

The Effect of Encoding Specificity on Learning in a Multimedia Environment

by

Emet L. LaBoone

Dissertation submitted to the faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

In

Curriculum and Instruction

Dr. Peter Doolittle, Chair

Dr. John K. Burton

Dr. Tonya L Smith-Jackson

Dr. Gary Whitt

April 26, 2006

Blacksburg, VA 24061

Keywords: encoding specificity, context dependent learning,
cognitive multimedia learning, multimedia learning

The Effect of Encoding Specificity on Learning in a Multimedia Environment

Emet L. LaBoone

(ABSTRACT)

The purpose of this study was to examine the effect of encoding specificity on learning in a multimedia environment. Based upon the theory of encoding specificity there should be a relationship between the modality for which a learner encodes information into memory and the modality used to assess the learner's knowledge. Modality attributes for purposes of this study included visual (animation) and verbal information (narration and text).

Two-hundred and fifteen students viewed a computer animation on lighting formation which was presented in one of three different modalities (animation with narration, animation with text, text only). Following the instruction students were assessed in one of three modalities (animation with narration, animation with text, text only) on recall and transfer. A 3 Encoding/Study x 3 Retrieval/Test (animation with narration, animation with text, text only) full-factorial post-test only design was used to assess the effects of matched and mismatched encoding and retrieval modalities in a multimedia environment.

Encoding specificity suggests that there is an interaction between the conditions at encoding and retrieval such to say that the to-be-remembered item will not be as effective during retrieval unless the cue was specifically encoded at time of storage. Unfortunately, the present study did not find much to support the claim of encoding specificity based upon modality. The use of modality in both encoding and retrieval condition to support encoding specificity was found only in the AT-AT matched recall group versus the mismatched groups. Furthermore, significance was not found in any of the matched mismatched transfer conditions.

Acknowledgements

I can finally look back on the countless hours in the library, searching for articles, typing on the computer, editing drafts and say that it was worth it. Wow, I finished, but I did not do it alone. This is an accomplishment that I share with everyone who has helped me and encouraged me along the way. The completion of this degree bestows upon me the honor to testify that through hard work, determination, perseverance, patience and faith you can overcome insurmountable obstacles. This might be a little long-winded as I am so grateful to many.

I first give honor and glory to God through which all things are possible and who has blessed me beyond compare.

This dissertation is dedicated to my mother whose memory I cherish and through her love gave me strength. I miss you, mom.

I want to thank my wife Kimberly for following me to this place called Blacksburg. She continues to be my light and I know that I could not have made it this far without her. I appreciate you sticking it out and I hope that it was not too bad for you, especially since you received the same degree to match. I also know that our children, Jacques, Kirstyn, and Essam are all tired of me talking about this dissertation that I have to finish. I appreciate their patience in putting up with both Kim and I as we pursued our degrees I know it has not been easy, but now that it is over we can enjoy ourselves and add to the extra-curricular activities.

My dad Walter, who has seen me in my various stages of evolution, was not deterred by me when he married my mom and I being a hard-headed kid at twelve years old. I thank you for hanging in there all these years and always providing me with a positive outlook on things. You have always been in my corner solid as a rock, thanks.

My grandmother, Nana, I also want to acknowledge. Although she did not make it to see me earn this PhD, her fiery spirit kept me driven. I have numerous family and extended family members to thank that I could not possibly name without forgetting someone so I want to acknowledge them all, as in some way they have all touched me in my development and knowing that they had my back I was able to stay the course.

I cannot go any further without acknowledging my committee, Dr. Peter Doolittle, Dr. John Burton, Dr. Tonya Smith-Jackson and Dr. Gary Whitt. My committee truly

embodied what this process is all about, educating. I could not have asked for a better chair, Dr. Doolittle. He took a chance on me as a student and kept me on task. I cannot thank him enough. Dr. Burton and Dr. Whitt saw me through some failed attempts, but believed in me despite my flaws. And of course, thanks to Dr. Smith-Jackson whose counsel has guided me through the process. I also need to acknowledge Dr. Glenda Scales, who early during my time at Virginia Tech introduced me to Instructional Technology.

Thank you to my IDDL family (Angie, Alpha, Betsy, Bien, Jackie, Jeff, Jenise, Josh, Tabitha, Pete, Rob, Odessa, Odie, and Reid) for putting up with me through this process. I especially want to recognize my boss, Tom, who is an excellent mentor and role model. I appreciate the continuous support you've shown me on this journey, the opportunity to grow professionally, and of course, the "eye of the tiger". Tammie, I appreciate your sweet spirit and kindness and assistance with your attention to detail in helping me get my document looking the way it should. Also, my good friend, Eric, who calls me crazy for pursuing this degree, but someone I can always rely on if I need a favor or just someone to kick it with.

Beside my current Virginia Tech family, along the way I have also had the honor of numerous role models that kept me encouraged. At every stop that has brought me to this point I would like to recognize a few that have made a difference. The faculty at Morehouse College – Eddie Gaffney, Sterling Hudson, Duane Jackson, Linda Lloyd-Crawford, and V. Clark who made my undergraduate experience memorable; my friends at West Chester University – Marlene Goss and John Kinslow who also inspired me during the summer I spent in Pennsylvania; my Upward Bound family – Darlene, Janice, Zenida, and Ernest who helped launch my work experience in education; and the brothers of Iota Phi Theta Fraternity, Inc., Ow-Ow! One member of the frat that I have to give a special acknowledgement to is Robert Clark who was one of the first to inspire me towards a career in education. He continues to work hard for students at City College of San Francisco and in the larger community. I hope to pay it forward.

Finally, forgive me if I left anyone out, as I did not do so intentionally, and I feel that my no means could I have made it this far without everyone's support. Thanks also to TriedStone and St. Paul's AME for providing spiritual covering for me and my family.

Table of Contents

CHAPTER I: INTRODUCTION	1
Purpose	4
CHAPTER II: REVIEW OF THE LITERATURE	5
COGNITIVE THEORY OF MULTIMEDIA	5
Memory	6
Cognitive multimedia model	7
Encoding	7
Memory Trace	9
Retrieval	9
Multimedia	10
Dual Coding Theory	13
Cognitive Load Theory	15
Active Learning	16
Principles of Multimedia Learning	17
Multimedia principle	17
Modality principle	19
Contiguity principle	20
Coherence principle	21
Redundancy principle	23
Segmentation principle	23
Pretraining principle	24
Signaling principle	26
Spatial ability principle	26
Summary of Cognitive Theory of Multimedia	27
ENCODING AND RETRIEVAL PROCESSES	29
Encoding Specificity	29
Context Dependent Memory	37
Mood and State Dependent Memory	44
SUMMARY	46
SIGNIFICANCE OF THE STUDY	48
RESEARCH QUESTIONS	48
HYPOTHESES	49
CHAPTER III: METHOD	50
Research Design	50
Participants	50
Treatment Groups	51
Study Groups	51
Animation-narration study group (AN)	51
Animation-text study group (AT)	51
Text-only study group (T)	52
Test Groups	52
Animation-narration test group (AN)	52

Animation-text test group (AT)	52
Text only test group (T)	53
Materials	53
Pre-Experiment Assessment	54
Instruction Instrument	55
Recall Assessment	55
Animation-text recall assessment.	57
Text-only recall assessment.....	57
Transfer assessment.	57
Animation-narration transfer assessment.	58
Animation-text transfer assessment.....	58
Text-only transfer assessment.	58
Procedures	59
Scoring	62
Analysis of Data.....	63
CHAPTER IV: RESULTS.....	64
INTRODUCTION.....	64
HYPOTHESES.....	64
DATA ANALYSIS	65
Pre-Experiment Filter Test.....	66
Hypothesis 1.....	67
Hypothesis 2.....	70
CHAPTER V: DISUCSSION	72
OVERVIEW OF FINDINGS	72
RELATIONSHIP OF THE FINDINGS TO PRIOR RESEARCH	74
Encoding Specificity	74
Cognitive Multimedia Learning	75
IMPLICATIONS FOR FUTURE THEORY OR PRACTICE	78
SUMMARY.....	79
REFERENCES.....	80
APPENDIX A: LIGHTNING FORMATION, ANIMATION + NARRATION	90
APPENDIX B: LIGHTNING FORMATION, ANIMATION + TEXT	93
APPENDIX C: LIGHTNING FORMATION, TEXT ONLY	96
APPENDIX D: PRE-EXPERIMENT FILTER TEST.....	97
APPENDIX E: RECALL QUESTIONS.....	98
APPENDIX F: TRANSFER QUESTIONS.....	105
RESUME.....	108

List of Tables

Table 1. Nine Principles of Cognitive Theory of Multimedia	28
Table 2. Representation of independent measures research design	50
Table 3. Descriptive statistics for pre-assessment data based upon the nine treatment groups	67
Table 4. General Descriptive statistics for AN, AN, and T Encoding/Retrieval Groups Based on Recall Scores	68
Table 5. Single Degree of Freedom Contrasts of Matched versus Mismatched Recall Groups	69
Table 6. General Descriptive statistics for AN, AN, and T Encoding/Retrieval Groups Based on Transfer Scores	70
Table 7. Single Degree of Freedom Contrasts of Matched versus Mismatched Transfer Groups	71
Table 8. Rank Mean Scores for Recall and Transfer Groups.....	77

List of Figures

Figure 1. Cognitive Multimedia Model of Processing Words Text, or Pictures	7
Figure 2. Major conditions of meaningful learning	9
Figure 3. Processing of spoken words in a cognitive multimedia theory	11
Figure 4. Processing of pictures in a cognitive multimedia theory	11
Figure 5. Processing of printed/on-screen words as text in a cognitive multimedia Theory	12
Figure 6. Dual processing model of multimedia learning.....	19
Figure 7. Scene 14 on lighting formation.....	56

CHAPTER I

INTRODUCTION

Information is packaged and delivered in a variety of different forms to be sent from instructors to learners (Mayer & Moreno, 1998; Moore, Burton, & Myers, 1996). In a multimedia environment, the instructor has to make a decision about how information is delivered to learners in a manner that optimizes its effectiveness and maximizes the possibilities that learning will occur (Mayer, 2001). While designing instruction, instructors often must consider the form in which information should be delivered. Is speech appropriate? Is the inclusion of pictures necessary? What about the use of text or animation? Does the media for which information is learned (encoded) have to be similar at the time of retrieval (recall)? These decisions are important not because of the availability of the technology needed to deliver the information, but how learners are able to process the type of information delivered.

Consider that the amount of information that is received by the senses vastly outweighs what is remembered. The senses are able to pick up everything that is in an auditory or visual range at a rapid pace whether attended to or not (Craik & Lockhart, 1972). However, once memory attempts to evoke meaning and process information further into memory one item is often sacrificed at the expense of another causing some of the items to decay from memory. Does this explain why learners are only able to recall some information and not recall the rest? Does this mean the information not recalled is lost forever? Even if the information can be recalled this does not infer that this same information can be used to solve problems. Moreover, if given the proper cues would it then be possible to not only recall information once thought to be lost forever but understand it?

The ability to recall to-be-remembered (TBR) information is a function of three elements: encoding, memory trace, and retrieval (Tulving, 1983). Encoding is the process of receiving TBR information from the environment and storing it for future use (Tulving, 1983). The memory trace is the stored record that holds the properties of the encoded information (Tulving, 1983). Lastly, the to-be-remembered information can be retrieved only if a given cue corresponds with information received at time of encoding

that is present in the memory trace (Tulving, 1983; Canelos, Taylor, Dwyer, & Belland 1985).

This research will examine the relationship between storage of information and retrieval of the same information. Specifically, if a person is said to learn information in a particular manner, does recreating the learned environment increase recall performance—encoding specificity. Moreover, does the modality (verbal/visual) of the cues (related items) in which the information that is learned have to be similar to that at recall. A sample of a problem that this research could answer is the following:

An understanding of weather is important as knowledge of weather forecasts guide how people dress and often dictates participation in outdoor activities. Since weather or meteorology as a science is something that can be applied to real life, the application in school curriculum seems natural. However, how we learn information about this science might limit our understanding of it. Consider the text about the formation of lightning:

Lightning can be defined as the discharge of electricity resulting from the difference in electrical charges between the cloud and the ground. When the surface of the earth is warm, moist air near the earth's surface becomes heated and rises rapidly, producing an updraft. As the air in these updrafts cools, water vapor condenses into water droplets and forms a cloud. The cloud's top extends above the freezing level. At this altitude, the air temperature is well below freezing, so the upper portion of the cloud is composed of tiny ice crystals. The return stroke produces the bright light that people notice in a flash of lightning, but the current moves so quickly that its upward motion cannot be perceived. The lightning flash usually consists of an electrical potential of hundreds of millions of volts. The air along the lighting channel is heated briefly to a very high temperature. Such intense heating causes the air to expand explosively, producing a sound wave we call thunder (Mayer, 2001, p. 22-23).

The text alone can be said to be informative and written in a clear and concise manner. But as a unit of instruction, does the text alone provide enough detail for a learner to recall the main steps in the formation of lightning? Can a typical learner solve problems

related to the material that was presented from the text alone? Although the printed word has long sufficed as the standard method for presenting instructional content, text alone might not always be the best format when it comes to recall and transfer of that same information.

First, does the nature of the instruction and assessment reflect appropriate design of instruction based upon how we learn (Doolittle, McNeill, Terry, & Scheer, 2005; Gellevij, Meij, Jong, & Pieters, 2002; Moreno & Mayer, 1999)? The learner might not be able to process the TBR information because of the limited capacity of working memory (Paas, Renkl, & Sweller, 2003). Assessments that require learners to recall or problem solve abstract concepts without the learner first being able to develop the appropriate mental models (verbal or visual) can present a problem of cognitive load (Mayer & Moreno, 2003). Thus, through proper instructional design how the instruction (encoding) and assessment (retrieval) blend together could make a difference in the amount of material that is learned (Pass, Tuovinen, Tabbers, & Van Gerven, 2003).

Second, does the way the test is administered have to provide cues that could help stimulate recall or transfer? The lesson on lightning formation could have possibly been learned only through a text only format but not accessible because the appropriate cues during the assessment had not been given (Canelos, Taylor, & Dwyer, 1984). Learners' performance on a test can be just as reflective of the "test's inability to provide appropriate cues, not solely a matter of what materials were actually mastered by the learner (Canelos, Taylor, & Dwyer, 1985 p. 75)."

The scenario described provides one perspective for the way information is encoded, stored, and retrieved through a more traditional method (textbook). Another consideration is how information can be delivered through media to be encoded and later retrieved. What if the same information on "how lightning is formed" was presented as text with animation or narration with animation; might the outcome be different in each of these different approaches? As the Internet grows a greater reliance will be to develop mediated instruction that can take place on-line/at a distance (Allen & Seaman, 2004).

"The goal, the *raison d'être*, the stuff of education is learning" (Swann, 2004). The lessons learned from the media comparison studies of the past suggest that the

focus should be the learning (Clark, 1983). The use of media comparison studies has long been refuted (Clark & Salomon, 1986) as a less stringent and non-scientific method of conducting research in instructional technology. However, on-line/computer-based (distance) education has prompted a resurgence of media comparison studies (Lockee, Burton & Cross, 1999). These studies, like the media comparison studies of the past, resulted in findings of "no significant difference." Subsequently, a bibliography has been dedicated to present findings of over 355 research reports and journal articles over the past 74 years that conclude what one author has titled the "no significant difference phenomenon" (Russell, 1999).

Research needs to measure the effectiveness of learning regardless of how it is delivered (Lee, Driscoll, & Nelson, 2004). Whether the course is taught face-to-face, through interactive video conferencing, or on-line with all the bells and whistles technology offers, there is still no guarantee learning will occur unless some time and effort has been placed into the design of the instruction (Gellevij, Meij, Jong, & Pieters, 2002). Cognitive psychology can play a role in answering questions about how learners' learn regardless of delivery. The focus of cognitive theories such as cognitive theory of multimedia (Mayer, 1997), dual-coding theory (Paivio, 1986), cognitive load (Pass, Tuovinen, Tabbers, & Van Gerven, 2003), active processing (Mayer, 1999), and encoding specificity (Tulving & Thomson, 1973) provide the framework for a discussion around how learners' learning in an electronic mediated environment. Each of these plays a role in the overall memory architecture.

Purpose

The purpose of this study was to examine the relationship between the modality for which a learner encodes information into memory with the modality used to assess the learner's knowledge in a multimedia environment. Modality attributes for purposes of this study will include visual and verbal information. The examination of these particular attributes was important to this study because it was designed to identify specific characteristics of multimedia presentations that contributed to learning. Learning was measured in two ways: retention of knowledge and transfer of knowledge.

CHAPTER II

REVIEW OF THE LITERATURE

This review examines the relationship between storage of information and retrieval of the same information. Specifically, if a person is said to learn information in a particular manner, does recreating the learned environment increase recall performance? Moreover, does the modality (verbal/visual) of the cues (related items) in which the information that is learned have to be similar to that at recall? To better understand the relationship between how information is stored in memory and how that same information is later retrieved a review of relevant literature is necessary. The review of the literature is divided into two major topics: cognitive theory of multimedia and encoding specificity.

The first major topic, cognitive theory of multimedia is divided into three sub-sections: (a) cognitive multimedia model (b) assumptions of cognitive multimedia, and (c) principles of cognitive multimedia. The sub-section on the cognitive multimedia model of memory will discuss the memory process of selecting, organizing, and integrating spoken words/text and pictures. The second sub-section on the cognitive multimedia assumptions reviews three cognitive processes. The third sub-section on principles of cognitive multimedia will discuss strategies that guide practice grounded in research.

The second major topic, encoding and retrieval process is divided into three sub-sections: (a) encoding specificity theory, (b) context dependent memory, and (c) mood and state dependent memory. The sub-section on encoding specificity theory reviews research by Endel Tulving that led to the concept of encoding specificity. The second sub-section reviews context dependent memory that features encoding specificity as the main premise. Finally, the third sub-section will review mood-dependent and state-dependent learning that features encoding specificity as the main premise.

Cognitive Theory of Multimedia

Learning is seen as a seemingly permanent change in mental associations attributed to experience or change in how a person makes associations based upon

experience (Mayer, 2003). Cognitively, the process of learning is examined by how an individual perceives, encodes, interprets, remembers, elaborates, and retrieves what they experience from memory (Moore, Burton, & Myers, 1996). Every waking moment people are constantly bombarded with limitless bits of information that are recorded through their senses into memory (Mayer & Moreno, 2003). However, there is a limit to the amount of information that an individual can process in memory at one time—limited resources (Baddeley, 1999; Moore, Burton & Myers, 1996; Paivio, 1986).

The theory of cognitive multimedia learning can help explain how individuals can best learn in a multimedia environment. The premise for the theory is to use a learner-centered approach that focuses on how individuals process information in memory. Moreover, other goals of the theory are to examine the sensory modality of the information (auditory and visual) and how the information is presented (spoken/text words versus pictures). In sum, cognitive multimedia learning seeks to determine the best approach to delivering meaningful content based upon how information is processed so the end result is a meaningful learning experience (Mayer, 2001). The cognitive theory of multimedia can best be explained through a more detailed look at memory, multimedia, theoretical assumptions of multimedia learning, and the related theoretical principles of multimedia learning.

Memory

To illustrate cognitive multimedia learning, a brief explanation is warranted. The structural framework of memory shows the interdependence between the functions of sensory memory, working memory and long-term memory (see Figure 1). Each component of memory plays an integral role in completing the function of memory. Retrieval completes the function of memory as information has successfully made the loop: initial abstract bit of information from the environment, to storage of the information, and finally to retrieval from storage.

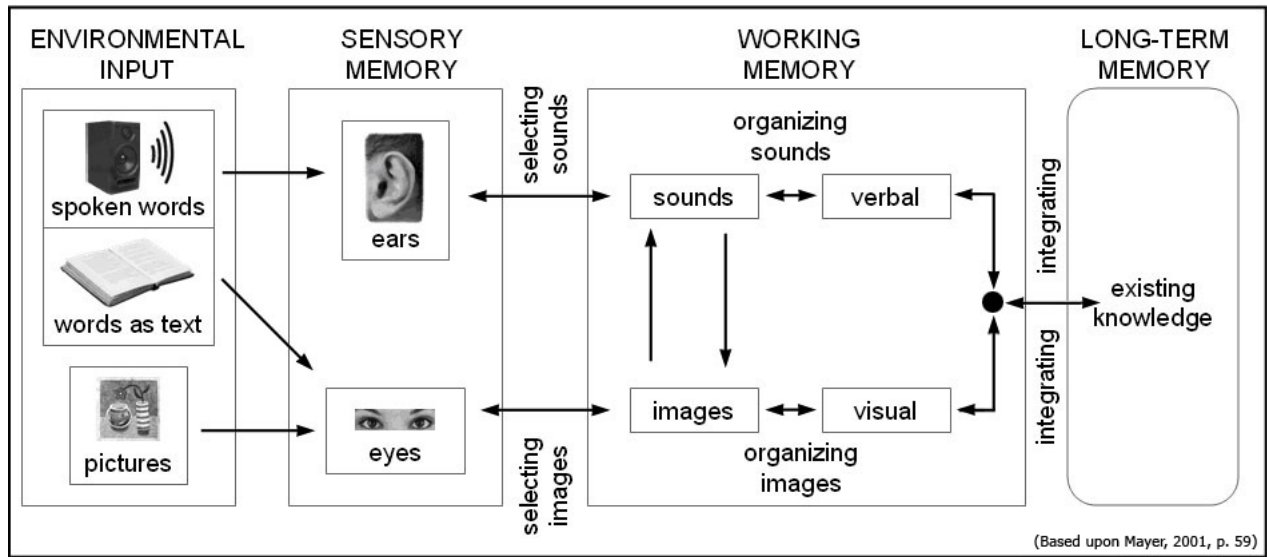


Figure 1. Cognitive multimedia model of processing spoken words/text, or pictures.

Cognitive multimedia model. Adapted from earlier models of memory (Anderson, 1983; Atkinson & Shiffrin, 1968; Baddeley, 1986) the cognitive multimedia model takes the same basic framework and elaborates based upon how words (spoken/text) and pictures are selected, organized, and integrated into memory (Mayer, 2001). According to the model information in the form of spoken words or written words/pictures are taken from the environment and enter the ears or eyes and the process begins in either the auditory or visual channel of sensory memory. Based upon the limited capacity of memory in each channel the learner has to select the most relevant auditory or visual information for further processing in working memory based upon previous knowledge taken from long-term memory (Mayer, 1996a). The most relevant auditory or visual information is then formed into a “coherent representation” in working memory which will become either a verbal model or visual model that makes sense to the learner. During the organization of information in working memory connections are made between word-based and image-based representations before they are integrated with existing knowledge in long term memory (Mayer, 2001).

Encoding. The information that is selected and organized in working memory is said to be encoded into memory. This process converts the information about an experienced event, in a particular setting, at a particular time, into a memory trace. A

memory trace is a permanent record of an experienced event in long-term memory. Accordingly, encoding is a necessary condition of learning (Tulving, 1983). Moreover, encoding helps relate incoming information to concepts and ideas already in memory. This concept is what is known as meaningful learning. Meaningful learning occurs when new experiences are related to what a learner already knows (Ausubel, 1962. p. 215). This type of learning assumes that the learner possesses some knowledge related to the new information and that the learner will consider the relationships between what is known and what has just been learned (Ausubel, 1962). Relating new information to previous knowledge is part of the synergistic relationship between working and long-term memory. Information that is made meaningful can be more effectively encoded from working memory into long-term memory. The best result of storing information in long-term memory has been found when an individual understands (Mayer, Bove, Bryman, Mars, & Tapangco, 1996), organizes (Dwyer & Dwyer, 1990), and integrates new information with experiences already in memory (Ausubel, 1968; Craik & Lockhart, 1972; Mayer, 1996a) (see Figure 2). The way information is received and eventually cataloged into memory is paramount to successful retrieval (Tulving, 1983, Moore, et al., 1996). As a key element in the memory process encoding establishes the foundation. Encoded information takes the form of a memory trace in long-term memory and is stored in long-term memory until the information is retrieved. The two remaining concepts that make-up the functions of memory, memory trace and retrieval, are integral parts of long-term memory.

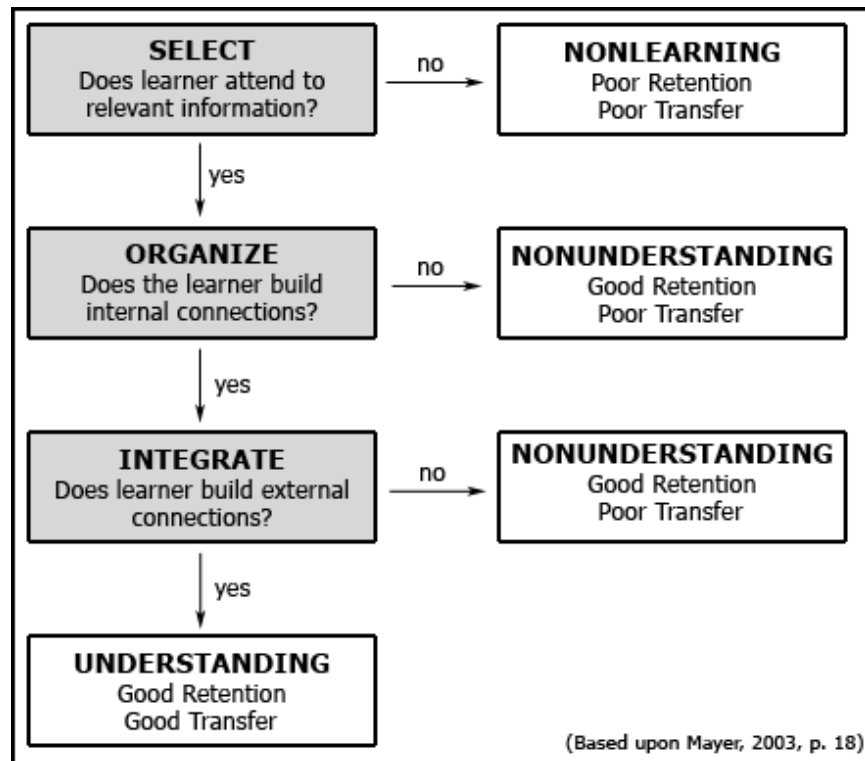


Figure 2. The three major conditions of meaningful learning.

Memory Trace. The function of long-term memory is generally seen as a large storage unit. However, the storage of information in memory is based upon how the information was initially encoded to form the properties of the memory trace. The encoding of information to form a memory trace in long-term memory is a pivotal role in the process of learning. How information is encoded into memory often determines how it is represented in the memory trace. The memory trace holds the salient properties of the initially encoded information which is later retrieved. The salient properties or attributes of the encoded information are things that make up the TBR information or object. For a given item, the memory trace might be comprised of visual and/or verbal information. Accordingly, the memory trace contains visual/verbal cues provided at the time of study (encoding) and when these same visual/verbal cues (retrieval cues) are given at the time of test they are said to maximize recall and recognition performance, a concept known as the encoding specificity theory (Tulving & Thomson, 1973).

Retrieval. The organization or structure of information held in memory directly relates to how successfully the information can be retrieved. The completion of the

memory process ends at retrieval (Tulving, 1983). Retrieval occurs when certain conditions are fulfilled such as the availability of appropriate trace information and the presence of a relevant retrieval cue (Brown & Craik, 2000). The consequences of retrieval are an increased probability that the event can be recalled on a subsequent occasion. Ultimately, learning is a process that begins with perceiving an event to be encoded, moves to formation of a memory trace to hold the event, and ends with a recollective experience (Tulving, 1983). The act of remembering an experience is captured through an assessment of how well encoded information can either be recalled or recognized.

An understanding of how spoken/text words and pictures are processed in memory are at the core of multimedia learning. Elements of encoding, memory trace, and retrieval are just as relevant in defining multimedia learning as interpretation of how spoken/text words and pictures are processed in memory. The next section will define multimedia and discuss the assumptions of multimedia learning.

Multimedia

Media is the presentation of materials delivered either verbally or visually (Mayer, 2001). Multimedia refers to the method of presenting multiple forms of materials that are either verbal and/or visual (Mayer, 1999). The verbal forms can be represented in narration, music, or text, while the visual forms can be represented in still pictures, animation, or illustrations. This definition of media relates to the attribute that a given device produces. Media attributes are the properties that convey certain capabilities such as the ability to show printed words, show objects in motion, or project sound (Levie & Dickie, 1973).

The definition of multimedia, as it relates to attributes, can be described through its presentation format or the sensory modality that the student uses to receive the instructional message (Mayer, 1997). While presentation format categorizes media as words or pictures, the sensory modality format categorizes media as verbal and visual (see Figure 3 and 4). With respect to the process that occurs as instructional messages are delivered, the presentation of words (speech) are processed through the verbal channels (ears), while pictures are processed through the visuals channel (eyes).

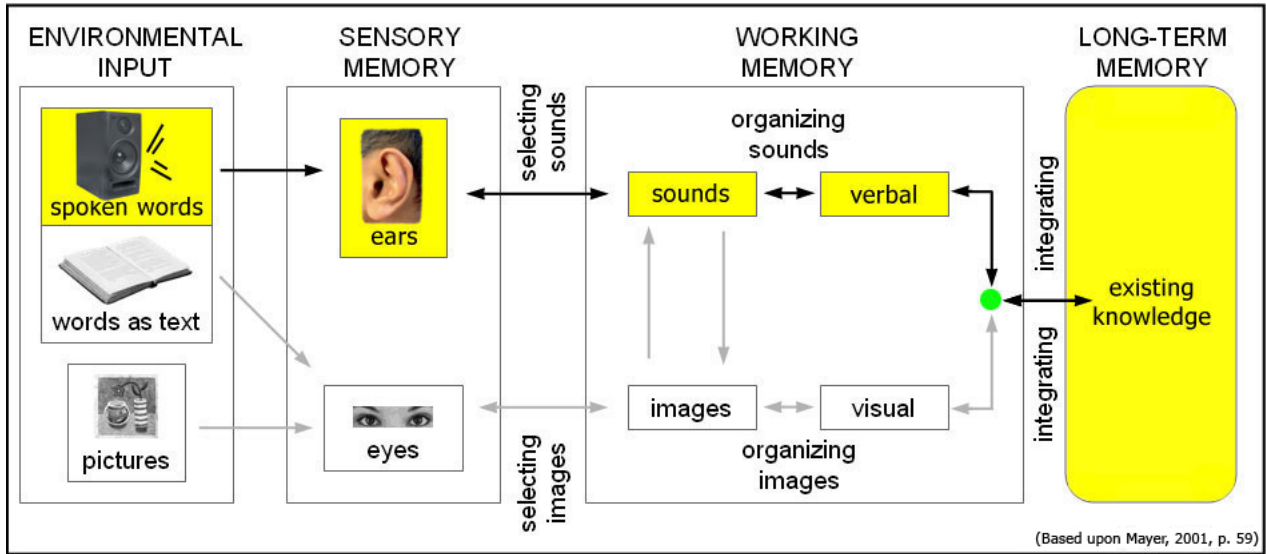


Figure 3. Processing of spoken words in a cognitive multimedia theory.

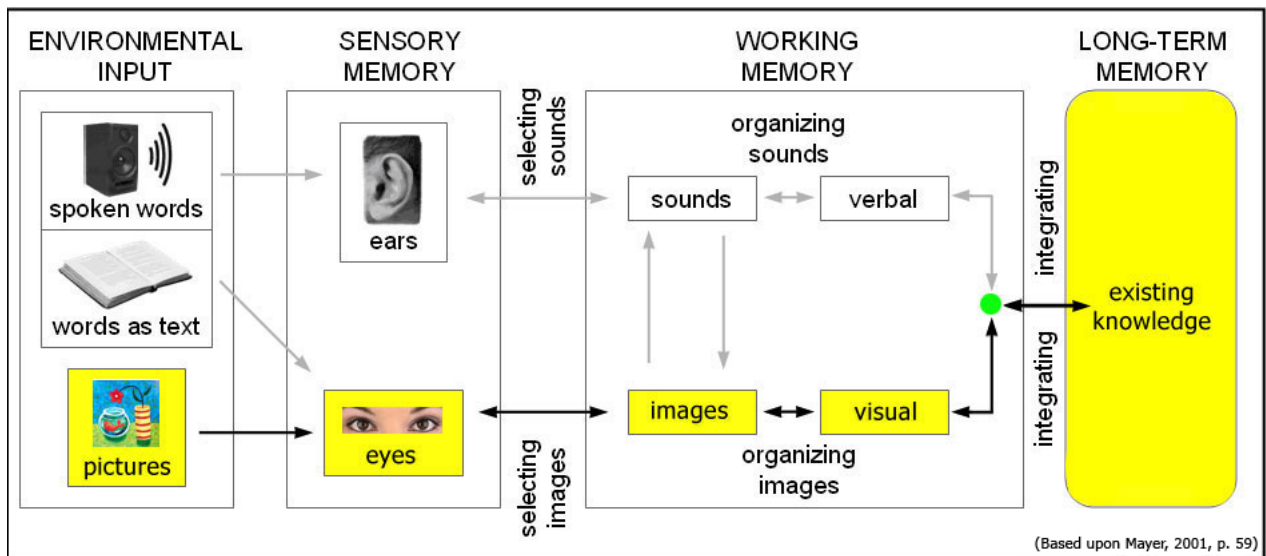


Figure 4. Processing of pictures in a cognitive multimedia theory.

The only discrepancy lies in the use of text (on paper or on-screen). The exception is that text is verbal information that is initially processed through the visual channel (see Figure 5). Information that is processed in one modality is often integrated to form the appropriate mental representation (visual or verbal).

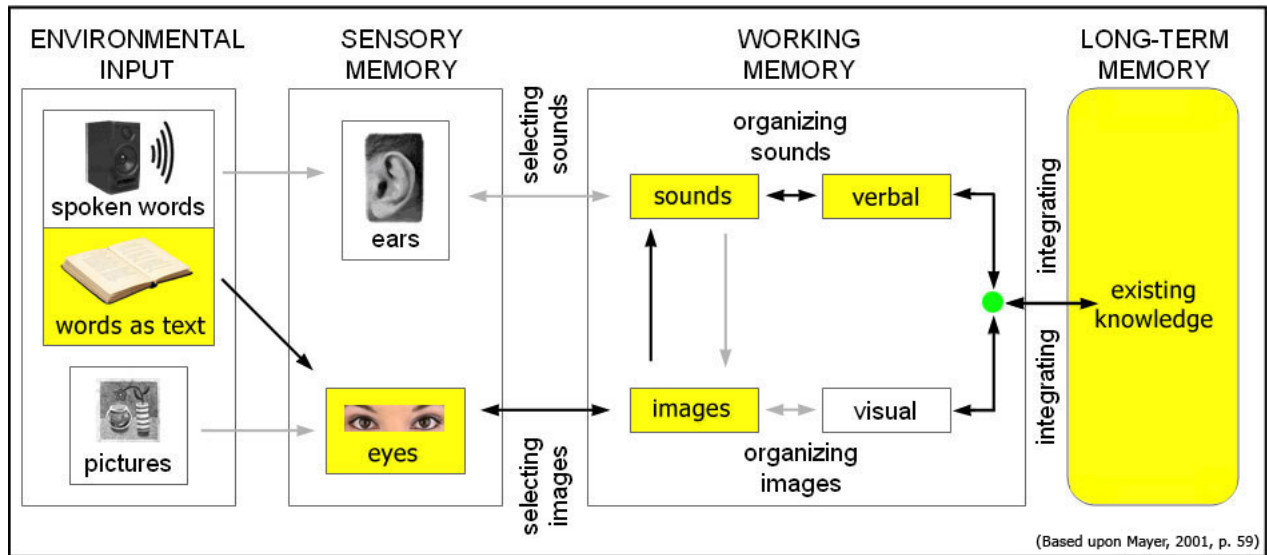


Figure 5. Processing of printed/on-screen words as text in a cognitive multimedia theory.

The explanation of multimedia as it relates to sensory modality allows for its application to cognitive theories of learning (Levie & Dickie, 1973). It is hypothesized that information that is presented to two sensory channels is more likely to lead to meaningful learning than if presented in one (Mayer & Gallini, 1990). This notion is consistent with research such as the dual-code theory (Paivio, 1986) and multi-channel communication (Moore, et al. 1996). Understanding how media works can provide insight into the best possible strategies for its use in the instruction process. Multimedia is particularly in high demand in course development because the perception is that it increases the instructional value by adding bells and whistles to the content (Moreno & Mayer, 2000). Multimedia can add to a presentation to ensure that the learner is able to capture information through more than one sensory modality. However, adding too much media, not placing the media in the right place, or not presenting the corresponding media at the right time can amount to minimal retention or transfer of information (Mayer & Anderson, 1992; Mayer & Chandler, 2001; Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 1999).

The design of instruction for learners in a multimedia environment is critical to a successful learning experience. Many of the tenants that are fundamental to cognitive

learning theory also compose the framework for the cognitive theory of multimedia (Moreno & Mayer, 1999). There are three assumptions underlying the cognitive theory of multimedia learning: dual-coding, limited capacity, and active processing. The first assumption is that students' process information through two separate verbal and visual processing systems (Pavio, 1986). The second assumption is that the two processing systems have a limited capacity (Chandler & Sweller, 1991). Lastly, learning requires that the student is an active participant and selects relevant information, organizes the information, and makes connections between verbal information, visual information, and existing knowledge (see Figure 2) (Mayer, 1997).

Dual Coding Theory

The first assumption of the cognitive multimedia theory refers to two separate channels that aid in processing information from working memory to long-term memory (Mayer & Anderson, 1991). The auditory/verbal channel processes verbal information while the visual/pictorial channel processes visual information (Mayer & Moreno, 2003). Both the verbal and visual channels comprise what will be referred to as the dual-coding theory. The dual-coding theory states that there are "two distinct subsystems for the representation and processing of non-verbal and verbal events and objects" (Pavio, 1986, p. 53). These two subsystems are part of working memory and can function independently; thus one system can be active without the other or they can work together. According to the dual-coding theory, learning performance increases when information is presented as spoken words and pictures, based upon how information is processed (Sweller, van Merriënboer, & Pass, 1998). The dual-coding theory deals with the management of specific functions of the cognitive memory architecture:

Human cognition is unique in that it has become specialized for dealing simultaneously with language and with nonverbal objects and events. Moreover, the language system is peculiar in that it deals directly with linguistic input and output (in the form of speech or writing) while at the same time serving a symbolic function with respect to nonverbal objects, events, and behaviors (Paivio, 1986, p. 53).

Based upon the dual-coding theory there are three connections that can be made in memory (a) verbal/verbal, (b) image/visual, and (c) verbal/visual (Mayer & Anderson, 1992). The first connection is between the verbal information that is presented at instruction and the learner's verbal "representation of that information in memory (Mayer & Anderson, 1992, p. 444)". The second connection is between various types of images (photographs, illustrations, animations) that are presented as instruction and the learner's visual "representation of that information in memory" (Mayer & Anderson, 1992, p. 444). The third connection is the compatibility between the verbal/image that is presented at instruction and the learner's verbal/visual "representation in memory" (Mayer & Anderson, 1992, p. 444).

Dual-coding theory is important in understanding how sensory data can be processed for higher learning performance. When both words and pictures are used the learner is able to build the appropriate referential connections and mental models (Mayer & Anderson, 1991). The use of dual-coding theory in designing instruction is only one aspect. If only one system, either visual or verbal is used during instruction it is possible that based upon the limited capacity of memory, potential learning is reduced (Sweller, van Merriënboer, & Pass, 1998). Subsequently, if too much verbal and visual information is provided at the time of instruction there is a possibility of redundancy (Mayer, Heiser, & Lonn, 2001) that also increases the load on working memory (Gellevis, Meij, Jong, & Pieters, 2002).

Cognitive Multimedia theory provides a basis for presenting instructional materials that take advantage of a dual-system of information processing. The appropriate use of verbal and visual information to form a symbiotic spoken word-image relationship fosters a more meaningful learning experience (Mann, 1995) than if verbal and visual information is presented alone (Mayer & Anderson, 1991). Subsequently, each system has been shown to have superior effects on retention respectively. Studies on picture and word triads manipulating the type of distraction have shown a greater recall of pictures (Burton, 1982; Burton & Bruning 1982; Pellegrino, et. al., 1975, 1976). Conversely, verbal presentations have resulted in higher recall than visual presentations in recall tasks (Penny, 1989; Tripp & Roby, 1996) and gaining attention (Bishop & Cates, 2001). Regardless of the position that a given researcher has chosen, studies on

both sides have accounted for strengthening theories of a dual-coding system and the use of a given modality's effectiveness to promote learning. In most studies of visual and verbal presentations, when used in combination, the two fostered better retention and transfer than when used separately.

Cognitive Load Theory

The second assumption to the cognitive theory of multimedia has to do with the limited capacity of working memory. Cognitive load can be viewed as the amount of 'mental energy' that is imposed on the learner when performing a task (Cooper, 1990; Pass, Tuovinen, Tabbers, & Van Gerven, 2003; Sweller, van Merriënboer, & Pass, 1998). From the dual-coding theory we know that information can be processed by either a verbal channel or visual channel. Cognitive load theory considers the amount of information that is processed so that an individual channel is not overburdened (Sweller, van Merriënboer, & Pass, 1998). If too much information is presented to an individual channel at one time, the likelihood of information to be processed by working memory is reduced and learning decreases (Mayer & Moreno, 1998; McCrudden, Schraw, Hartley, & Kiewra, 2004). The use of cognitive load theory in multimedia learning attempts to account for the possibilities of cognitive processing overload. Ultimately, the design of instruction is said to play a critical role in reducing the threat of cognitive overload (Gellevij, Meij, Jong, & Pieters, 2002; Pass, et al., 2003).

The design of instruction can reduce cognitive load by developing instruction that considers what demands the presentation will have on cognitive processing and the individual differences of the learner. All together there are three different demands on cognitive load that make up working memory—intrinsic cognitive load, extraneous cognitive load, and germane cognitive load (Paas, Renkl, & Sweller, 2003).

Intrinsic load has to do with the difficulty of the learning material (Renkl & Atkinson, 2003) and also can be determined by the expertise of the learner. If the complexity of the instruction requires a high level of learner interactivity with the content this taxes working memory (Sweller, van Merriënboer, & Pass, 1998). The level of interactivity is determined by how parts of a given task interact in such a way that instructional materials have to be attended to simultaneously to be understood (Renkl &

Atkinson, 2003). This is the only aspect of the three tenants of cognitive load theory that is outside the control of the design of instruction (Doolittle, McNeill, Terry, & Scheer, 2005).

Extraneous load is based upon the mental energy that is consumed while processing learning material that does not contribute to the actual learning process (Renkl & Atkinson, 2003). Extraneous cognitive load is a function of poorly designed instruction (Sweller, van Merriënboer, & Pass, 1998). Instructional intervention however, can overcome the burden of extraneous cognitive load upon working memory. Finally, germane load is the demand placed on working memory that directly contributes to the actual learning process (Renkl & Atkinson, 2003).

If the demand of intrinsic cognitive load is low and the design of instruction minimizes extraneous cognitive load, then the unused working memory can be used towards germane cognitive load. The demand of germane cognitive load can be attributed directly to the instruction (Renkl & Atkinson, 2003). Germane cognitive load helps to select, organize, and integrate instructional materials (Mayer & Moreno, 2003). Through this active process, germane cognitive load can make sense of learning materials towards the goal of schema acquisition (Paas, Renkl, & Sweller, 2003).

Active Learning

The third and final assumption of the cognitive multimedia theory is that learners are constantly processing information and making decisions as to what he/she learns (Mayer, 2001; Rothkopf, 1996). The process of making individual decisions about learning involves the use of forming mental associations or making mental models, which in turn involves organizing and relating new knowledge based upon previously organized and learned information that can be retrieved (Mayer, 1997). Active learning involves the process of selecting, organizing, and integrating relevant material (Mayer, 2001).

The process of active learning is when relevant visual and/or verbal stimulus is presented to a learner. The learner would select (attends) relevant words or images from the multimedia presentation (Mayer, 1999). Then the learner organizes the information in a format that is based upon a "coherent representation" (Mayer, 1996b).

The learner would organize the selected words or pictures from the multimedia presentation (Mayer, 1999). Finally, the student integrates words and picture representations with prior knowledge (Mayer, 1999).

The three assumptions that comprise cognitive multimedia theory are considered to be interrelated and not work in isolation (Doolittle, et al. 2005; Mayer, 2001). Dual coding affects what type of sensory information is processed, limited capacity affects how much of that sensory information can be processed, and active processing is how the information is compiled into a mental model (Mayer, 2001). The three assumptions form the basis for cognitive process that at the core of multimedia learning. As a part of the active processing of memory the cognitive processes are selecting, organizing and integrating. Specifically, cognitive multimedia includes the following: (a) selecting relevant words from multimedia; (b) selecting relevant pictures from multimedia; (c) organizing the selected words; (d) organizing the selected pictures; (e) integrating the organized words and pictures into a coherent mental model (Mayer, 1999). The three assumptions of multimedia along with the core cognitive processes serve as the framework for nine principles of multimedia learning. The principles are a set of guidelines that have both a theoretical and empirical rationale. These principles grounded by research can help guide pedagogy. Many of the principles show evidence of either the three assumptions or five cognitive processes. The nine principles are (Mayer & Moreno, 2003): (a) multimedia principle; (b) modality principle; (c) contiguity principle (spatial-contiguity effect and temporal contiguity effect); (d) coherence principle; (e) redundancy principle; (f) segmentation principle; (g) pretraining principle; (h) signaling principle; (i) spatial ability principle.

Principles of Multimedia Learning

Multimedia principle. The multimedia principle is defined as words and pictures that are presented together during instruction (Mayer, 1999). The use of words and corresponding pictures are used opposed to using words alone for instruction. The rationale for using both words and pictures is that learners can more easily create visual and verbal mental models then creating links between them. If words are used alone the learner will create a verbal mental model. A number of studies have shown that recall

and transfer is greater when both words and pictures are used in conjunction with one another and learners do not necessarily have to attempt to create a mental image on their own (Mayer, 1999, 2001; Mayer & Gallini, 1990; Mayer & Sims, 1994).

Most easily and effectively, multimedia principle can be explained through the word-picture relationship. As the foundation for all the remaining principles, the multimedia principle describes the most basic premise of an increase in learning through the presentation of verbal and visual information. The principle rests upon foundational work such as the dual-code theory (Paivio, 1986) and multi-channel communication (Moore, et al. 1996). Although visual and verbal information are different in the manner in which they are delivered and received, they can complement one another. When conducting research on the sound attribute, Mann (1992) found that there is often a symbiotic and synergistic effect in the sound-picture relationship.

A study that had a similar premise examined the retention of a news broadcast transmitted by audiovisual, audio-only, and print with explanative descriptions of figures (Gunter, Furnham, & Leese, 1986). The results were consistent with the multimedia principle, showing that audiovisual subjects were able to recall more information in the case of cued and multiple-choice recall than their audio-only counterparts. Subsequently, the subjects in the print with explanative description of figures groups recalled significantly more information than both the audio-only and audiovisual group. This is consistent with studies that show that in short-term memory tasks, auditory information results in higher recall than visual information (Penny, 1989).

Although a number of variables can account for this rationale, auditory information is often able to convey visual imagery without the benefit of a visual referent. The ability to vividly describe a visual image through the use of auditory information can make the content more meaningful; thus a mental representation of the image can be more readily formed and the information can be better retained.

Several other studies have shown positive effects on retention and transfer performance using multimedia (Mautone, & Mayer, 2001; Mayer, 1997; Mayer & Anderson, 1991; Mayer & Sims 1994; Plass, Chun, Mayer, & Leutner, 1998; Pollock, Chandler, & Sweller, 2002). A variety of principles underlie the method for applying multimedia to instructional practice. The appropriate use of these principles, when

designing instruction, can account for the overall effectiveness of a learning experience. Although there are probably numerous other reasons that can account for differences in results, the general principles are the spatial contiguity, temporal contiguity, modality, and redundancy.

Modality principle. The modality principle is defined through the use of narration (the spoken word), and animation (moving pictures), presented together during instruction (Penney, 1989; Moreno & Mayer, 1999; Mousavi, Low, & Sweller, 1995). Narration in this case, would replace either printed or on-screen text. The rationale is that learners will be able to expand the limited capacity of memory by using the visual channel (animation) and the verbal channel (narration).

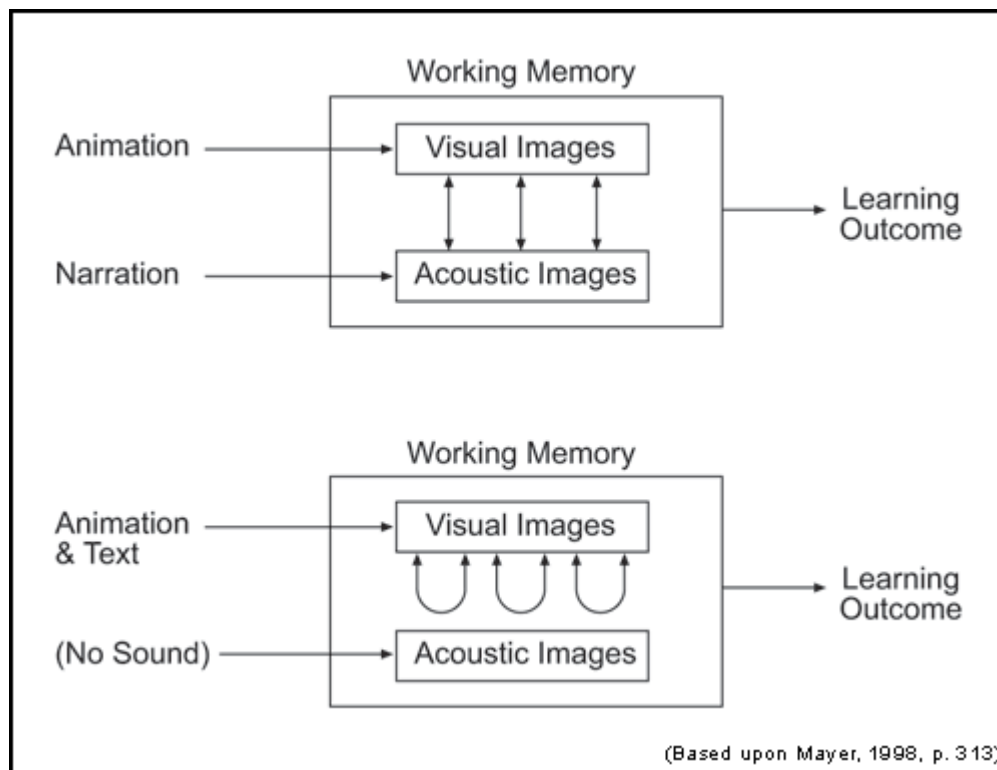


Figure 6. Dual processing model of multimedia learning.

Although printed text is thought to be verbal information (words/text), it is processed visually. The modality principle explains the burden that is placed in working memory when animation/pictures and printed text are presented together. If working memory is required to process two presentations of the same modality, it can be

overloaded—while the auditory channel remains unused. Unlike visual information, verbal information can change modality without altering the content (Penney, 1989). The research shows that less cognitive resources are required to divide (split) attention between two concurrent presentations of information (verbal vs. visual).

Mayer and Moreno (1998) conducted a study to examine the modality principle. Extending research in the area of split-attention done by Mousavi, et. al. (1995) and conducted in a pencil-paper environment, this study found that geometry statements presented verbally, rather than as text, yielded better results in problem-solving. Participants in the Mayer and Moreno (1998) study, viewed an animation on a computer with either concurrent narration or on-screen text. The results were consistent with those of Mousavi, et al. (1995): students in the animation with narration performed better in retention, problem solving transfer, and visual-verbal matching.

Contiguity principle. The contiguity principle refers to the relative effectiveness of multimedia when printed text (verbal) and pictures (visual) are presented alongside or nearby one another in space or time instead of being isolated (Mayer & Anderson, 1992; Moreno & Mayer, 1999). The rationale is that learners do not have to use excessive cognitive resources to hold words or pictures in memory while they search/wait for the corresponding words or pictures that are physically or temporally separated. This principle can be expanded into two distinguishable effects.

The spatial-contiguity effect (also known as the split-attention effect) is based upon the proximity of printed/on-screen text and pictures, as in the case of printed text, explaining an example that is placed on a subsequent page. The spatial contiguity principle suggests that learning is more likely to occur when words and pictures are placed in greater proximity (space) to each other rather than far away (Moreno & Mayer, 1999). When words and pictures are placed in closer proximity, cognitive resources are not wasted in the attempt to find the corresponding materials (Mayer & Anderson, 1992).

A number of studies conducted on retention and transfer have shown positive results when verbal and visual information is integrated (Mayer, 1989; Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Mousavi, et al., 1995). Moreno and Mayer (1999) conducted an experiment to test the spatial contiguity of text and pictures. Information

was on the subject of meteorology, presented to novice learners on a computer screen, either as text and pictures that were integrated, text and pictures that were separated, or an animation with concurrent narration. The results concluded that the proximity of the text-to-image relationship was both important and consistent with previous research in the area (Anderson & Mayer, 1992; Moreno & Mayer, 1999) of retention and transfer test (Chandler & Sweller, 1991): when on-screen text was spatially separated from pictures, students performed poorer.

The temporal contiguity effect is defined on the time sequence presentation of the verbal-visual relationship. The verbal information (text or spoken) is presented simultaneously with an animation rather than successively (Mayer & Anderson, 1992). In this case, it is the proximity of time between when the verbal and visual information is presented. Learning is more likely to occur when information is synchronized (Moreno & Mayer, 1999). Mayer and Anderson (1992) examined the retention and problem solving performance of participants who received concurrent versus successive presentations of animations and narration. Their results confirmed the effect of temporal contiguity. Participants who were presented with synchronized narration and animation had greater improvements between pre and post test. The conclusion was offered that by presenting words and pictures simultaneously, the learner does not burden short-term memory and can more readily build connections between the verbal and pictorial representations (Mayer & Anderson, 1992).

Coherence principle. The coherence principle can be defined as: (a) the use of irrelevant words and pictures added to multimedia impairs student learning, (b) the use of irrelevant sounds and music added to multimedia impairs student learning, (c) the deletion of unnecessary words from multimedia improves student learning (Moreno & Mayer, 2000). The rationale for the principle is that seductive details (irrelevant additional verbal or visual stimuli) in multimedia presentations often distract learners and can take attention away from the relevant content. The coherence principle explains the poor recall and transfer performance results when seductive details create an overload on available cognitive resources (Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2000).

The purpose of multimedia is to facilitate learning through the use of two delivery modes (visual and verbal). However, the lure of technology can lead to the overuse and abuse of multimedia in the development of instructional presentations. The case is often made that adding more of the same information by more paths provides the most desirable results (Mayer, Heiser, & Lonn, 2001). For example, consider a presentation that is delivered via animation, narration, on-screen text, and sound effects. This type of presentation, no matter how appealing, does not in itself automatically promote learning.

An argument for using this type of multi-multimedia presentation is based upon "arousal theory." This theory suggests that a fast pace presentation increases arousal and captures attention. Information that is presented to arouse is often entertaining, but irrelevant. The addition of this verbal or visual information is called "seductive details". Primarily, this has been shown to have only mild increases on retention and transfer in young children (Moreno & Mayer, 2000).

Consider a study conducted to test if the use of irrelevant words and pictures added to multimedia. In three out of four experiments, irrelevant details were added to the narration and video (Mayer, Heiser, & Lonn, 2001). The results, which were an extension of previous experiments in a paper-pencil environment, showed that adding seductive details in a computer-based environment will yield poorer results in both retention and transfer performance.

A second study tested the use of irrelevant sounds and/or music that were added to multimedia. The study was based upon the use of two different multimedia messages where irrelevant auditory material was added to an instructional multimedia message. Again, the results favored the coherence effect on retention and transfer (Moreno & Mayer, 2000).

A third study examined the use of concise summaries to improve learning. A text-picture multimedia presentation was given on the subject of meteorology. The treatments were a summary, summary + 50 word booklet, and summary + 500 word booklet. The results showed that, incrementally, the amount of information provided beyond the explanative summary, the poorer the performance. Thus, the study concluded that the amount of information that is delivered, is not as important as the efficiency by which it is delivered.

Redundancy principle. The redundancy principle is the addition of on-screen text to a multimedia presentation featuring animation and narration (Mayer, Heiser, & Lonn, 2001). The rationale for the use of the redundancy principle is the additional burden that is placed in working memory when too much information is processed through one channel. Learners perform better on recall and transfer test when the load on each individualized channel (visual/verbal) is minimized (Mayer, Heiser, & Lonn, 2001).

Koroghlanian and Sullivan (1999) examined the use of three modes of presentation in a computer based environment. Subjects in the experiment were assigned to a full-text and picture group; full-text, full audio, and picture group; or lean-text, full audio, and picture group. The results of an achievement test were similar for each group and no significant difference was found. Although not mentioned in the study, the results of the tri-modal group could have been explained by the redundancy theory (Mayer, Heiser, & Lonn, 2001).

In four experiments, that also tested the coherence effect of a presentation explaining the formation of lighting, Mayer, Heiser, and Lonn (2001) examined the effect of adding concurrent on-screen text that either summarized or duplicated the narration. The addition of on screen text was justified by the notion that on-screen text is said to accommodate student's learning preference in what is called "learning preference hypothesis" (Mayer, 2001). Results of the two experiments, testing the redundancy principle, confirmed that students who received the addition of an on-screen summary or concurrent on-screen text, remembered significantly less on retention test, and transferred less information on the problem solving test.

Segmentation principle. The segmenting principle gives learners additional time to process information between consecutive segments of a given presentation. Using the segmenting principle a presentation is reduced into smaller more manageable segments. The rationale is if too much information is presented at one time the learner will not have an opportunity to process the information thus causing working memory to be overloaded. The strain on working memory can be reduced if information can be segmented into smaller chunks, which can be easier to understand, and later organized and integrated into, long term memory (Mayer & Moreno, 2003), which is part of the

active learning framework. The ability for students to perform better on transfer test, when they exercised control over the pace of a multimedia presentation (segmented), versus when they viewed the entire presentation without any learner control (non-segmented), provided support for the segmentation principle (Mayer & Chandler, 2001).

The conventional approach to a multimedia presentation is to show the entire sequence from the standpoint of not disrupting the learning process (Mayer & Chandler, 2001). This approach to viewing multimedia presentations was tested against individual segments that allow for increased learner control (Mayer & Chandler, 2001). Two groups of students were shown either the entire presentation (WW group) or parts of the presentation (PP group). Both groups were shown exactly the same presentation. The results of the study showed that students in the PP group performed significantly better on transfer test than those in the WW group. The study suggests that the cognitive load was decreased, as learners were able to build better mental models learning, when they can dedicate more cognitive resources.

The process of segmentation fits into a distance education model as this provides the user autonomy over his/her learning as described in the theory of transactional distance. Moreover, if multimedia presentations are better delivered through segmenting this, suggest that more consideration should be placed on the design of instruction.

Pretraining principle. The pretraining principle provides the learner with instruction prior to the upcoming learning experience (Mayer & Moreno, 2003). Thus, the pretraining principle functions similar to an advanced organizer (Ausubel, 1968), by providing the learner with preexisting knowledge of the subject matter in order to construct appropriate mental models. Other principles of cognitive multimedia learning have discussed, that how information is presented (type and design) to learners can play an important role in the amount of information that is learned. But, the pretraining principle is concerned with how learning is affected when the information that is presented is integrated with the learner's preexisting knowledge? The rationale is that the role of the learner's preexisting knowledge can have an affect on how much information is learned from a given presentation on a particular subject matter.

The pretraining effect supports the claim of active learning. Learners that are given pretraining are able to develop proper mental models that can be built upon during actual instruction (Mayer, Mathias, & Wetzell, 2002). This concept of pretraining is similar to that of an Advanced Organizer. The advanced organizer proposes to “explain, integrate, and interrelate the material in the learning task with previously learned material” (Ausubel, 1968, p. 148). Pretraining provides learners with knowledge in advance that will assist them when learning new material.

Three experiments were done to examine the effect of pretraining on learning in a multimedia environment. The initial experiment provided learners with pretraining through a worksheet that provided verbal (text) and diagrams. Two groups were established, one that received pretraining and another group that received no pretraining. Both groups were then given a multimedia instructional presentation on a car’s braking system followed by a retention and transfer test. The second experiment was similar to the first, with the exception of delivering the pretraining using multimedia. The third experiment was similar to the second experiment, however added a third participant group which was given the multimedia instructional presentation and then given post-training which was identical to the pretraining given in the other group.

The results in all three experiments concluded that there were no significant differences in the recall of the main points based upon pretraining. Subsequently, significance was found in learners who were pretrained versus those who were not on the basis of having a greater understanding (transfer test) in applying what they learned. Similar results were found when using isolated interacting elements (segmentation), versus interacting elements (presentation all at once), only prior to instruction with novice and advanced learners (Pollock, Chandler, & Sweller, 2002). Isolated interacting elements was said to provide learners with schema creation which aids in the greater understanding of complex information. Novice learners were found to perform better when pretrained using a segmented approach. As expected, the pretraining method had no significant effect on advanced learners since they already had developed appropriate schemas for learning the semi-new materials (Pollock, Chandler, & Sweller, 2002).

As with the segmentation experiments, design of instruction plays a critical role in facilitating the methods incorporated to deliver instruction. Both the pretraining and

segmentation affect suggest that designers must consider learning strategies that provide ample opportunity to develop mental models in order to increase learning performance.

Signaling principle. Signaling can be defined as a process whereas appropriate cues are provided to the learner to aid in learning new information. The importance of signaling is to focus attention or organize information that is viewed as particularly relevant (Mautone & Mayer, 2001). The rationale is that the learner is better able to discriminate between materials that are relevant and irrelevant when they can distinguish between these items easily. For example, techniques for text-based materials include titles, headings, font characteristics (e.g. color, size, bold, italics), and phrases (e.g. “this section will cover. . .”).

Although a number of studies have been conducted in support of the signaling effect none have looked at the use of multimedia (Mautone & Mayer, 2001). A challenge to the standard experimental approach to signaling used a cause-and-effect multimedia presentation on the subject of how airplanes achieve lift (Mautone & Mayer, 2001). Signaling was manipulated through a text only version, voice only version, and a narrated animation version (four varieties of signaling used) with retention and transfer being measured. The results found signaling to have a significant difference in transfer scores for all groups except animation signaling. The rationale that animation signaling was not found to have a significant difference was that the animation was not complex enough or learners are more adept at taking cues from text or voice cues (Mautone & Mayer, 2001).

Spatial ability principle. Spatial ability refers to the ability to create, hold, and transform visual images in memory from verbal presentations (Mayer, 2001). A learner with high spatial abilities is usually able to make connections between verbal and visual information to develop working mental images while a learner with low spatial ability is generally challenged. For example, when a learner is reading a “how-to” book, he/she should be able to visualize performing the given task. Moreover, the learner should be able to visualize changes to that image based upon additional information that alters the initial task. Spatial ability has increased application to multimedia presentations since learning occurs in both sensory modalities—verbal and visual. Since multimedia

presentations are both visual and verbal the rationale for spatial ability is that learners are able to generate, store, and manipulate mental images for recall or transfer.

The pedagogy, as suggested earlier, plays an important role in designing instruction to fit learners needs (Mautone & Mayer, 2001; Mayer & Chandler, 2001; Mayer, Mathias, & Wetzell, 2002; Mayer & Simms, 1994). A study on spatial ability can help researchers identify how best to design instruction that uses visual and verbal information. A subsequent experiment provided data on how low/high experienced, low/high spatial ability learners performed on retention and transfer test. The experimental manipulations were as follows: animation and narration simultaneously, animation followed by narration (temporal contiguity effect), and narration followed by animation (temporal contiguity effect), no instruction.

The results found that high spatial learners in the concurrent group significantly outperformed high-spatial learners in the successive groups. Low-spatial learners receiving the concurrent presentation performed similar to those in the successive. Overall, results from this study support the dual-coding hypothesis suggesting that appropriate connections be made between visual and verbal representations (Mayer & Simms, 1994).

Summary of Cognitive Theory of Multimedia

The nine principles related to cognitive multimedia learning provide suggested guidelines on how to design and develop instruction using multimedia. One of three assumptions that cognitive multimedia learning is based, defines the design function of instruction as critical to reducing cognitive load theory. Specifically, extraneous and germane cognitive load can be prevented through proper design. Another of the assumptions—dual coding theory, refer to the use of visual and verbal modalities as having a synergistic relationship. Recall and Transfer is said to increase when instruction is design employing strategies that employ both visual and verbal that complement one another. Lastly, learning is an active process of selecting, organizing and integrating. The design of instruction should facilitate active as opposed to dormant styles of learning.

The cognitive multimedia model defines the synergistic relationship between the separate functions of memory that make up one larger system that makes learning possible. A discussion of the components of the cognitive multimedia model of memory provides the basis for an understanding of human memory yet only scratches the surface. Details relating to how a perceived object can be encoded, stored as a memory trace, and later retrieved based upon a cue merits additional inquiry. The next section will review the theory of encoding specificity.

Table 1

Nine Principles of Cognitive Theory of Multimedia

Principle	Description
Multimedia	Words and pictures that are presented together during instruction (Mayer, 1999).
Modality	Use of narration (the spoken word) and animation (moving pictures) presented together during instruction (Penney, 1989; Moreno & Mayer, 1999; Mousavi, et. al., 1995).
Contiguity	Relative effectiveness of multimedia when printed text (verbal) and pictures (visual) are presented alongside or nearby one another in space or time instead of being isolated (Mayer & Anderson, 1992; Moreno & Mayer, 1999).
Coherence	The use of irrelevant words and pictures added to multimedia impairs student learning; the use of irrelevant sounds and music added to multimedia impairs student learning; and the deletion of unnecessary words from multimedia improves student learning (Moreno & Mayer, 2000).
Redundancy	Addition of on-screen text to a multimedia presentation featuring animation and narration (Mayer, Heiser, Lonn, 2001).
Segmentation	Gives learners additional time to process information between consecutive segments of a given presentation. Using the segmenting principle a presentation is reduced into smaller more manageable segments.
Pretraining	Provides the learner with related instructional materials prior to the upcoming learning experience to help the learner build appropriate mental models (Mayer & Moreno, 2003).
Signaling	A process whereas appropriate cues are provided to the learner to aid in learning new information. The importance of signaling is to focus attention or organize information that is viewed as particularly relevant (Mautone & Mayer, 2001).
Spatial Ability	To create, hold, and transform visual images in memory from verbal presentations (Mayer, 2001).

Encoding and Retrieval Processes

How do we remember information? What about remembering information that has not been used for a long period of time? For instance, the taste of your grandmother's apple pie, the sound of wave's crashing down at your favorite beach, the look and feel of your first bicycle. Do you remember? Can you name that great restaurant where you stopped to eat while on vacation last year? While trying to recall this information you might believe that recollection is eminent, but you cannot quite verbalize the item. What if you were given cues? Would that help? Most likely if you were given the appropriate cue (whatever that might be) you would be able to come up with the correct response from memory.

This section is concerned with how information that is encoded is eventually recalled. Items that are available in memory cannot always easily be recalled unless appropriate retrieval cues are provided (Tulving & Thomson, 1973). These retrieval cues might be associative in nature, but mainly retrieval cues need to be relative to recreating the event that occurred at encoding or that which is similar to salient properties in the memory trace (Tulving, 1983). This is known, in part, as encoding specificity. Encoding specificity states "that only that can be retrieved that has been stored, and that how it can be retrieved depends on how it was stored" (Tulving & Thomson, 1973, p. 359).

Encoding Specificity

Encoding specificity outlines three basic functions of memory: elements of encoding, properties of memory trace, and elements of retrieval (Tulving, 1983). Encoding is part of the memory process beginning at the perception of an event and ends at the formation of a memory trace. The memory trace is the recorded properties of the encoded memory stored in long-term memory. Finally, retrieval is the process that begins with a retrieval cue that is perceived and ends with the confirmation of the recollective event.

The interaction between the conditions at encoding and retrieval are central to the conversation about encoding specificity. Recollection of an event is complete at the retrieval of the to-be-remembered (TBR) item, and begins with encoding the item into

the memory trace (Tulving & Thomson, 1973). Specifically, the encoding specificity principle states that

specific retrieval cues facilitate recall if and only if the information about them and about their relation to the TBR words is stored at the same time as the information about the membership of the TBR words in a given list. (Tulving & Osler, 1968, p. 599)

By definition, encoding specificity differed from other hypotheses that suggested that the strength of word associations plays a major role in the effectiveness of retrieval cues (Thomson & Tulving, 1970). A number of experiments demonstrated that associated strength of the cue with the TBR words will not be effective during retrieval unless the cue was specifically encoded at time of storage (Thomson & Tulving, 1970; Tulving & Osler, 1968; Tulving & Pearlstone, 1966; Tulving & Thomson, 1973).

One of the earliest studies done in this particular category of memory, storage and retrieval, sought to examine forgetting as the inability to find memory trace information from storage as opposed to the generally accepted position that the trace data were not available at all in memory (Tulving & Pearlstone, 1966). The study used list of words in various lengths, items organized by different levels of categories, and different conditions of recall to test 929 high school students. Subjects had to memorize a list of TBR words which were organized based upon a category level (i.e. – METALS: ALUMINUM, STEEL). The study found that higher recall was obtained under cued recall conditions (category names given) rather than non-cued recall conditions (no category names given). Moreover, the study suggests that “specific information” about the word must be available in memory trace in order for the word to be recalled even if the information is not accessible under a different set of recall conditions (Tulving & Pearlstone, 1966).

Questions about how information that was available in a memory trace only under certain conditions was the focus of another experiment that sought to clarify the effectiveness of retrieval cues (Tulving & Osler, 1968). A total of nineteen different combinations of experimental conditions were derived from encoding and retrieval cues. The results showed that TBR words could be recalled at a higher rate by weakly-

associated cues that were presented at encoding versus non-cued recall. Research questions concerning the effectiveness of retrieval cues facilitating recall if present only at retrieval, and the effectiveness of two cues at encoding and retrieval on recall were found to be non-conclusive (Tulving & Osler, 1968). The study suggested that “a retrieval cue is effective only if the information about it and its relation to the TBR item is stored at the same time with the TBR” (Tulving & Osler, 1968, p. 600).

The effectiveness of a cue at retrieval still remained from the Tulving and Osler experiment (1968). When cues are given only at retrieval they are considered to be extralist cues as opposed to those that are given at both encoding and retrieval which are to be intralist cues. For example, any word given to the learner during retrieval or is based upon pre-experimental associations to the TBR word this is considered extralist. Those given during encoding (with the TBR word) is said to be intralist. The exception is when the learner is left to his or her own devices at study (no cue), he/she is said to attempt to encode based upon meaning or other salient properties of the word also known as the word's associate (Tulving, 1983). This covert unobservable process of creating a relatable cue for the TBR word is known as subjective coding (Tulving, 1983). When a learner subjective codes a cue for the TBR word when no cue is presented at encoding, then that same word is presented as a cue during retrieval the cue functions as an intralist cue. Although the cue was not observable during encoding, the learner encoded the cue on his/her own in relationship to the TBR word making the cue an intralist cue, “namely, the to-be-remembered word was encoded with respect to it” (Tulving, 1983, p. 213).

An example would be the TBR word OCEAN. A learner with no given cue might automatically associate this with water and use it as a cue during retrieval. Essentially, water as it relates to OCEAN is a pre-experimental association that was not controlled for during the experiment. Therefore, there is no way of knowing if the learner was able to retrieve the TBR word OCEAN from the cue water that was given or based upon subjective coding if no control was considered. Subsequently, the claim of subjective coding altered the main emphasis of the encoding specificity principle which was modified to suggest that not only is the effectiveness of the retrieval cues important, but a key factor is also the interaction between encoding and retrieval (Tulving, 1983).

The modified version of encoding specificity theory sought to clarify the relationship between encoding and retrieval. Encoding specificity implied that no cue regardless of strength of association with the TBR word would be effective unless the cue was specifically encoded with the TBR word. This definition did not go without challenge as the encoding specificity theory was in contrast to the associative continuity hypothesis. The effectiveness of retrieval cues is also explained by the associative continuity hypothesis. The associative continuity hypothesis states that a pre-experimental association for each word event in a given list already exists. By definition the pre-experimental association that exist between word A and word B can serve as effective cues. Thus, word B can serve as an effective cue for word A and vice versa word A as a cue for word B. This association is said to exist regardless of what occurred at the time of the storage of the TBR item. The 1970 study by Thomson and Tulving considers the pre-experimental history important, but only slightly as it determines the encoding of a given TBR item at encoding. However, the effectiveness of cueing at retrieval is strongly determined by specific encoding of the TBR item at encoding, thus the pre-experimental history should have little affect on recall of an event (word is an event), even if the word is highly associative, “unless the encoding has influenced that event” (Thomson & Tulving, 1970, p. 256).

Since the question of association was still lingering, weak and strong cues were examined as these terms relate to the TBR word (Thomson & Tulving, 1970). Weak cues are words that have a lower frequency of eliciting the TBR word in a free associative test. Conversely, strong cues are words that would have a higher frequency of eliciting the TBR word in a free associative test. The purpose was to find out how both these types of associations, strong and weak work between the encoding and retrieval process. The experiment was set up similar to that of the Tulving and Olser 1968 study. There were three encoding conditions where words were (a) presented alone, (b) paired with a strong association or (c) paired with a weak association. The retrieval conditions were (a) non-cued recall, (b) recall of TBR word with weak retrieval cue, and (c) recall of TBR word with strong retrieval cue. When no word pairs were associated at study the TBR word presented at retrieval was said to be an extralist cue. Study of single words at study resulted in a greater recall probability under strong

associations then weak associations. However, when the weak associated word was paired with TBR word at encoding a greater recall probability was found when the cue was similar to weak then strong. The strong cue was not as effective during retrieval when a weak cue was encoded at study was paired with the TBR word (Thomson & Tulving, 1970). This provided more evidence for the encoding specificity hypothesis, which stated “among other things, no cue, however strongly associated with the TBR item or otherwise related to it, can be effective unless the TBR item is specifically encoded with respect to that cue at the time of its storage” (Thomson & Tulving, 1970, p. 255).

A replication of the weak/strong cued recall experiment (Thomson & Tulving, 1970) found a discrepancy in the original experimental design (Higham, 2002). Although the study was not to “undermine the general principle” of encoding specificity “the study found flaws in the method in which subjects were required to respond” (Higham, 2002, p. 67). The free-report retrieval method used in the original study was defined in Higham’s study (2002) as allowing non-responses to retrieval cues and was thought to have report bias and monitoring. Alternatively, using a signal detection model the effect of cue type (strong vs. weak) on retrieval could be determined along with accounting for report bias and monitoring (Higham, 2002, p. 70). The signal detection model uses the correct and incorrect reported responses from a free report and the correct and incorrect withheld responses from a forced report. The free report requires a response, but provides a reward for correct responses, a penalty for incorrect responses, and no penalty/reward for a blank response (monitoring). A forced report persuades the participant to provide a response to all test cues even if guessing is necessary (report bias). To estimate retrieval, report bias, and monitoring, a formula used response rates for both weak/strong cue types based upon the option to omit responses (free) versus not omit responses (forced).

The results found that retrieval was generally unaffected by free or forced response based upon cue type (Higham, 2002). Weak cues were unaffected by whether the participants had the option to withhold answers. Conversely, the retrieval of strong cues was not as good when participants had the option to withhold responses whereas they did better under the forced report condition. One of the main differences between

cue types can be illustrated by the potential correct responses using the free report condition. The weak cue type produced only 92% correct responses among participants in the free report condition compared to 28% correct responses from the strong cue type.

As expected, the data collected on free report retrieval, forced report retrieval, and cue type (strong/weak) reduced report bias and monitoring. Subsequently, the results still suggested encoding specificity, but considered a new procedure for collecting responses from subjects. Higham (2002) regarded the original study as providing weak evidence for the encoding specificity theory based upon flaws in research design. However, if memory researchers were to be surveyed the encoding specificity theory was thought to be one of the most important principles (Higham, 2002, p. 77).

Another aspect of encoding specificity that was discovered during an episodic memory task experiment was that of recognition failure of recallable words. Tulving and Thomson (1973) discovered that some TBR words that subjects could recall were not recognized. The definition of recognition failure of recallable words is “the phenomenon that previously studied items cannot be identified as ‘old’ although their names can be reproduced to other cues” (Tulving, 1983, p. 269). During the encoding process a unique memory trace is formed that consists of properties that correspond to the TBR word. The given properties of a TBR word are stored in the memory trace as cues for future retrieval. According to encoding specificity, the effectiveness of the retrieval cue depends on the relationship between the cue and the TBR word at encoding. As encoding specificity relates to recognition failure of recallable words, if a cue other than the word itself is used to facilitate the retrieval of the TBR word recall is said to occur. If the TBR word itself also known as a copy cue is used to facilitate retrieval then recognition is said to occur.

To test recall and recognition, participants were given three lists of word pairs. Two of the lists were to establish the participants in the process of encoding a TBR word with another word. The third list was used as the actual test of recall and recognition which consisted of 24 TBR words and weak cues. Participants either were given a recognition test then a recall test or the order of the test reversed. The

recognition test procedure was a free association task where participants were asked to write down at least four words for each of the cue words from the third list (Tulving & Thomson, 1973). From the list of words that the subjects developed the subject was to pick out the word that most likely was a TBR word. The recall test consisted of participants being given the cues from the same third list of 24 word pairs and then asked to write down the TBR word. Accordingly, the number of words that were recalled exceeded the number of words that were recognized by a ratio of 15 to 1 (Tulving & Thomson, 1973, p. 364). The rationale for such a counterintuitive claim was based upon the generality of the encoding specificity theory—“specific encoding operations performed on what is perceived determines what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored” (Tulving & Thomson, 1973, p. 369).

Although the encoding specificity theory was generally supported, there were still concerns over certain aspects of the theory. One specific challenge to the encoding specificity theory had to do with the controversial claim of recognition failure of recallable words. The challenge was not to directly dismiss the claim, but more so to clarify a contradiction made by the encoding specificity theory about another memory theory – generation-recognition theory (Martin, 1975).

The theory of generation-recognition states that if a TBR item is called upon for recall a person *generates* a set of possible candidates for which he/she then chooses upon the one that he/she *recognizes* as the most likely candidate (Martin, 1975). As another component of the encoding specificity theory experiment (Tulving & Thomson, 1973), a free-association task had participants attempt to generate or write 4 or 5 words thought to be the TBR words using strong extralist cues that were each associated with a TBR word, but not given as part of the original 24 paired list. From the words generated, the participants were then asked to attempt to recognize the TBR words from the list (similar to definition for generation-recognition theory). The participants were given a recall test using weak intralist cues either prior to or after the free-association recognition test. The results showed that the cued-recall words that were initially recalled (60% to 80%) were not readily recognized (20% to 30%).

The concern over the encoding specificity resulted from the claim of recognition failure of recallable words using two separate cues for recall and recognition test. According to the encoding specificity theory, how an item is stored during encoding is paramount to how that same item will be retrieved. Considering the semantic properties a TBR word could have multiple meanings, but only that for which is associated with the TBR word during encoding would be essential at retrieval based upon theory. Using a different cue for recognition is counter to providing a similar cue at encoding and retrieval and is similar to the argument of strong or weak cues. Even if the recognition test might result in the same TBR word being generated, the word carries a different meaning and is semantically not the same word (Martin, 1975). Drawing from the example used in the counterclaim, given the cue HEAD to return TBR word LIGHT (lamp) is distinctively different then if given the cue *dark* to return TBR word LIGHT (luminance) (Martin, 1975, p. 152). Therefore, since the cue provided in the free-association was not initially encoded with the TBR word it is possible that even if the exact TBR word was generated it would not be recognized because it is not compatible with what was originally encoded. Although the copy cue and the TBR word are identical, the specifically encoded trace of the item is different semantically (Tulving & Thomson, 1973; Wiseman & Tulving, 1976). The general argument was that encoding specificity theory did not actually demonstrate recognition failure of recallable words (Martin, 1975).

As a response, recognition failure of recallable words can be further explained when taking into account the total conditions in the cognitive environment at encoding (Tulving & Thomson, 1973). The TBR word is encoded based upon the context at study which produces a 'unique trace' (Wiseman & Tulving, 1976). Recognition failure occurs based upon the TBR word itself used as a cue not being appropriately matched to the 'unique trace' of the TBR word that was created at study (Wiseman & Tulving, 1976). The recall of the TBR word is based upon the retrieval cue that is successful at match with the encoded trace. The TBR word itself as a cue is placed in a different context then the list cue at recognition and thus can be considered as different then the original word (Wiseman & Tulving, 1976). Moreover, a more recent study confirmed that different factors affect recognition and recall (Hannon & Craik, 2001). For recall, the

factors appear to be the depth and semantic strength at encoding, the semantic significance between the encoding cue and the TBR word, and how the context is delivered at time of retrieval (Craik & Lockhart, 1972). On the other hand, for recognition, there needs to be similarity between the encoding and retrieval context as well as enough information about the semantic properties given during the encoding context (Hannon & Craik, 2001, p. 241).

The position of the encoding specificity theory has responded to matters relating to the encoding/retrieval paradigm. The encoding specificity theory claims: (a) specific information about a TBR word must be available in storage in order for the word to be recalled (Tulving & Pearlstone, 1966); (b) retrieval cues are effective if information about and the relation to the TBR word is encoded at the same time (Tulving & Osler, 1968); (c) weak cues would prevail over strong cues no matter how strong the association, if the weak cue was paired with the TBR word at encoding (Thomson & Tulving, 1970); and (d) words that were initially recalled might not be recognized (Tulving & Thomson, 1973).

Context Dependent Memory

The word-event experiments relating to encoding specificity have already alluded to context playing a role in the encoding/retrieval paradigm (Wiseman & Tulving, 1976). Related inquires into encoding specificity sought to expand upon the verbal/written laboratory type experiments to environments that provide a more practical approach (Canelos, Taylor, Dwyer, & Belland, 1985). The context of a given event extends well beyond just verbal/written cues that are encoded. The context of a given event opens the door to a host of attributes/properties that could serve as appropriate cues towards successful recollection.

Context for the benefit of this review relates to the learning context. More specifically, context is defined as the interrelated conditions at time of encoding which can have an effect on how information is stored and ultimately retrieved (Dwyer & Dwyer, 1990). The learning context can also include various views of multimedia – delivery, presentation, and sensory (Mayer, 2001). The rationale is that the learning context (encoding) of information can be based upon how the encoded information is

delivered, how it is presented, or how it is sensed. Each of these views of multimedia, according to the encoding specificity theory, has a corresponding memory trace and retrieval is therefore dependent upon the appropriate cue.

A series of studies were designed to add to the plausibility of encoding specificity by considering various other modes for which learning occurs in non laboratory or more natural environments (Canelos, Taylor, & Dwyer, 1984; Canelos, et al., 1985; Dwyer, 1987; Dwyer & Dwyer, 1990; McNeal & Dwyer, 1999; Williams & Dwyer, 2004; Yu & Berliner, 1981). The purpose of these studies was to add to research in instructional technology by designing effective instructional models that have been field tested through an examination of the dynamics that occur between encoding, storage, and retrieval. The context of a standard classroom lecture and mediated instruction formats provide a backdrop for examining the validity of encoding specificity that would be more generalizable (Canelos, et al. 1984, p. 81).

Common to most classroom based instruction is the standard lecture format. The use encoding specificity in a lecture format would suggest that information that is encoded during lecture would be most effective in retrieval if specific cues from the lecture were used at time of retrieval (testing). Subsequently, within the context of a lecture, other strategies are also employed, such as using an outline or taking notes. Do these additional mathemagenic activities (behaviors that lead to learning) aid in providing a wealth of salient cues from the environment that can be paired with the to-be-learned information that is stored and later retrieved?

One such study examined the use of encoding in the context of a typical lecture, where students were split into treatment groups based upon different encoding contexts a) listened to the lecture only; b) listened to lecture with notes; c) listened to lecture with an outline; and d) listened to lectures with notes and an outline (Yu & Berliner, 1981). In addition to the levels of encoding, subjects were placed into an after-lecture review (no review vs. review) and before-test review (no review vs. review). The retrieval of information was assessed by using a recognition test (multiple choice) and a short answer test (recall).

The results found some evidence for encoding specificity based upon the recognition and recall test performance. The listening to a lecture with notes and an

outline condition produced superior scores on both recognition and recall test versus the other contexts (Yu & Berliner, 1981). However, there was no clear indication if the results were based upon reviewing the notes and lecture after-test or before-test. The results would have lent themselves to stronger support of encoding specificity if significance was found through a three way interaction between encoding with outline, after-lecture review, and before test review (Yu & Berliner, 1981).

Instruction that is provided to students is not always verbal in nature. Visual Instruction can also be provided to students (Canelos, et al., 1984). Instruction that relates to “equipment operations”, “specific procedures”, and provides examples of how something looks, can often be best explained with a visual aid. Subsequently, even when the instruction is given in a visual context the assessment of what is learned tends to be verbal (Canelos, et al., 1984). The encoding specificity theory would consider the difference between the encoded visual context and retrieval verbal context as a mismatch, whereas recall and recognition would be lower.

Experiments that concentrated on the dynamics of visual instruction and encoding specificity had varied results. One study that found support for encoding specificity, examined visual and verbal context within an applied learning situation (Canelos, et al., 1984). Separate visual and verbal instruction conditions were used to instruct and assess students on the parts and process of the human heart. Both the visual and verbal conditions were presented using a synchronized audio tape slide presentation that named and described various categories of the heart. However, the slides for visual condition were illustrations along with verbal identifying labels and the slides for the verbal condition were verbal identifying labels (no illustration). The testing conditions for the study were free recall, visually cued-recall and verbally cued recall. The free recall condition was required to list the parts of the heart. Participants were able to recall without additional cues. The visual test condition was required to view illustrations of various parts of the heart and write down the corresponding response (no verbal cue). The verbal testing condition was required to record the various parts of the heart after being given the heart category and the first three letters for the test (no visual cue). The final breakdown for the study was six treatment and testing conditions: (a)

visual-free, (b) visual-visual, (c) visual-verbal, (d) verbal-free, (e) verbal-visual, and (f) verbal-verbal.

The results found significant support for the encoding specificity in the visual-visual (13.68 of 21, 65.1%) and the verbal-verbal (15.1 of 21, 72.2%). In addition, visual-verbal (15.3 of 21, 72.8%) treatment and testing condition was also found to be significant (Canelos, et al., 1984). Conclusions from the study suggested that there are two different encoding patterns for encoding the visual context and verbal context. The rationale was that the visual context processed the TBR information in a visual and verbal memory trace and thus allowing for more variance in the type of cues for retrieval (Canelos, et al., 1984). Basically, the TBR information encoded and ultimately stored in the visual condition appears to have been both visual and verbal, therefore, allowing the possibility that a visual or verbal cue in the testing environment be a match. The recommendation was that cues provided in the instructional setting should be the same as cues provided at time of test. Moreover, if visuals are part of the instruction then they should also be part of the testing (Canelos, et al., 1984).

A similar effect on encoding specificity was also found in a study which focused on the effectiveness of visual and verbal testing when retrieving information from visual instruction with varied rehearsal strategies and students knowledge levels (Dwyer & Dwyer, 1990). The visual rehearsal strategy had students overtly interact with the instructional content functioned best for the visual retrieval test, but also similarly well for the verbal retrieval test (Dwyer & Dwyer, 1990; McNeal & Francis, 1999). Moreover, the success of the verbal retrieval test from a visual encoded referent was an indication that some verbal cues might have been provided during visual instruction. The support for the encoding specificity from the various visual rehearsal strategies was also said to provide more elaborate information for students to retrieve which could lend to the possibilities of depth of processing from visual information (Craik & Lockhart, 1972). Furthermore, when not using overt visual strategies, simply looking at an object is not always adequate enough to produce the kind of cue necessary for future retrieval (McNeal & Dwyer, 1999).

Since a typical classroom environment tests students verbally, visual instruction alone does not always provide sufficient cues for retrieval (Canelos, et al., 1984;

Canelos, et al., 1985; Dwyer & Dwyer, 1990; McNeal & Francis, 1999). According to encoding specificity theory and context the information that is provided at encoding is important in determining relative cues for retrieval. The research on encoding specificity and context were generally found in favor of the theory even in a limited capacity (Canelos, et al., 1984; Canelos, et al., 1985; Yu & Berliner, 1981). Conversely, there have been a few studies that have drawn concerns for the encoding specificity theory.

The common practice in most classrooms is towards written assessments even when the primary mode of delivery is speech (Whitt, 2000). According to encoding specificity the effectiveness of retrieval cues is based upon how information is initially encoded (Tulving, 1983). Therefore, if the context for which information is encoded is speech (typical lecture) a similar context at retrieval should be the most effective. Related to the context of encoding and retrieval is a study that examined the effects of speech cues on long-term memory (Whitt, 2000). Students listened to a one-minute narrated story and were randomly assigned to one of three retrieval conditions. The treatment versus testing conditions were: (a) same voice reading questions from story (same-voice vs. same-voice), (b) different voice reading questions from story (same-voice vs. different-voice), and (c) narrated story and text only questions (same-voice vs. text).

The results of the study found no significant difference in recall and recognition for any of the treatment and testing conditions. The application of voice in both learning and testing environments would generally lean in favor of encoding specificity. The effectiveness of the retrieval cue is generally thought to be a direct relationship to the context for which the cue is initially encoded. The matching voice or even the distinctness of an individual's voice at both encoding and retrieval appears to be a function of encoding specificity. However, the finding of no significance does not support the encoding specificity claim. The results of the study suggest that there is not separate encoding for speech cues versus text cues. The relatedness of both speech cues and text cues given speech driven instruction were equally as effective (Whitt, 2000).

As noted earlier, written assessments are commonly used even when the instruction is delivered by speech (Whitt, 2000). But, what occurs when visual

instruction is paired with varied visual test formats? Does encoding specificity occur? Previous studies that focused on visual instruction, examined prior knowledge on retrieval; prior knowledge and test format; and visual and verbal test formats (Canelos, et al., 1984; Canelos, et al., 1985; Dwyer, 1987; Dwyer & Dwyer, 1990; McNeal & Dwyer, 1999). All of these studies primarily supported some form of encoding specificity. However, a study that examined the effect of visual instruction on varied visual test formats was unable to endorse the encoding specificity theory (Williams & Dwyer, 2004).

The Williams and Dwyer study (2004) differed from previous studies on visualized instruction by examining the effectiveness of visual test formats to retrieve information about certain educational objectives. Students were assigned to low and high prior knowledge groups based upon scores on a pre-assessment. Following the pre-assessment, students were given a multiple choice test to measure three educational objectives: facts, concepts, and procedures (Williams & Dwyer, 2004). The students in both high and low knowledge groups were then given visualized instruction that consisted of a self-paced booklet with detailed images of the physiology of the heart, labels on the parts of the heart, location of parts, and procedures during systolic/diastolic phases of the heart. Treatments consisted of (a) text only test, (b) visual simple test, (c) visual intermediate test, and (d) visual detailed test. The criterion for each test was to identify parts and position, define specific facts, and comprehend the function of various parts of heart based upon the position of another part.

The analysis revealed that the claims for encoding specificity were not substantiated. Previous considerations of rather weak support for encoding specificity that highlighted the possibility of a linkage with visual instruction with supplemental verbal components could not be found (Canelos, et al., 1985; Dwyer & Dwyer, 1990; McNeal & Francis, 1999). The poor results found that the visual instruction used “contained considerable superfluous stimuli”, moreover the limited capacity of memory suggests an overload of the type of information that could be stored in memory and later retrieved during testing (Williams & Dwyer, 2004).

Limited capacity of memory can possibly overload what can be encoded and thus have a negative effect on what is retrieved. Another study that had negative results

supporting encoding specificity was one that examined a slightly different context than those studies previously mentioned. The study examined the sensory context of motor encoding/retrieval enactment and verbal encoding/retrieval. The purpose of the study was to explore the effect of retrieval enactment on recall of verbal commands following motor encoding or verbal encoding (Kormi-Nouri, NyBerg, & Nilsson, 1994). Motor encoding consisted of completing a specific task after being given a verbal noun-verb command phrase. The verbal encoding was only the noun-verb command phrase. The testing groups were either motor retrieval or verbal retrieval and matched/mismatched with the treatment groups. Students in the motor retrieval would have to enact the entire task after only being given the verb portion of the noun-verb command. Moreover, verbal retrieval was only a written test where students were given only the verb portion of the noun-verb command and would have to recall the noun portion.

Results show that retrieval enactment did not improve memory. Performance was higher for motor encoding followed by a verbal test (Kormi-Nouri, NyBerg, & Nilsson, 1994, p. 723). The results suggest that motor cues might not be effective because of what had been stored as verbal cues. "Enactment increases the efficiency of the cue not the match between storage and retrieval formats" (Kormi-Nouri, NyBerg, & Nilsson, 1994, p. 726). The motor items encoded (processing at encoding) are fundamentally different from those items available at retrieval. Moreover, encoding specificity would have been effective if the encoded info would have been stored in some sort of "motoric code" then motor cues would have been effective and encoding specificity advantage would have been found" (Kormi-Nouri, NyBerg, & Nilsson, 1994, p. 727).

Shortcomings in support for encoding specificity might have been found if other cognitive theories of memory such as the redundancy principle (Mayer, Heiser, & Lonn, 2001) and extraneous cognitive load were used (Renkl & Atkinson, 2003). These two theories outline the inability of memory processes to function effectively if too much redundant information or irrelevant information is given at the time of study.

Context-dependent memory provides another viewpoint for examining encoding specificity theory. The use of context-dependent memory has wavered in support of encoding specificity (Whitt, 2000; Williams & Dwyer, 2004). Most of the studies in

context-dependent memory recognize the contribution of encoding specificity has made in memory research and still considers the question of matching context at study to context at test a significant research question to examine (McNeal & Dwyer, 1999).

Mood and State Dependent Memory

Variations on encoding specificity, other than those already mentioned, have also found support for the theory. Similar to context-dependent memory, studies on mood and state dependent memory have found that when a match occurs between either mood or state, recall and recognition performance is superior (Eich, Macaulay, & Ryan, 1994; Weingartner, Adefris, Eich, & Murphy, 1976). The measure of mood-dependent memory is fairly difficult to capture accurately (Eich, Macaulay, & Ryan, 1994). Mood dependent memory similar to context dependent memory is based upon matching the subject's mood at study (encoding) and at test (retrieval). The concern for demonstrating mood dependence is that 'mood' as a trait is often unobservable and is rather challenging to affectively create the exact same mood at study and at test (Eich, Macaulay, & Ryan, 1994). State dependent memory is somewhat easier to control as a subject's 'emotional state' is regulated and measured through the use of drugs (Weingartner, et al., 1976). The experiments in state dependent learning generally use alcohol as the drug of choice to examine if information that is encoded and stored during intoxication can be more effectively retrieved while the subject is in an intoxicated or sober state (Weingartner, et al., 1976).

A study examining the state dependent effects of alcohol on memory found that alcohol did not have an effect in the same state conditions (Duka, Weissenborn, & Dienes, 2001). Subjects in alcohol conditions as well as in sober conditions at both study and test had similar recall and familiarity scores. Early studies using alcohol have shown that while the overall scores of recall were not high, subjects performed better under matched state conditions as opposed to unmatched (Goodwin, Powel, Haskel, Hoine, & Stern, 1969; Weingartner, et al., 1976).

Despite the challenge of demonstrating mood dependence at study and at test, a number of experiments have shown mood related encoding specificity. Two experiments on extremely pleasant and extremely unpleasant moods found that

subjects were more likely to recall what was encoded several days earlier when moods matched (Eich, Macaulay, & Ryan, 1994). Another mood-dependent experiment examined learning at extremely stressful conditions such as that of skydiving (Thompson, Williams, L'Esperance, & Corenelius, 2001). Replicating the methodology of the classic scuba diving experiment (Godden & Baddeley, 1975), skydivers learned words in the air (high stress mood) and on land (low stress mood). Overall, extremely stressful conditions, even for experienced skydivers, did not merit the ability to learn well. However, under less stress conditions, recall was greatest when the context environments matched (Thompson, et al., 2001).

Much like context dependent memory studies on state/mood dependent learning have varying results on encoding specificity. Research examining state dependent memory during aerobic exercise and at rest found performance levels to be equivalent (Miles & Hardman, 1998). On the other hand, the use of fear-related state dependent memory (using spiders and snakes) was in support for matching (fear-fear/relax-relax) states at study and test “under the right set of conditions” (Lang, Craske, Brown, & Ghaneian, 2001, p. 702).

Mood and state dependent memory have been documented in the literature and have primarily shown support for encoding specificity. Although most of the general studies covering encoding specificity have been verbal/written and visual in nature, other sensory modalities have also been examined. One such study (three experiments) used ‘ambient’ odors that were pleasant (chocolate), unpleasant (mothballs), or no odor (control) paired with words stems at study and at test (Schab, 1990). According to the results, olfactory stimuli as a context cue was supported on the basis of encoding specificity in all three experiments (Schab, 1990, p. 654). “Once a clear association is developed, performance for odors can be equivalent to other modalities, but subsequent associations to the same odor are difficult to create” (Cann & Ross, 1989, p. 92).

Summary of Encoding and Retrieval Processes

The theory of encoding specificity has endured over three decades of scrutiny. Although there has been numerous concerns with regard to the methodology and validity of claims (Hannon & Craik, 2001; Kormi-Nouri, NyBerg, & Nilsson, 1994; Martin,

1975; Whitt, 2000; Williams & Dwyer, 2004) the basic premise is still considered invaluable to memory research and is fairly intuitive:

A TBR item is encoded with respect to the context in which it is studied, producing a unique trace which incorporates information from both target and context. For the TBR item to be retrieved, the cue information at the time of retrieval must appropriately match the trace of the item-in-context. (Wiseman & Tulving, 1976, p. 349-350).

Essentially, how one encodes information plays a role on our ability to recall or recognize what we have learned. However, several researchers have also eluded to the test (retrieval mechanism) being at the root of the problem and not necessarily what is learned (Canelos, et al., 1985; McNeal & Dwyer, 1999). Accordingly, the learner could have effectively learned all the TBR items, but the test could fail to provide the appropriate retrieval cues for the learner to recall or recognize.

The encoding specificity theory is fairly far reaching in scope. Thus far, experiments ranging from verbal, visual, smell, context, mood, and state have all shown support for encoding specificity (Dwyer & Dwyer, 1990; Eich, Macaulay, & Ryan, 1994; Schab, 1990; Tulving & Thomson, 1973). However, is encoding specificity a consideration when designing instruction and subsequent assessments? What does technology do to the development of appropriate instruction that takes advantage of being able to simulate most closely at both study and test? The interest of this theory will continue to be examined as researchers probe and explore how the human memory system works.

Summary

The literature review was designed to examine how students learn in multimedia environments. More specifically, the review was concerned with how information that is encoded into memory at study is effectively retrieved (the processes). The main topics covered in the review spanned memory, encoding specificity, and cognitive multimedia learning.

A plethora of research has been conducted on memory and as one author points out, no research has been as pivotal or recognized as that based upon the interaction

between encoding, storage, and retrieval; specifically that of encoding specificity (Higham, 2002, p. 77). The main body of research in this area has examined the use of verbal information to promote the match of information at study to that of test. The problem with much of the past research in encoding specificity, however was that learning tasks, learning materials, and presentation methods, employed in the experimental context, are too removed from typical instructional methods and classroom settings. This situation makes it difficult to apply these significant research results to the task of designing appropriate evaluation and testing methods that match instruction in terms of the basic memory elements of encoding, memory trace, and retrieval cues (Canelos, et al., 1984). Over time encoding specificity studies evolved to focus on elements such as visual, olfactory, context, mood, and state. The more recent studies, and perhaps the most relevant, also focused on creating environments that resembled actual learning situations which could be more generalizable. A number of the more recent studies conducted, also employed a multi-modal approach (visual and verbal) to learning. Unfortunately, these studies varied in support for encoding specificity. Some studies found that the matching of study and test modalities in support (visual-visual/verbal-verbal) and other studies found conflicting results between how information was encoded and thus retrieved using more than one modality. The results in these studies suggested that greater performance between mix-match modes at study and at test could be based upon the dual-coding theory or even depth of processing based upon the context.

The high volume of multimedia employed in the classroom whether face-to-face, stand-alone (self-paced), or at a distance lends itself well to reexamining the dilemma caused in earlier studies. The theory of cognitive multimedia learning provides nine principles that are guided by theories of learning which are ultimately grounded by the theories in memory. These principles of cognitive multimedia learning can outline best practices in designing instruction which can reduce cognitive load, which can block learning from occurring. Moreover, these principles can provide strategies for techniques using multiple modes at just the right dosages that optimize the possibilities for learning to occur.

A problem that can occur and often goes relatively unnoticed, is when learning occurs but the tool used to retrieve that for which is learned is ineffective. The problem is not the learner, but the tool for which the learning is assessed. Thus, the TBR information can not be recalled or recognized based upon the cues given at the time of testing. The function of the cognitive multimedia learning theory to drive design is limited to that of a single modality at the time of testing. An extension on both encoding specificity theory and cognitive multimedia theory would integrate the use of these two theories to determine if there is an optimal environment for which learning can be observed and measured.

Significance of the Study

The purpose of this study is to examine the effects of encoding specificity on learning in a multimedia environment. Encoding specificity theory states “that only that can be retrieved that has been stored, and that how it can be retrieved depends on how it was stored” (Tulving & Thompson, 1973, p. 359). Based upon the theory of encoding specificity there should be a relationship between the modality for which a learner encodes information into memory and the modality used to assess the learner’s knowledge. Modality attributes for purposes of this study included visual (animation) and verbal information (narration and text). The examination of these particular attributes is important to this study because it is designed to identify characteristics of electronic media presentations that contribute to learning. Learning was measured in two ways: retention of knowledge and transfer of knowledge.

Research Questions

The study explored the impact that encoding specificity has on learning. More specifically, this study examined how different presentation methods of instruction (i.e., animation and narration [AN]; animation and on-screen text [AT]; and text only [T]) impact participants’ recall and transfer scores based upon match/mismatched study and test environments. Subsequently, the study sought to answer the following questions:

1. What is the effect of encoding specificity on *recall* scores in a multimedia environment?

2. What is the effect of encoding specificity on *transfer* scores in a multimedia environment?

Hypotheses

The research questions presented were investigated through an experimental design. The study was designed to collect data and conduct analyses to test the following hypotheses:

- H₁: There will be no mean difference in *recall* scores for participants that experience match or mismatch during study and test conditions based upon modality (i.e., AN, AT, T).
- H₂: There will be no mean difference in *transfer* scores for participants that experience match or mismatch during study and test conditions based upon modality (i.e., AN, AT, T).

CHAPTER III

METHOD

Research Design

The study employed a 3 Encoding/Study (AN, AT, T) x 3 Retrieval/Test (AN, AT, T) full-factorial post-test only design (Wallen & Fraenkel, 2001).

Table 2

Representation of independent variables research design

		Retrieval Modality (Recall and Transfer Assessment)		
		Animation Narration	Animation Text	Text Only
Encoding Modality (Study)	Animation Narration			
	Animation Text			
	Text Only			

The research design was constructed to assess the effects of matched and mismatched encoding and retrieval modalities. Assignment to a group was randomized with each group receiving one of nine different combinations of study and test modality based upon the three levels of the two independent variables. The dependent variables is distinguishable among two specific measures of learning, one for recall and one for transfer.

Participants

The participants were 228 undergraduate students enrolled at a large research university in the mid-Atlantic region of the U.S. The participants were enrolled in a 1000-level personal health class and provided course credit upon completion of the entire investigation. All participants that were used in the final analysis were classified as

having low-experience in meteorology on the basis of a pre-assessment questionnaire. Previous studies have indicated that modality effects were stronger for low-experience learners (Moreno & Mayer, 1999). Based upon the scores from the pre-experiment assessment 13 participants were removed from the study who were classified as having high-experience in meteorology. This resulted in a total number of 215 participants.

Of the participants that were used in the final analysis, 34% (n=73) were female and 66% (n=142) were male. The majority of the participants were White/Caucasian 80.00% (n=172). The ethnicity of the remaining participants were Asian 10.23% (n=22), Black/African-American 3.26% (n=7), other descents 2.33% (n=5), Multiracial 1.86% (n=4), Hispanic/Latino 1.40% (n=3), and American-Indian/Alaskan Native .93% (n=2). The average age of the participants was 19.75 ($SD = 1.54$) with a range from 17 – 27 years old. All participants were undergraduate students with 41.86% (n=90) seniors, 28.84% (n=62) freshman, 20.47% (n=44) juniors, 8.37% (n=18) sophomores, and .46% (n=1) undeclared.

Treatment Groups

Participants in this study were randomly assigned to one of nine treatment groups. The groups were based upon a matched or mismatched modality at study and test. The content for each group at study and test was exactly the same, the process of how lightning is formed; but the format that the content was delivered at study and test could vary. The total of nine groups were: AN/AN, AN/AT, AN/T, AT/AN, AT/AT, AT/T, T/AN, T/AT, and T/T. The combinations were based upon three different study and test conditions described as followed.

Study Groups

Animation-narration study group (AN). Participants randomly assigned to the animation-narration study group received a unit of instruction on lightning formation using animation with synchronized narration (see Appendix A). The participants viewed the animated unit of instruction while listening to narration spoken in a male voice illustrating key steps in lightning formation.

Animation-text study group (AT). Participants randomly assigned to the animation-text study group received the exact same content of instruction on lightning

formation as the AN group, but the animation-text study group received animation with synchronized on-screen text, rather than animation with synchronized narration. The text was the same as the narration (see Appendix B).

Text-only study group (T). The participants randomly assigned to the text only group received the exact same content of instruction on lighting formation as the AN and AT study groups minus the animation and narration. The text-only group only received on-screen text of the instruction on lighting formation. The text that the participants read was exactly the same as the text given to the animation-text study group (see Appendix C).

Test Groups

Animation-narration test group (AN). After completion of the instruction, participants randomly assigned to the animation-narration test group were given recall and transfer tests. Each recall and transfer question began with an *animated-narrated* clip of varying length on lighting formation followed by either a recall or a transfer question. The questions were delivered using narration. There were 10 recall questions and 4 transfer questions. The same male voice that was used in the animation-narration study group was used for the question narration. The recall test required the participants to type in the appropriate response to an animated-narrated question in a short-answer form (see Appendix E). The transfer test consisted of an animated-narrated segment from the instruction treatment followed by a corresponding narrated learning question (see Appendix F).

Animation-text test group (AT). After completion of the instruction, the participants randomly assigned to the animation-text test group received the exact same recall and transfer questions that were provided in the animation-narration test group except that the questions were all in the form of animation with accompanying on-screen text. Each question began with an *animated-text* clip of varying length on lighting formation followed by either a recall or a transfer question. There were 10 recall questions and 4 transfer questions. The recall test required the participants to type in the appropriate responses to a series of short-answer questions from reading text and

watching animation. Similarly, the transfer test consisted of an animated-text segment from the instruction followed by a corresponding on-screen text question.


Text only test group (T). After completion of the instruction, participants randomly assigned to the text-only group received the exact same recall and transfer questions that were provided in the other two test groups (AN, AT); however there were no accompanying narration or animation. The on-screen text was exactly the same as the AT test group. Each question began with *text* of varying length on lighting formation followed by either a recall or a transfer question. There were 10 recall questions and 4 transfer questions. The recall test required the participants to type in the appropriate response to a series of short-answer questions after reading the text. The transfer test consisted of a text segment from the instruction followed by a corresponding text question.

Materials

The materials used in this study included a pre-experiment questionnaire, three different modes of instruction, and three different modes of assessment. The pre-experiment questionnaire was also administered on a computer using a web-based form. The pre-experiment questionnaire only assesses the participants experience in meteorology and the score was not included in the final data analysis. The content for each study and test session were exactly the same, but delivered via animation-narration, animation-text, or text-only. The study and the test sessions were administered on a computer using Macromedia Flash™ with the aid of standard over-the-head audio headphones designed for everyday home/office use. The instruction is based upon a unit of instruction originally developed by Moreno and Mayer (1999) and adapted by Doolittle and Hicks (2005). The assessment questions for the recall test were adapted from the original study in order to accommodate the use of animation (see Appendix E). The assessment questions for the transfer test are verbatim from the Mayer study but were adapted to include the addition of animation-narration or animation-text (Moreno & Mayer, 1999).

Pre-Experiment Assessment

Prior to the onset of the actual experiment each participant was given a questionnaire to assess his or her knowledge of meteorology. Using a computer the participants were given a six-item knowledge checklist and a five-item self-assessment. The instructions for the six-item knowledge checklist explain that participants should “Place a check mark next to the item that applies to you” (Moreno & Mayer, 2000 p. 119). The six items were as follows:

- I regularly read the weather maps in the newspaper
- I know what a cold front is
- I can distinguish between cumulus and nimbus clouds
- I know what a low pressure system is
- I can explain what makes the wind blow
- I know what this symbol means 

The five-item self assessment scale requires the participants to rate his or her knowledge of meteorology on a five point scale from 1 very little to 5 very much. The instructions for the self assessment asked the participant to “Please put a check mark indicating your knowledge of meteorology (weather) (Moreno & Mayer, 2000, p 119).”

very little	less than average	average	more than average	very much
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5

The pre-assessment filter test score was calculated by giving a point for every domain-related activity the participant checked from the checklist and adding that number to the number indicated by the participant in the self-assessment. The self assessment was scored by giving: 0 – very little, 1 – less than average, 2 – average, 3 – more than average, 4 – very much. Only participants with low-experience in meteorology as indicated by a score of 7 or less were included in the study. The criterion cut-off is based upon previous studies that used a similar pre-assessment filter test (Mayer & Moreno, 1998; Moreno & Mayer, 1999). Previous research on the

modality principle (using animation and narration presented together during instruction) suggest a stronger effect for low experience learners than for high experience learners (Mayer & Moreno, 1998; Moreno & Mayer, 1999). The results of the pre-experiment filter test was based solely on the meteorology checklist and self-assessment to obtain the participants level of experience (low or high) and not used in hypothesis testing.

Instruction Instrument

The unit of instruction was a 240-second segment on lightning formation created in Macromedia Flash™ and administered on a computer. The participant received no navigational controls and was not able to stop, pause, fast-forward, or rewind the presentation once it began. Three different versions of the instruction were used. Each version represented a slightly different mode of presentation to facilitate the instruction; animation-narration (AN), animation-text (AT), and text-only (T). The unit of instruction was viewed at a size of 800 mega pixels wide by 600 mega pixels high. The instructions for the animation-narration version prompted participants to wear headphones in order to hear the narration. The following text appeared on screen: “make sure you have, and are wearing, headphones. Click on ‘continue’ when you ready to begin” (see Appendix F). The instructions for both the animation-text version and text-only version were the same and informed the participant that he or she will not need the headphones that were sitting in front of them. The following text appeared on screen: “You do not need headphones for this tutorial. Click on ‘continue’ when you ready to begin”.

Once the participant clicked the continue button on any of the three versions, the unit of instruction on lightning formation began. After a duration of 240 seconds the unit of instruction was complete. The caption on the screen prompted the participant to click a button that took them to the assessment portion of the experiment.

Recall Assessment

To measure the effect of encoding specificity based upon modality, each participant was assessed in a specific modality, animation with narration (AN), animation with text (AT), or text only (T). Similar to the unit of instruction the assessment was also administered via a computer and viewed at 800 x 600. Recall is

defined as the ability to reproduce information that was previously presented (Mayer, 2001).

Animation-narration recall assessment. The instructions for the recall assessment for animation-narration began with a prompt to ensure that the participant had his or her headphones on in order to hear the narration (see Appendix G). The participant was given instructions relating to how to take the first part of the assessment. The following text appeared on-screen: “A short clip will be presented followed by a question, after hearing each question, type your response in the space provided. Click ‘continue’ when you are ready to begin”. The participants sequenced through each question one-by-one. They first watched and heard a short animated-narrated clip on lighting formation followed by a recall question. All AN recall questions were presented in narration format. Once the participants had answered the question by typing their responses in the appropriate text field they were prompted to proceed to the next question until they completed all ten questions.

For example, an instructional segment for scene 14 was presented in animation-narration format (regardless of what format the participant originally was given).

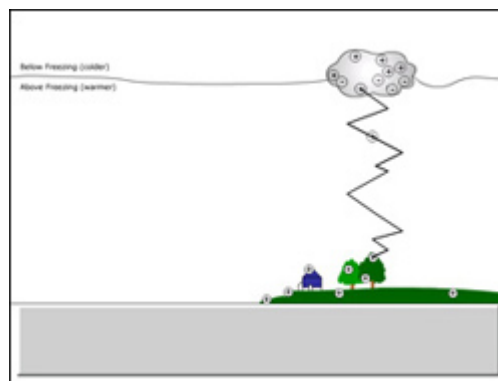


Figure 7. Scene 14 on lighting formation.

The corresponding narration was as follows: “Negatively charged particles then rush from the cloud to the ground along the path created by the leaders. It is not very bright”. A short pause will occur, the recall question will then be narrated to the participant: “When negative charges rush from the cloud to the ground, what happens?”

The correct response would be “positive charges rush from the ground to the cloud, forming lightning”.

Animation-text recall assessment. The animation-text assessment participants were given on-screen instructions prior to beginning of the assessment that they will not need headphones. The instructions for participants in the animation-text assessment were as follows: “A short clip will be presented followed by a question, after reading each question, type your response in the space provided. Click ‘continue’ when you are ready to begin”. The AT recall assessment used the exact same clips on lightning formation and was the same duration as the AN format. The only difference was that the short-clip and recall questions used on-screen text versus narration. The participants sequenced through each question one-by-one. They first watched and read a short animated-narrated clip on lightning formation followed by a recall question. All AT recall questions were presented in text format. Once the participants answered the question by typing their responses in the appropriate text field they were prompted to proceed to the next question until they completed all ten questions.

Text-only recall assessment. The instructions for the text-only assessment were as follows: “A short passage will be presented followed by a question, after reading each question, type your response in the space provided. Click ‘continue’ when you are ready to begin”. The T recall assessment used the exact same clips on lightning formation and was the same duration as the AN and T formats. The only difference was that the short-clip and recall questions were used only as on-screen text and there was no animation or narration. The participants sequenced through each question one-by-one. They first read a short animated-narrated clip on lightning formation followed by a recall question. All T recall questions were presented in text format. Once the participants answered the question by typing their responses in the appropriate text field they were prompted to proceed to the next question until they completed all ten questions.

Transfer assessment.

Transfer describes the ability to apply what was learned to problem solve (Mayer, 2001). A transfer assessment is able to gather “not only what the participants remember

but how they are able to apply what they have learned in a new situation, in other words measure the participants understanding (Mayer, 2001, p. 29). The transfer assessment was the same four questions used in the Mayer and Moreno (1998) study. The transfer questions were given in animation-narration, animation-text, or text-only formats and are as follows:

1. What could you do to decrease the intensity of lightning?
2. Suppose you see clouds in the sky, but no lightning. Why not?
3. What does air temperature have to do with lightning?
4. What causes lightning? or What do electrical charges have to do with lighting?

The presentation mode for the transfer questions corresponded to the recall questions; so, if the recall questions were in animation-text mode then the transfer questions were also in animation text mode. Moreover, all three presentation modes AN, AT, T were exactly the same duration.

Animation-narration transfer assessment. The animation-narration transfer assessment prompted the participant to wear his or her headphones before beginning. The next set of on-screen instructions were: "A short clip will be presented followed by a question, after hearing each question, type your response in the space provided. Click 'continue' when you are ready to begin". The participant first viewed a short animation-narration segment from the animation-narration instruction on lightning formation followed by a transfer question (see Appendix G). The transfer question was presented in a narration format.

Animation-text transfer assessment. The animation-text transfer assessment informed the participants that his or her headphones are not necessary to complete the additional questions. The next set of on-screen instructions for the animation-text transfer assessment were: "A short clip will be presented followed by a question, after hearing each question, type your response in the space provided. Click 'continue' when you are ready to begin". The participant viewed and read the animation-text segment followed by questions presented in a text format.

Text-only transfer assessment. After informing the participant that they do not need headphones the text-only transfer assessment instructions were: "A short passage

will be presented followed by a question, after reading each question, type your response in the space provided. Click 'continue' when you are ready to begin". The participant read the text-only segment from the original instruction as verbal cues and then read the transfer questions that were presented as text (see Appendix G).

Procedures

Undergraduates taking a 1000-level personal health course were solicited to take part in the study. Participants who are interested were required to go to a web site and register for the study. The compensation for partaking in the study was 15% of the participant's final course grade for the personal health course. Participants who chose not to participate in the study were given the option of a weight change project worth the same 15% of the participant's final course grade. As part of the online registration for the study, the participant provided some demographic information, completed a pre-experiment filter test, and scheduled a time to participate in the study. Prior to the registration process and the actual study, the protocol was approved by the university in accordance with the institution's Institutional Review Board (IRB) that governs all research conducted using human subjects.

As part of the online registration, all participants were asked to read an electronic informed consent form which was designed to provide general information about the study, the purpose of the study, procedures, risks, contact information, confidentiality statement, and notation that participation in study is voluntary. Once the informed consent was read, the participant either selected if they agree or disagree to take part in the study. Participants that agreed to take part in the study automatically was sent a copy of the Informed Consent form by e-mail and preceded to the first section, the participant questionnaire.

The first section, the participant questionnaire, consisted of general demographic information (i.e., e-mail, age, gender, classification, ethnicity and major). Once the participant completed the demographic information he/she was given some basic instructions for the second section; the pre-experiment filter test. For the pre-experiment filter test the participant was asked to provide his/her e-mail, place a check mark next to the item that applies to his/her knowledge of meteorology (six-item checklist), and then

rate his/her knowledge of meteorology (five-item self-assessment). Once the online pre-experiment filter test was completed; the six-item knowledge checklist and five-item self-assessment scores were automatically calculated and compiled in a database along with the demographic information. The third section, the scheduling page was designed for the participant to schedule a time to physically come into the lab to partake in the study. Once the participant's submitted his/her schedule the registration process is complete. The participant received an email confirmation that includes the date and time that he/she had selected and further details regarding the study.

When each participant arrived to lab he/she was asked by the experimenter to sit at one of the available computer workstations. Participants were tested individually in groups of 1 to 6 per session. Once all of the participants arrived and were settled the study began. First, the experimenter presented oral instructions regarding the procedures for the study. The experimenter explained that the study will take approximately 30 to 45 minutes to complete. After explaining the procedures the participants were given ample time to ask questions.

Second, the participants were asked to login using the user information that he/she used during the registration process. Once the participants have logged in successfully, they were given on-screen instructions to wait for the experimenter before proceeding. After the experimenter confirms that all participants have successfully logged in the experimenter informed the participants that they can click the 'next' button to begin the first part of the study.

Third, the participants were directed to the on-screen instructions for the unit on "how lighting forms". The first page of directions clearly outlined, in text format, the series of events that began with an instructional unit followed by some questions. The participants were prompted to click 'next' when they are ready to continue. The next set of instructions prompted only those in the AN instructional treatment to put on headphones. Participants in the AT and T instructional treatments were informed that headphones were not needed. The participants clicked 'continue' when they were ready to proceed. The 240 second instructional treatment was presented only once with no opportunity to stop, pause, advance, or rewind. Upon completion of the instructional

treatment the participants were notified to “wait for instructions from the experimenter before clicking the ‘next’ button.

Once the experimenter acknowledges that all the participants have completed the instructional treatment the experimenter informed the participants to click the ‘next’ button to proceed. Participants in the AN assessment treatment only were prompted to put on headphones. Participants in the AT and T assessment treatments were told that headphones will not be needed. The relevance for these statements in both the instruction treatment and the assessment treatment is that some participants might be asked to wear headphones during the instructional treatment and not during the assessment treatment. Conversely, some participants who did not wear headphones during the instructional treatment may need to wear headphones for the assessment treatment. The participants clicked ‘continue’ when they were ready to proceed to the actual assessment starting with ten recall questions followed by four transfer questions.

Each recall question was presented one at a time, beginning with a short instructional segment from the instructional treatment followed by a question. The instructional segment always matched the modality of the assessment treatment. The AN recall questions were an animated-narrated segment, followed by a narrated question. The AT recall questions were an animated-text segment, followed by a text question. The T recall questions were a text only segment, followed by a text question. Each question regardless of format was exactly the same duration. Following the question, a text box appeared and the participant was asked to “type in the appropriate response and click ‘next’ to continue to the next question”. The participant was asked to click to the next question until he/she completes the tenth and final recall question and then he/she was asked to “wait for instructions from the experimenter before clicking the ‘next’ button.

Once the experimenter acknowledged that all the participants have completed the recall questions he/she informed the participants to click the ‘next’ button to proceed to the next part. The next part was the transfer questions. The modality (AN, AT, T) for the transfer questions and the recall questions was exactly the same for each participant. Moreover, the format for the transfer questions was similar. The AN transfer questions were an animated-narrated segment, followed by a narrated question. The AT

transfer questions were an animated-text segment, followed by a text question. The T transfer questions were a text only segment, followed by a text question. Each question, regardless of format, was exactly the same duration. Following the question a text box appeared and the participant was asked to “type in the appropriate response and click ‘next’ to continue to the next question”. The participant was asked to click to the next question until he/she completes the fourth and final transfer question and then he/she was asked to “wait for instructions from the experimenter before clicking the ‘next’ button. The final screen thanked the participants for participating in the study. The experimenter also thanked the participants for participating in the study and dismissed the participants.

Scoring. The scoring for the recall and transfer test was done separately. Scorers who were not aware of the individual treatment groups were given a rubric from which to accurately score each test. Several formal training sessions were held to discuss the recall and transfer rubrics. The training sessions covered specific examples of acceptable and non-acceptable responses for recall/transfer and to practice scoring responses according to the rubric. Only one scorer was used for the recall test since there was only one possible correct response (see Appendix E). One point was given for each correct response with a total of ten possible (see Appendix E). Since there was more variability for responses to the four transfer questions two scorers were used. The scorers were trained to increase the reliability of the transfer scores. The two scorers for the transfer assessment determined whether the response to the questions were within the acceptable answer range or unacceptable (see Appendix F). Comparisons between the two scores were made to ensure agreement and any disagreements were determined by consensus (Moreno and Mayer, 1999). Transfer scores were based upon an acceptable response given with one point possible per correct acceptable response and no points given for unacceptable responses. Since the transfer questions are open-ended, the participants were given the opportunity to receive as many points per problem as acceptable answers they provided (see Appendix F).

Analysis of Data

Data collected from the recall and transfer scores were quantitative. The first analysis was a between-groups analysis of variance (ANOVA) using the scores from the pre-experiment filter test. The analysis was done to determine if there are any differences in group means based upon the nine different treatment groups (AN-AN, AN-AT, AN-T, AT-AN, AT-AT, AT-T, T-AN, T-AT, T-T). This analysis was conducted to determine group equality, relative to meteorological knowledge, prior to experiencing the treatments.

The next set of analyses were two 3 x 3 between groups analyses of variance (ANOVA) based on recall and transfer scores. The procedure was used to determine if the factorial levels of the independent variable and the interaction between the factorial levels have an effect on the dependent variables (recall and transfer) that is statistically significant (Gall, Borg, & Gall, 1996). All analysis was conducted at an alpha level of .05

CHAPTER IV

RESULTS

Introduction

The purpose of this study was to examine the effects of encoding specificity on learning in a multimedia environment. Based upon the theory of encoding specificity there should be a relationship between the modality for which a learner encodes information into memory and the modality used to assess the learner's knowledge. Participants were randomly assigned to one of nine treatment groups. The groups were based upon a matched or mismatched modality at study and test. The content for each group at study and test was exactly the same, the process of how lightning is formed; but the modality that the content was delivered at study and test could vary. The nine groups, based on study modality/test modality were: animation-narration/animation-narration (AN-AN), animation-narration/animation-text (AN-AT), animation-narration/text-only (AN-T), animation-text/animation-narration (AT-AN), animation-text/animation-text (AT-AT), animation-text/text-only (AT-T), text-only/animation-narration (T-AN), text-only/animation-text (T-AT), and text-only/text-only (T-T), (see Table 2).

First, the study employed a between-groups analysis of variance on the scores from the pre-experiment filter test for each group. This design assessed if the participants in each group had relatively the same amount of meteorological knowledge prior to experiencing the treatments. Next, the study employed a 3 encoding (AN, AT, T) x 3 retrieval (AN, AT, T) full-factorial post-test only design for recall scores and then transfer scores (Wallen & Fraenkel, 2001). This design assessed the effect of matched encoding modality and retrieval modality to mismatched encoding modality and retrieval modality on participants' recall and transfer scores.

Hypotheses

The research questions presented were investigated through an experimental design. The study was designed to collect data and conduct analyses to test the following hypotheses:

- H₁: There will be no mean difference in *recall* scores for participants that experience match or mismatch during study and test conditions based upon modality (i.e., AN, AT, T).
- H_{A1}: There will be a mean difference in *recall* scores for participants that experience match or mismatch during study and test conditions based upon modality (i.e., AN, AT, T). Specifically, based upon the modality principle (participants learn better when words are spoken rather than on-screen in a multimedia presentation) there is an expectation that participants in the AN-AN group will demonstrate significantly higher recall scores (Mayer, 2001, p. 134).
- H₂: There will be no mean difference in *transfer* scores for participants that experience match or mismatch during study and test conditions based upon modality (i.e., AN, AT, T).
- H_{A2}: There will be a mean difference in *transfer* scores for participants that experience match or mismatch during study and test conditions based upon modality (i.e., AN, AT, T). Specifically, based upon the modality principle there is an expectation that participants in the AN-AN group will demonstrate significantly higher recall scores.

Data Analysis

The data collected included a pre-experiment filter test, a post-test only score for recall and a post-test only score for transfer. The pre-experiment filter test consisted of a meteorological knowledge checklist and self-assessment worth 11 points (see Appendix D). The recall assessment consisted of ten short-answer questions designed for the participant to be able to reproduce information that was previously presented on lightning formation worth a maximum of 10 points (see Appendix E). A single independent rater scored the recall assessment (see Appendix E). The transfer assessment consisted of four short answer questions designed for the participant to be able to apply what was learned in a new situation within the subject of lightning formation worth a maximum of 8 points (see Appendix F). Two independent raters were trained to score the transfer assessment using a rubric (see Appendix F). The transfer

scores between the two scorers were compared to ensure that agreement and disagreements were determined by consensus. All data from the pre-experiment test, recall assessment, transfer assessment and demographic information were stored in a central database until the end of the study at which time the data were extracted, downloaded, and imported into SPSS for analysis.

Pre-Experiment Filter Test

The data collected for the pre-experiment filter test included a six-item knowledge checklist and a five-option self-assessment on meteorology (Moreno & Mayer, 2000 p. 119). Each item on the checklist was worth one point if checked for a possible of 6 points. The five-option, Likert-type scale, self assessment, (Please put a check mark indicating your knowledge of meteorology/weather), was scored from 1 (very little) to 5 (very much) points. The total potential score for the pre-experiment assessment ranged from 1 to 11 (see Appendix D). A one-way analysis of variance was conducted to determine pre-experimental group equality, relative to meteorological knowledge. The independent variable encoding/retrieval modality conditions included nine different groups (AN-AN, AN-AT, AN-T, AT-AN, AT-AT, AT-T, T-AN, T-AT, T-T). The dependent variable was the pre-experiment assessment score. In addition, a general descriptive analysis was performed that reported the means and standard deviations for each of the nine encoding-retrieval modality group conditions (see Table 3). The ANOVA was not significant, $F(8, 206) = 1.36$, $p = .21$, partial $\eta^2 = .05$ indicating no significant difference in pre-existing meteorological knowledge.

Table 3

Descriptive statistics for pre-assessment data based upon the nine treatment groups

		Retrieval Modality								
		Animation Narration			Animation Text			Text Only		
		n	M	SD	n	M	SD	n	M	SD
Encoding Modality (Study)	Animation Narration	24	3.79	1.93	21	3.48	1.63	22	3.41	1.99
	Animation Text	21	3.57	1.40	23	4.52	1.44	27	3.44	1.80
	Text Only	23	4.26	1.74	34	3.41	1.67	20	3.40	1.85

Max Score = 11, Low-Learner = 0 -7, High Learner = 8-11

Hypothesis 1

The data collected for the post-test only score for recall was based upon ten recall questions presented in either animation-narration, animation-text, or text-only with only one possible correct response. The total possible points for the recall score was 10. Since responses were based upon an objective test a single independent rater was trained to score the recall test questions using an assessment rubric (see Appendix E).

The first hypothesis measured the mean difference in *recall scores* for participants that experienced modality match (AN-AN, AT-AT, T-T) or mismatch (AN-AT, AN-T, AT-AN, AT-T, T-AN, T-AT) at study and test. The hypothesis was initially analyzed using a 3 x 3 between groups ANOVA. In addition, general descriptive analysis was performed that reported the means and standard deviations for each group condition for recall (see Table 4).

Table 4

General Descriptive statistics for AN, AN, and T Encoding/Retrieval Groups Based on Recall Scores

		Retrieval Modality								
		Animation Narration			Animation Text			Text Only		
		n	M	SD	n	M	SD	n	M	SD
Encoding Modality	Animation Narration	24	6.08	2.59	21	5.67	3.20	22	5.46	3.20
	Animation Text	21	7.33	1.98	23	8.13	1.42	27	4.93	2.20
	Text Only	23	5.57	1.78	34	4.85	2.28	20	3.90	2.94

Max Score = 10

The ANOVA revealed a significant difference in recall, $F(8, 206) = 6.88, p = .00$ partial $\eta^2 = .21$. Using the partial η^2 as the measure of association for the interaction between encoding modality and retrieval modality accounted for 21% of the total variability in the recall score. Given that significances were found in recall scores a series of single degree of freedom contrasts were used to determine specifically if matched versus mismatched groups were significantly different.

Follow-up test were conducted to evaluate pairwise differences among the means. Because the variances among the nine groups ranged from 2.03 to 10.23, this indicated that the variances might be different from each other and not homogeneous. Accordingly a Levene's test was used to test if nine samples have equal variances. Based upon the finding of significance on the Levene's test $F(8, 206) = 2.69, p = .008$ equal variances are not assumed therefore a post hoc procedure that does not require the population variances to be equal was confirmed (Green & Salkind, 2003). The Dunnett's C post hoc procedure was used since this procedure does not assume equal variances across the multiple pairwise comparisons and controls for Type I error.

Since hypothesis 1 was concerned with the mean differences between matched and mismatched scores, not the overall mean levels of encoding modality with the mean levels of retrieval modality, a test of the main effects was not conducted. Instead, simple effect analysis were conducted to examine the effect of a specific level (matched encoding/retrieval modality) on another variable (mismatched encoding/retrieval modality).

The purpose of the single degree of freedom contrasts was to determine where the significant differences were among the matched and mismatched recall groups. The contrasts assessed the means of the three matched modality encoding and retrieval groups with the mean of the four associated mismatched groups (see Table 7). The mismatched groups were associated with the matched group if they shared a common modality in either encoding or retrieval (e.g. the matched AN-AN group would have the following mismatched groups AN-AT, AN-T, AT-AN, and T-AN). There was no significant difference in mean recall scores between the matched AN-AN group ($M = 6.08$, $SD = 2.59$) and the combined mean mismatched group ($M = 6.00$, $SD = 2.47$), see Table 7. However, there was a significant difference in recall scores found between the matched AT-AT group ($M = 8.13$, $SD = 1.42$) and the combined mean mismatched group, ($M = 5.70$, $SD = 2.57$), and between the T-T group ($M = 3.90$, $SD = 2.94$) and the combined mean mismatched group, ($M = 5.19$, $SD = 2.18$), for recall scores (see Table 5).

Table 5

Single Degree of Freedom Contrasts of Matched versus Mismatched Recall Groups

Matched Modality	Mismatched Modality	<i>t</i>	<i>df</i>	p-value (2-tail)	Mean Difference	Standard Error
AN-AN	AN-AT, AN-T, AT-AN, T-AN	0.14	206	.88	.08	.54
AT-AT	AT-AN, AT-T, AN-AT, T-AT	4.49	206	.00*	2.43	.54
T-T	T-AN, T-AT, AN-T, AT-T	-2.27	206	.02*	-1.29	.57

* α at $p < .05$

Hypothesis 2

The data collected for the post-test only score for transfer was based upon four transfer questions presented as either animation-narration, animation-text, or text-only with several possible correct responses. Transfer scores were based upon an acceptable response(s) given with one point possible per correct acceptable response and no points given for unacceptable responses, with a maximum of 2 points per question. Thus, the total possible points for the transfer score was 8. Since the responses of the transfer test were open-ended two independent raters were trained to score the transfer questions using an assessment rubric (see Appendix F). Inter-rater reliability (r) for the transfer data was .81.

The second hypothesis measured the mean difference in *transfer scores* for participants that experienced modality match (AN-AN, AT-AT, T-T) or mismatch (AN-AT, AN-T, AT-AN, AT-T, T-AN, T-AT) at study and test. The hypothesis was initially analyzed using a 3 x 3 between groups ANOVA. In addition, a general descriptive analysis was performed that reported the means and standard deviations for each group condition for recall (see Table 6).

Table 6

General Descriptive statistics for AN, AN, and T Encoding/Retrieval Groups Based on Transfer Scores.

		Retrieval Modality								
		Animation Narration			Animation Text			Text Only		
		n	M	SD	n	M	SD	n	M	SD
Encoding Modality	Animation Narration	24	2.42	.97	21	2.05	1.32	22	2.00	1.31
	Animation Text	21	3.14	1.20	23	2.70	.97	27	2.04	1.02
	Text Only	23	2.65	1.37	34	1.97	1.11	20	1.65	1.23

Max Score = 8

The ANOVA revealed a significant difference for main effects in transfer, $F(8, 206) = 3.58, p = .00$ partial $\eta^2 = .12$. Using the partial η^2 as the measure of association

for the interaction between encoding modality and retrieval modality accounted for 12% of the total variability in the transfer score. Given that significance was found in transfer scores a series of single degree of freedom contrasts were conducted.

Since hypothesis 2 was concerned with the mean difference between matched and mismatched scores, not the overall mean levels of encoding modality with the mean levels of retrieval modality, a test of the main effect was not conducted. Instead, simple effects were conducted to examine the effect of a specific level (matched encoding/retrieval modality) on another variable (mismatched encoding/retrieval modality).

The purpose of the single degree of freedom contrasts was to determine where the significant differences were among the matched and mismatched transfer groups. The contrasts assessed the means of the three matched modality encoding and retrieval groups with the mean of the four associated mismatched groups (see Table 7). The mismatched groups were associated with the matched group if they shared a common modality in either encoding or retrieval (e.g. the matched AN-AN group would have the following mismatched groups AN-AT, AN-T, AT-AN, and T-AN). There was no significant difference in mean recall scores between the matched AN-AN group ($M = 2.42$, $SD = .97$) and the combined mean mismatched group ($M = 2.46$, $SD = 1.36$); matched AT-AT group ($M = 2.70$, $SD = .97$), and the combined mean mismatched group, ($M = 2.30$, $SD = 1.22$); and between the T-T group ($M = 1.65$, $SD = 1.23$) and the combined mean mismatched group, ($M = 2.16$, $SD = 1.21$), for recall scores (see Table 7).

Table 7

Single Degree of Freedom Contrasts of Matched versus Mismatched Transfer Groups

Matched Modality	Mismatched Modality	<i>t</i>	<i>df</i>	p-value (2-tail)	Mean Difference	Standard Error
AN-AN	AN-AT, AN-T, AT-AN, T-AN	-.16	206	.87	-.04	.27
AT-AT	AT-AN, AT-T, AN-AT, T-AT	1.47	206	.14	.40	.27
T-T	T-AN, T-AT, AN-T, AT-T	-1.81	206	.07	.51	.28

* α at $p < .05$

CHAPTER V

DISCUSSION

The goal of this study was to explore the effect of encoding specificity on recall and transfer in a multimedia environment. The study utilized multimedia methods to present materials in same or different modalities at study and test. The design for the multimedia presentations were based upon cognitive multimedia lessons in meteorology (Mayer, 2001) and encoding specificity of matched groups performing differently than mismatched groups.

The overall effect of encoding specificity on multimedia learning was assessed through two tests. Specifically, the participants were tested on their ability to recall information on lightning formation that was previously presented and to apply what was learned to problem solve (transfer). The independent variables encoding/study modality (animation-narration [AN], animation-text [AT], and text-only [T]) and retrieval/test modality (animation-narration [AN], animation-text [AT], and text-only [T]) were manipulated in order to assess the recall or transfer of knowledge measures in the participants. The discussion of the findings are based on results from statistical analyses, while the discussion on extending the findings is based on several questions posed within the literature as the study pertains to encoding specificity (Tulving, 1983) and cognitive multimedia learning (Mayer, 2001).

Overview of Findings

The two hypotheses posed by this research were analyzed statistically to attempt to isolate the possible significance of the matched and mismatched modality conditions on participants' multimedia learning.

The first hypothesis attempted to determine the effects of encoding specificity on participants' recall of a short multimedia tutorial on lightning formation. The analysis found that there was a significant difference in recall scores and subsequent single degree of freedom contrasts revealed that there was significant difference between the matched AT-AT group and the AT mismatched group (AT-AN, AT-T, AN-AT, T-AT). This finding indicates that participants in the matched AT-AT group performed better (+2.43) on average than participants in the AT mismatched group. Specifically,

participants were able to score the highest on recall test when animation-text encoding matched with animation-text retrieval. The finding of this individual analysis would lean to support encoding specificity.

There was also a significant difference between the matched T-T group and the mismatched AT group (T-AN, T-AT, AN-T, AT-T). However, even though significance was found in the T-T match group, the mean difference was less than that for the mean of the mismatched groups. The findings indicate that participants in the matched T-T group performed worse (-1.29) on average than participants in the T-T mismatched group. Specifically, participants scored lower on recall test when text-only encoding matched with text-only retrieval. The lower mean scores for the matched group versus the higher scores for the mismatched group dampen the effect of support for encoding specificity.

The second hypothesis attempted to determine the effects of encoding specificity on participants' performance on transfer. The analysis found that there was a significant difference in transfer between the nine groups (AN-AN, AN-AT, AN-T, AT-AN, AT-AT, AT-T, T-AN, T-AT, T-T). However the contrast analysis revealed that there were no significant differences between the matched and mismatched groups. The findings indicate that none of the matched treatment groups versus mismatched treatment groups had an effect on transfer scores. Participants scores did not appear to be affected either higher or lower by the fluctuation between similar or different encoding and retrieval conditions. Therefore, it can be concluded that encoding specificity based upon modality was not supported.

Subsequently, many of the mean scores tended to pile up toward the low end (floor effect) where there is not much variation based upon the lowest possible score. The assumption of a possible floor effect is based upon the measurement device actually measuring transfer effectively. According to the definition of transfer participants should not only remember new material but, are expected to apply what they learned to a new situation (Mayer, 2001, p. 29). The four transfer questions required participants to infer from what they learned to display a higher level of comprehension. The possible outcome was that the transfer questions were too challenging based upon what participants encoded. The low performance on the transfer test could have possibly

been reflective of a flaw in the test design. The use of different types of transfer assessments or the possibility of different levels of depth of knowledge to assess transfer merits revisiting.

Overall, there was little support for an encoding specificity multimedia principle. The use of modality to support encoding specificity was only found in 1 out of the 6 contrast analysis. The findings suggest that modality did not have an effect on participants' recall or transfer scores. The overall findings of lack of support for encoding specificity might not contribute drastically to the literature on encoding specificity; however, the findings do appear to have implications that can be inferred on the topic of cognitive multimedia learning.

Relationship of the Findings to Prior Research

The present study extended research in encoding specificity and multimedia learning by examining a blend of verbal/visual information in both the learning and testing environments; however, the study did not find much to support the claim of encoding specificity based upon modality. The use of modality in both encoding and retrieval condition to support encoding specificity was found only in the AT-AT matched recall group versus the mismatched groups. Although significance was found in the T-T matched group versus the mismatched groups the mismatched groups did significantly better than matched group and thus does not support the encoding specificity claim. Furthermore, significance was not found in any of the matched/mismatched transfer conditions.

Encoding Specificity

According to the theory of encoding specificity, what is encoded is a necessary condition of learning (Tulving, 1983). Subsequently, the "retrieval environment is just as paramount to learning as the encoding environment" (Whitt, 2000, p. 69). Encoding specificity suggests that there is an interaction between the conditions at encoding and retrieval thus, the to-be-remembered item will not be as effectively remembered during retrieval unless the cue was specifically encoded at time of storage (Thomson & Tulving, 1970; Tulving & Thomson, 1973). A number of studies have corroborated encoding specificity by demonstrating through word-event, context-dependent, state-

dependent and mood-dependent studies (Canelos, Taylor, & Dwyer, 1984; Godden & Baddeley, 1975; Thompson, Williams, L'Esperance, & Corenelius, 2001; Tulving & Thomson, 1973;). Moreover, the support of encoding specificity has also been found when using olfactory stimuli as a context cue in both encoding and retrieval conditions (Schab, 1990).

On the other hand, a number of studies did not find encoding specificity. Similar to Whitt (2000) the current study found no difference between recall and transfer scores when either aural or text cues were used following animated-narrated instruction. When a contrast analysis was done comparing matched AN-AN retrieval versus AN-AT, AN-T, AT-AN, T-AN there was only .07 mean difference in recall scores and .04 mean difference in transfer scores which was not significant. This implies that for recall the type of retrieval method (AN, AT, T) for animation-narration instruction does not make a difference and that encoding specificity was not supported.

The results of the current study are similar to other encoding specificity studies that found conflicting results between matched/mismatched modalities at study and test (Canelos, Taylor, & Dwyer, 1984; Whitt, 2000). Overall, the finding of no difference between modality encoding and retrieval conditions was evident and will not greatly impact research on encoding specificity. The results did provide however, some interesting revelations concerning cognitive multimedia learning.

Cognitive Multimedia Learning

The current study utilized the research on cognitive multimedia to attempt to manipulate the types of encoding and retrieval conditions that were designed. Although not much was found to suggest encoding specificity the findings have implications for research on cognitive multimedia learning.

The theory of cognitive multimedia learning is based upon the assumptions of dual-coding, limited capacity, and active processing and provides a framework for the principles of multimedia learning (Mayer, 2001). Numerous studies have been conducted in support of the principles of cognitive multimedia learning. The design of the current study used the exact same lesson on lightning formation used in previous studies (Mayer & Moreno, 1998; Moreno & Mayer, 1999). Specifically, the lesson was

based upon the use of principles such as the multimedia principle, modality principle, and coherence principle. The multimedia principle considers the use of printed words and pictures presented together during instruction. The modality principle factors the use of animation and narration over animation and text during instruction. Finally, the coherence principle creates a more precise learning experience by excluding irrelevant printed/spoken words, sounds, and pictures during instruction.

The finding of significance for matched AT-AT recall group versus mismatched AT recall group contradicted the modality principle of cognitive multimedia learning. Moreover, the overall mean score for AT was higher (8.13, See table 4) than all eight of the other groups. The modality principle clearly suggests that replacing text with narration eliminates competing verbal and nonverbal visual inputs and increases recall and transfer performance (Moreno & Mayer, 1999). Off-loading words as narration reduces the processing demands of the visual channel from an animated and on-screen text presentation (Mayer & Moreno, 2003). Moreover, an extensive review of research on auditory and visual modalities used for instruction concluded that working memory can be increased by using both the auditory and visual channels which supports the dual-coding theory (Penny, 1989). The current findings do not support the modality principle when using the same modality at both study and test.

One indication from the literature to support the counterintuitive findings in favor of animation-text is based upon the information delivery theory (Mayer, & Moreno, 2002; Mayer, 2001). According to this view, the computer is a method for delivering information. The information can be distributed from the computer to learner's as on-screen text, spoken words, pictures, or animation. One component of the theory defines a single mode of presentation just as effective in learning as a multimedia presentation. However, the theory also considers individual differences of the learner. Thus, another component of the theory considers multimedia presentations effective since the learner can choose the processing channel (visual/verbal) they prefer (Mayer & Moreno, 2002).

An observation that appears to support cognitive multimedia learning is the low scores for the T-T matched group in both recall and transfer. The use of text-only as a method of delivery at both encoding and testing yielded the lowest scores overall in both recall and transfer tests (see Table 8). The multimedia principle considers performance

to be greater when words and pictures are presented together rather than just text (Mayer, 1999, 2001). The use of a visual image (animation/illustration) helps the learner to focus attention, build internal connections, and reinforce/compliment text that is often difficult to understand by making the material more meaningful (Mayer, 1989).

Table 8

Rank Mean Scores for Recall and Transfer Groups

Recall Scores			Transfer Scores	
#	Encoding/Retrieval Group	mean	Encoding/Retrieval Group	mean
1	AT-AT	8.13	AT-AN	3.14
2	AT-AN	7.33	AT-AT	2.70
3	AN-AN	6.08	T-AN	2.65
4	AN-AT	5.67	AN-AN	2.42
5	T-AN	5.57	AN-AT	2.05
6	AN-T	5.46	AT-T	2.04
7	AT-T	4.93	AN-T	2.00
8	T-AT	4.85	T-AT	1.97
9	T-T	3.90	T-T	1.65

Recall scores based upon a maximum of 10 and transfer scores based upon a maximum of 8. T-T matched group represented by shaded area, T mismatched group represented by dotted line.

The results of previous studies on the multimedia principle (Mayer & Gillini, 1990; Mayer & Simms, 1992) coupled with the mean descriptive results from this study casually provide an indication that the addition of animation/picture at either study or test could improve recall and transfer scores (see Table 8). The importance of this observation is based upon the common practice of text-only instruction and assessment in traditional and online environments. The implications of simply adding some type of animation/picture to either the instruction or assessment to improve learning deserves further investigation.

The current research was able to use the results to explore in more detail encoding specificity and cognitive multimedia. The lack of no real significant difference

based upon modality provides pause for further investigation into encoding specificity on this topic. However, the counterintuitive superior recall score for the animation-text matched group appears to be open for additional inquiry into research on cognitive multimedia learning.

Implications for Future Theory or Practice

Based upon the findings of this study and the already existing body of research on cognitive multimedia learning, there exists potential to examine individual differences to explain the phenomenon between how individual encode information and how they retrieve information in a multimedia environment.

A variation to the current study is to do a within-subjects design where each participant will view one of the three levels for the factor of encoding (e.g. – animation-narration), and then assessed on all levels of the factor retrieval (e.g. – animation-narration, animation-text, text-only). The purpose would be to examine if there are any individual differences in a particular type of assessment modality based upon recall/transfer scores. Subsequently, a twist to this variation is to have each participant view all levels of encoding while only being tested on one of the three levels of retrieval. The application of this type of experiment would require that each participant be exposed to three different multimedia presentations to drown out several threats to internal validity.

The current research was based upon a 240 second multimedia cause-and-effect presentation conducted in a lab. Future research can be conducted in an actual multimedia classroom that has numerous opportunities for presenting materials and testing in different modalities over the course of a semester. The study could allow students to choose or be randomly assigned to various modality groups for study and test with the opportunity to drop several of the lowest test scores. This type of study would provide ecological validity as the results are more generalizable. Results could also have immediate implications for best practices in designing multimedia instruction.

The current research only examined the effect of encoding specificity and multimedia learning and did not find much in the way of significant differences. However, it is possible that there are individual differences that attribute to a difference

in encoding and retrieval conditions. Other variations of a similar study could examine individual differences on factors such as gender, age, reading ability, knowledge, type of instructional content, and field dependence. This would encourage the design and development of learning that is more meaningful to the learner through customization.

Summary

The dominant technology employed in instruction today is still the traditional lecture method (oratory instruction from teacher to student in a single classroom setting), but, that too is changing. The growing rate of technologies to supplement face-to-face instruction as well as instruction at a distance demands a paradigm shift in teaching and learning methodologies. Proper instructional design is essential to blend the theory of teaching and learning with practice.

The present study examined the relationship between the modality for which a learner encodes information into memory with the modality used to assess the learner's knowledge in a multimedia environment. Although the findings do not provide conclusions towards one modality that is best suited for instruction and assessment it does suggest that a multiple approach could accommodate different learner preferences. Typically, society has always fallen into the trap of a one-size fits all no-child left behind. We all learn differently and we should examine different methods of instruction and assessment that best meet the needs of the learner.

REFERENCES

- Aarntzen, D. (1993). Audio in courseware: Design knowledge issues. *Educational and Training Technology International*, 30(4), 354-366.
- Allen, I. E., & Seaman, J. (2004). *Entering the mainstream: The quality and extent of on-line education in the United States, 2003-2004*. Sloan Center for On-line Education at Olin and Babson Colleges: Needham, MA. Retrieved March 16, 2005, from http://www.sloan-c.org/resources/entering_mainstream.pdf.
- Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.
- Anderson, J. R. (2000). *Learning and memory* (2nd ed.). New York, New York: John Wiley & Sons, Inc.
- Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence and J. T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 2, pp. 89-195). New York, New York: Academic Press.
- Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York, New York: Holt, Rinehart and Winston, Inc.
- Ausubel, D. P. (1962). A subsumption theory of meaningful verbal learning and retention. *Journal of General Psychology*, 66, 213-244.
- Baddeley, A. D. (1986). *Working memory*. Oxford, UK: Oxford University Press.
- Baddeley, A. D. (1999). *Human memory*. Boston, MA: Allyn & Bacon.
- Bishop, M. J., & Cates, W. M. (2001). Theoretical foundations for sound's use in multimedia instruction to enhance learning. *Journal of Education, Training, Research and Development*, 49(3), 5-22.
- Bower, G. H. (2000). A brief history of memory research. . In E. Tulving and F. I. M. Craik (Eds.), *The Oxford Handbook of Memory* (pp. 3-32). New York, New York: Oxford University Press, Inc.
- Brown, S. C. & Craik, F. I. M. (2000). Encoding and retrieval of information. In E. Tulving and F. I. M. Craik (Eds.), *The Oxford Handbook of Memory* (pp. 93-107). New York, New York: Oxford University Press, Inc.

- Brown, R. & McNeill, D. (1966). The "tip of the tongue" phenomenon. *Journal of Verbal Learning and Verbal Behavior*, 5, 325-337.
- Burton, J. K. (1982). Dual coding of pictorial stimuli. *Journal of Mental Imagery*, 6, 159-168.
- Burton, J. K., & Bruning, R. H. (1982). Interference effects on the recall of pictures, printed words and spoken words. *Contemporary Educational Psychology*, 7, 61-69.
- Cann, A. & Ross, D. A. (1989). Olfactory stimuli as context cues in human memory. *American Journal of Psychology*, 102(1), 91-102.
- Canelos, J., Taylor, W., & Dwyer, F. (1984). *The effects of recall cue and cognitive trace compatibility when learning from mediated instruction: An applied view of Encoding Specificity*. Paper presented at the Annual Convention for the Association for Educational Communication and Technology, Dallas, TX, 72-98.
- Canelos, J., William, T., Dwyer, F., & Belland, J. (1985). *The psychological construct of encoding specificity and its relationship to designing instruction and tests*. Paper presented at the Annual Convention for the Association for Educational Communication and Technology, Anaheim, CA, 1-12.
- Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, 8(4), 293-332.
- Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research*, 53(4), 445-459.
- Clark, R. E., & Salomon, G. (1986). Media in teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed.). New York, New York: MacMillian Publishing.
- Cooper, G. (1990). Cognitive load theory as an aid for instructional design. *Australian Journal of Educational Technology*, 6(2), 108-113.
- Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 11, 671-684.
- Doolittle, P. & Hicks, D. (2005). *Cognitive theory of multimedia treatments: Lighting formations*. Retrieved December 18, 2005, from <http://edpsych.claahs.vt.edu/mayer/>

- Doolittle, P. E., McNeill, A., Terry, K. P., & Scheer, S. B. (2005). Multimedia, cognitive load and pedagogy. In S. Mishra & R. C. Sharma (Eds.) *Interactive multimedia in education and training* (pp. 184-212). Hershey, PA: IDEA group.
- Duka, T., Weissenborn, R., & Dienes, Z. (2001). State-dependent effects of alcohol on recollective experience, familiarity and awareness of memories. *Psychopharmacology*, 153, 295-306.
- Dwyer, C. A. (1987). *The effect of varied practice activities in complementing visualized instruction*. Paper presented at the Association for Educational Communications and Technology, Atlanta, GA, (pp. 185-203).
- Dwyer, F. M., & Dwyer, C. A. (1990). *Effects of students' prior knowledge and presentation mode on achievement (visual/verbal testing) of different educational objectives*. Paper presented at the Association for Educational Communications and Technology, Anaheim, CA, (pp. 194-209).
- Eich, E. (1995). Mood as a mediator of place dependent memory. *Journal of Experimental Psychology: General*, 124(3), 293-308.
- Eich, E., Macaulay, D., & Ryan, L. (1994). Mood dependent memory for events of the personal past. *Journal of Experimental Psychology: General*, 123(2), 201-215.
- Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction*. White Plains, NY: Longman Publishers.
- Gellevij, M., Meij, H. V. D., Jong, T. D., & Pieters, J. (2002). Multimodal versus unimodal instruction in a complex learning context. *The Journal of Experiential Education*, 70(3), 215-239.
- Godden, D. R., & Baddeley, A. D. (1975). Context-dependent memory in two natural environments: On land and underwater. *British Journal of Psychology*, 66(3), 325-331.
- Goodwin, D., Powell B., Bremmer, D., Hoine H., & Stern, J. (1969). Alcohol and recall: State-dependent effects in man. *Science*, 163, 1358-1360.
- Green, S. B. & Salkind, N. J. (2003). *Using SPSS for Windows and Macintosh*, 3rd Ed. Upper Saddle River, NJ: Prentice Hall.

- Gunter, B., Furnham, A., & Leese, J. (1986). Memory for information from a party political broadcast as a function of the channel of communication. *Social Behaviour, 1*, 135-142.
- Hannon, B., & Craik, F. I. M. (2001). Encoding specificity revisited: The role of semantics. *Canadian Journal of Experimental Psychology, 55*(3), 231-243.
- Higham, P. A. (2002). Strong cues are not necessarily weak: Thomson and Tulving (1970) and the encoding specificity principle revisited. *Memory & Cognition, 30*(1), 67-80.
- Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist, 38*(1), 23-31.
- Kormi-Nouri, R., Nyberg, L., & Nilsson, L. G. (1994). The effect of retrieval enactment on recall of subject-performed tasks and verbal tasks. *Memory & Cognition, 22*(6), 723-728.
- Koroghlanian, C. M., & Sullivan, H. J. (1999, February 10-14). *The use of audio in computer-based instruction*. Paper presented at the Association for Educational Communications and Technology (AECT), Huston, TX.
- Lang, A. J., Craske, M. G., Brown, M., & Ghaneian, A. (2001). Fear-related state dependent memory. *Cognition and Emotion, 15*(5), 695-703.
- Lee, Y., Driscoll, M. P., & Nelson, D. W. (2004). The past, present, and future of research in distance education: Results of a content analysis. *The American Journal of Distance Education, 18*(4), 225-241
- Levie, W. H., & Dickie, K. E. (1973). The analysis and application of media. In R. Traverse (Ed.), *Second handbook of research on teaching* (pp. 858-882), Chicago, IL: Rand McNally.
- Lewis, P. A., & Critchley, H. D. (2003). Mood-dependent memory. *Trends in Cognitive Sciences, 7*(10), 431-433.
- Lockee, B. B., Burton, J. K., & Cross, L. H. (1999). No comparison: Distance education finds a new use for 'no significant difference'. *Journal of Education, Training, Research and Development, 47*(3), 33-42.
- Loftus, G. R., & Loftus, E. F. (1976). *Human memory: The processing of information*. Hillsdale, NJ: Lawrence Erlbaum Associates.

- Martin, E. (1975). Generation-recognition theory and the encoding specificity principle. *Psychology Review*, 82(2), 150-153.
- Mann, B. L. (1992). The SSF Model: Structuring the functions of the sound attribute. *Canadian Journal of Educational Communication*, 21(1), 45-65.
- Mann, B. L. (1995). Focusing Attention with Temporal Sound. *Journal of Research on Computing in Education*, 27(4), 402-424.
- Mautone, P. D., & Mayer, R. E. (2001). Signaling as a cognitive guide in multimedia learning. *Journal of Educational Psychology*, 93(2), 377-389.
- Mayer, R. E. (1989). Systematic thinking fostered by illustrations in scientific text. *Journal of Educational Psychology*, 81(2), 240-246.
- Mayer, R. E. (1996a). Learners as information processors: Legacies and limitations of educational psychology's second metaphor. *Educational Psychologist*, 31(3/4), 151-161.
- Mayer, R. E. (1996b). When less is more: Meaningful learning from visual and verbal summaries of science textbook lessons. *Journal of Educational Psychology*, 88(1), 64-73.
- Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions? *Educational Psychologist*, 32(1), 1-19.
- Mayer, R. E. (1999). Multimedia aids to problem-solving transfer. *International Journal of Educational Research*, 31, 611-623.
- Mayer, R. E. (2001). *Multimedia learning*. New York, NY: Cambridge University Press.
- Mayer, R. E. (2003). *Learning and instruction*. Upper Saddle River, NJ: Merrill Prentice-Hall.
- Mayer, R. E., & Anderson, R. B. (1991). Animations need narrations: An experimental test of a dual coding hypothesis. *Journal of Educational Psychology*, 83(4), 484-490.
- Mayer, R. E., & Anderson, R. B. (1992). The instructive animation: Helping students build connections between words and pictures in multimedia learning. *Journal of Educational Psychology*, 84(4), 444-452.

- Mayer, R. E., Bove, W., Bryman, A., Mars, R., & Tapangco, L. (1996). When less is more: Meaningful learning from visual and verbal summaries of science textbook lessons. *Journal of Educational Psychology, 88*(1), 64-73.
- Mayer, R. E., & Chandler, P. (2001). When learning is just a click away: Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology, 93*, 390-397.
- Mayer, R. E., & Gallini, J. K. (1990). When is an illustration worth ten thousand words? *Journal of Educational Psychology, 82*(4), 715-726.
- Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: when presenting more material results in less understanding. *Journal of Educational Psychology, 93*(1), 187-198.
- Mayer, R. E., Mathias, A., & Wetzell, K. (2002). Fostering understanding of multimedia messages through pre-training: Evidence for a two-stage theory of mental model construction. *Journal of Experimental Psychology: Applied, 8*(3), 147–154.
- Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: evidence for dual processing systems in working memory. *Journal of Educational Psychology, 90*(2), 312-320.
- Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*(1), 43-52.
- Mayer, R. E., & Moreno, R. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review, 14*(1), 87-99.
- Mayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology, 86*(3), 389-401.
- McCrudden, M., Schraw, G., & Hartley, K. (2004). The influence of presentation organization and example context on text learning. *The Journal of Experimental Education, 72*(4), 289-306.
- Mclsaac, M. S., & Gunawardena, C. N. (1996). Distance education. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 403-437). Simon & Schuster Macmillan: New York, New York.

- McNeal, J. M., & Dwyer, F. (1999). Effect of varied rehearsal strategies and testing format on student achievement. *International Journal of Instructional Media*, 26(4), 435-445.
- Miles, C., & Hardman, E. (1998). State-dependent memory produced by aerobic exercise. *Ergonomics*, 41(1), 20-28.
- Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *The Psychological Review*, 63, 81-97.
- Miller, H. B., & Burton, J. K. (1994). Images and imagery theory. In D. M. Moore and F. M. Dwyer (Eds.), *Visual literacy: A spectrum of visual learning* (pp. 65-83). Englewood Cliffs, NJ: Educational Technology Publications.
- Moore, D. M., Burton, J. K., & Myers, R. J. (1996). Multiple-channel communication: The theoretical and research foundations of multimedia. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 851-875). New York, New York: Simon & Schuster, Macmillian.
- Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology*, 91(2), 358-368.
- Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology*, 92(1), 117-125.
- Mousavi, S. Y., Low, R., & Sweller, J. (1995). Reducing cognitive load by mixing auditory and visual presentation modes. *Journal of Educational Psychology*, 87(2), 319-334.
- Paivio, A. (1986). *Mental representations: A dual-coding approach*. New York, New York: Oxford University Press.
- Pass, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design recent developments. *Educational Psychologist*, 38(1), 1-4.
- Pass, F., Tuovinen, J. E., Tabbers, H., & Van Gerven, P. W. M. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist*, 38(1), 63-71.

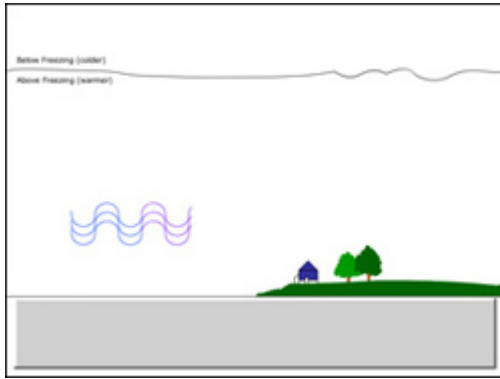
- Pellegrino J. W., Siegel, A. W., Dhawan, M. (1975). Short-term retention of pictures and words: evidence for dual coding systems. *Journal of Experimental Psychology: Human Learning*, 104(2), 95-102.
- Pellegrino, J. W., Siegel, A. W., & Dhawan, M. (1976). Short-term retention of pictures and words as a function of type of distraction and length of delay interval. *Memory & Cognition*, 4(1), 11-15.
- Penney, C. G. (1989). Modality effects and the structure of short-term verbal memory. *Memory & Cognition*, 17(4), 398-422.
- Plass, J. L., Chun, D. M., Mayer, R. E., & Leutner, D. (1998). Supporting visual and verbal learning preferences in a second-language multimedia learning environment. *Journal of Educational Psychology*, 90(1), 25-36.
- Pollock, E., Chandler, P., & Sweller, J. (2002). Assimilating complex information. *Learning and Instruction*, 12, 61–86.
- Postman, L., & Keppel, G. (Eds.). (1969). *Verbal learning and memory*. Baltimore, MD: Penguin Books.
- Renkl, A., & Atkinson, R. K. (2003). Structuring the transition from example study to problem solving in cognitive skills acquisition: A cognitive load perspective. *Educational Psychologist*, 38, 15-22.
- Rothkopf, E. Z. (1996). Control of mathemagenic activities. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 879-896). New York, New York: Simon & Schuster, Macmillian.
- Russell, T. L. (1999). *The No Significant Difference Phenomenon: A comparative Research Annotated Bibliography on Technology for Distance Education*. Montgomery, AL: International Distance Education Certification Center [Electronic version]. Retrieved April 6, 2005, from <http://www.nosignificantdifference.org/>
- Schab, F. R. (1990). Odors and the remembrance of things past. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 16(4), 648-655.
- Schacter, D. L., Wagner, A. D., & Buckner, R. L. (2000). Memory systems of 1999. . In E. Tulving and F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 627-643). New York, New York: Oxford University Press.

- Sweller, J., van Merriënboer, J. G., & Pass, F. G. W. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, 10(3), 251-296.
- Thompson, L. A., Williams, K. L., L'Esperance, P. R., & Cornelius, J. (2001). Context-dependent memory under stressful conditions: The case of skydiving. *Human Factors*, 43(4), 611-619.
- Thomson, D. M., & Tulving, E. (1970). Associative encoding and retrieval: Weak and strong cues. *Journal of Experimental Psychology*, 86(1), 255-262.
- Tripp, S. D., & Roby, W. B. (1996). Auditory Presentations and Language Laboratories. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 821-850). New York, New York: Simon & Schuster Macmillan.
- Tulving, E. (1983). *Elements of episodic memory*—Oxford psychology series No. 2. New York, New York: Oxford University Press.
- Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 80(5), 352-373.
- Tulving, E. and Osler, S. (1968). Effectiveness of retrieval cues in memory for words. *Journal of Experimental Psychology*, 77(4), 593-601.
- Tulving, E., and Pearlstone, Z. (1966). Availability versus accessibility of information in memory for words. *Journal of Verbal Learning and Verbal Behavior*, 5, 381-391.
- Wallen, N. E. & Fraenkel, J. R. (2001). *Educational research: A guide to the process* (2nd Edition). Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Weingartner, H., Adefris, W., Eich, J. E., & Murphy, D. L. (1976). Encoding-imagery specificity in alcohol state-dependent learning. *Journal of Experimental Psychology: Human Learning and Memory*, 2(1), 83-87.
- Whitt, G. (2000). *The effects of speech cues on long-term memory*. Unpublished Dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA.
- Williams, J., & Dwyer, F. (2004). The relative effectiveness of varied visual testing formats in retrieving information related to different educational objectives. *International Journal of Instructional Media*, 31(3), 257-266.

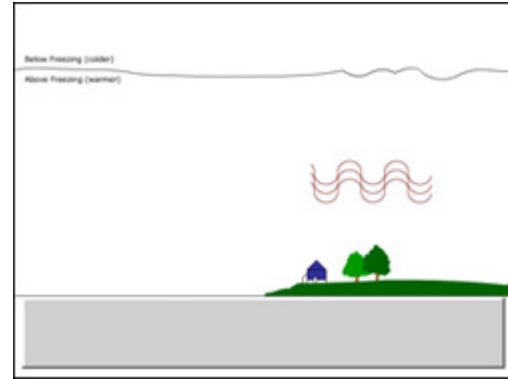
- Winn, W., & Snyder, D. (1996). Cognitive perspectives in psychology. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 112-142). Simon & Schuster Macmillan: New York, New York.
- Wiseman, S. & Tulving, E. (1976). Encoding specificity: Relation between recall superiority and recognition failure. *Journal of Experimental Psychology: Human Learning and Memory*, 2(4), 349-361.
- Yu, H. K., & Berliner, D. C. (1981). *Encoding and retrieval of information from lecture*. Paper presented at the Annual meeting of the American Educational Research Association, Los Angeles, CA, 2-24.

APPENDIX A: LIGHTNING FORMATION, ANIMATION + NARRATION

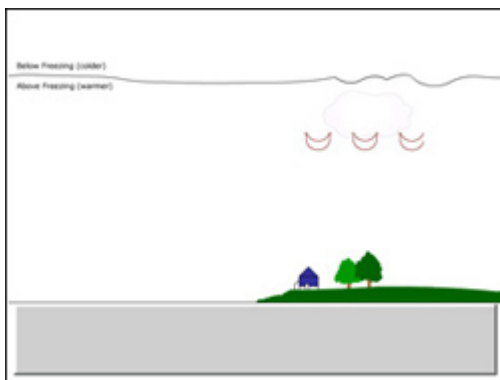
Duration: 240 seconds



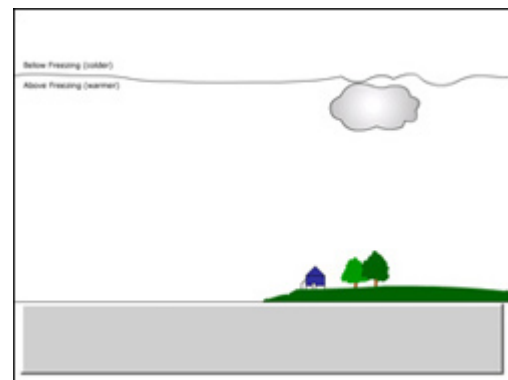
Scene 1: Cool moist air moves over a warmer surface and become heated.



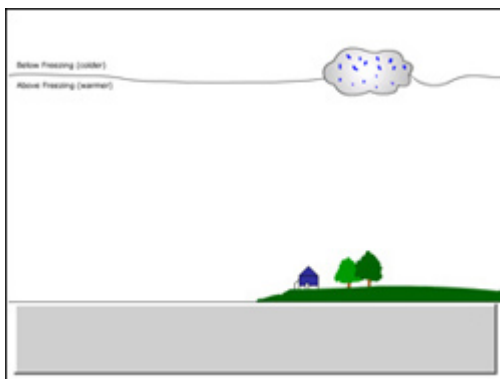
Scene 2: Warmed moist air near the earth's surface then rises rapidly.



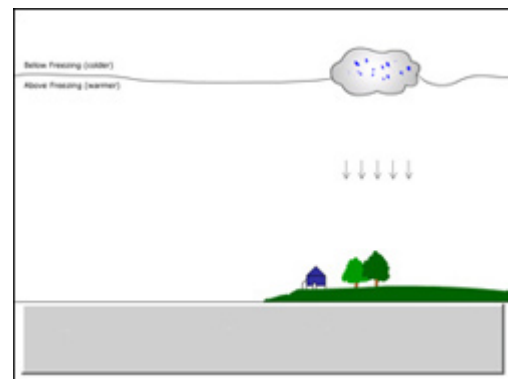
Scene 3: As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.



Scene 4: The cloud's top extends above the freezing level, so the upper portion of the cloud is composed of tiny crystals.



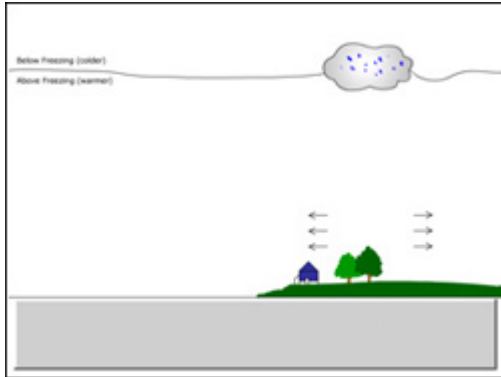
Scene 5: Eventually, the water droplets and ice crystals become too large to be suspended by the updrafts.



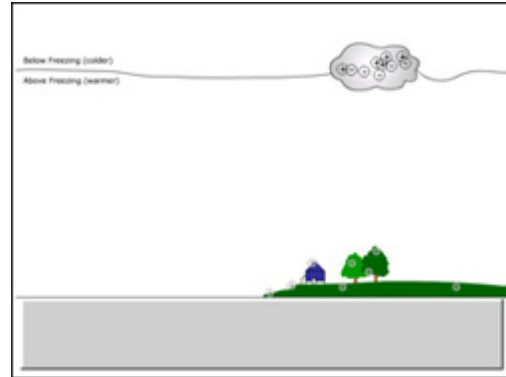
Scene 6: As raindroplets and ice crystals fall through the cloud, they drag some of the air in the cloud downward, producing downdrafts.

URL: <http://edpsych.clahs.vt.edu/mayer/treatments/G2.html>

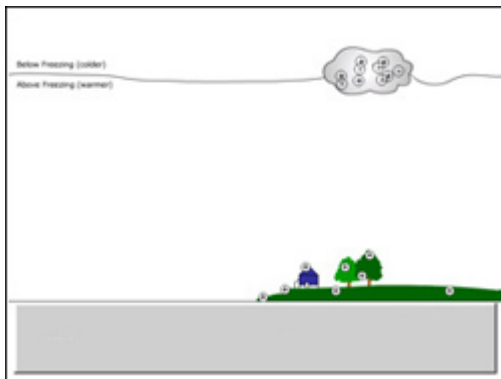
APPENDIX A: LIGHTNING FORMATION, ANIMATION + NARRATION (continued)



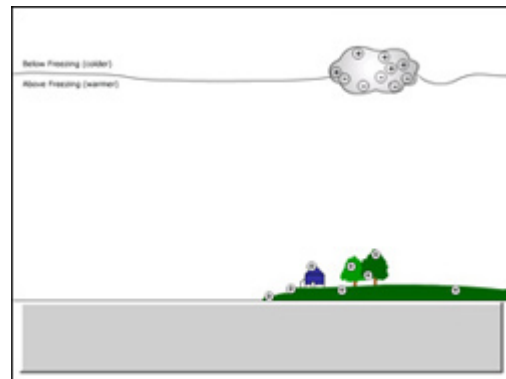
Scene 7: When downdrafts strike the ground, they spread out in all directions, producing the gusts of cool wind people feel just before the start of rain.



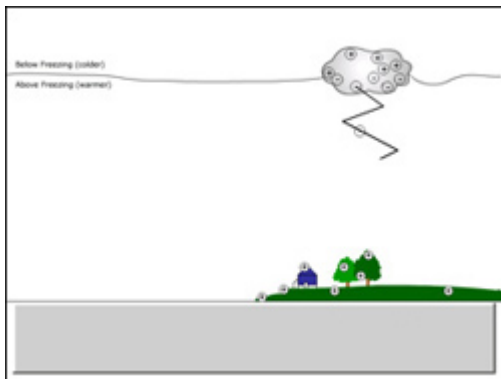
Scene 8: Within the cloud, the rising and falling air currents cause electrical charges to build.



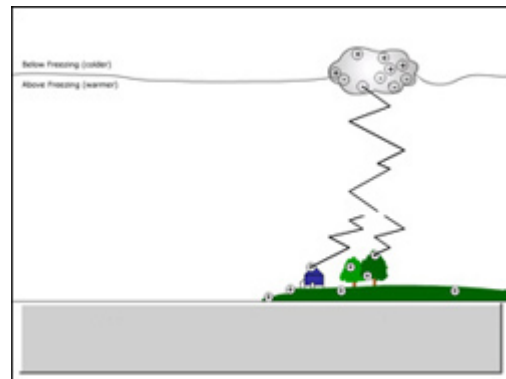
Scene 9: The charge results from the collision of the cloud's rising water droplets against heavier, falling pieces of ice.



Scene 10: The negatively charged particles fall to the bottom of the cloud, and most of the positively charged particles rise to the top.



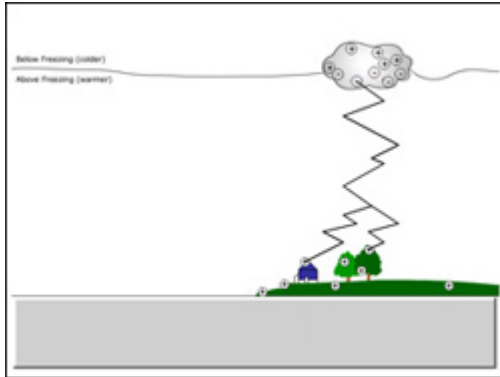
Scene 11: A stepped leader of negative charges moves downward in a series of steps. It nears the ground.



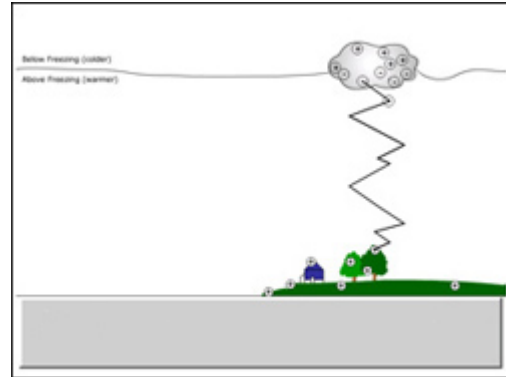
Scene 12: A positively charged leader travels up from such objects as trees and buildings.

URL: <http://edpsych.clahs.vt.edu/mayer/treatments/G2.html>

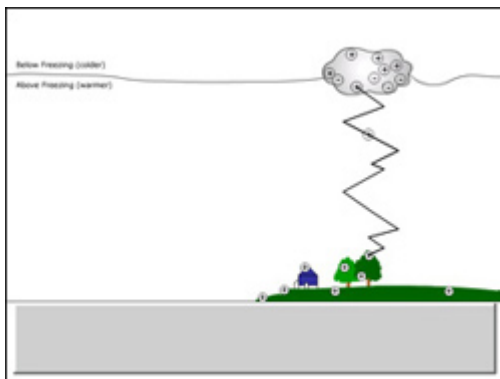
APPENDIX A: LIGHTNING FORMATION, ANIMATION + NARRATION (continued)



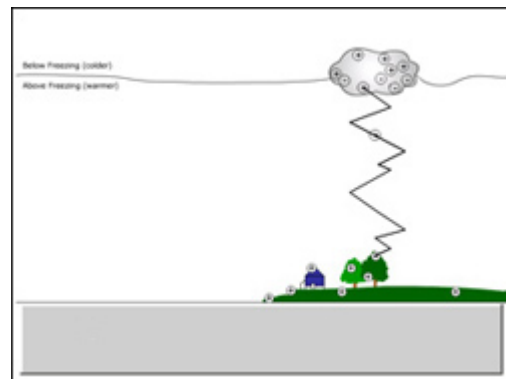
Scene 13: The two leaders generally meet about 165-feet above the ground.



Scene 14: Negatively charged particles then rush from the cloud to the ground along the path created by the leaders. It is not very bright.



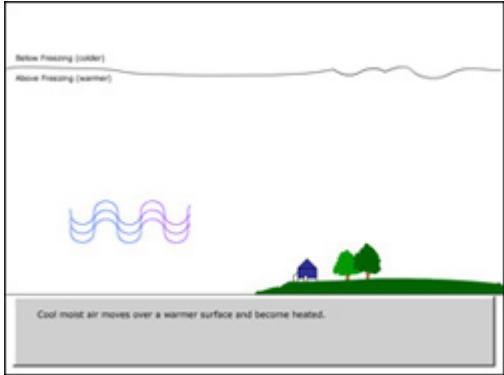
Scene 15: As the leader stroke nears the ground, it induces an opposite charge, so positively charged particles from the ground rush upward along the same path.



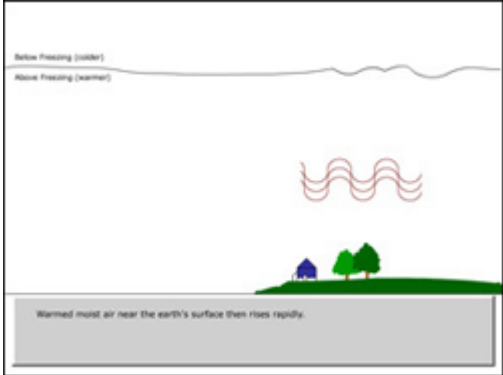
Scene 16: This upward motion of the current is the return stroke. It produces the bright light that people notice as a flash of lightning.

APPENDIX B: LIGHTNING FORMATION, ANIMATION + TEXT

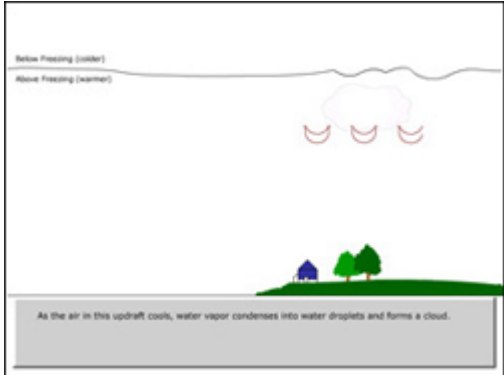
Duration: 240 seconds



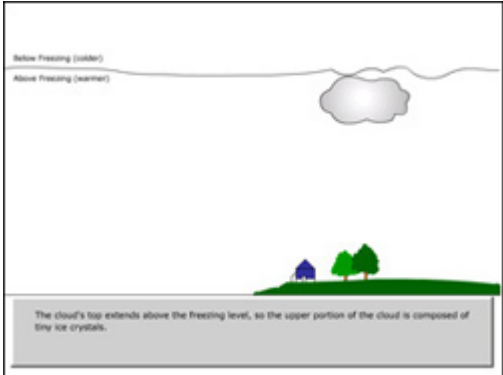
Scene 1



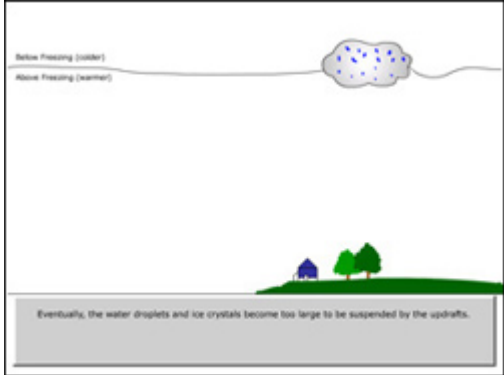
Scene 2



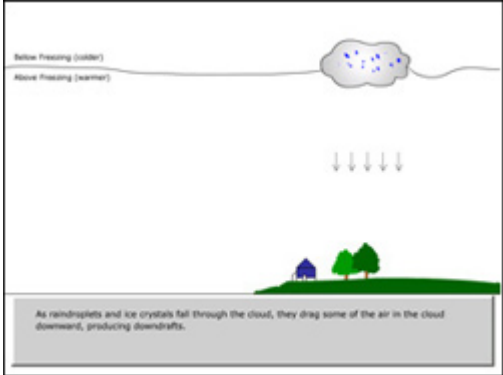
Scene 3



Scene 4



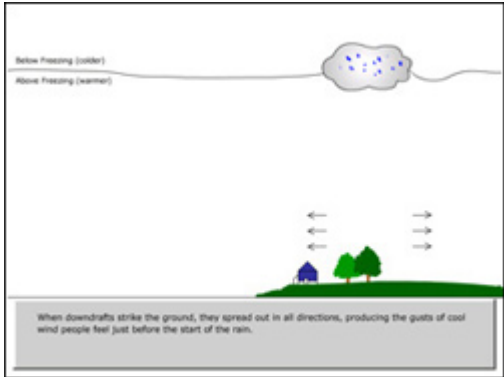
Scene 5



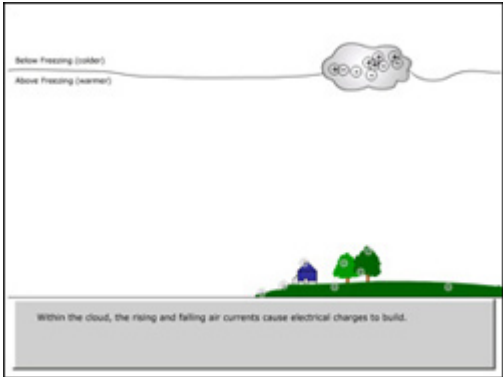
Scene 6

URL: <http://edpsych.clahs.vt.edu/mayer/treatments/G2.html>

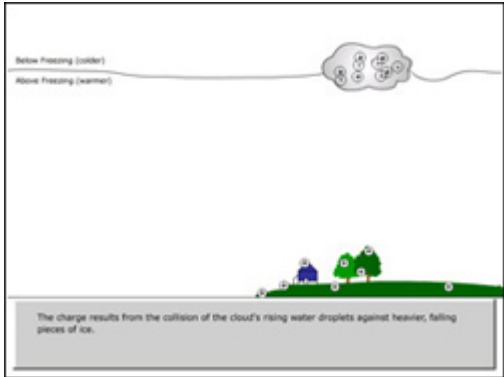
APPENDIX B: LIGHTNING FORMATION, ANIMATION + TEXT (continued)



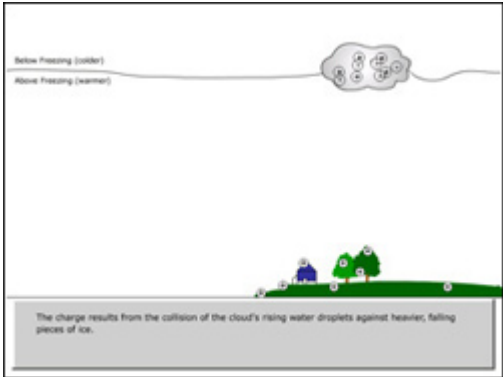
Scene 7



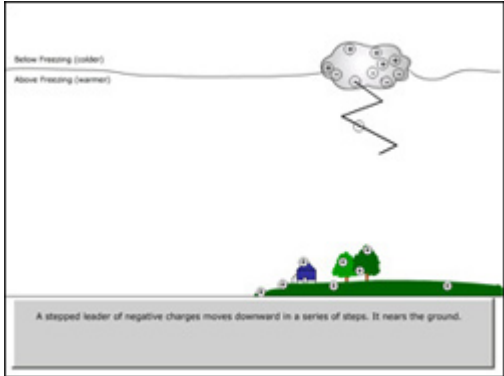
Scene 8



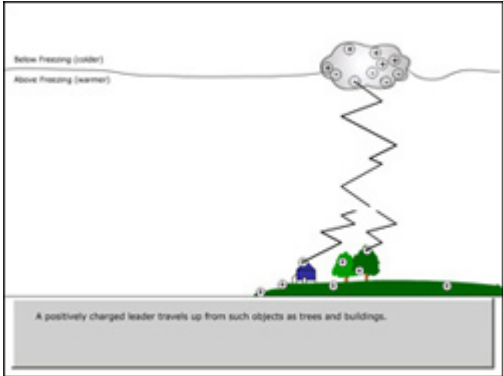
Scene 9



Scene 10



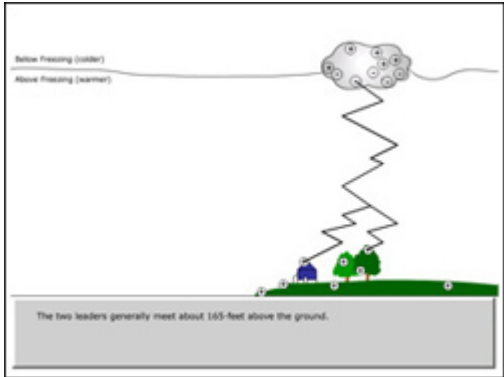
Scene 11



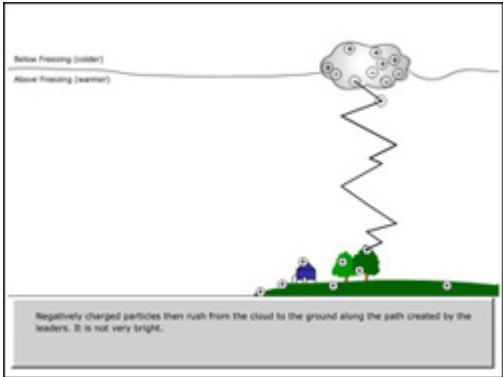
Scene 12

URL: <http://edpsych.clahs.vt.edu/mayer/treatments/G2.html>

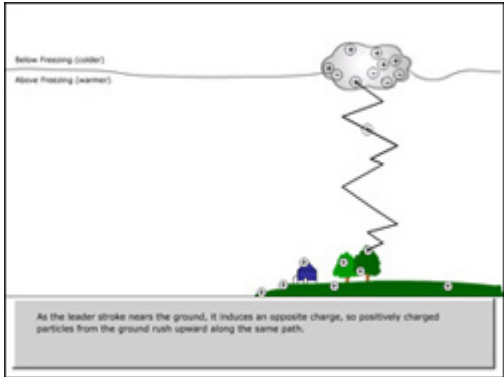
APPENDIX B: LIGHTNING FORMATION, ANIMATION + TEXT (continued)



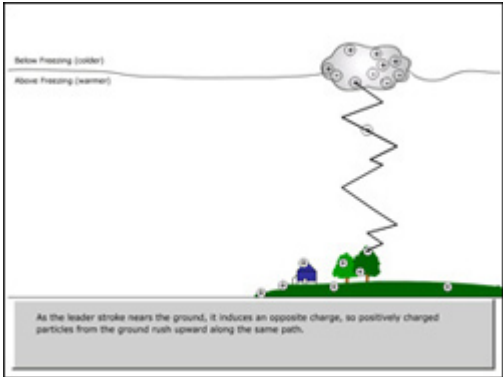
Scene 13



Scene 14



Scene 15



Scene 16


APPENDIX C: LIGHTNING FORMATION, TEXT ONLY

Duration: 240 seconds

Scene	Text
1	Cool moist air moves over a warmer surface and become heated.
2	Warmed moist air near the earth's surface then rises rapidly.
3	As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.
4	The cloud's top extends above the freezing level, so the upper portion of the cloud is composed of tiny crystals.
5	Eventually, the water droplets and ice crystals become too large to be suspended by the updrafts.
6	As raindroplets and ice crystals fall through the cloud, they drag some of the air in the cloud downward, producing downdrafts.
7	When downdrafts strike the ground, they spread out in all directions, producing the gusts of cool wind people feel just before the start of rain.
8	Within the cloud, the rising and falling air currents cause electrical charges to build.
9	The charge results from the collision of the cloud's rising water droplets against heavier, falling pieces of ice.
10	The negatively charged particles fall to the bottom of the cloud, and most of the positively charged particles rise to the top.
11	A stepped leader of negative charges moves downward in a series of steps. It nears the ground.
12	A positively charged leader travels up from such objects as trees and buildings.
13	The two leaders generally meet about 165-feet above the ground.
14	Negatively charged particles then rush from the cloud to the ground along the path created by the leaders. It is not very bright.
15	As the leader stroke nears the ground, it induces an opposite charge, so positively charged particles from the ground rush upward along the same path.
16	This upward motion of the current is the return stroke. It produces the bright light that people notice as a flash of lightning.

APPENDIX D: PRE-EXPERIMENT FILTER TEST

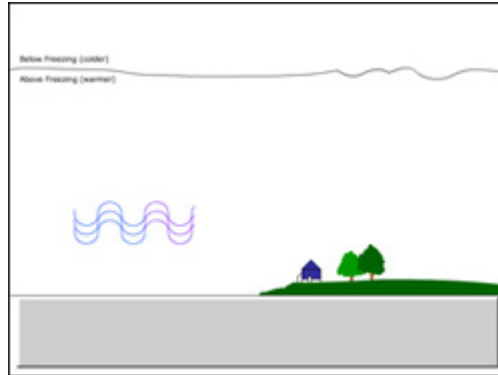
Place a check mark next to the item that applies to you

- I regularly read the weather maps in the newspaper
- I know what a cold front is
- I can distinguish between cumulus and nimbus clouds
- I know what a low pressure system is
- I can explain what makes the wind blow
- I know what this symbol means 

Please put a check mark indicating your knowledge of meteorology (weather)

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| very little | less than average | average | more than average | very much |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 1 | 2 | 3 | 4 | 5 |

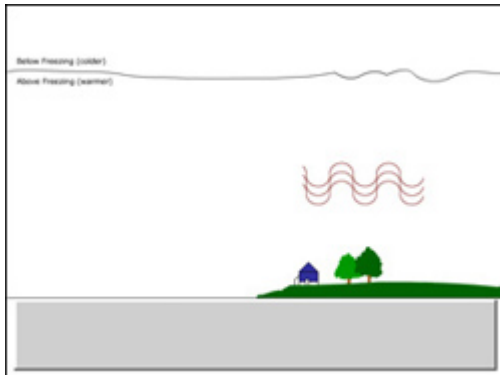
APPENDIX E: RECALL QUESTIONS



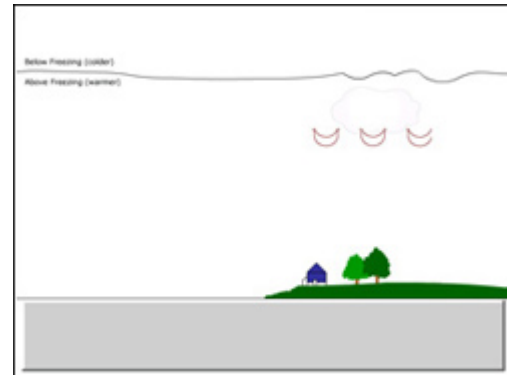
Scene 1: Cool moist air moves over a warmer surface and become heated.

Question 1 When cool moist air moves over a warmer surface, what happens?

Answer air becomes heated and *the air rises*



Scene 2: Warmed moist air near the earth's surface then rises rapidly.

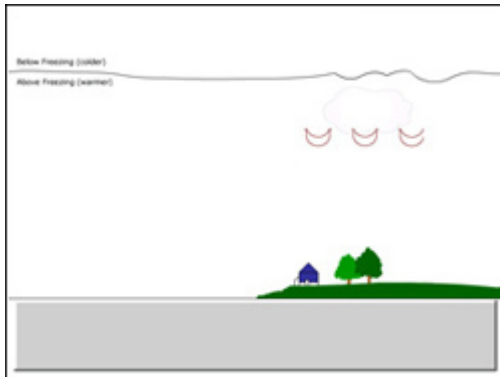


Scene 3: As the air in this updraft cools.

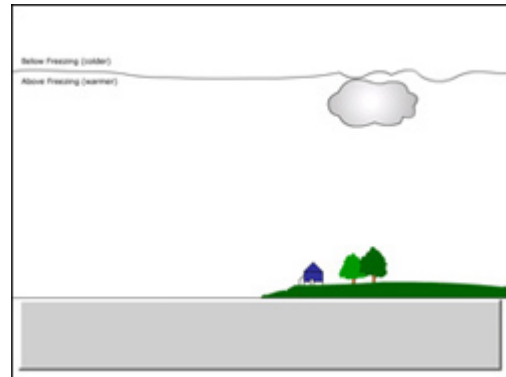
Question 2 As the air in the updraft cools, what happens?

Answer water vapor condenses and *a cloud forms*

APPENDIX E: RECALL QUESTIONS (continued)



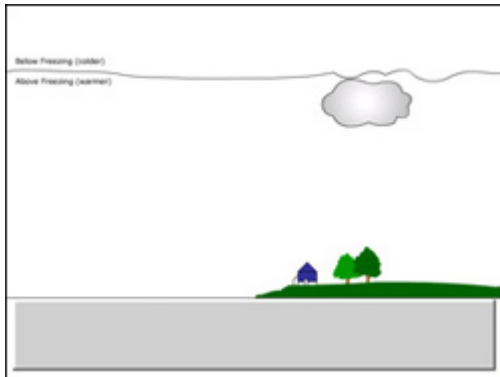
Scene 3: As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.



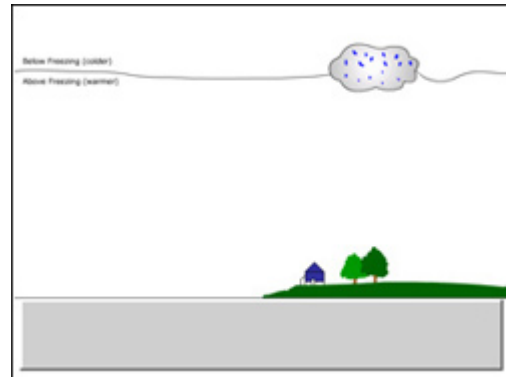
Scene 4: The cloud's top extends above the freezing level.

Question 3 As the cloud's top extends above the freezing level, what happens?
Answer *ice crystals form*

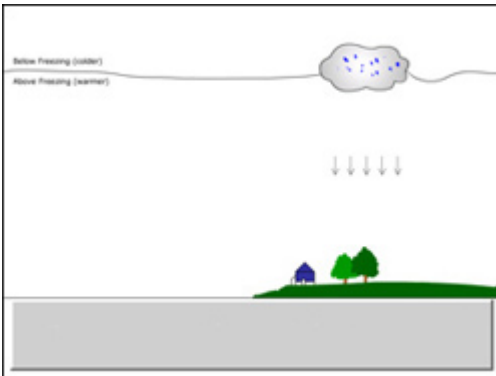
APPENDIX E: RECALL QUESTIONS (continued)



Scene 4: The cloud's top extends above the freezing level, so the upper portion of the cloud is composed of tiny crystals.



Scene 5: Eventually, the water droplets and ice crystals become too large to be suspended by the updrafts.

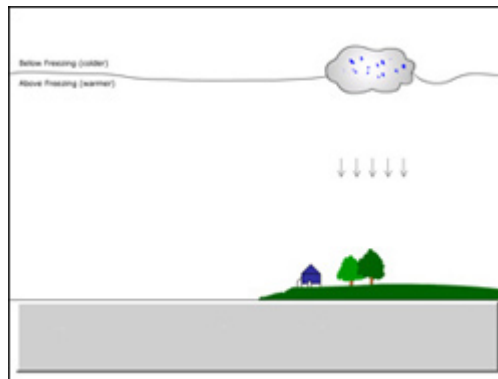


Scene 6: The raindrops and ice crystals fall through the cloud,

Question 4 As raindrops and ice crystals fall through the cloud, what happens?

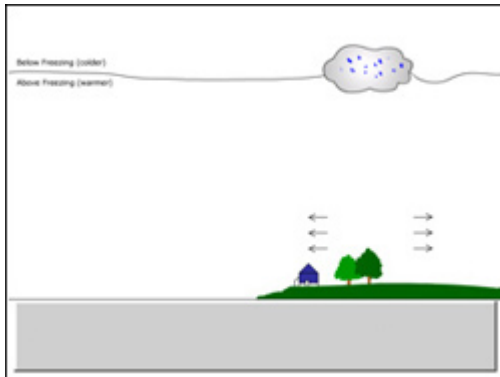
Answer air is dragged down producing a *downdraft*

APPENDIX E: RECALL QUESTIONS (continued)

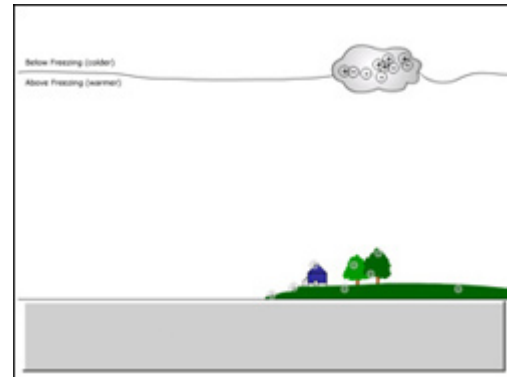


Scene 6: As raindroplets and ice crystals fall through the cloud, they drag some of the air in the cloud downward, producing downdrafts.

Question 5 When downdrafts strike the ground, what happens?
Answer the air spreads out in all directions *producing a cool wind*



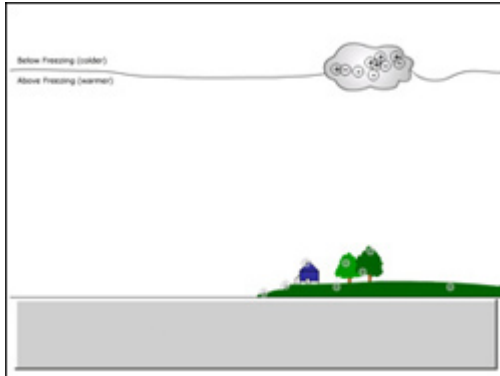
Scene 7: When downdrafts strike the ground, they spread out in all directions, producing the gusts of cool wind people feel just before the start of rain.



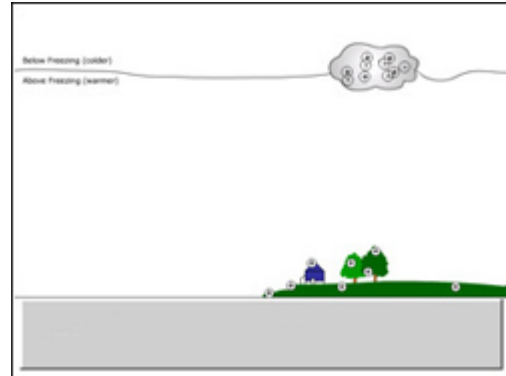
Scene 8: The air currents rise and fall within the cloud.

Question 6 When the air currents in the cloud begin to rise and fall, what happens?
Answer *electrical charges build*

APPENDIX E: RECALL QUESTIONS (continued)

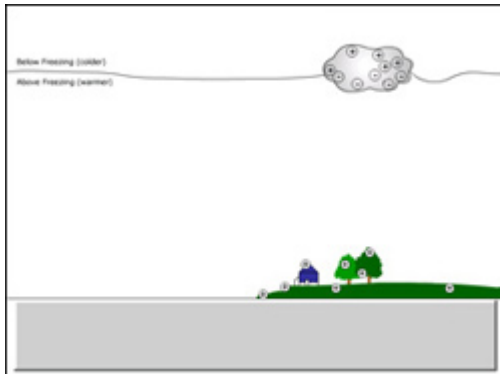


Scene 8: Within the cloud, the rising and falling air currents cause electrical charges to build.

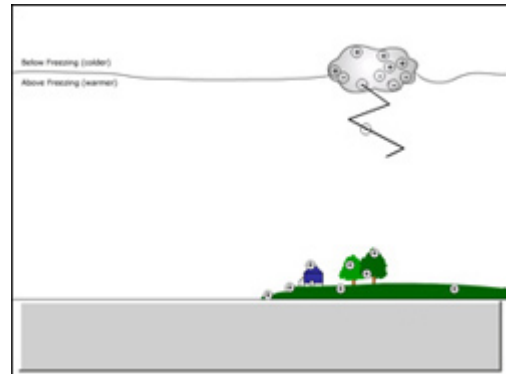


Scene 9: The charge results from the collision of the cloud's rising water droplets against heavier, falling pieces of ice.

Question 7 As charged particles in the cloud begin to form, what happens?
Answer *negative charges fall to the bottom, positive charges rise to the top*



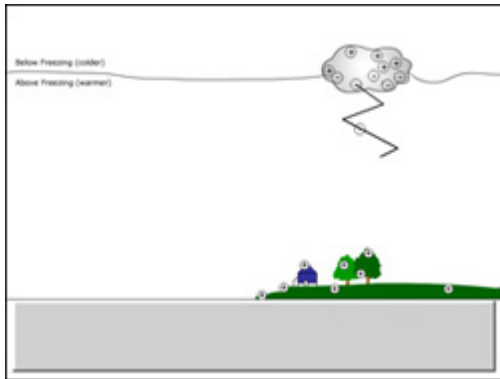
Scene 10: The negatively charged particles fall to the bottom of the cloud, and most of the positively charged particles rise to the top.



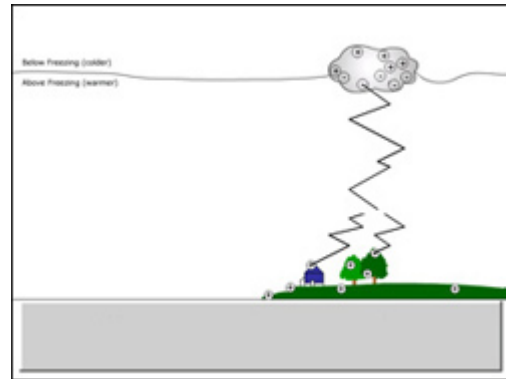
Scene 11: A stepped leader of negative charges moves downward in a series of steps. It nears the ground.

Question 8 As a stepped leader of negative charges move downward toward the ground, what happens?
Answer *a positively charged leader travels up from the ground*

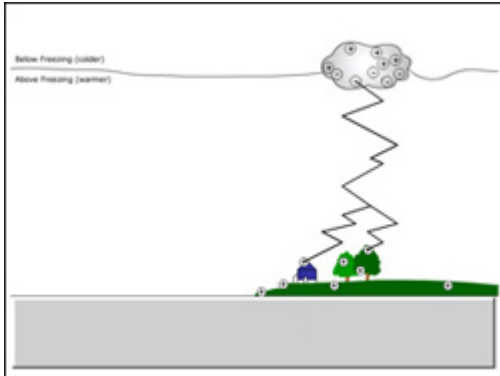
APPENDIX E: RECALL QUESTIONS (continued)



Scene 11: A stepped leader of negative charges moves downward in a series of steps. It nears the ground.



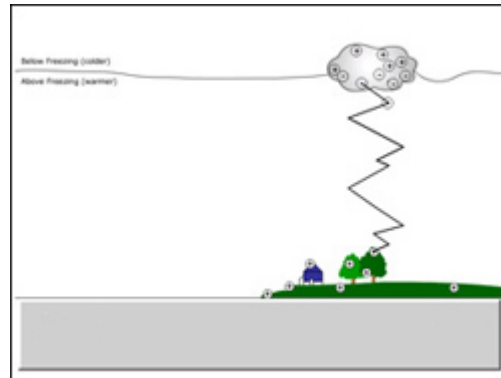
Scene 12: A positively charged leader travels up from such objects as trees and buildings.



Scene 13: The two leaders generally meet about 165-feet above the ground.

Question 9 When the negative and positive leaders meet, what happens?
Answer *negative charges rush from the cloud to the ground*

APPENDIX E: RECALL QUESTIONS (continued)



Scene 14: Negatively charged particles then rush from the cloud to the ground along the path created by the leaders. It is not very bright.

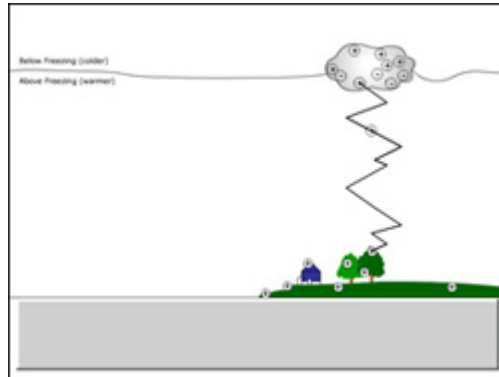
Question 10 When negative charges rush from the cloud to the ground, what happens?
Answer *positive charges rush from the ground to the cloud, forming lightning*

APPENDIX F: TRANSFER QUESTIONS

1. What could you do to decrease the intensity of lightning?

Acceptable Answers: removing positive ions from the ground or reducing the temperature difference between the ocean and the earth

Unacceptable Answers: removing trees and tall objects from the ground

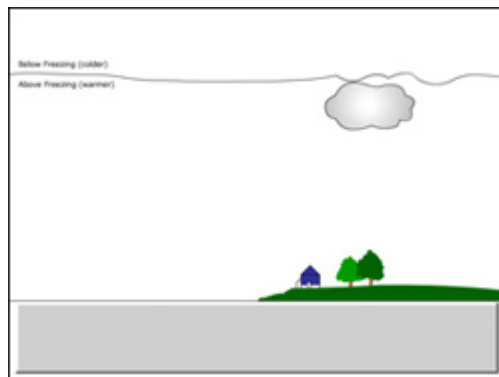


Scene 15: As the leader stroke nears the ground, it induces an opposite charge, so positively charged particles from the ground rush upward along the same path.

2. Suppose you see clouds in the sky, but no lightning. Why not?

Acceptable Answers: tops of the clouds might not be high enough to freeze or that positive and negative charges might not have built up yet

Unacceptable Answers: stating that the cloud was not a rain cloud



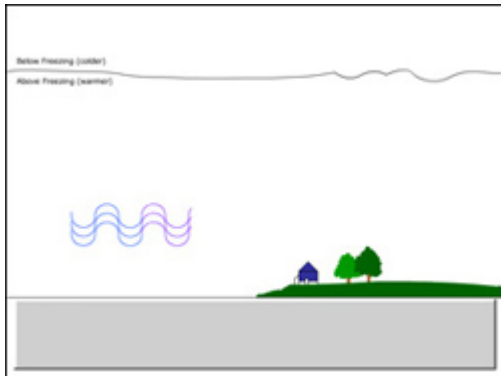
Scene 4: The cloud's top extends above the freezing level, so the upper portion of the cloud is composed of tiny crystals.

APPENDIX F: TRANSFER QUESTIONS (continued)

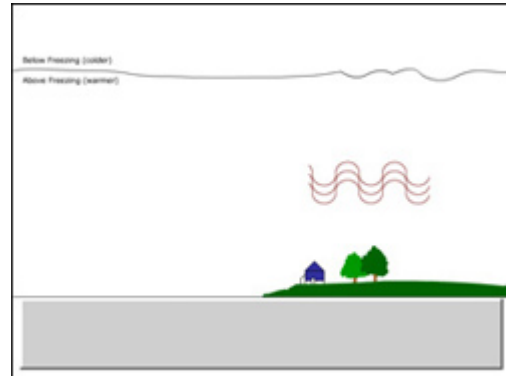
3. What does air temperature have to do with lightning?

Acceptable Answers: air must be cooler than the ground or that the temperature has to be low enough for the cloud's top to freeze

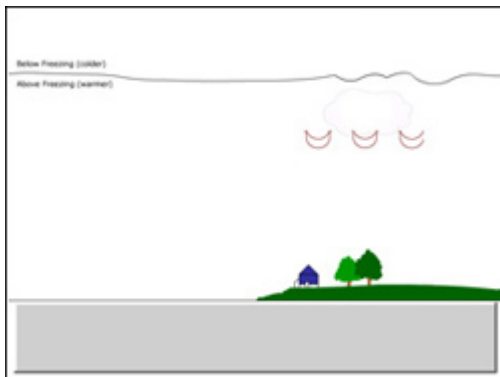
Unacceptable Answers: stating that warm air rises



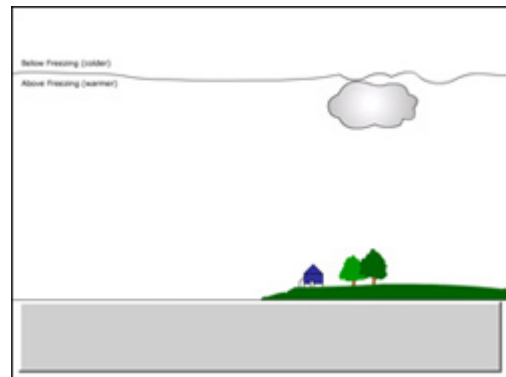
Scene 1: Cool moist air moves over a warmer surface and become heated.



Scene 2: Warmed moist air near the earth's surface then rises rapidly.



Scene 3: As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.



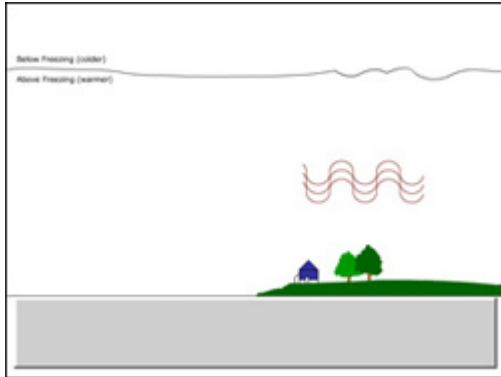
Scene 4: The cloud's top extends above the freezing level, so the upper portion of the cloud is composed of tiny crystals.

APPENDIX F: TRANSFER QUESTIONS (continued)

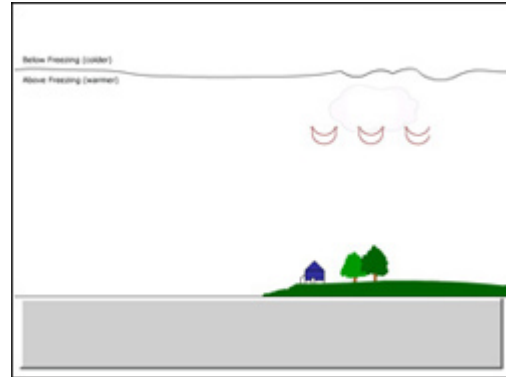
4. What causes lightning? or What do electrical charges have to do with lightning?

Acceptable Answers: difference in electrical charges in the cloud or the difference in temperature between the top and the bottom of the cloud

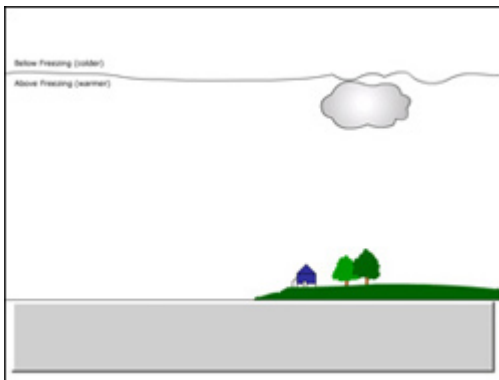
Unacceptable Answers: describing the animation step by step without specifying that the difference in charges or temperature were the actual cause



Scene 2: Warmed moist air near the earth's surface then rises rapidly.



Scene 3: As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.



Scene 4: The cloud's top extends above the freezing level, so the upper portion of the cloud is composed of tiny crystals.

RESUME

EMET L. LABOONE

EMET L. LABOONE (elaboone@vt.edu)

1803 GLADE ROAD • BLACKSBURG, VA 24060 • (540) 961-2858

<http://www.laboone.com>**EDUCATION**

Doctor of Philosophy, Curriculum and Instruction, May 2006

Virginia Tech, College of Human Resources and Education, Blacksburg, VA

Masters of Education, Administration, Planning, and Social Policy, June 1995

Harvard University, Graduate School of Education, Cambridge MA

Bachelors of Arts, Psychology, Cum Laude, with Departmental Honors, May 1994

Morehouse College, Atlanta, GA

Associate of Arts, General Studies, with Honors, December 1991

City College of San Francisco, San Francisco, CA**PROFESSIONAL EXPERIENCE****Virginia Tech**, Blacksburg, VA

Institute for Distance and Distributed Learning

Assistant Director for Instructional Design, Development and Support

July 2001 to Present

Instructional Designer/Developer

- Project manager for courses, training, and programs delivered within an electronically mediated environment
- Supervise full and part-time team of faculty and staff based on a holistic approach to teaching and learning
- Provide vision and scope for instructional design, development and faculty support area
- Manage efforts to provide continued strength in the area of faculty support
- Create high quality courses that effectively integrate technology with teaching and learning principles
- Collaborate with faculty and staff across the university, nationally, and internationally as it relates to instructional design and development.
- Conduct a variety of workshops related to emerging technologies.

Office of the Vice President of Student Affairs

Special Assistant to the Vice President of Student Affairs

August 1998 to July 2001

- Design and develop web sites for the Division of Student, Hokie Tracks Interactive, Alcohol Abuse Prevention, and Dean of Students' Office
- Systems Administrator for the Office of the Vice President of Student Affairs
- Research and Assessment for the Alcohol 101 project and Hokie Tracks Interactive

Educational Technologies, Faculty Development Institute

Teaching Assistant

Summer 1998

- Provide training and technical support for faculty on topics related to basic computing, web-based instruction, web-development and distance learning.

Office of the Provost

Graduate Assistant

August 1997 to August 1998

- Design and maintain web pages on special initiatives and programs
- Data collection and analysis for special report
- Assist Associate Provost on HBCU Partnership Project
- Recruit potential graduate students for Virginia Tech

Department of Education,

Community Technology Centers, Washington DC

Field Reader

Summer 2002

Preparing Tomorrow's Teachers to Use Technology, Washington DC

Reader / Panel Chair

Summer 1999

Morris Brown College, Counseling & Testing Department, Atlanta, GA

Interim Director/Counselor

August 1995 to August 1997

- Coordinated New Student Orientation, National Collegiate Alcohol Awareness Week, and Parents Weekend.
- Personal, career, academic, and psychological counseling
- Supervised, trained and coordinated the Peer Counseling component
- Administered National Graduate Exams as scheduled by Educational Testing Service
- Conducted research on counseling programs' impact and preventive services

University of San Francisco, Upward Bound, San Francisco, CA

Head and Field Counselor

Summer 1993 to Summer 1995/May 1991 to August 1992

- Director of Residential Living for high school students in program
- Scheduled and trained a staff of residential counselors
- Developed and facilitated workshops on college applications, financial aid, scholastic testing guidelines, and social issues related to teens
- Counsel students on personal concerns, college decisions, and high school course selection

Harvard University, Cambridge, MA

Graduate School of Arts & Sciences, Housing Services

Computer Services Coordinator

February 1995 to June 1995

- Assessed technology requirement of graduate students living in four Residential Halls
- Project manager and proposal writer for technology project

Graduate School of Education, External Relations Office

Office Assistant

January 1995 to May 1995

- Conducted research on academic issues in educational publications

Graduate School of Education, Office of Admissions

Admissions Assistant

October 1994 to May 1995

- Processed files for final admission decision
- Facilitated workshops on admissions to Graduate School of Education

Cambridge Peace Commission, Cambridge, MA

Counselor

October 1994 to May 1995

- Produced and organized a two-hour, bi-weekly radio show about issues concerning teens
- Co-facilitated weekly meetings on non-violent strategies for teens

Boston University, Center for English Language Orientation Programs, Boston, MA

Assistant Orientation Coordinator/Intern

October 1994 to January 1995

- Maintained budget and related items with Student Activities Office

- Implemented programs to promote cultural interaction and new student orientation
- Organized and promoted many of the class field trips, and social/cultural events

United States Marine Corps Reserve, Alameda, CA and Marietta, GA

Corporal, E-4

May 1988 to May 1994

- Helped manage dining facility to assure proper distribution of meals and dining supplies
- Military Occupation Skill: Food Service Specialist

Morehouse College, Office of Admissions, Atlanta, GA

Office Assistant

August 1992 to May 1994

- Assisted in the preparation of admissions applications for final decisions
- Led motivational tours of the campus, highlighting the important aspects of the institution for recruitment

TEACHING EXPERIENCE

West Chester University, West Chester, PA.

Professional & Secondary Education

Instructor, Introduction to Instructional Communications

Summer Session II 2001

Radford University, Radford, VA.

Department of Accounting, Finance, Information Systems

Instructor, Introduction to Information Systems

Spring 2000

Virginia Tech, Blacksburg, VA

College of Natural Resources

Instructor, Introduction to Microcomputers in Forestry and Natural Resources

Spring 2000

Residential Dining Programs

Facilitator, First Year Experience, The Wing

Fall 1997 to 1999, & 2002

Morris Brown College, Atlanta, GA

Department of Psychology

Instructor, Supervised Internship

Fall 1996 and Spring 1997

General Studies Program

Instructor, New Student Success Seminar

Fall 1995 to Spring 1997

Program for Young Negotiators, Cambridge, MA

Negotiation Instructor

Spring 1995

PUBLICATIONS

Holmes, G., & LaBoone, E. (2002). *The importance of culture when creating audio enhanced, web-based instruction*. *Tech Trends*, 46(2), 56-61.

Hirt, J. B., Bayless, L., Collins, D., Dobbins, T., Fravel, P., LaBoone, K., LaBoone, E., Lichty, M., Werth, P., & Wood, P. (1999). *An assessment of computer skill levels among user groups on campus*. *College and University Media Review*, 5(2), 11-27

Hyer, P. B., LaBoone, E. L., & Mottley, E. L. (1998). *Women and Minorities at Virginia Tech*. Blacksburg, VA: Virginia Tech, Office of the Senior Vice President and Provost.

PRESENTATIONS

- LaBoone, E. (2006). *Improving Teaching and Learning at a Distance*. Presented at the Learning & Technology Symposium: Bridging the Divide. Effat College, Jeddah, Saudi Arabia.
- LaBoone, E. (2006). *Creating Effective Tutorials with Multimedia*. Presented at the Learning & Technology Symposium: Bridging the Divide. Effat College, Jeddah, Saudi Arabia.
- Scales, G. R., Peed, C., & LaBoone, E. (2005, October) *Providing Distance Learning with New Tools for the VT/WFU Biomedical Engineering and Science School*. Presented at the EDUCAUSE annual conference, Orlando, FL.
- LaBoone, E. (2005, April). *Organizing your Course to Maximize Learning and Increasing Quality*. Present at the Innovative Teaching Strategies for Faculty Using Blackboard, Virginia Commonwealth University, Richmond, VA.
- LaBoone, E. (2004, November). *Designing Effective Instruction in a Digital Environment*. Presented at the Appalachian College Association Summit 2004, Southwest Virginia Higher Education Center, Abingdon, VA.
- Turner, S., & LaBoone, E. (2002, June). *VTalumnNET: A Virtual Gateway to Lifelong Learning for Virginia Tech Alumni*. Poster presented at the Ed-Media, World Conference on Educational Multimedia, Hypermedia & Telecommunications, Denver, CO.
- LaBoone, E., (2002, June) *Web Development and Design*. Training for the Summer Training Academy for Rising Stars, on the campus of Virginia Tech, Blacksburg, VA.
- Holmes, G., & LaBoone, E. (2001, November). *The Importance of Culture When Creating Audio-Enhanced, Web-Based Instruction*. Presented at the annual conference of the Association for Educational Communications and Technology, Atlanta, GA.
- Snider, R., Macedo, P., LaBoone, E., & Penny S. (2001, November). *The Development of a Model for Using E-portfolios in Instructional Technology Programs*. Presented at the annual conference of the Association for Educational Communications and Technology, Atlanta, GA.
- Holmes, G., & LaBoone, E (2001, February). *Learning via Audio and the Internet: Rethinking Instructional Radio Paradigms*. Paper presented at the annual conference of the Eastern Educational Research Association, Hilton Head, SC.
- LaBoone, E. (2001, May). *Web Site Concept Development: Using Principles of Instructional Design*. Training for the Virginia Department of Alcoholic Beverage Control, Mill-e-nium Campus Conference on the campus of James Madison University, Harrisonburg, VA.

HONORS & ACTIVITIES

Wes McJulien Minority Graduate Scholarship Award (2001), Association for Educational Communications and Technology • Frederick Douglass Fellow, West Chester University • American Society for Information Science • American College Personal Association • Gold Key National Honor Society • Psi Chi, Psychology Honor Society • Alpha Gamma Sigma Honor Society, City College of San Francisco • Oprah Winfrey Scholar (1993-1994) • Honor Roll; Deans List (1990 - 1994) • Who's who Among College Students (1993 & 1994) • Psychology Association, Morehouse College • Tour Guide, Student Tiger Recruiting Interested Persons for Enrollment Stability (1992 - 1994) • Photographer, Maroon Tiger Newspaper & Torch Yearbook • Volunteer/Mentor, Families First; The Atlanta Project, Harper Cluster; Capitol Area Mosaic; Atlanta, GA (1993 - 1994)