TILED-WINDOWS INTERFACE MODE

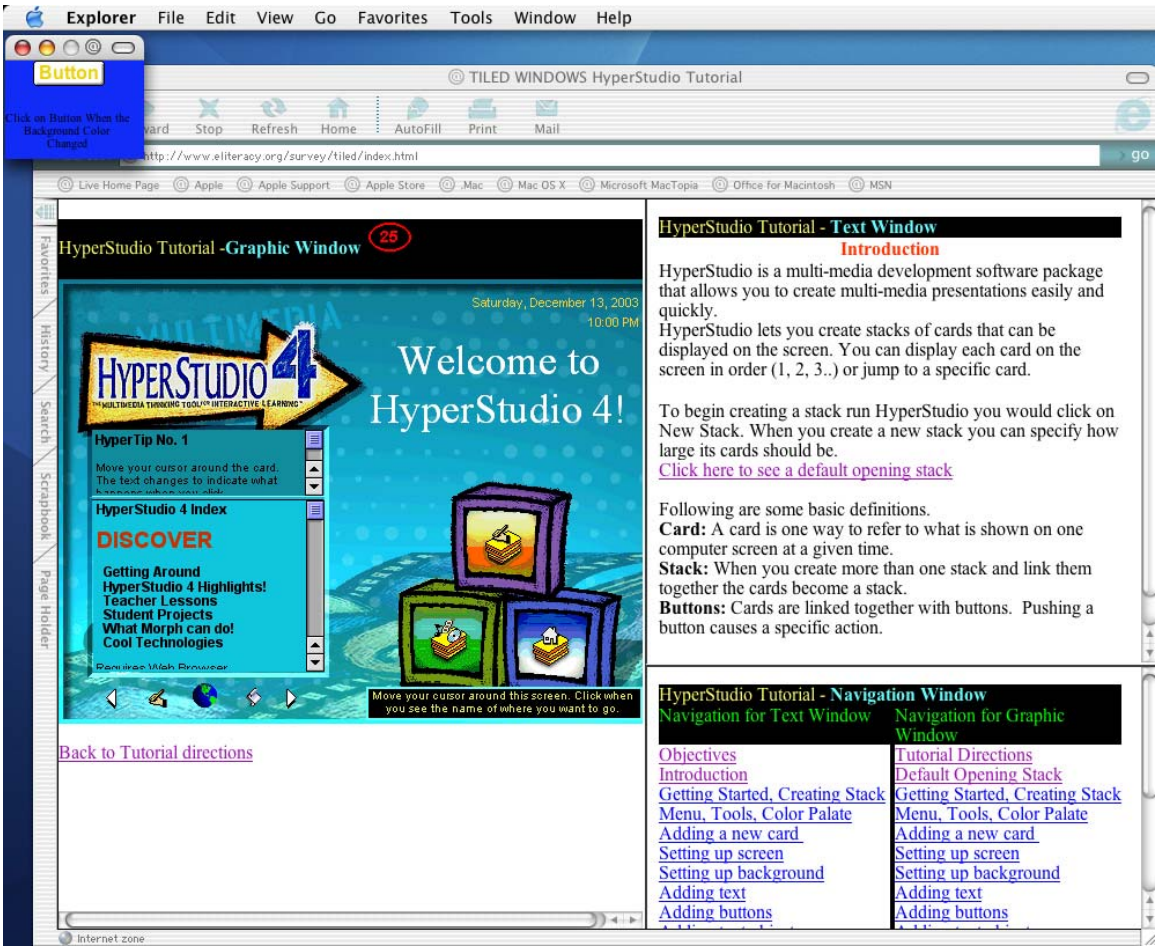


Figure E-1. Screen capture of tiled-windows interface mode.

APPENDIX F
OVERLAPPING-WINDOWS INTERFACE MODE

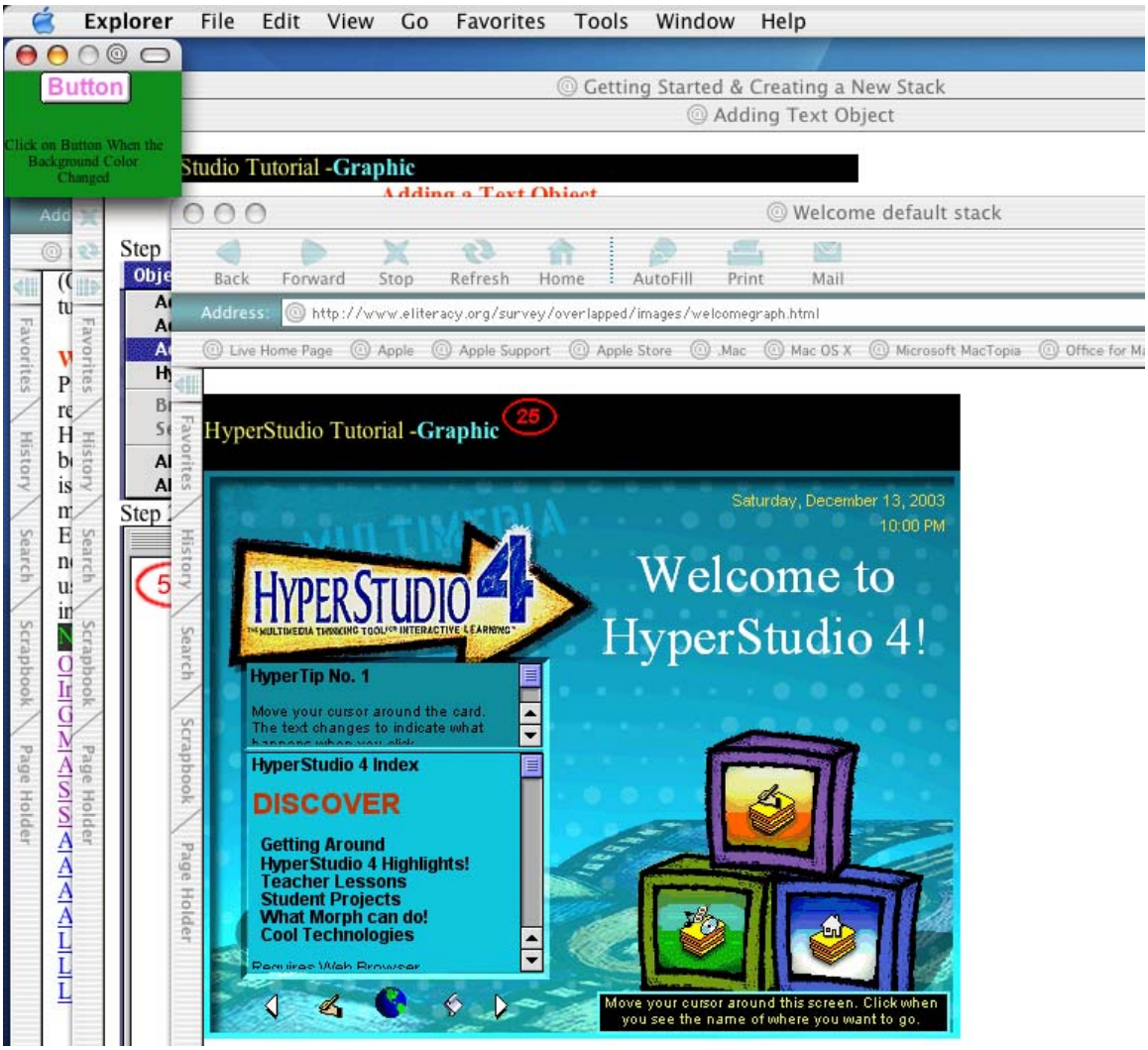
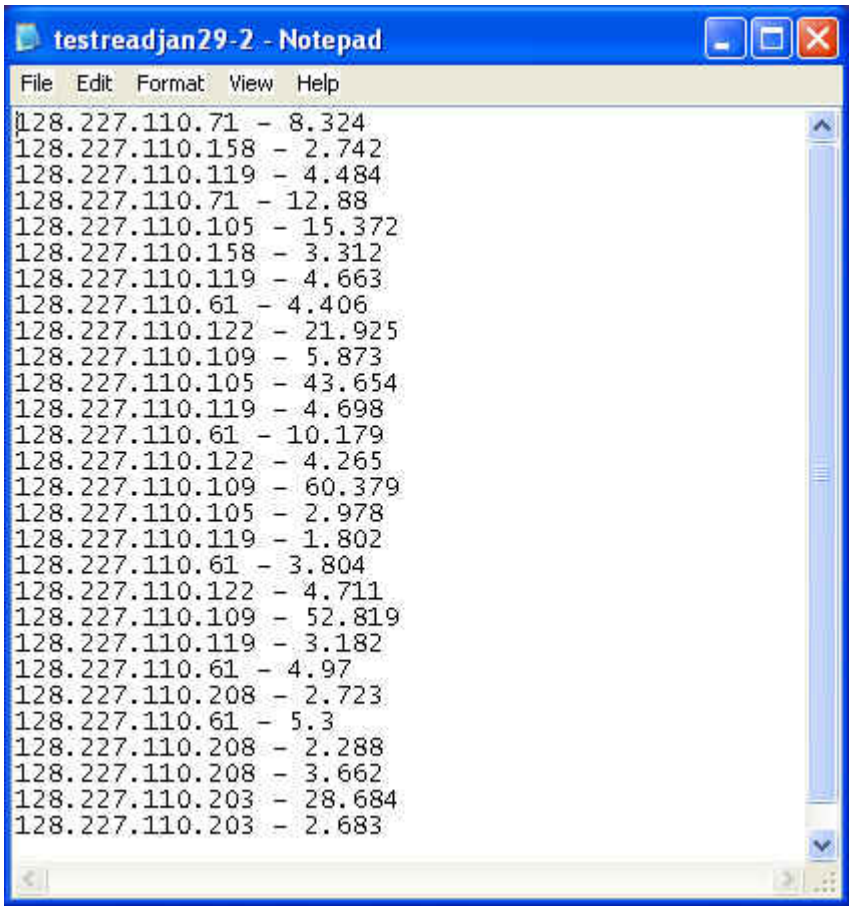


Figure F-1. Screen capture of overlapping-windows interface mode.

APPENDIX G
SAMPLE LOG FILE

IP Address Time




```
128.227.110.71 - 8.324
128.227.110.158 - 2.742
128.227.110.119 - 4.484
128.227.110.71 - 12.88
128.227.110.105 - 15.372
128.227.110.158 - 3.312
128.227.110.119 - 4.663
128.227.110.61 - 4.406
128.227.110.122 - 21.925
128.227.110.109 - 5.873
128.227.110.105 - 43.654
128.227.110.119 - 4.698
128.227.110.61 - 10.179
128.227.110.122 - 4.265
128.227.110.109 - 60.379
128.227.110.105 - 2.978
128.227.110.119 - 1.802
128.227.110.61 - 3.804
128.227.110.122 - 4.711
128.227.110.109 - 52.819
128.227.110.119 - 3.182
128.227.110.61 - 4.97
128.227.110.208 - 2.723
128.227.110.61 - 5.3
128.227.110.208 - 2.288
128.227.110.208 - 3.662
128.227.110.203 - 28.684
128.227.110.203 - 2.683
```

Figure G-1. Screen capture of log file.

The information contained in the log file consist IP address and the Second Task Reaction Time (second).

APPENDIX H
SAMPLE INTERNET EXPLORER HISTORY FILE

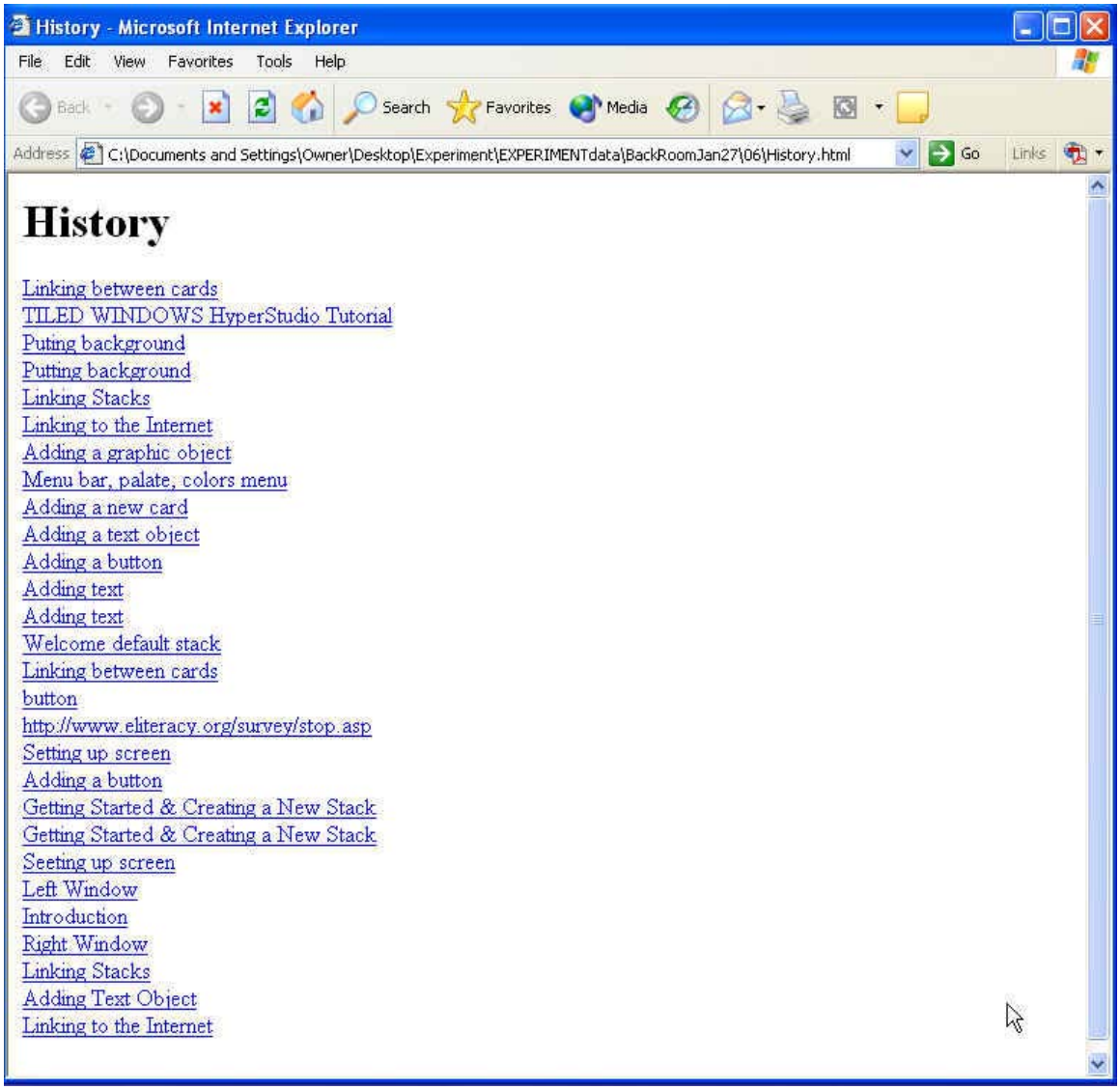


Figure H-1. Screen capture of history file from tiled-windows treatment

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