DYNAMIC CONCEPT MAPS AS KNOWLEDGE REPRESENTATION TOOLS FOR LEARNING

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Abstract

The purpose of this thesis is to extend research on educational node-link displays with animated multimedia presentation. The thesis focuses on an empirical study of the learning effectiveness of a dynamic concept map synchronized with audio presentation. 133 undergraduates, who were randomly assigned to four groups, participated in this experiment. The two experimental groups viewed plain and graphically enhanced concept maps that were semantically equivalent to the narration. These animated concept maps were synchronized with the audio track. The two control groups viewed text versions of the narration, one synchronized with the audio track and another version preceding the audio track. All visual presentations were incremental and cumulative. Both map groups outperformed the text groups on a free recall test. The plain map group outperformed the text groups on a comprehension test. Implications of this work are discussed with respect to cognitive and multimedia theories of learning.

Dedication

To God, who gave me the strength and wisdom to complete the degree,

To my wife and two daughters who endured my time away from home to complete this thesis.

To my parents, who prayed for me.

Acknowledgements

Now, I can breathe a sigh of relief and move unto other challenges of life but with great thanks and appreciation to those who have contributed to the completion of the study. This thesis would not have been possible without my senior supervisor, Dr. John Nesbit. He was very inspirational to the design of the study and gave me valuable support and guidance throughout my program. Thank you, John. I can never forget what you have done for me. I also thank my other supervisor, Dr. Janet McCraken who also stood by me in the graduate school. Both of these supervisors supported my quest for knowledge and gave me a chance when least expected. I would also like to thank the other members of my examining committee, Dr. David Kaufman and Dr. John Bowes for their critical evaluation and suggestions to improve the work.

To my dearest wife, Tolulope and my 2 daughters, Florence and Felicia, I say thank you for bearing with my "I can't do that now because of my thesis". It is a great joy to see this not only as a product of my effort but also your relentless support all through my pursuit of this degree. I would like to thank my mother for being a great supporter, taking care of the kids during the time of writing this thesis. We appreciate you so much Mum and thanks for being there for us. To Dad, the younger ones and all other family members who prayed along, I also say "thank you". I am most grateful for the great support given me by all my family members.

Kindest regards to all my church folks and those who have supported my pursuits over the years. I thank you all for your invaluable assistance, encouragement and most importantly prayers for me as I ventured into this 'unknown territory. I am glad that we can all share this success together and thank God for answered prayers.

I appreciate the enthralling academic environment provided by the School of Interactive Arts and Technology (SIAT), Simon Fraser University. I thank the faculty members, staff and fellow graduate students of the school. I especially thank Ben, Dan and David for all the roles they played to make this work a success. I would continue to cherish the memories of good things we graduate students have all achieved together in the school. We have been product of change and the change has brought out the best of us. It is indeed true that there is nothing as constant as change and the way we respond to it shows our true character. We have all made the best use of the situation and would be glad we did in years to come. The school has taught us not only academic lessons but also important life lessons. I am very grateful for this.

Most importantly, I will like to thank God for giving me the strength to do this work. I will forever be grateful for all the Lord has done for me.

Table of Contents

List of Figures

List of Tables

List of Acronyms

CALL:	Computer Aided Language Learning
CI:	Confidence Interval (lower and upper bounds – in meta-analysis)
C-Map:	Concept map
CRH:	Conjoint Retention Hypothesis
DCT:	Dual coding theory
ES:	Effect size
ESL:	English as a Second Language
gMap:	Graphically enhanced map
GO:	Graphic organizer
k-Map:	Knowledge map
N:	Number of studies (in meta-analysis), sample size (in single study)
nText:	Non-synchronized text
pMap:	Plain map
SE:	Standard Error
SLA:	Second Language Acquisition
sText:	Synchronized text
TCU:	Texas Christian University

1 Introduction

This thesis is divided into 5 chapters. Chapter 1 is a statement of the motivation for this research and the problem being addressed. Also discussed in this chapter are the research questions driving this work and the significance of the study with respect to node-link mapping research. Chapter 2 provides a review of relevant literature starting with the theoretical framework of concept and knowledge map as well as a description and results of a meta-analysis of the literature on concept mapping and learning. Chapter 3 outlines the methodology of the research and highlights the participants of the study, the setting under which it was conducted, the multimedia materials used, the dependent variables and the procedure for the study. Chapter 4 reports and discusses the results of the study and Chapter 5 concludes with findings and limitations of the study and recommendations for future research. The general overview of the study is shown in Figure 1 in a concept map format.

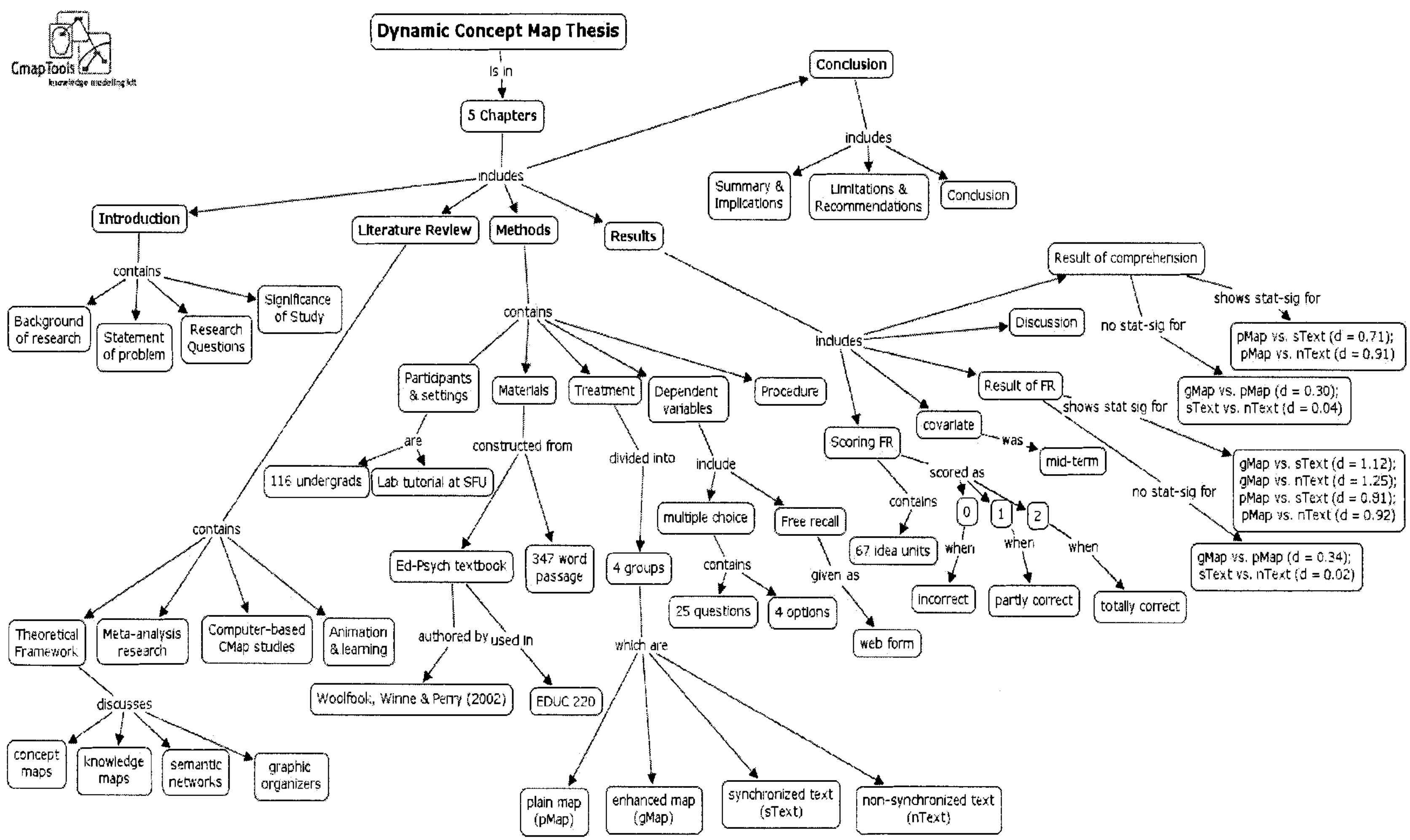

Figure 1. **Concept Map showing overview of the study**

1.1 Background

Over the last three decades, researchers have demonstrated increasing interest in the instructional use of node-link spatial tools such as concept maps (Novak, 1990a; 1990b) and knowledge maps (O'Donnell, Dansereau & Hall, 2002; Dansereau & Newbern, 1997). Figure 2, constructed from data in Appendix A, shows the historical account of literature on node-link displays since 1970. This figure reveals that interest in this area of research has grown since the early 80s with Novak & Gowin's (1984) publication on learning how to learn.

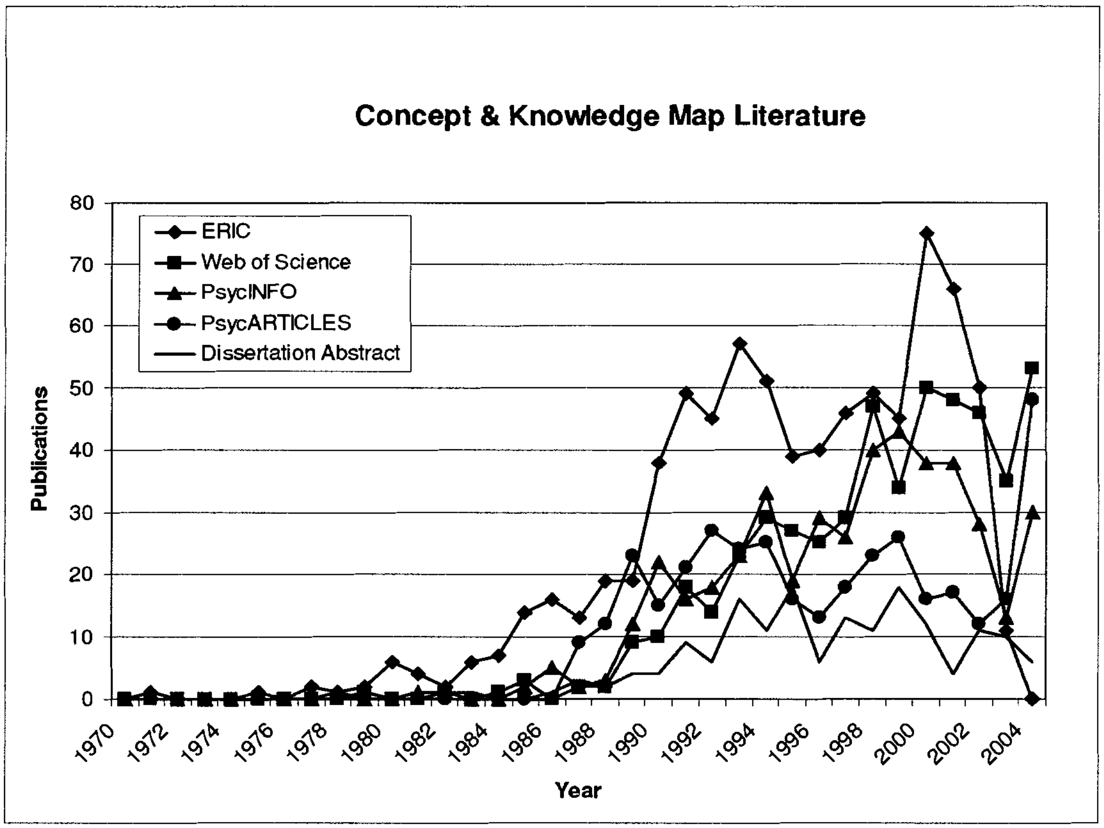

Figure 2. Publication trends in concept, knowledge and node-link map research. The graph shows studies retrieved with the search term *(concept or knowledge or node-link) map in March 2005.**

There has been widespread use of node-link spatial tools for learning. Research has extensively showed that these tools can promote learning because of their inherent characteristics. One of the reasons attributed to the effectiveness of node-link maps is its minimum use of text, which makes it easier for students to scan for information in spatial tools than in texts (Plotnick, 1997). Furthermore, there are several empirical studies that have validated the hypothesis that node-link spatial tools are effective because of reduction in the amount of verbiage in comparison to typical text (O'Donnell & Dansereau, 2002; Blankenship & Dansereau, 2000). Compared with typical academic language, node-link maps offer a relatively consistent and simple syntax (node-link-node). They may be easier to comprehend for learners with lower verbal ability or learners studying in a second language. Also, unlike texts that have only one processing fashion, i.e. top-down and left-right; node-link spatial tools have different processing routes (Lambiotte et al., 1989). This is very useful for cognitive processing and could facilitate meaningful learning. Irrespective of these advantages of node-link maps over conventional text, there are few shortcomings that may reduce the efficiency of these node-link displays.

One of these shortcomings is commonly known as map shock (Dansereau, Dees & Simpson, 1994), which occurs when learners are overwhelmed by the complexity of map display. When learners are presented with a static map with many nodes and linking labels, they may be overwhelmed by the map, especially if they are not regular users of concept maps. Map shock could lead to ineffective processing of map elements and could also lead to lack of motivation to process the map. An approach to eliminate map shock was proposed by Blankenship & Dansereau (2000) where students were presented with animated node-link maps projected onto a screen. However, this approach poses another problem as students did not have control of the animation. For some students, the animation might have been too fast and for some, it might have been too slow. While Blankenship et al. approach was intended to eliminate map shock, it might have introduced negative affective reactions in low motivation to studying the material.

Another problem with static node-link display is poor visual configuration. Wiegmann, Dansereau, McCagg, Rewey & Pitre (1992) proposed that concept maps may be less effective if they fail to use node proximity to signal semantic similarity. Wallace, West and Ware (1998) found that learners who studied plain concept maps attained only a .35 standard deviation advantage over learners who studied a text passage; while learners who studied a concept map enhanced with colors, node shapes and structural arrangements to emphasize semantic relatedness attained a 1.1 standard deviation advantage over the text group.

1.2 Statement of the Problem

The huge volume of literature in node-link tools has shown the effectiveness of concept and knowledge maps as tools for improving learning. However, since most of these findings were observed from paper-based medium research, more studies should be conducted in a computer-based environment. While some authors have theorized that node-link display could be a powerful learning medium when implemented as interactive software (Canas et al., 2003; Novak, 2002), our meta-analysis of node-link map research (Nesbit & Adesope, 2005) found only four methodologically sound, published studies that investigated computer-based concept map applications (Blankenship & Dansereau, 2000; Chang, Sung & Chen, 2002; Reynolds, Patterson, Skaggs & Dansereau, 1991; Reynolds & Dansereau, 1990). The small number of studies indicates the need for further methodologically sound research on node-link displays using computers.

Furthermore, only one of these studies tested the effect of animation in learning through mapping. Animation, if effectively implemented, can enhance learning. Thus, we would like to test the effect of animated node-link maps with self-paced control. Lastly, none of these four computer-based studies or any of the node-link research has ever addressed the effectiveness of audio narration with concept mapping. This is one opportunity that computer-based node-link tools can afford. Explanations have been suggested for the positive effects of concept maps on learning that refer to their dual, visual-verbal format. Viewing or constructing maps may produce dual coding, that is, cognitive representation of the information in both verbal and visual memory (Paivio, 1986). In other contexts, presenting integrated pictorial and verbal representations has been shown to enhance knowledge retention and transfer (Mayer, 2001). If concept maps are partially processed by the visual channel of working memory, they may avoid overloading the verbal channel and consequently improve learning. Therefore, this study will attempt to test the effectiveness of dual coding (through audio narration) with concept maps over texts.

1.3 Research Questions

Drawing largely from the body of literature we have in knowledge representation through node-link maps, we found out that there are still a number of issues that need to be addressed. Before we advance to complex, interactive designs with dynamic concept maps, we believe it is important to establish that dynamic maps can function effectively when presented in a simple, less interactive format. Hence, this study asks six major exploratory research questions. These are:

(1) How much do dynamic concept maps benefit learning in comparison with text displays that are synchronized or not synchronized to an audio narration?

(2) Are visual configurations like color and other graphical enhancements important in boosting any advantages for dynamic maps relative to text?

(3) Are graphically enhanced maps more effective for learning than plain maps?

(4) Is learning enhanced when text passages are synchronized with audio narration than when they are not synchronized?

(5) How do dynamic concept maps compare with the overall effectiveness of static paper-based maps research?

(6) When compared with dynamic text, are dynamic maps effective for recalling central and detail ideas?

Answering these research questions will provide a window of opportunity into how effective dynamic maps could be relative to text and will also serve as springboard into further research programs in dynamic nature of node-link displays. One application that easily comes to mind is in music education where musical passages (in audio format) could be embedded in nodes.

1.4 Significance of the Study

While it is true that the huge literature on node-link displays has proved their effectiveness as learning tools, there is only one study on animated node-link maps. This study is an attempt to contribute to research on node-links maps in the following ways:

First, this study sets out to seek a deeper understanding of whether audio narration synchronized with node-link displays will produce a better learning effect than synchronized text. This will be the first study to investigate audio narration in node-link research and will open up another dimension in this area of research.

Moreover, the study will not only contribute to the body of research in node-link displays but also extend the research base on computer-based mapping tools. Nesbit and Adesope (2005) observed that there are only four published methodologically sound empirical studies on computer-based concept maps. Hence, this will be another big step towards enhancing the effectiveness of concept maps through the use of the computer.

Finally, this study has the potential to extend the design of knowledge management tools we currently have (e.g. Inspiration, CMapTools, etc). With the result of the research, there are possibilities that providing learners with dynamic mapping tools could enhance learning. Thus, the study has both social and conceptual justifications for it to be conducted.

2 Literature Review

This chapter will review literature on node-link displays. It consists of four parts. The first part reviews theoretical frameworks of concept maps by examining their origins in work by Novak and his research associates, based on Ausubel's assimilation theory of meaningful learning. Another theory driving this study is Paivio's dual-coding hypothesis. There is also a brief review of schema theory. The second part of the literature review deals with the meta-analysis of empirical research in node-link literature while the third part is a review of computer-based mapping literature. The last part highlights the role of animation in learning with respect to node-link literature.

2.1 Theoretical Framework

The cognitive revolution of the 1960s paved the way for several theories which led to the development of spatial learning tools that mimic the way information is stored in human memory. Novak and Gowin (1984) traced the history of the development of concept map to Ausubel's assimilation theory of cognitive learning which states that new information is linked to relevant, preexisting aspects of cognitive structure and both the newly acquired information and the preexisting structure are modified in the process to form a more highly differentiated cognitive structure (Ausubel, 1963; 1968). Ausubel asserts that the most important factor influencing learning is what the learner already knows. In Novak's quest to better understand "what the learner already knows", he and his research team faced the arduous task of determining how changes in children's knowledge of science were occurring in first and second grades students over a period of

12 years. As reported in Novak and Musonda (1991), this study eventually led to the development of the concept mapping tool. Node-link diagrams have been used for education since at least the 13th century, as depicted in the "*Tree of Porphyry*" (Sowa, 2000). However, Novak appears to be the first author to use the term "concept map" for such diagrams.

Closely related to Ausubel's assimilation theory is schema theory, which emphasizes the importance of prior knowledge to learning. A schema is a structure that portrays the way knowledge is represented and processed in memory. Schema theorists (Rumelhart, 1980; Norman & Rumelhart, 1981) have posited that schemas are dynamic, and existing schemas can be modified or expanded as new schemas are constructed or added to the existing ones. It is common for people to use their schemas constructed from previously experienced situations to interpret new, related experiences. Integration and assimilation of new information with prior knowledge and experiences help people to obtain more generalized structures and make new sense of situations and information as they get integrated with prior information. For example, my personal experience of grocery shopping before I came to North America was purely that of an open market system where there is price haggling during grocery shopping. That was what I had as schema of shopping based on my prior knowledge and experience. However, when I came to North America, my shopping schema was expanded to include mall shopping and other forms of fixed-price shopping which were not originally parts of my shopping schema. Some cognitive theorists have worked on network models to explain how semantic information is organized in the memory. One such theorist is Quillian (1968) who researched node-link representations of long-term memory called semantic networks. He suggested that human memory may be organized as a network-like structure consisting of nodes, which correspond to concepts, and links, which represent the relations between the concepts.

Stoyanova & Kommers (2002) noted that an important advantage of concept mapping is that it models the way the human memory organizes knowledge and also offers close correspondence between psychological constructs and their external mode of representations. It appears that spatial displays that conform to this node-link representation seem to benefit learning because learners are more capable of encoding and retrieving information in that format.

Another important theory supporting this work is Paivio's dual coding theory, popularly called DCT (Paivio, 1986; 1991). As shown in Figure 3, Paivio theorized that there are two different memory representations for verbal and visual information and that connection between these representations afford easier retrieval of information and consequently leads to improved learning. Because short-term memory is limited in capacity, information processing can deteriorate when dealing with too much information. The big challenge then is finding ways by which we can organize information for increased attention and encoding. Dual-coding theory plays a huge role in this attempt by supporting the effectiveness of multiple-channel communication. Viewing or constructing maps in conjunction with text or spoken presentations of the same information may support dual coding. Although dual coding may not be effective for depicting abstract knowledge, the theory has thrived in the representation of concrete knowledge or objects. For example, while it may be challenging to code the abstract word "honest" as an image, it is easier to code the word "bird". Nevertheless, it is a theory which is relevant to this concept map research.

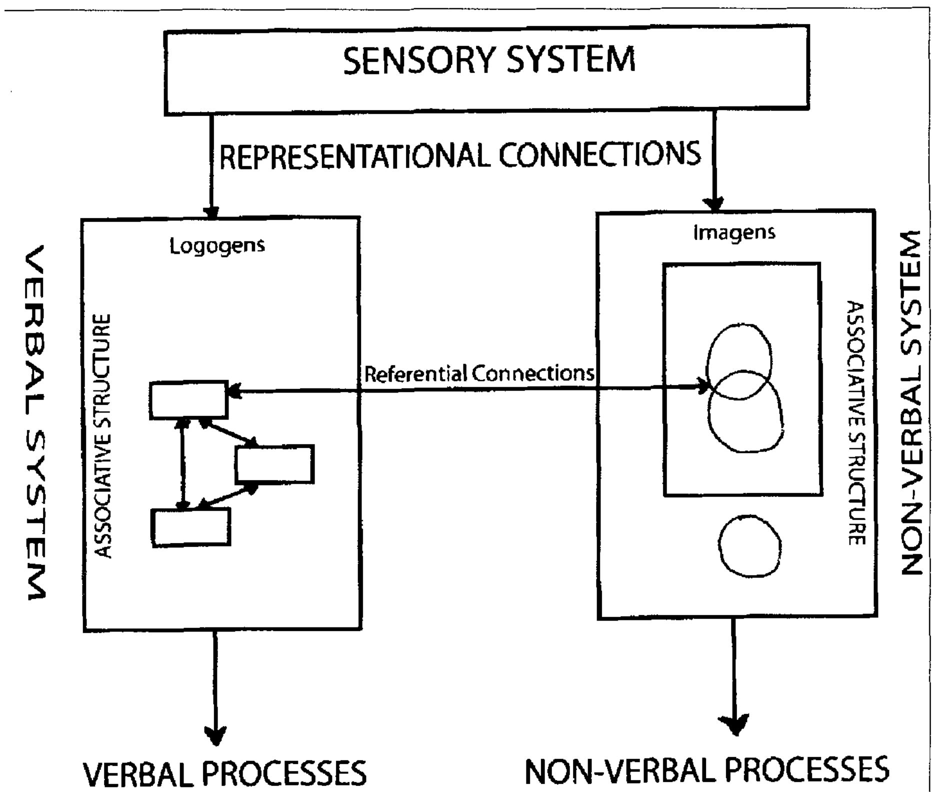

Figure 3. General model of dual coding theory

Paivio contends that information supported by both aural and visual cues have the potential to increase retention. Empirical studies have shown that visual information helps to process and remember verbal information and vice versa (Mayer & Anderson, 1991). Multiple-channel communication is very prevalent in our society today with the advent of several technologies like cell phones, television, movies and games. We often see people using cell-phone in parallel with typing on the computer and doing other things. Even in face- to-face communication, we simultaneously process verbal and non-verbal information. Thus, we know, to a certain extent, that multiple-channel communication and dual-coding could play a great role in learning. However, the effectiveness of dual-coding in node-link displays like concept maps using audio narration has not been studied. If concept maps are partially processed by the visual channel of working memory, they may avoid overloading the verbal channel and consequently improve learning. Understanding concept maps may require translation between visual and verbal information and thus promote cognitive processing.

Although some concept mapping software allows users to represent each node as an image, none of the literature reviewed examined this idea of 'mimetic' icons, i.e. pictures that help the learners to retrieve prior knowledge about the concept and code the concept as an image. We know that when information is referenced in a text and accompanying map, they are encoded both verbally (as in a text or spoken text) and spatially (as in a map) and thus offer a dual-coding advantage for storing and retrieval of such information (Paivio, 1986). This extension of dual-coding theory is called the conjoint retention hypothesis (CRH) because both the map and the text are "conjointly retained" (Kulhavy, Lee & Caterino, 1985).

While it is true that this work is not rooted in research in mental imagery, it has derived inspiration from it. Kosslyn's (1989) work on understanding charts and graphs, especially the important laws in graphical displays is worthy of mention. However, untangling the inconclusiveness of mental imagery research debate (Kosslyn, 1994; Pylyshyn, 1994) is outside the scope of this work.

Although node-link representational systems were originally developed to provide models of semantic memory structures and mental processing (Rumelhart & Norman, 1985); they have since afforded researchers the opportunity for developing spatial learning tools using this framework. Given an understanding of the way learners represent information internally, the major steps then was to find learning tools that can boost this internal representation. Based on Ausubel's theory of assimilation, schema theory, node-link models, and the assumption that effective and efficient learning strategies encourage learners to construct structures that parallel actual mental processing (Holley & Dansereau, 1984), major spatial learning strategies have been developed, including Dansereau's knowledge mapping (Rewey et al., 1989; Holley & Dansereau, 1984) and Novak's concept mapping (Novak & Gowin, 1984). Concept and knowledge maps can either be presented to students (Cliburn, 1986; Lambiotte & Dansereau, 1992) or constructed by students (Chang, Chen & Sung, 2002; McCagg & Dansereau, 1991).

It would be ambitious to attempt to describe all the literature pertaining to these node-link spatial tools. For brevity and clarity, we describe a few selected papers that are relevant to this work. Extensive review of literature in concept and knowledge maps could be found in Novak (1990a; 1990b) and O'Donnell, Dansereau & Hall (2002) respectively. A brief highlight of these node-link spatial learning tools is given below.

2.1.1 Concept Maps

Concept maps are visuo-spatial formats that facilitate the organization, presentation, processing and acquisition of knowledge. Their development is grounded in cognitive learning theory. Building on Ausubel's theories of assimilation and subsumption (Ausubel, 1968), seminal work by Novak (1977) from Cornell University emphasized the potential of concept mapping for constructing new knowledge in relation to prior knowledge. Ausubel (1968, pg. 34) contended that *"the most important single* *factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly."* A primary process in learning is subsumption in which new material is related to relevant ideas in the existing cognitive structures. Concept maps were developed in the course of Novak's research in which he sought to understand changes in children's knowledge of science.

A concept map consists of nodes that contain a concept or item and links connecting the nodes. Links, which show relationships between the nodes, can be non-directional or uni-directional and can also be labeled or unlabelled. An example of a concept map showing information about Nigeria is shown in Figure 4. The figure below is also an example of a uni-directional concept map. Labels can be used in a variety of ways to illustrate the semantic relationship between the nodes. For example, the figure below shows that Nigeria "is in" West Africa and it "is part of" Africa.

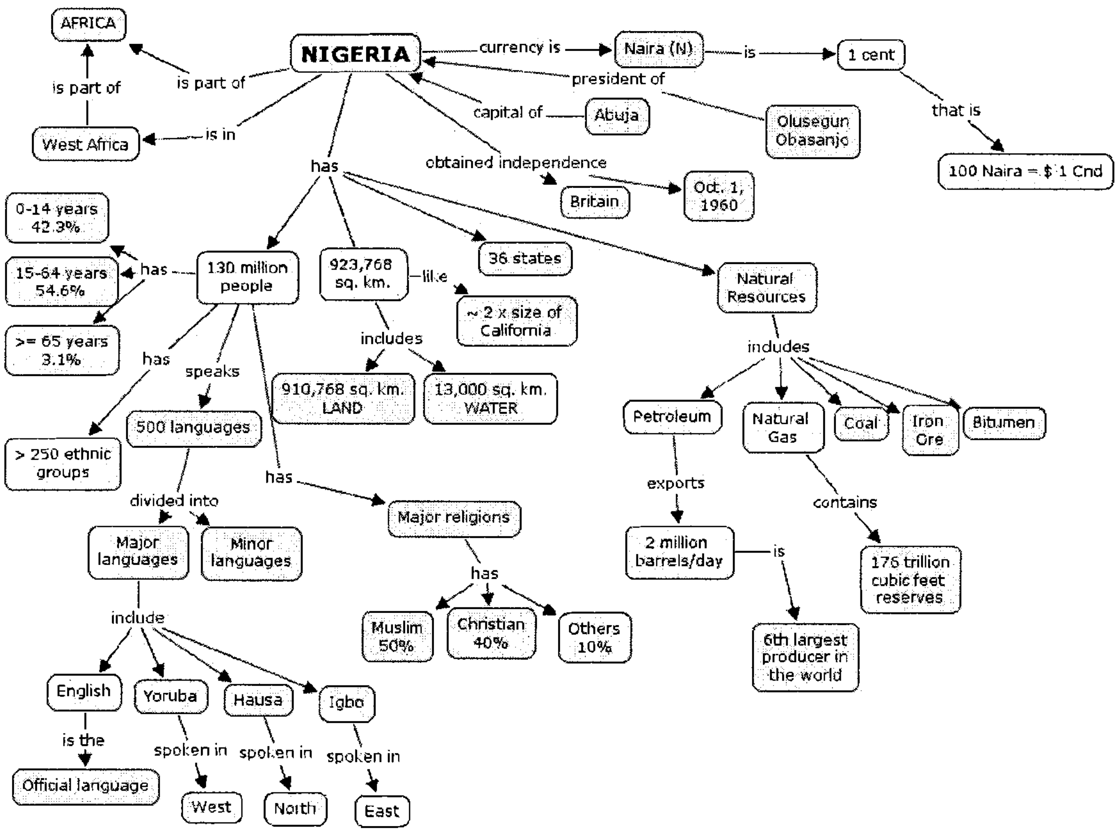

Figure 4. A concept map showing information about Nigeria

As previously discussed, Novak and Musonda (1991) reported that a 12-year longitudinal study of children's concept development led to the invention of concept mapping tool. In that study, concept map was used to monitor changes in conceptual understanding of science students over a 12-year period. Thereafter, concept map has been refined and used also as a tool for studying because of its summarization ability. They have also been used as advance organizers (Willerman & MacHarg, 1991); as assessment tools (Ruiz-Primo & Shavelson, 1996; Schmid & Telaro, 1990); cooperative learning tools (Stoyanova & Kommers, 2002); as anxiety reduction tools (Czerniak & Haney, 1998; Jegede, Alaiyemola & Okebukola, 1990) and as communication tools for organizing ideas and promoting problem solving strategies (Okebukola, 1992).

2.1.2 Knowledge Maps

Dansereau, Holley, and their colleagues from Texas Christian University (TCU) developed a node-link representational system called knowledge map (Holley & Dansereau, 1984). In knowledge maps, learners are given a set of fixed named links (e.g. "P" for part of, "L" for leads to, "C" for characteristics) to identify important concepts in the material and represent interrelationships and structures in the form of a network map. Knowledge maps are diagrams that use a spatial arrangement of nodes and links to communicate about concepts and to specify the multiple relationships among concepts in a given knowledge domain (Lambiotte, Dansereau, Cross & Reynolds, 1989; Lambiotte & Dansereau, 1992; Rewey, Dansereau, Dees, Skaggs & Pitre, 1992; Rewey, Dansereau & Peel, 1991). Knowledge maps are mostly generated by experts rather than by novices (students) and have been found to facilitate recall when used in conjunction with other learning strategies such as summarization (Rewey et al., 1991) and cooperative learning (Rewey et al., 1992). Knowledge maps have also been used for drug abuse counseling (Dansereau, Joe & Simpson, 1993; 1995).

Figure 5 shows a transformation of information about Nigeria in Figure 4 into a knowledge map. There have been consistent findings in knowledge map research over the years. Studies have shown that knowledge maps enhance performance on delayed free recall, especially for main ideas (Hall & O'Donnell, 1996; Lambiotte & Dansereau, 1992; Rewey, Dansereau & Peel, 1991). Furthermore, knowledge maps have aided learning for users with low prior knowledge and low verbal ability (Patterson, Dansereau & Wiegmann, 1993; Lambiotte & Dansereau, 1992). Researchers have also studied the affective outcomes of maps (Bahr & Dansereau, 2001; Hall & O'Donnell, 1996).

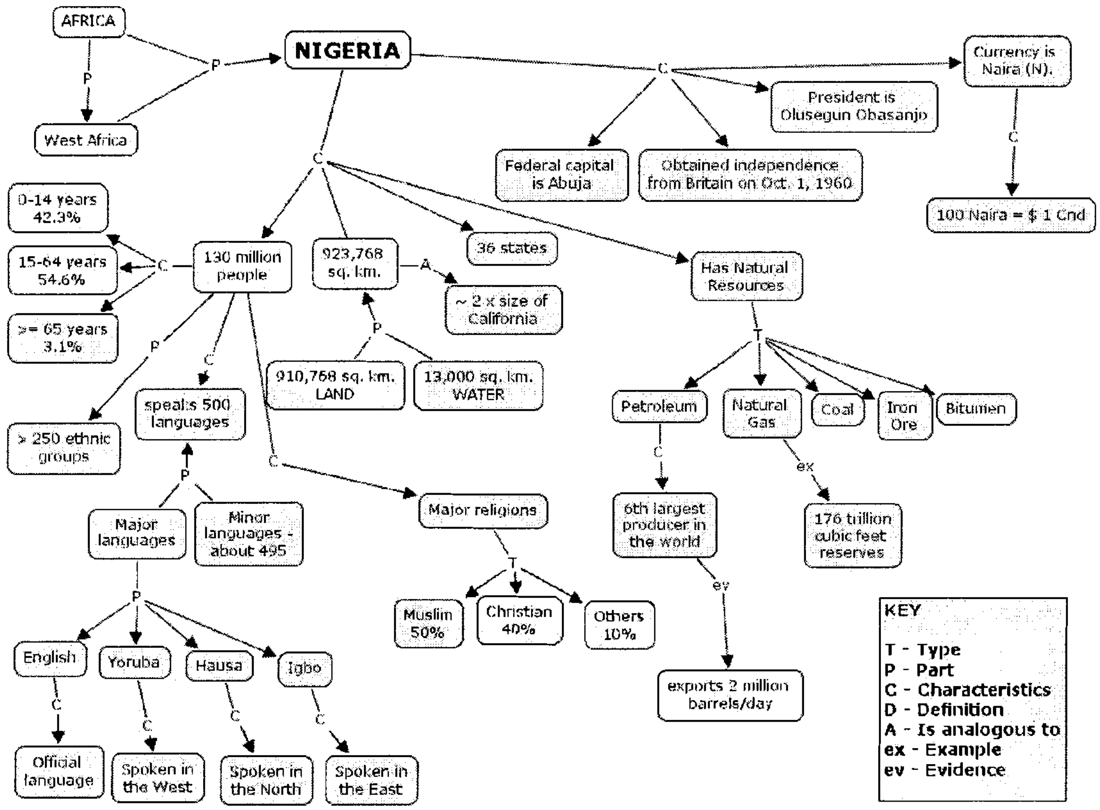

Figure 5. A knowledge map showing information about Nigeria

In summary, concept and knowledge maps are diagrams showing interrelationships among concepts as node-link assemblies. Research has explored the use of such diagrams as the focus of constructive activities, and as communication aids in lectures, study materials and collaborative learning (Canas et al., 2003). The only major difference between a concept map and a knowledge map is the use of fixed links in knowledge maps. With this minor difference, we will henceforth use the term concept map for both concept and knowledge maps because of their similarities.

2.1.3 Semantic Networks

Some researchers have loosely used the term semantic network to mean concept maps (Jonassen, 2000; Jonassen, Reeves, Hong, Harvey & Peters, 1997). However, semantic networks are somewhat different from concept maps in that semantic networks are knowledge representation schemes (and not tools) involving nodes and links. As in concept maps, the nodes represent concepts and the links represent relations between nodes. However, the links in semantic networks are directed and labeled; thus, a semantic network could be termed as a directed graph. Apart from concepts being linked by relations, one other component of a semantic network is called an instance. An instance of a relation is the occurrence of two concepts linked by that relation. One of the early theorists of semantic memory structure hinted that human memory can be organized in node-link-node format (Quillian, 1968). Since then, researchers have extended this idea. Semantic networks as representation of knowledge are now being used in artificial intelligence (AI) research for human reasoning and ontological work.

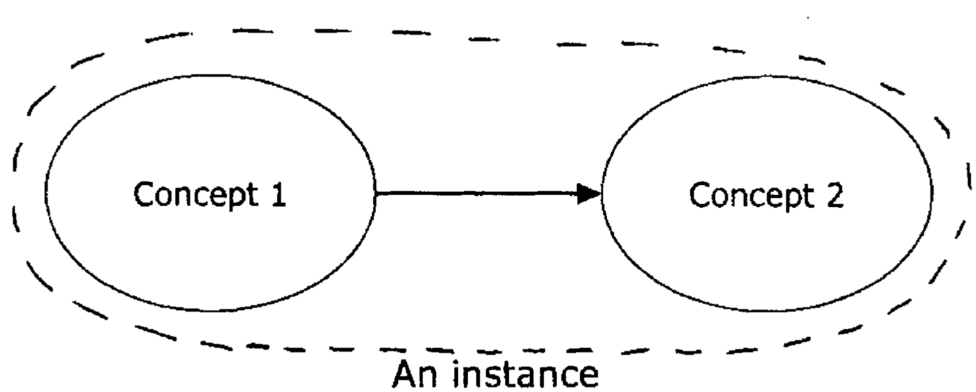

Figure 6. Components of a semantic network

Although there are other types of node-link spatial displays like pathfinder networks, which are node-link network displays originally used to analyze and model patterns in proximity data (Schvaneveldt, Durso & Dearholt, 1989), we have only described the above three node-link spatial displays (concept map, knowledge map and semantic network) because they have been used extensively in the mapping literature. The next type of display we describe is the graphic organizer. It is not a node-link display but is presented here because it has also been used as spatial display for learning.

2.1.4 Graphic Organizers

Another type of spatial display of text information is the graphic organizer (GO). Graphic organizers show relationships among concepts by two-dimensional visual devices like spatial position, connecting lines, and intersecting figures (Winn, 1991). According to Katayama & Robinson (2000), GOs are similar to knowledge and concept maps because they use two-dimensional space to communicate concept relations. Figure 7 below shows the relationships between graphic organizers and other types of spatial displays that we have previously described.

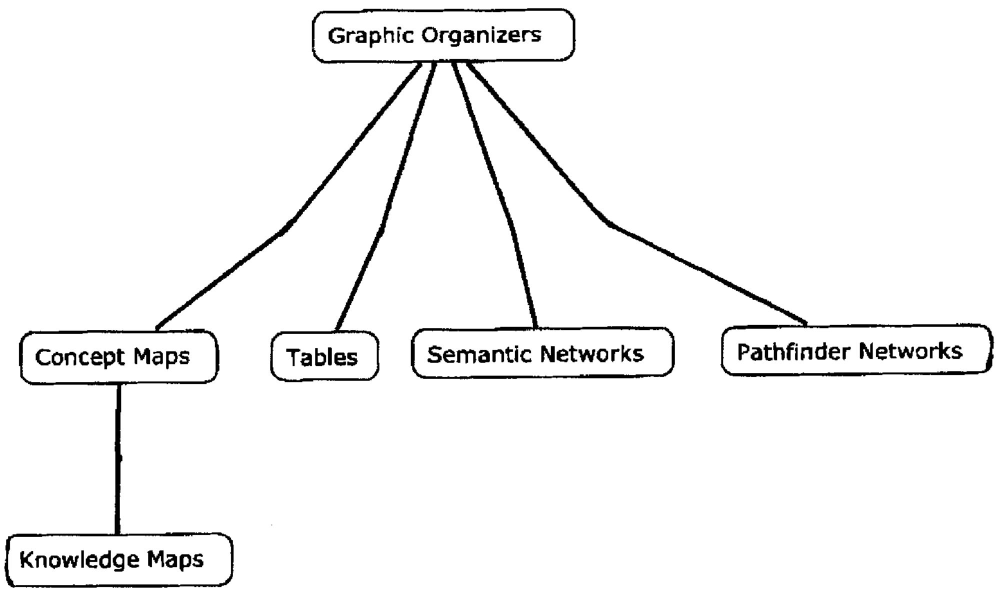

Figure 7. Hierarchy of node-link spatial displays

Graphic organizers can be regarded as a category that subsumes concept maps, tables, and timelines, and flowcharts, because they spatially represent abstract knowledge that is not inherently visual. GOs were inspired by Ausubel's theory of meaningful learning (Ausubel, 1968) and initially designed as advance organizers to activate prior knowledge and show its relationship with new concepts being learned. Concept map is a type of graphic organizer that is distinguished by the use of labeled nodes and links. We also view knowledge maps as a form of concept maps because they both spatially use "node-link-node" syntax to depict knowledge.

GOs are spatial displays of text information that can be provided to students as study aids (i.e., adjunct displays) that accompany text. However, GOs do not use labeled links to show relationships among concepts but rather use only the relative spatial locations of words. Several researchers have found that when students are provided with

GOs to study along with text, they perform better (e.g., Robinson & Kiewra, 1995; Robinson & Schraw, 1994, Katayama & Robinson, 2000). A review by Moore & Readance (1984) shows that GOs are effective when they follow the presentation of content while a recent study by (Robinson, Corliss, Bush, Bera & Tomberlin, 2003) suggests that multiple GOs might be presented as a set before the text is presented so as to learn more macrolevel, concept related text information effectively. A layout of this thesis in a graphical organizer format is shown in Figure 8.

Dynamic Map Thesis	1. Introduction	
	2. Literature Review	
	3. Methods	
	4. Results	Effect size of free recall = .94
		Effect size of comprehension = .65
	5. Conclusion	

Figure 8. Graphic organizer showing layout of thesis

In summary, we know that all the tools discussed so far are spatial and are used to organize knowledge for proper encoding and retrieval. The next section reports our work on integrative review or meta-analysis of two of these spatial tools, i.e. concept and knowledge maps.

2.2 Meta-analysis of Concept Mapping Tools

Meta-analysis, developed by Gene Glass, is an integrated review of literature in a specific domain. In meta-analysis, research results, and not people, are summarized, integrated and interpreted (Lipsey & Wilson, 2001). Initial aggregation of empirical research of concept mapping tools was conducted by Horton et al. (1993). In this work, 18 classroom-based concept map studies were meta-analyzed. None of the studies investigated the effect of computer-based maps on learning. They were mainly studies conducted with paper-based maps. These researchers only aggregated the results of classroom-based studies but did not look into laboratory studies. A more comprehensive meta-analysis was done by Nesbit & Adesope (2005). Compared with the meta-analysis by Horton et al., we expanded the inclusion criteria to cover laboratory studies in which learners volunteered as research participants and the learning outcomes were not used for grading purposes. Although such studies have lower ecological validity they are usually better controlled and, as it happens, include many studies in which maps are presented rather than constructed.

This meta-analysis reviews experimental and quasi-experimental studies in which students learned by constructing, modifying or viewing node-link diagrams. We searched the databases listed in Table 1 using the search query: “concept map*” OR “knowledge map*” OR “node-link map*”.

Table 1. Results of Searches Conducted March, 2005

database	number of studies
ERIC	837
Web of Science	500
PsycInfo (empirical studies)	359
PsycARTICLES	326
Academic Search Elite	236
Digital Dissertations	159

Apart from searches from online databases, we did physical search for relevant papers by looking into the reference sections of a few comprehensive review papers

(Canas et al., 2003; Horton et al., 1993; Novak, 1990b; O'Donnell, Dansereau & Hall, 2002). In the selection phase, I, as one of the researchers, read the abstract or online text of each study found in the search. If the abstract did not provide sufficient information to exclude the study according to our selection criteria, the researcher scanned the methods, procedure and data collection parts of the paper to retain or exclude the paper. Borderline cases were retained for further inspection. For each thesis found through the Digital Dissertations database, the researcher read the first 24 pages to determine eligibility for inclusion. Studies identified as not meeting the selection criteria were eliminated, resulting in a list of 103 studies for which full text copies were obtained.

Following a preliminary examination of empirical studies and reviews, we formed criteria to capture studies with research designs testing the educational and learning effects of concept maps. To be included in the meta-analysis, studies were required to have: (a) contrasted effects of map studying, construction or manipulation with other learning activities. Contrasting groups must have activities designed to promote learning; (b) measured cognitive or motivational outcomes such as recall, problem solving transfer, learning skills, interest or attitude; (c) reported sufficient data to allow an estimate of standardized mean difference effect size; (d) assigned participants to groups prior to differing treatments; (e) randomly assigned participants to groups, or used a pretest or other prior variable correlated with outcome to control for pre-existing differences among groups. Studies reporting a pretest effect size outside the range $-.40 < d < .40$ were excluded from the meta-analysis.

Following an exhaustive search for studies meeting specified design criteria, 97 standardized mean difference effect sizes were extracted from 50 studies involving 5,141 participants who learned in domains such as science, psychology, statistics, and nursing with an inter-coder agreement of 96.2%. A mean effect size was obtained for each set of statistically dependent effect sizes by averaging over different outcome constructs and treatments, yielding 63 effect sizes. Figure 9 shows the distribution of these effect sizes.

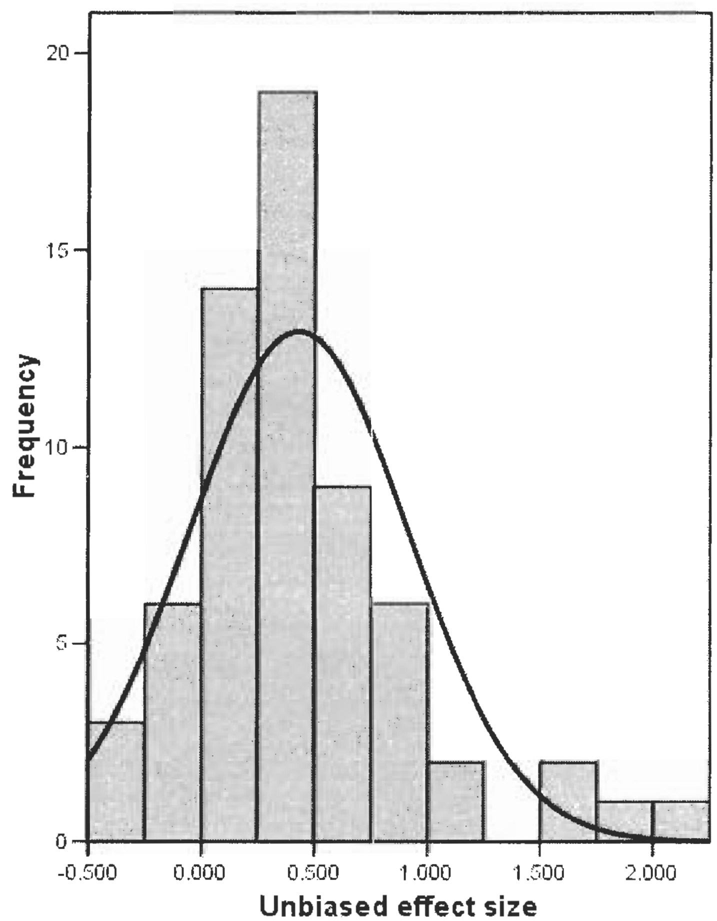

Figure 9. Distribution of 63 effect sizes obtained from 49 studies ($M = .43$, $SD = .49$, $Mdn = .41$)

Generally, we found that students like concept maps because they derive greater satisfaction in the use of maps. As shown in Table 2, six accepted studies measured students' self-report outcomes. These affective outcomes were tagged as affect (anxiety, frustration with learning, satisfaction), self-efficacy, motivation, and perceived use of learning strategies. Due to limited number of studies measuring self-report outcomes, we decided not to meta-analyze them. Instead, these six studies, as shown in Table 2, portray vividly, students' perception of their use of concept map for learning.

Table 2: Effect sizes of motivational or attitudinal outcomes
Effect sizes for concept map studies that obtained self reports of affect, self-efficacy, motivation, and use of learning strategies.

Study, treatments, sample size and outcome construct	Effect size
Bahr and Dansereau (2001), studying bilingual maps versus lists, N = 64	
ease of learning	.48
satisfaction with presentation format	.46
motivation and concentration	.26
confidence in future performance	.44
Chulerut and De Backer (2004), mapping versus teacher-led discussions, N = 79	
use of self-monitoring strategies	4.34*
use of knowledge acquisition strategies	3.48*
English as a second language self-efficacy	.98*
Czerniak and Haney (1998), cooperative mapping versus lecture, N = 118	
anxiety toward teaching and learning (sign reversed)	.41
Jegede and Alaiyemola (1990), mapping versus lectures, N = 51	
anxiety (sign reversed)	1.11*
Reynolds and Dansereau (1990), studying hypermaps versus hypertext, N = 38	
satisfaction	.87*
frustration and confusion (sign reversed)	.80*
Reynolds et al. (1991), studying hypermaps versus hypertext, N = 38	
satisfaction	.47
frustration and confusion (sign reversed)	.62

* p < .05

The remaining studies measured outcomes such as retention, transfer and mixed retention & transfer. In a variety of settings the use of concept maps was associated with moderate and statistically significant increments in knowledge retention, and under some conditions greater knowledge transfer. We found that studies comparing learning from concept maps to learning from text passages show that studying maps offers gains in learning outcomes averaging about d=.36 standard deviations. Tables 3 to 6 below from our meta-analysis (Nesbit & Adesope, 2005) show the summary of the effect of constructing or studying with concept maps.

Table 3. Weighted Mean Effect Sizes for Participants and Settings

	Maps Constructed or Modified				Maps Studied			
	n	mean	*SE*	$CI_{.95}$	n	mean	*SE*	$CI_{.95}$
Educational level								
Intermediate (4-7)	4	.17	.12	-.06 <> .40	3	.61*	.16	.30 <> .91
Secondary (8-12)	10	.34*	.06	.22 <> .46	1	.41		
Postsecondary	11	1.08*	.08	.93 <> 1.24	39	.34*	.04	.26 <> .42
Setting								
Laboratory	0	-	-	-	30	.32*	.05	.27 <> .37
Classroom	20	.49*	.05	.39 <> .58	7	.38*	.09	.21 <> .55
Location								
US and Canada	18	.36*	.06	.25 <> .47	37	.36*	.04	.28 <> .44
Nigeria	4	1.43*	.11	1.22 <> 1.63	0	-	-	-
Asia	2	.06	.13	-.20 <> .31	1	.00	-	-

*$p < .05$

Table 4. Weighted Mean Effect Sizes for Treatment Features

	Maps Constructed or Modified				Maps Studied			
	n	mean	*SE*	$CI_{.95}$	n	mean	*SE*	$CI_{.95}$
Treatment Duration								
Less than 90 min.	2	.86*	.17	.53 <> 1.18	26	.27*	.05	.17 <> .37
Greater than 90 min.	13	.94*	.07	.81 <> 1.08	14	.50*	.06	.38 <> .62
Student Interaction								
Individual	9	.42*	.07	.27 <> .56	32	.36*	.04	.28 <> .45
Collaborative	2	.83*	.16	.51 <> 1.15	7	.24*	.11	.02 <> .46
Mixed	10	.88*	.08	.72 <> 1.04	0	-	-	-
Adjunct Materials								
No adjunct materials	1	.36	-	-	15	.43*	.06	.31 <> .54
Text	19	.44*	.05	.38 <> .54	18	.26*	.06	.14 <> .38
Control Task								
Text	3	.75*	.13	.50 <> 1.01	26	.35*	.05	.26 <> .45
Outline or list	3	.05	.09	-.12 <> .22	12	.30*	.08	.15 <> .44
Lecture or discussion	12	.92*	.07	.78 <> 1.05	1	.68	-	-
Other	7	.32*	.01	.13 <> .51				
Animation	0	-	-	-	2	.76*	.17	.42 <> 1.09

* $p < .05$

Table 5. Weighted Mean Effect Sizes for Outcome Constructs

	Maps Constructed or Modified				Maps Studied			
	n	mean	*SE*	$CI_{.95}$	n	mean	*SE*	$CI_{.95}$
Retention only	6	.44*	.10	.24 <> .65	31	.35*	.04	.26 <> .43
Mixed retention and transfer	15	.50*	.05	.40 <> .61	3	.28	.17	-.05 <> .60
Transfer only	1	1.23	-	-	3	.16	.15	-.14 <> .45
Learning skills	2	.65*	.16	.33 <> .97	0	-	-	-

Table 6. Weighted Mean Effect Sizes for Methodological Features

	Constructed or Modified				Studied			
	n	mean	*SE*	$CI_{.95}$	n	mean	*SE*	$CI_{.95}$
Confidence in ES								
Low	4	.14	.10	-.05 <> .33	1	.43	-	-
Medium	10	.30*	.07	.17 <> .43	6	.30*	.10	.11 <> .48
High	11	1.10*	.07	.96 <> 1.25	31	.35*	.05	.27 <> .44
Treatment Fidelity								
Low	4	.09	.09	-.08 <> .27	1	-.10	-	-
Medium	6	.77*	.12	.54 <> .99	9	.34*	.09	.17 <> .52
High	15	.69*	.06	.58 <> .81	28	.36*	.05	.27 <> .45
Random Assignment								
Yes	7	.81*	.10	.60 <> 1.01	35	.33*	.04	.24 <> .40
No	18	.49*	.05	.40 <> .59	3	.48*	.11	.26 <> .70

* $p < .05$

2.3 Related Work - Computer-based Concept Mapping Research

Our meta-analysis revealed that there are only four methodologically sound, published empirical studies that investigated computer-based concept map applications (Blankenship & Dansereau, 2000; Chang, Sung & Chen, 2002; Reynolds, Patterson, Skaggs & Dansereau, 1991; Reynolds & Dansereau, 1990) in spite of researchers' observations that concept maps may be a powerful learning medium when implemented as interactive software (Canas et al., 2003; Novak, 2002). Also, only the Blankenship &

Dansereau (2000) study investigated the effect of animation on learning through maps. Chang et al. (2002) studied 126 elementary students using educational concept mapping software and a text passage to correct or complete a concept map provided by the teacher. The software provided feedback indicating the degree of correctness of the map. In comparison with simply studying the text, students in the map correction condition showed a mean gain in comprehension ability of approximately one standard deviation. In a study by Blankenship and Dansereau that tested the effect of animated node-link displays on information recall, 37 students were given an animated node-link map presentation while 27 studied animated text presentation. Two days later, participants recalled more main-idea information from animated node-link maps than from animated text. This study is the most related work with respect to our research because of the use of animation. However, the animation used was not designed to be controlled by the students. All the subjects in the map group only saw projected animated map from a slide. This research will not only allow self-paced animated maps but will also include audio narration.

In Reynolds et al. (1990; 1991) studies, subjects worked with computer-based hypermaps and hypertext. Both studies showed that hypermaps were not superior to hypertext for learning but students reported greater satisfaction and less frustration and confusion with hypermaps.

2.4 The Role of Animation in Learning

Animation has been defined as a series of rapidly changing computer screen displays that represent the illusion of movement (Rieber & Hannafin, 1988). Over the years, some researchers have had success using animation to support learning (Mayer, 2001; Szabo & Poohkay, 1996; Rieber, 1990).

Recent technological advances have helped in the use of animation for learning purposes. However, the use of animation has been consistently questioned in the literature. Rieber (1996) argues that animation could distract from learning when it is used as a 'cosmetic function' to make the material more attractive or aesthetically appealing. There are tendencies that learners' attention could be drawn away from the actual learning material to the 'cosmetic' part of the animation thereby resulting in less cognitive processing of the material and consequently in less meaningful learning. This could be explained by the information processing theory of learning, which infers that students' attention could be easily distracted as a result of stimuli competing for the attention of students. This theory was taken into consideration in the design of animation in this study on animated concept maps. The animated maps and texts were designed only to convey the material and not for 'cosmetic' purpose.

Recently, Tversky, Morrison and Betrancourt (2002) argued that animation violates the apprehension principle of good graphics, which states that graphics should be accurately perceived and appropriately conceived. These authors further contend that animations are often too complex and too fast to be accurately perceived and thus could be detrimental to learning.

We propose that this shortcoming of animation may be minimized or even resolved when learners can control the speed and also review the animation. In the concept mapping studies we reviewed, none followed this self-paced principle of learning with studying animated maps. Blankenship & Dansereau (2000) projected their map onto a screen. Node and links were formed with an average interval of about 3 seconds between the appearance of new nodes and links. In this research, we designed the presentations to be controlled by the students, so that they are more able to integrate the process into their cognitive structure.

3 Research Methodology

This chapter consists of five parts. The first part describes the setting in which the experiment took place as well as the participants. The next part gives an overview of the multimedia materials used for the study. The third part is about the instructional treatments while the last two sections are about the dependent variables and the entire procedure of the main thesis study.

3.1 Participants and Settings

Of the 240 students enrolled in an introductory undergraduate course in educational psychology, 133 consented to participate in the experiment. Students who chose not to participate used the lab computers to work on an unrelated course assignment. The participants who consented had the option of withdrawing from the study at any time.

The study was conducted at Simon Fraser University, Canada. Over a period of eight weeks prior to the experiment, students who attended all lectures were presented with 22 concept maps in course lectures and online. In assignments completed three weeks prior to the experiment, each student constructed two concept maps depicting selected course topics. The graphical conventions used in the research materials were similar to those used in lectures and assignments. Students were very familiar with constructing and studying with concept maps. The experimental data were collected over a period of one week at the normally scheduled tutorial sessions.

3.2 Materials

The multimedia presentations were Macromedia Flash animations constructed from a 347-word passage on attribution theory from the course textbook (Woolfolk, Winne & Perry, 2002, pp. 358-359). The audio narration was a recording of a human voice reading the passage. Prior research guided the format and style of the presentation of the material (Tversky, Morrison & Betrancourt, 2002; Rieber, 1996; Graesser, Hoffman & Clark, 1980; Hooper & Hannafin, 1986). The text presentation was left justified because research has affirmed that left justified text can be read faster than full justified ones (Hooper & Hannafin, 1986). Font and other style characteristics were legible.

The presentations were constructed such that the participant could advance through the content by clicking on a "next" button. Table 7 shows the structure of the presentations. For the plain map (pMap), graphically enhanced map (gMap), and synchronized text (sText) materials, the animations were synchronized to the audio narration such that a node-link-node structure, or sentence in the case of the sText material, appeared on the screen at approximately the same time that the participant heard the audio segment to which it corresponded. For the non-synchronized text (nText) material, participants first advanced through the display of sentences in the text passage before the audio narration was presented.

Table 7. Structure of Material

Material	Properties	Colour	Audio	Synchronized with audio
pMap	• Animated presentation synchronized to audio narration	No	Yes	Yes
gMap	• Semantically related nodes shaded with same color • Animated presentation synchronized to audio narration	Yes	Yes	Yes
sText	• Animated text presentation synchronized to audio narration	No	Yes	Yes
nText	• Animated text presentation not synchronized to audio narration. • Text displayed before audio • Audio segments played contiguously with no learner control	No	Yes	No

The design of the materials reflects the kind of research questions we set out to answer. With this design, we were able to compare the effectiveness of maps with text, plain map with enhanced map and synchronized text with non-synchronized text.

For all materials, visual contents remained on the screen while subsequent content was introduced. Screen shots from the pMap and sText animation are shown below in Figures 10 and 11. Note that in Figure 11, the information with audio is displayed in sentential format – one at a time until the whole passage is displayed

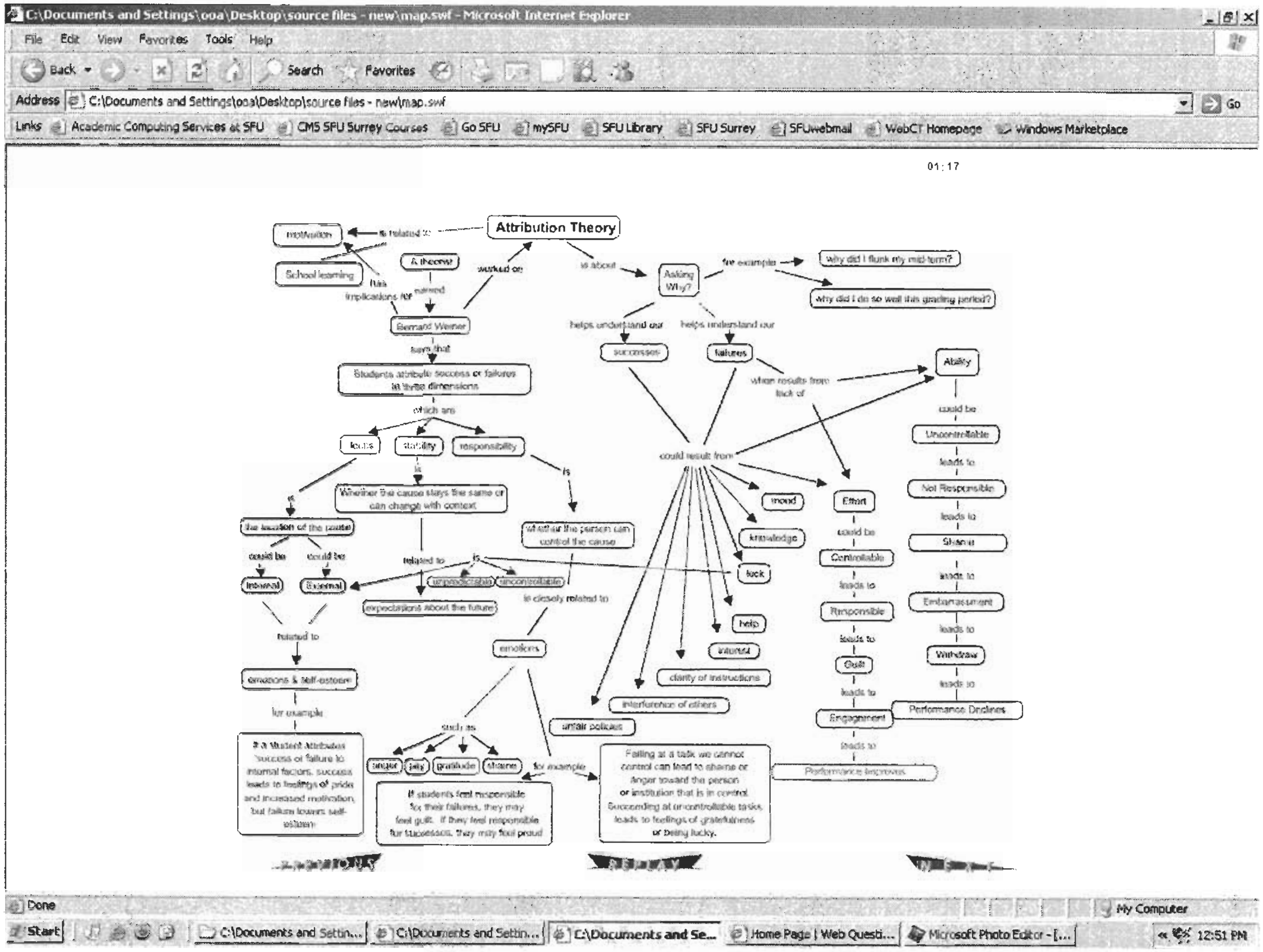

Figure 10. Screenshot of the pMap material.

MS Explorer frame, Microsoft® screen shot reprinted with permission from Microsoft Corporation

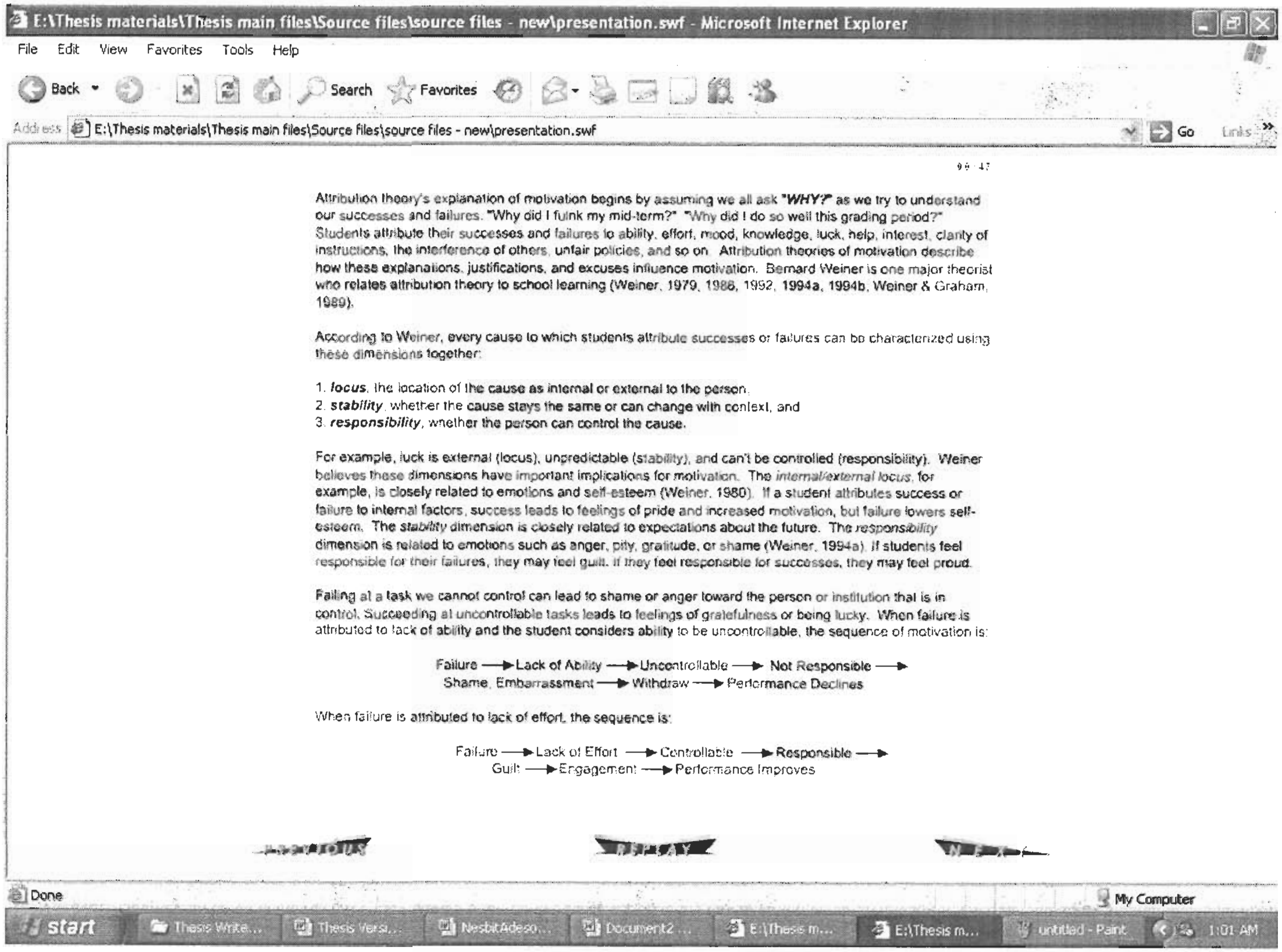

Figure 11. Screenshot of the sText material.
MS Explorer frame, Microsoft® screen shot reprinted with permission from Microsoft Corporation

3.3 Dependent Variables

The two dependent variables were free recall and multiple choice tests. A 25-item multiple choice test, shown in Appendix B, was designed to assess recall, understanding and application (Anderson & Krathwohl, 2001) of the attribution theory passage. These tests used four-alternative multiple choice questions at the knowledge, comprehension, and application levels. The test was delivered through an online web form after participants had completed the free recall task. This multiple choice test was designed using a questionnaire research tool called "Web Questionnaire" which is being developed as part of a large research project. It allowed participants to answer the questions and students' responses were saved into a database format that was exported to SPSS, a statistical analysis package.

In order to measure retention after the treatment, participants engaged in an immediate written free recall of the attribution theory passage. Free recall has been used as a dependent measure in many studies of this nature because it provides a sensitive measure of retained information. After presentation of the material, participants were instructed to enter as much information as they could remember in an open text web form. They were allowed 10 minutes to complete the recall task. None of the subjects indicated a need for additional time.

3.4 Procedure

This study was conducted for a whole week. Prior to the treatment session, subjects were duly briefed and randomly assigned to four experimental conditions. The study was conducted in an instructional computer lab with participants seated in front of a computer monitor and wearing headphones. Each participant attended one session lasting for 50 minutes. Before the students started studying, the researcher emphasized the importance of studying very well within the time allotted. Participants were encouraged to study the material as if they were studying for a final examination. They were told that after the presentation, they would be tested based on the material. They were instructed to advance through the multimedia presentation within 8 minutes and then review it for 2 minutes (see review page in Appendix D). Informal observation by the researcher showed that students heeded these instructions as much as possible. There was also an introductory page, as shown in Appendix C, explaining the sequence of the presentation. After 10 minutes of the multimedia presentation, participants were logged out and presented with a "START TEST" screen, shown in Appendix E. Participants were asked to click "start test" and then were presented with the free recall open text web form (see Appendix F) which contained the student name, id and free form area and asked to recall any information from the multimedia material presented. They were told that they could recall the information in any format without preference for the order of the presentation. The recall session lasted 10 minutes and none of the subjects indicated need for more time to recall. When they finished the recall, they clicked the submit button and then each subject's typed information was sent to the researcher. After the recall session, participants were presented with a 25-item multiple-choice test. The test used four-alternative multiple choice questions at the knowledge, comprehension, and application levels and was delivered online. Subjects logged on to the test site using their usual IDs (see logon screen in Appendices G and H). Subjects were not allowed access to the multimedia materials during the test. After the multiple choice test was completed by the students, we conducted debriefing sessions where participants were thanked for their participation in the study. Subjects were further invited to participate in an interview session held the following week. Subjects were interviewed based on their experiences of using the dynamic tools and also their ability to recall information from the material. Although 20 subjects agreed to participate in the interview session, only 4 turned up. The interview was semi-structured such that participants were able to express themselves based on a set of questions that were not constrained. Follow-up questions came up based on subjects' responses. Appendix I shows excerpts of questions and answers from two of the subjects interviewed.

Results of the study are shown in the next chapter.

4 Results

This chapter presents and describes the general results of the study conducted in Chapter 3 and is divided into five sections. The first section focuses on the methods used in scoring the free recall data. The second section gives a brief overview of the covariate used with the study. The third section presents the result of the free recall while the fourth section focuses on the result of the multiple-choice test. The last section of this chapter discusses the results of the study in the context of node-link research. The data gathered in the study were analyzed using the SPSS ver. 13 statistical software package.

4.1 Scoring the Free Recall

The subjects had their free recall tests sent through a web form to the researcher's e-mail address. A propositional scoring method was used to score the free-recall test. The original passage was divided into 67 idea units that consist of simple fact stated in a declarative sentence (see Appendix J for these idea units). A scorer who was blind to the treatment conditions determined the free recall scores for all the participants drawing largely from scoring techniques by Dansereau et al. (1979) and Meyer (1975). The scoring technique used in this study is a modification of Dansereau's scoring technique. For each of the participants, the scorer assigned a score for each idea unit. Depending on the accuracy of the match, participants received a score ranging from 0 to 2, where:

0 represents idea unit absent or totally inaccurate,

1 represents idea unit partially present or partially accurate, and

2 represents idea unit entirely present and accurate.

We determined the overall free recall scores by summing scores for all statements with a score of 1 and 2. This was done so that credit would be given to statements that have at least some accurate information. Scoring reliabilities were established by having another experienced scorer score 15 randomly selected samples of the free recalls, yielding r = 0.91.

4.2 Covariate

In order to statistically control for prior differences between the randomly assigned treatment groups, a midterm examination was used as covariate. The midterm examination was given two weeks prior to this study and consisted of 48 multiple choice items at the knowledge, comprehension, and application levels. It did not cover the textbook chapter that included the attribution theory passage.

The internal consistency reliability of the midterm exam scores was α=.77. Pearson's correlations of the midterm scores with free recall ($r = .24, p = .009$) and comprehension ($r =.53, p < .001$) were statistically significant. ANOVA was used to determine that differences between treatment groups on the midterm exam were not statistically significant ($F_{1,129} = 2.14, p = .099$). Two outliers were identified in the midterm scores: a high score ($z = +2.69$) belonging to a member of the graphically enhanced map group (gMap), and a low score ($z = -2.97$) belonging to the non-synchronized text group (nText). Because ANOVA without the two outliers found reduced prior differences between treatment groups on the midterm ($F_{1,127} = 1.55, p = .204$), the two participants with outlying scores were eliminated from all subsequent analyses (Tabachnick & Fidell, 2001).

4.3 Result of Free Recall Test

The descriptive statistics for the free recall measure showing the observed and covariate-adjusted means, standard deviation and sample size for each of the treatment groups are presented in Table 8. Analysis of covariance using the midterm exam scores as the covariate found a statistically significant effect due to treatment ($F_{3,112} = 11.06, p < .001$). Bonferroni-adjusted multiple comparisons found differences for gMap vs. sText ($d = 1.12, p < .001$), gMap vs. nText ($d = 1.25, p < .001$), pMap vs. sText ($d = .81, p = .019$), and pMap vs. nText ($d = .92, p = .025$). No statistically significant differences were found for gMap vs. pMap ($d = .34, p = .678$), and sText vs. nText ($d = .02, p > .999$).

Table 8. Free Recall Performance of the Four Treatment Groups

Treatment	Observed Mean	*SD*	Adjusted Mean	Sample size
gMap	52.50	18.10	51.66	32
pMap	44.22	17.17	45.70	27
sText	32.13	18.10	31.39	30
nText	30.75	13.14	31.63	28
Total	40.16	16.82	40.29	117

Because we were primarily interested in the difference between the synchronized map and text treatments, and no significant difference was found between the two map groups, we reanalyzed the free recall data as a comparison of the sText group with the pooled map groups (pMap and gMap). Table 9 shows the means and standard deviations for this comparison. An analysis of covariance using the midterm exam as the covariate found a statistically significant difference between the sText and pooled map groups (F=19.19, p < .001) with a standardized mean difference effect size d = .94.

Table 9. Free Recall Performance of Synchronized Text and Map Groups

Treatment	Observed Mean	*SD*	Adjusted Mean	Sample size
gMap and pMap (pooled)	48.71	18.01	48.94	59
sText	32.13	18.10	31.69	30

This result shows that animated maps are better for learning that text on a test of free recall.

4.3.1 Central Idea Recall

In order to be able to answer the sixth research questions, we divided the free recall scores into central (main) and detail ideas. For the central idea recall, the inter-rater reliability for the 15 free recall responses that were scored by two raters was (r= .91). Heterogeneity of variance among the treatment groups was not detected ($\text{Levene}_{3,113}$ =.44, p = .726).

Table 10 shows the free recall means (observed and covariate-adjusted), standard deviation and sample size for each of the treatment groups. Analysis of covariance using the midterm exam scores as the covariate found a statistically significant effect due to treatment ($F_{3,112}$ = 5.02, p < .003). The partial η^2 was .12, indicating that 12% of central idea recall variance could be attributed to treatment. Bonferroni-adjusted multiple comparisons found differences for gMap vs. sText (d = .71, p = .014). No statistically significant differences were found for gMap vs. nText (d = .70, p = .054), pMap vs. sText (d = .69, p = .05), pMap vs. nText (d = .69, p = .139), gMap vs. pMap (d = .08, p > .999), and sText vs. nText (d = -.09, p > .999).

Table 10. Central Recall Performance

Treatment	Observed Mean	*SD*	Adjusted Mean	Sample size
gMap	67.45	19.15	66.56	32
pMap	64.51	15.86	65.18	27
sText	53.06	20.99	52.29	30
nText	52.83	16.59	54.01	28
Total	59.58	19.32	-	117

Because we were also interested in the difference between the synchronized map and text treatments, we reanalyzed the free recall data as a comparison of the sText group with the pooled map groups (pMap and gMap). Table 11 shows the means and standard deviations for this comparison. An analysis of covariance using the midterm exam as the covariate found a statistically significant difference between the sText and pooled map groups (F=11.13, p = .001, partial η^2 = .12), with a standardized mean difference effect size d = .73.

Table 11. Performance of Synchronized Text and Map Groups (Central)

Treatment	Observed Mean	*SD*	Adjusted Mean	Sample size
gMap and pMap (pooled)	66.10	17.64	65.93	59
sText	53.06	20.99	52.29	30

4.3.2 Detail Idea Recall

For detail idea recall, the inter-rater reliability for the 15 free recall responses that were scored by two raters was high (r= .89). Heterogeneity of variance among the treatment groups was not detected ($Levene_{3,113}$ =2.00, p = .118).

Table 12 shows the free recall means (observed and covariate-adjusted), standard deviation and sample size for each of the treatment groups. Analysis of covariance using the midterm exam scores as the covariate found a statistically significant effect due to treatment ($F_{3,112}$ = 10.257, p < .001). The partial η^2 was .22, indicating that 22% of detail idea recall variance could be attributed to treatment. Bonferroni-adjusted multiple comparisons found differences for gMap vs. sText (d = 1.10, p < .001), gMap vs. nText (d = 1.24, p < .001), and pMap vs. nText (d = .78, p <.05). No statistically significant differences were found for pMap vs. sText (d = .68, p = .051), gMap vs. pMap (d = .42, p = .48), and sText vs. nText (d = .01, p > .999).

Table 12. Detail Recall Performance

Treatment	Observed Mean	*SD*	Adjusted Mean	Sample size
gMap	33.01	14.53	32.53	32
pMap	26.13	14.40	26.50	27
sText	17.64	13.11	17.22	30
nText	16.43	9.47	17.07	28
Total	23.51	14.64	-	117

Again we reanalyzed the detail free recall data as a comparison of the sText group with the pooled map groups. Table 13 shows the descriptive statistics for this comparison. An analysis of covariance using the midterm exam as the covariate found a statistically significant difference between the sText and pooled map groups (F=16.41, $p < .001$, partial $\eta^2 = .16$), with a standardized mean difference effect size $d = .88$.

Table 13. Performance of Synchronized Text and Map Groups (Detail)

Treatment	Observed Mean	*SD*	Adjusted Mean	Sample size
gMap and pMap (pooled)	29.86	14.75	29.77	59
sText	17.64	13.11	17.22	30

4.4 Result of Multiple-Choice Test

The internal consistency of the comprehension scores was α=.64. The descriptive statistics of comprehension test showing the observed and covariate-adjusted means, standard deviation and sample size for each of the treatment groups are presented in

Table 14. Analysis of covariance using the midterm exam as the covariate found a statistically significant effect due to treatment ($F_{3,110} = 5.42, p = .002$). Bonferroni-adjusted multiple comparisons found differences for pMap vs. sText ($d = .71, p = .006$), and pMap vs. nText ($d = .91, p = .013$). No statistically significant differences were found for gMap vs. pMap ($d = .30$), and sText vs. nText ($d = .04$).

Table 14. Comprehension Performance of the Four Treatment Groups

Treatment	Observed mean	SD	Adjusted mean	Sample size
gMap	20.59	2.32	20.09	29
pMap	20.37	2.45	20.82	27
sText	18.77	3.68	18.57	31
nText	18.39	2.89	18.70	28
Total	19.51	2.91	19.51	115

Again we reanalyzed the data as a comparison of the sText group with the pooled map groups (pMap and gMap). Table 15 shows the means and standard deviations for this comparison. An analysis of covariance using the midterm exam as the covariate found a statistically significant difference between the sText and pooled map groups ($F = 13.01, p = .01$). The standardized mean difference effect size was $d = .65$.

Table 15. Comprehension Performance of the Synchronized Text and Map Groups

Treatment	Observed mean	*SD*	Adjusted Mean	Sample size
gMap and pMap (pooled)	20.48	2.37	20.55	56
sText	18.77	3.68	18.66	31

Figure 12 below shows the mean score for each group on comprehension and free recall tests

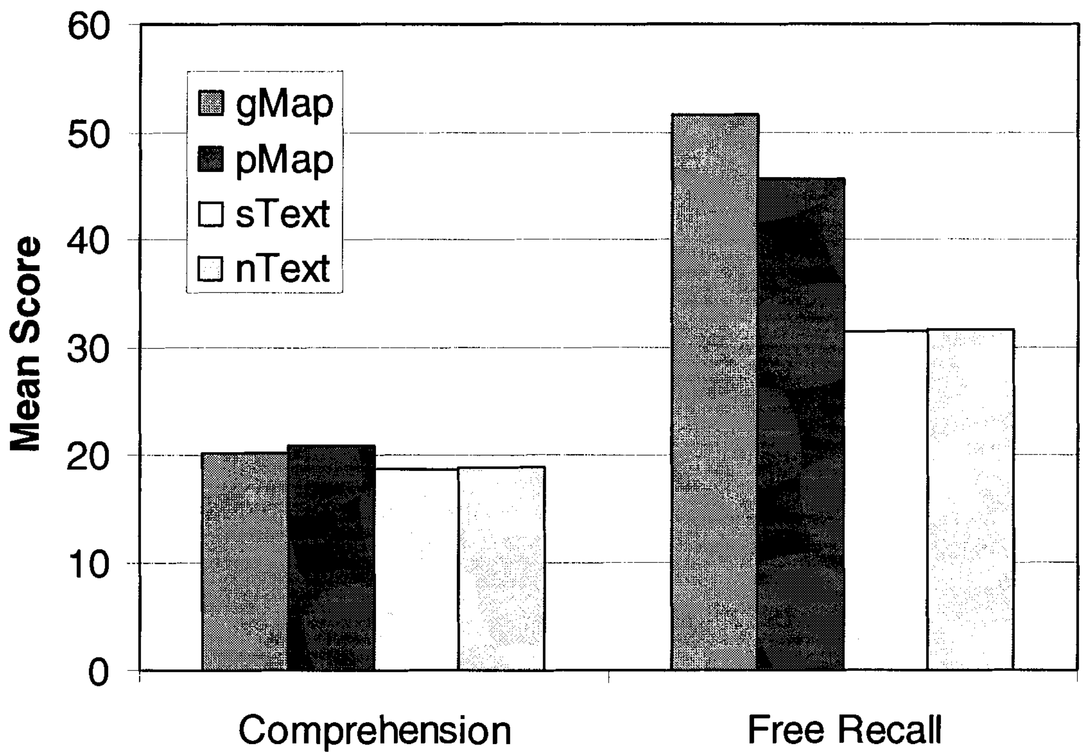

Figure 12. Adjusted mean scores for each group on comprehension and free recall.

As shown in the tables above, animated maps are good for learning. The section below discusses the qualitative aspect of this research.

4.5 Result of Interview

The interview data was divided into categories showing students' preferences and suggestions for improving the presentations. One common theme that ran across the interview data was the fact that subjects considered these dynamic maps and texts as a form of learning. Three of the four interviewed participants were of the opinion that tools like the dynamic maps could help reduce cognitive load associated with reading.

Several studies have shown researchers quest to effectively manage cognitive load, especially extraneous cognitive load, so that it will not impede learning (Paas, Renkl & Sweller, 2003; Sweller, Merrienboer & Paas, 1998; Mayer, 2001; Mousavi, Low & Sweller, 1995). Dynamic map presentations might play a good role towards achieving this educational objective. Those interviewed said that audio narrated presentations helped them in the encoding process. They also commented that dynamic maps helped to reduce being overwhelmed with map shock and also useful in summarizing the main points of the passage. The following interview excerpts show that students believe that they benefited from the presentation.

> *"I found the dynamic map very useful. I love the fact that you can go back and review it and also the fact that audio goes closely with the formation of the knowledge. I also love the way it (the map) showed important concepts. It relieved me of the mental effort because it helped me summarize."*

"For me, I've used a bit of concept map this term and umm. Concept map can be really confusing and overwhelming but I could make a sense of it in the bit-pieces it was presented. This concept map is fairly well laid out. Concept maps work for me when I am able to make the links between major and minor points as I normally do in outline"

From the excerpts of the interview below, we could infer that maps are good for macrostructure or main idea retention as in previous studies (Blankenship & Dansereau, 2000; Hall & O'Donnell, 1996).

"I got the overall picture, so that was really helpful. I could put more time into actually learning it instead of summarizing and learning. I think that we should use more dynamic concept maps like this in tutorials so as to help students understand concepts. It would be really helpful in chemistry and biology but not so much in Maths."

One other interesting finding in the interview is that when learners are able to convert information from one format to another, there is possibility that they are more able to cognitively process the information. Translating information between a text format and a node-link-node format requires that learners process meaning more thoughtfully than if they read text. According to this view, learners benefit from receiving information in a text format and converting it to a map format, or visa versa. The statement below supports the notion.

"When the map was revealed to me, I changed it in my mind to the outline form that I am familiar with. It really helped me make sense of the material in my head."

However, because of limited interviews, we would not be able to generalize the effect of dynamic tools for learning based on these interviews. Instead, the interview data suggests further research into this area and conduct of more interviews or qualitative inquiries along this area of research. One such area is the involvement of students in recording audio narration of texts they want to study. If tools that allow students to record text passages and convert to spatial node-link formats are available, this will engage students in more constructive process of learning. In another context, this idea has flourished in Computer Aided Language Learning (CALL) programs, especially in teaching of speaking skills or tone drills for tonal languages. Students are encouraged to record their own voice with a list of words or sentences and compare with instructor's pre-recorded voice until they reach mastery level. It is promising that self-paced dynamic maps could foster learning by reducing cognitive load associated with overwhelming information.

4.6 Discussion

The discussion of the result is divided into three sections. One section discusses the result of the free recall test. Findings related to the comprehension test are discussed in the second section. The last section briefly highlights the result of the interview with cautionary notes. One overall interesting finding is that there is great promise for the use of animated concept maps for learning. In a recent review, Tversky, Morrison & Betrancourt (2002) contended that animations are ineffective because they are often too complex or too fast to be accurately perceived. These researchers conclude that for animation to be useful, learners need to be in control of the speed of animation and can view and review it. Our user-regulated dynamic concept maps with animation have adequately addressed the issue raised by these researchers. More than resolving the problem of animation, our dynamic maps have also reduced or completely eliminated map shock. According to Dansereau, Dees & Simpson (1994), students tend to be overwhelmed by the scale and complexity of a map when presented with static maps. These researchers described several problems that may arise when students experience map shock. One is incomplete processing of map elements (i.e., nodes and links) and their relationships to each other. Map shock may also result in a lack of motivation to process the map. Such a reaction may arise from a feeling of bewilderment of not knowing where to start or how to penetrate the topography of the map. Dynamic concept maps used in this study might help reduce map shock in node-link displays.

4.6.1 Findings with Free Recall

Our first research question seeks to know if dynamic concept maps could benefit learning in comparison with text displays that are synchronized or not synchronized to an audio narration. On a test of free recall of materials presented, the graphically enhanced map group as well as the plain map group performed better than both the synchronized and non-synchronized text groups. When pooled together, the map groups still performed better than the synchronized text group. This result confirms previous findings that have demonstrated the superiority of studying with concept maps over text on free recall test (Blankenship & Dansereau, 2000; Hall & O'Donnell, 1996, Hall & Sidio-Hall, 1994; Hall, Dansereau & Skaggs, 1992; Moreland, Dansereau & Chmielewski, 1997; Patterson, 1993; Patterson, Dansereau & Newbern, 1992; Rewey et al., 1992, Rewey et al., 1989; Wachter, 1993; Wallace, West & Ware, 1998; Wiegmann, 1992).

Another research question seeks to know how effective dynamic concept maps are when compared with the overall effectiveness of static paper-based maps research. One very interesting finding with this research is that we found a statistically significant difference with a mean difference effect size of .94 between the map groups and synchronized text group. Drawing from our meta-analysis result (Nesbit & Adesope, 2005), the mean effect size of .94 found in this study is much higher than published research that compared the study of concept maps with text. Only few studies where participants were presented with static maps have larger effect sizes than the one obtained from this thesis (Wallace et al, 1998; Wiegmann, 1992) This offers a promising result for the use of dynamic maps for learning and also extends previous findings by demonstrating that participants are able to recall more information presented in a dynamic map than they can when studying with text. While it is true that the process of learning is far more than recalling information, it is still very vital to accurately recall information before such information can be transferred into other learning contexts.

Our third research question asks if graphically enhanced maps are more effective for learning than plain maps. This study did not find any statistically significant differences between graphically enhanced map and plain map on recall. The failure to detect a significant advantage for graphically enhanced map is inconsistent with previous research which showed great significant advantage for the use of graphically enhanced maps (Wallace, West & Ware, 1998). Wallace et al. had a huge effect size of 1.1 for delayed recall favoring enhanced maps. One possible reason for this discrepancy is that the significant advantage of enhanced maps found in the Wallace et al. study might be due to structural differences between the plain and enhanced maps which characterized their study but not this. They reported that their enhanced map had different shapes denoting specific relationships between nodes.

The fourth research questions seeks to know if learning is enhanced when text passages are synchronized with audio narration than when they are not synchronized. There was no significant difference between the synchronized and non-synchronized text presentations. This might be so because the time between the presentation of the text and the narration is short. Mayer (2001) cautions that temporal contiguity principle, which states that students tend to learn better when corresponding words and pictures are presented simultaneously rather than successively, may not be clearly evident if the time between hearing a sentence and seeing the corresponding portion of animation is short because learners may still be able to build connections between verbal and visual representations. This is exactly what happened in the study described in Chapter 3, where there was a considerably short period of time between the presentation of the text and the hearing of the animation in the non-synchronized group. This might have accounted for the non-difference effect between this group and the group with synchronized text. Thus, both the synchronized and non-synchronized control presentations as well as the plain and enhanced experimental group presentations followed the rules of spatial contiguity principles of multimedia learning (Mayer, 2001). With spatial contiguity principle, students tend to learn better when corresponding words and pictures are presented near rather than far from each other.

The sixth research question asks if dynamic maps effective for recalling central and detail ideas when compared with dynamic text. This study shows that students recalled a greater proportion of the central ideas than the detail ideas. However, unlike prior research that compared the retention of central and detailed ideas in maps versus text (Lambiotte & Dansereau, 1992; Rewey, Dansereau & Peel, 1991), this study found greater advantage for concept maps in presenting detail ideas than main ideas. Possibly, the sequential presentation of map information obscures cues signaling idea superordination. Since these previous studies on central and detail ideas used static maps, it may also be that participants focused more on central ideas than detailed ones. However, in this thesis, the sequential presentation of animated maps might not allow for idea superordination.

4.6.2 Findings with Multiple-Choice

The multiple choice questions tested students at comprehension and application levels. The plain map group outperformed both the synchronized and non-synchronized text groups with statistically significant differences. When pooled together, the map groups still performed better than the synchronized text group. This result further confirms previous findings that learning from concept maps is better than learning from text on objective item test (Willerman & MacHarg, 1991; Zittle, 2001). A mean difference effect size of .65 between the map groups and the synchronized text group found in this study is also very interesting and points to the positive effect of using maps over text. Previous controlled research with objective test items yielded lower effect size (Willerman & MacHarg, 1991). Thus, the study has addressed the first research question about comparing the effect of dynamic maps with texts.

There were no significant differences between the plain and enhanced map groups and also between the synchronized and non-synchronized text groups. The same explanation in free recall could have accounted for the non significant effect.

5 Conclusion

This chapter provides a summary of the research as well as its implications and limitations. It concludes with recommendations for future research in node-link displays.

5.1 Summary and Implications

This study shows that dynamic maps are effective for learning. This finding has important implications for node-link mapping research. It offers evidence that concept maps may be superior to text as synchronized, incrementally expanding visual accompaniment to an audio narration. One other promising note of this research is that comparing this study with those where maps were statically presented to students, animated maps seem to benefit learners more. This is corroborated in the study by Blankenship and Dansereau (2000) where the effect of animated knowledge map was compared with text. However, this study has extended research in node-link displays by investigating not only animation but also audio narration with concept maps. Animation and audio narration seem to lend learning support to those who studied with maps. A self-paced approach to presenting the material has also helped in alleviating the problems often reported with animation for learning purposes (Tversky, Morrison & Betrancourt, 2001). This initial research study shows that dynamic concept maps work and could be used by teachers and instructional designers. When they are combined with audio narration, as experimented in this study, they may replace prose text.

5.2 Limitations and Recommendations for Future Research

While this research opens up a new dimension in node-link literature, it is not devoid of limitations. One of the limitations is that, as usual with most preliminary studies, we exercise caution as to the generalization of the result of this study to other learning contexts. Our research plan is to be able to take this notion of dynamic maps into other disciplinary contexts. We would like to test the effect of dynamic maps in second language acquisition (SLA) especially in English as a Second Language (ESL), biology, and other sciences. We would also like to know if dynamic maps are useful as reading support for students with learning disabilities as well as children in early reading education. Since we already know that dynamic concept maps work, it would be interesting to know the situation and contexts in which they will be most beneficial for learning. Our research agenda is inspired by that of Dansereau's TCU knowledge mapping system where the effectiveness of these maps has been tested over a range of subjects and people. Nevertheless, this does not jeopardize the internal and external validity of this study. Subjects were randomly assigned to groups with researcher not having prior knowledge of the subjects. Also, the animated materials studied by students were controlled by the computer clock such that all the students spent exactly the same amount of time in studying the material. Subjects in this study represent a fairly large sample of students with different majors, thus suggesting that, to a certain extent, this is a representative student sample. However, a replication of this study with more stringent controls would increase the validity of the research.

Another limitation of the study has to do with the brief time and content limits. It will be interesting to see the outcome if subjects are given longer passages with more time to study them. Future studies should investigate the effects of altering these two variables on dynamic maps and texts.

This study found greater advantage for concept maps in presenting detail ideas than central ideas. This does not concur with literature that has produced consistent findings in this area (Blankenship & Dansereau, 2000; Hall et al., 1992; Rewey et al., 1991) where students with maps recalled more central information than detailed one. It will be interesting to research further why the result of animated concept map in this study differs from those of the static maps in other studies, with respect to central and detail idea.

Finally, a constructivist epistemological view of learning suggests that students learn more when they construct knowledge themselves. Although concept maps were presented to students in this study, characteristics of the maps like animation and self-paced control afford students to cognitively process the information. This increased processing may lead to more effective encoding of information which ultimately engenders learning. Students' attention were drawn towards the generation of the map as the maps are generated node-by-node and not presented to the students in a static form. However, our research agenda in future will investigate the effect of learner constructed dynamic concept maps over text.

To further establish the viability of dynamic concepts maps as effective tools for communication and learning, researchers should investigate the effectiveness of dynamic concept maps in comparison with static concept maps. Although we noticed that difference between the two types of maps in this study was too small, future research should confirm whether graphically enhanced maps are better than plain maps as in

Wallace et al. (1998) or if there is no difference between the two as in this study. Future works should also investigate temporal and spatial contiguity principles of multimedia in node-link displays.

5.3 Conclusion

This study was a preliminary effort to investigate the effect of dynamic maps on learning. In the study, we compared the effectiveness of dynamic maps with that of dynamic text. Results obtained from the study provide promising line of research for audio narration with concept maps and thus promotes the idea that dual-coding (audio narration with map display) could help in meaningful learning.

The result further shows the potential role for animation and audio narration to manage intrinsic cognitive load inherent in study materials. As shown in the result and discussion sections of this work, students who were presented with dynamic maps outperformed those who studied with incrementally presented text with statistically significant differences. The fusion of maps with animation flavored with self-paced learning principles, as demonstrated in this research, has moved node-link research to another level of inquiry. The present results leave us with no doubt that dynamic concept maps may be another pedestal for meaningful learning. It remains to be seen whether dynamic maps can replace textbooks in future. What we can conclude from this study is that dynamic maps can serve as supplements to textbooks, especially for visual learners who tend to benefit most from visual display of maps.

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Appendices

Appendix A. Publication in Node-Link Displays

Year	Web of Science	ERIC	PsycINFO	PsycARTICLES	Dissertation Abstract
1970	0	0	0	0	0
1971	0	1	1	0	0
1972	0	0	0	0	0
1973	0	0	0	0	0
1974	0	0	0	0	0
1975	0	1	1	0	0
1976	0	0	0	0	0
1977	0	2	0	0	0
1978	0	1	1	0	0
1979	1	2	0	0	0
1980	0	6	0	0	0
1981	0	4	1	0	0
1982	1	2	1	0	1
1983	0	6	0	0	1
1984	1	7	0	0	0
1985	3	14	2	0	0
1986	0	16	5	0	1
1987	2	13	2	9	3
1988	2	19	3	12	2
1989	9	19	12	23	4
1990	10	38	22	15	4
1991	18	49	16	21	9
1992	14	45	18	27	6
1993	23	57	23	24	16
1994	29	51	33	25	11
1995	27	39	19	16	18
1996	25	40	29	13	6
1997	29	46	26	18	13
1998	47	49	40	23	11
1999	34	45	43	26	18
2000	50	75	38	16	12
2001	48	66	38	17	4
2002	46	50	28	12	11
2003	35	11	13	16	10
2004	53	0	30	48	6

Appendix B. Multiple Choice Test

Please choose the BEST answer.

1. Attribution theory explains motivation by
   a. one set theory, with clear cut boundaries.
   b. a collection of theories, which can often be controversial.
   c. trying to understand successes and failures.
   d. Attributing instructional design principles as a factor that leads to success.

2. Students attribute their successes and failures to
   a. one factor which could be luck.
   b. Several factors that do not include luck.
   c. Only two factors – luck and ability.
   d. Several factors.

3. One major theorist who relates attribution theory to school learning is:
   a. David Jonassen.
   b. Lev Vygotsy.
   c. Bernard Weiner.
   d. Joseph Novak.

4. Every cause to which students attribute successes or failures is characterized using how many dimensions?
   a. Five.
   b. Three.
   c. One.
   d. Several.

5. The dimensions of attribution are
   a. Locus and stability.
   b. Stability and possibility.
   c. Ability, locus and stability.
   d. Locus, stability and responsibility.

6. The internal/external locus is closely related to
   a. Emotions and self-esteem.
   b. Emotions and self-dependence.
   c. Emotions and stability.
   d. Stress.

7. Florence has just passed her programming course with an A+. Her success made her proud and consequently increased her motivation to take more programming courses. What kind of factor is responsible for her success?

a. External factors.
b. Internal factors.
c. a and b.
d. None.

8. Which dimension is related to emotions such as anger, pity & gratitude?
a. Stability.
b. Locus.
c. Responsibility
d. Ability.

9. Which dimension is closely related to expectations about the future
a. Ability.
b. Locus.
c. Responsibility
d. Stability.

10. Jennifer failed her Biology test by just 2 marks. She feels she is very unlucky because she made few mistakes in the test. What is the likely outcome if Jennifer takes the course again next semester?
a. She will hope to perform better.
b. She will expect to fail because she does not know Biology very well.
c. She can perform worse of the stability
d. None.

11. A fellow student states that he missed class because of injuries received in an automobile accident. When you hear this you think to yourself that he seems like the kind of person who would be careless, exceed the speed limit, and not wear a seatbelt. Your attributions for this event are
a. internal
b. stereotypic
c. self-serving
d. situational

12. A friend of yours tells you she was fired from her job. Your judgement is that she was probably fired because of downsizing in her area of expertise. What kind of attribution are you making?
a. internal
b. external
c. personality-based
d. biased

13. The professor is returning tests. Two students receive failing grades, but no one else does. The professor is likely to attribute this to
a. uncomfortable factors such as bad luck.

b. lack of motivation and disinterest on the part of the students.
c. the unfairness of the test.
d. the poor teaching performance of the instructor.

14. Felicia has just passed a very difficult examination that she never thought she could pass. When the teacher announced the scores in the class, she got the highest mark while many other students did not do well. She is likely to attribute her success to:

a. her excellent job.
b. her hard work.
c. favor from the teacher.
d. being lucky.

15. What are students likely to attribute their successes and failures to?

a. over-eating, ability & luck.
b. over-speeding, effort & help.
c. ability, effort & interest.
d. None.

16. In a situation where failure is attributed to lack of effort and effort is controllable, the ultimate sequence of events will lead to:

a. Excellent performance.
b. Improved performance.
c. Decline in performance.
d. Fluctuating performance.

17. If a student fails because of lack of ability and ability is not controllable, the ultimate chain of events leads to:

a. Excellent performance.
b. Improved performance.
c. Decline in performance.
d. Fluctuating performance.

18. Nathaniel feels he is very much in control of learning his Maths 801. The mid-term home work was extremely difficult. What do you think Nathaniel's attitude will be to the homework?

a. He will apply more efforts.
b. He will back out.
c. He will persist in solving the problem.
d. a and c.

19. What is the likely outcome of a student's self-esteem if he thinks he cannot control his study time?

a. Will diminish.
b. Will increase with time.
c. Will diminish and then increase if his attitude remains the same .
d. None

20. Sasha failed woefully in her test. She realized her mistakes and worked very hard the following Semester. What do you think will happen to Sasha's performance, if all other factors remain the same?

a. Will diminish.
b. Will improve.
c. Will remain the same because all factors remain the same .
d. None

21. Pride or shame for one's own actions is likely to be felt most strongly by those who attribute their actions to

a. unstable causes.
b. stable causes.
c. external causes.
d. internal causes

22) According to attribution theory, students who see the causes of their failures as internal and controllable will react to those failures by

a. exhibiting confusion and anxiety.
b. berating themselves for their failure.
c. finding strategies to succeed the next time.
d. assuming things will work out better in the future.

23) Pat believes that the reason for her success in reading is because she puts so much effort into it. Pat is reflecting what type of locus of control?

a. stable.
b. external.
c. internal.
d. transitional

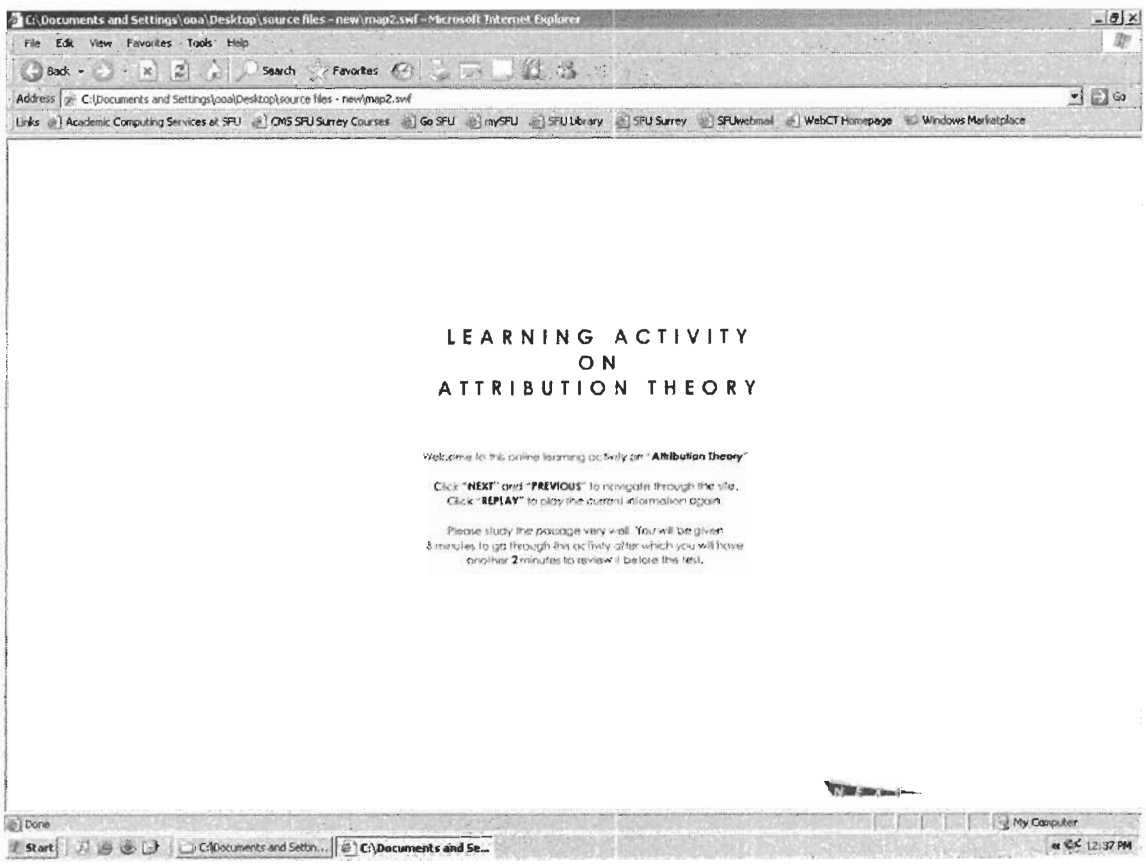
24) As Jim looks at his report card, he remarks to Judy, "I got that B because I really didn't work hard in Mr. Widell's calculus class." On the basis of this one statement, we might guess that Jim has a(n)

a. external locus of control.
b. positive self-concept.
c. moderate need to achieve.
d. internal locus of control

25) Several students in Mr. Chung's educational psychology class "forgot" to study for the midterm examination and ended up at the bottom of the test score distribution. Weiner would attribute the cause of these failures to what combination of factors?

a. external-unstable-controllable.
b. external-stable-uncontrollable.
c. internal-stable-uncontrollable.
d. internal-unstable-controllable

Appendix C. Screenshot of Introductory Page



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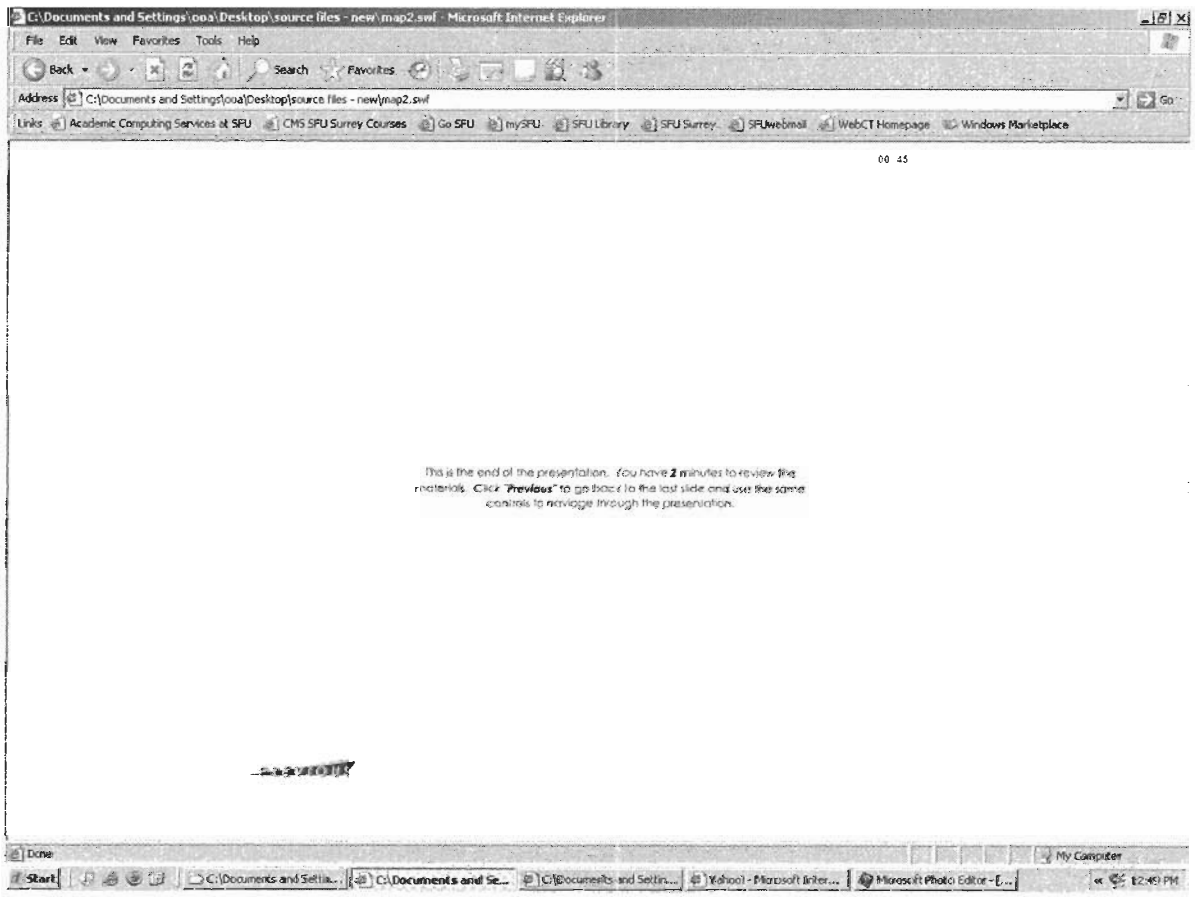
Appendix D. Screenshot of Review Page



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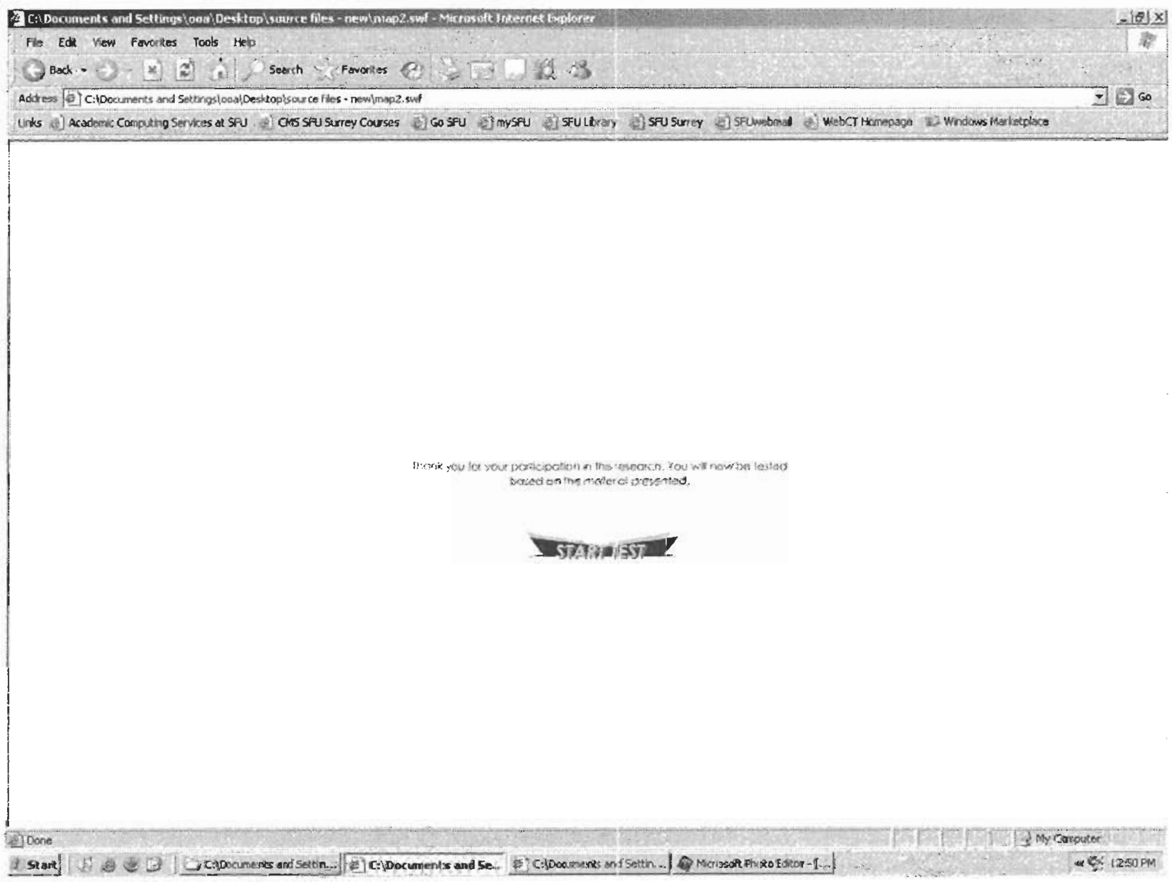
Appendix E. Screenshot of "Start Test"



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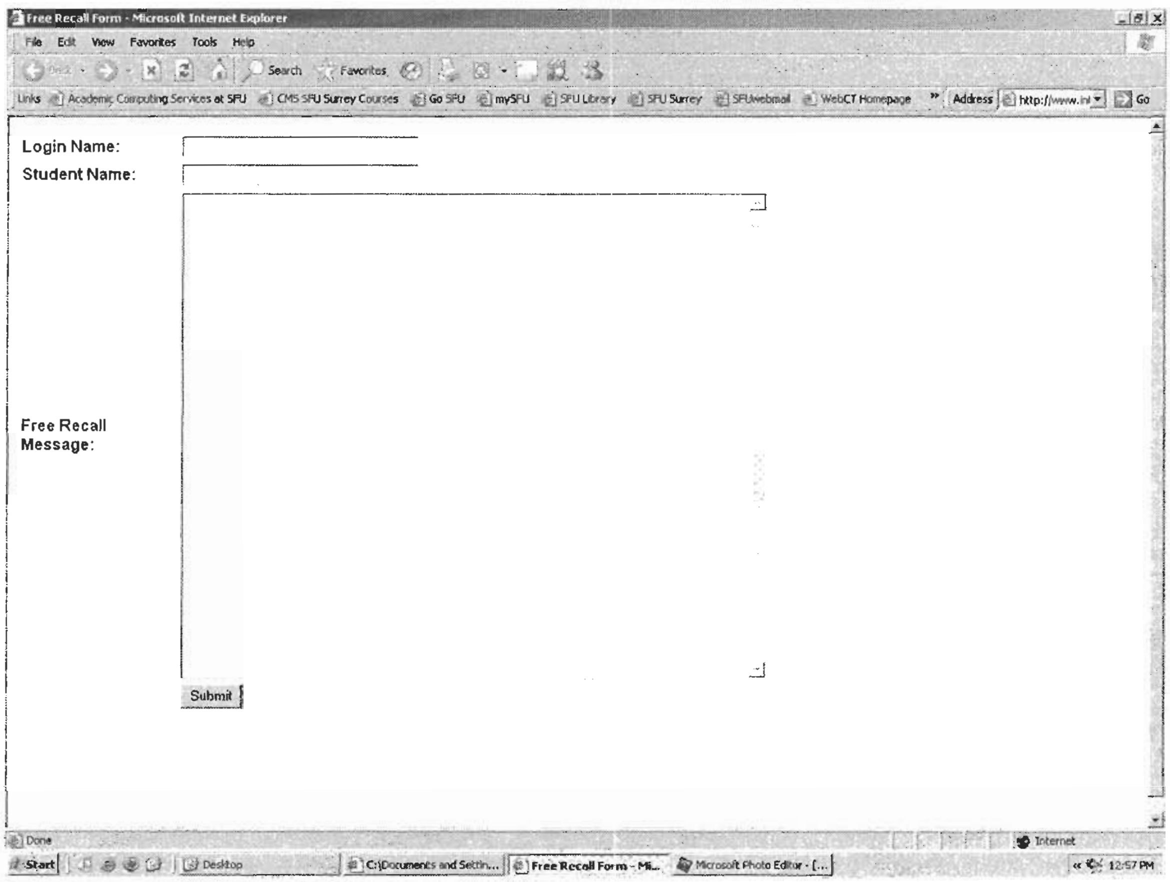
Appendix F. Screenshot of "Free Recall Web Form"



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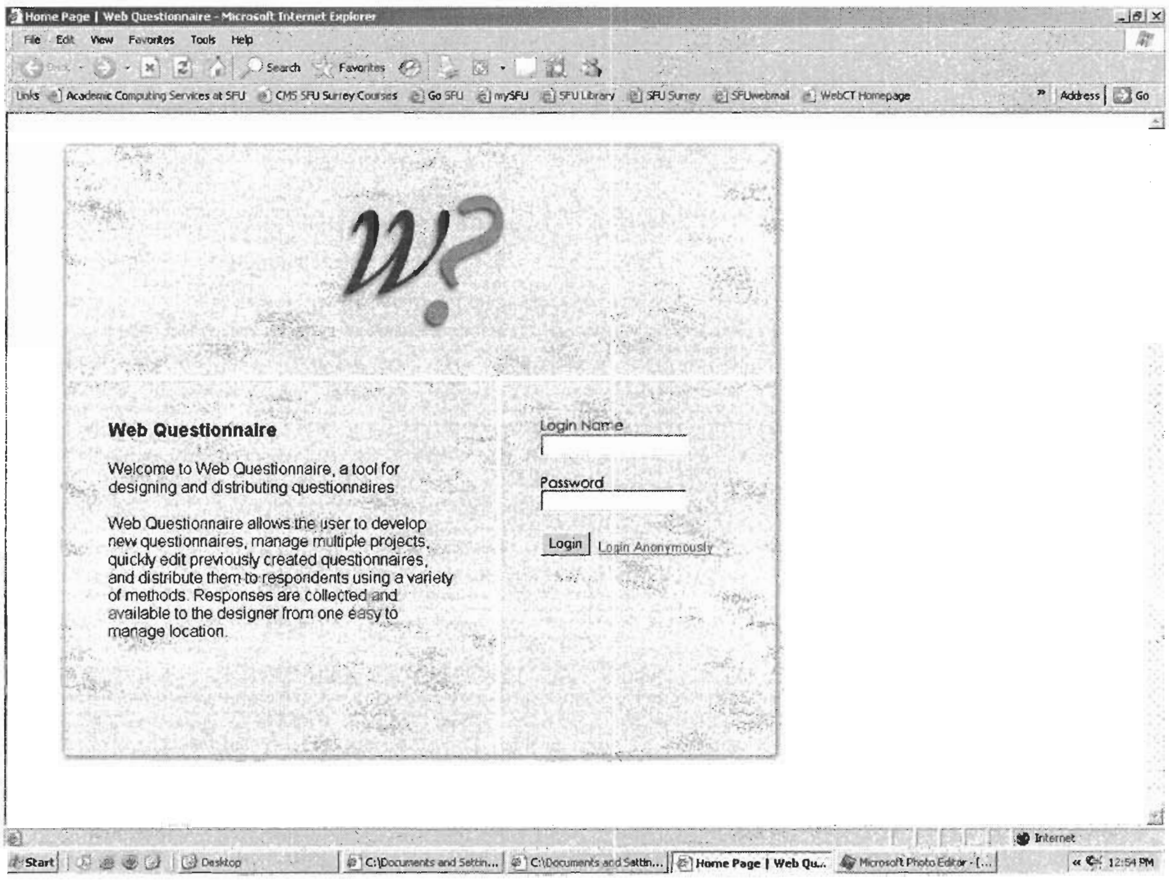
Appendix G. Screenshot of "web questionnaire logon page"



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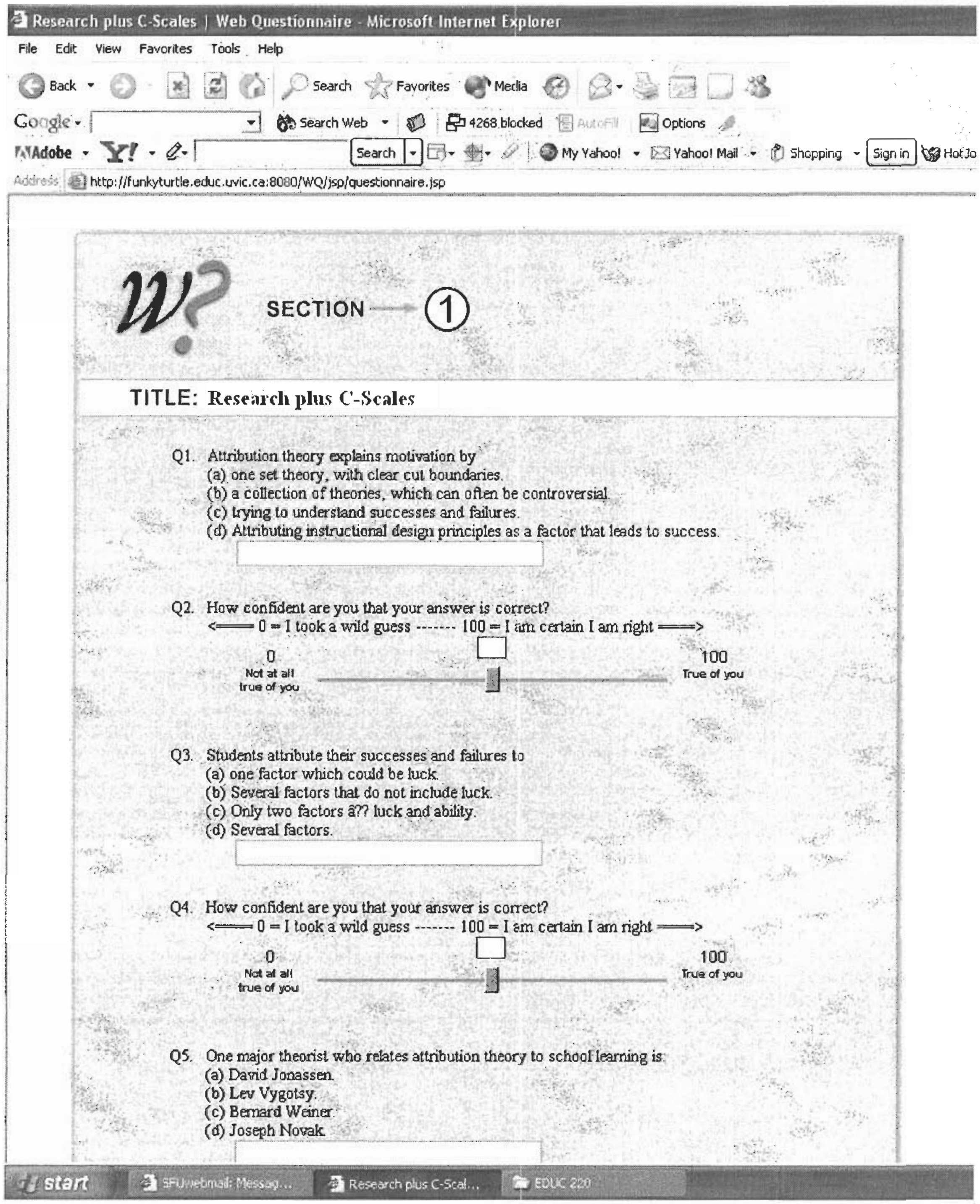
Appendix H. Screenshot of "Web Questionnaire Multiple-Choice Page"



Appendix I. Excerpts from Interview

S1 = Student 1
S2 = Student 2
R = Researcher

Excerpts from interview 1

R: What is your understanding of attribution theory?
S1: Good question. Ummm. What you attribute to your learning – maybe to your success.

R: And may also be for failure too
S1: That's true

R: Is there anything in the presentation that really aided your learning of the material?
S1: Quite honestly, what I did when it (the material) was being revealed to me on the computer screen what that I just remembered as much as I could based on the concept map structure, going from the bigger concept to the parts that make up the concepts and examples.

R: Did that aid your retention of the material?
S1: The map presentation aided retention very easily. When the map was revealed to me, I changed it in my mind to the outline form that I am familiar with.

R: Did the map with audio helped in understanding of the material?
S1: I think it was helpful to me. I was a little bit surprised that I did well in the information afterward. When I was recalling the information, I remembered it just in the form as I saw it on the screen.

R: What would you like changed in the dynamic tool you were given?
S1: I would have loved an outline which I like to use but of course everyone likes something different but having said that the concept map presentation does a fairly good job of categorizing the main points and helped me to internalize the learning as supposed to just memorizing it. It really helped the internal process. It's a kind of an outline itself. It really helped me make sense of the material in my head.

R: Is there any other thing that did not work for you in the tool?
S1: For me, I've used a bit of concept map this term and umm. Concept map can be really confusing and overwhelming but I could make a sense of it in the bit-pieces it was presented. This concept map is fairly well laid out. Concept maps work for me when I am able to make the links between major and minor points as I normally do in outline.

Excerpts from interview 2

R: What is attribution theory?

S2: Aahh! let me just remember, it's been so long. Basically, when you're learning asking how you do certain things and why you have succeeded or failed. What type of learning did you do and what you did to prepare for certain situation.

R: You mean what actually contributed to...

S2: What contributed to your personal success or failure in that situation.

R: What's your impression of that learning activity? Did the map really help you at all? If so, how did it help?

S2: It did. The map was really helpful. Seeing it laid out in spatial form helped me to understand the concepts better. Having the layout helped a lot.

R: Then would you love a tool that can convert text into map?

S2: Yes, I really would. It gives you a view of important concepts unlike when you're reading the textbook when whole lots of things are lumped together. I'll consider myself as a visual learner.

R: Did the dynamic nature of the map with audio help. How?

S2: I found it very useful. I love the fact that you can go back and review it. I love the fact that audio goes closely with the formation of the knowledge and I also love the way it showed important concepts.

R: What did that do for you?

S2: It relieved me of the mental effort because it helped me summarize. I got the overall picture, so that was really helpful. I could put more time into actually learning it instead of summarizing and learning.

R: Do you see this as a good practice?

S2: I think that we should use more dynamic concept maps like this in tutorials so as to help students understand concepts. It would be really helpful in chemistry and biology but not so much in Maths.

Appendix J. Idea Units Developed for Scoring the Attribution Theory Passage

1. Attribution theory asks WHY.
2. Asking WHY helps understand our successes
3. Asking WHY helps understand our failures
4. "Why did I flunk my mid-term?" is an example of Asking why I failed
5. "Why did I do so well this grading period?" is an example of Asking why I succeeded
6. Successes could result from ability
7. Successes could result from effort
8. Successes could result from mood
9. Successes could result from knowledge
10. Successes could result from luck
11. Successes could result from help
12. Successes could result from interest
13. Successes could result from clarity of instructions
14. Successes could result from the interference of others
15. Successes could result from unfair policies
16. Failures could result from ability
17. Failures could result from effort
18. Failures could result from mood
19. Failures could result from knowledge
20. Failures could result from luck
21. Failures could result from help
22. Failures could result from interest
23. Failures could result from clarity of instructions
24. Failures could result from the interference of others
25. Failures could result from unfair policies
26. Attribution theory is related to motivation.
27. Bernard Weiner is an attribution theorist

28. Attribution theory is related to school learning
29. Weiner states that students attribute successes or failures to three dimensions
30. Students attribute successes or failures to LOCUS
31. Students attribute successes or failures to STABILITY
32. Students attribute successes or failures to RESPONSIBILITY
33. *Locus* is the location of the cause
34. Location of the cause could be internal
35. Location of the cause could be external
36. *Stability* is whether the cause stays the same or can change with context
37. *Responsibility* is whether the person can control the cause
38. Luck is external
39. Luck is unpredictable
40. Luck cannot be controlled
41. The *internal locus* is closely related to emotions and self-esteem
42. The *external locus* is closely related to emotions and self-esteem
43. For example, "If a student attributes success or failure to internal factors, success leads to feelings of pride and increased motivation, but failure lowers self-esteem"
44. The *stability* dimension is closely related to expectations about the future
45. The *responsibility* dimension is related to emotions such as anger
46. The *responsibility* dimension is related to emotions such as pity
47. The *responsibility* dimension is related to emotions such as gratitude
48. The *responsibility* dimension is related to emotions such as shame
49. For example, "If students feel responsible for their failures, they may feel guilt"
50. "If they feel responsible for successes, they may feel proud"
51. For example, "Failing at a task we cannot control can lead to shame or anger toward the person or institution that is in control"
52. "Succeeding at uncontrollable tasks leads to feelings of gratefulness or being lucky"
53. When failure is attributed to lack of ability and the student considers ability to be *uncontrollable*, the sequence of motivation is:
54. Failure as a result of Lack of Ability
55. Lack of Ability is seen as uncontrollable
56. Uncontrollable leads to not responsible
57. Not responsible leads to shame

58. Shame leads to embarrassment
59. Embarrassment leads to withdraw
60. Withdraw leads to Performance decline
61. When failure is attributed to lack of effort, the sequence is:
62. Failure as a result of lack of effort
63. Lack of effort seen as controllable
64. Controllable leads to being responsible
65. Responsibility leads to guilt
66. Guilt leads to engagement
67. Engagement leads to Performance Improvement